OCS EIS/EA
BOEM 2011-001

Outer Continental Shelf Oil and Gas Leasing Program: 2012-2017

Draft Programmatic Environmental Impact Statement

November 2011

U.S. Department of the Interior
Bureau of Ocean Energy Management
www.boem.gov

Bureau of Ocean Energy Management

OCS EIS/EA
BOEM 2011-001

Outer Continental Shelf
Oil and Gas Leasing Program: 2012-2017

Draft Programmatic Environmental Impact Statement

Bureau of Ocean Energy Management

Published by
U.S. Department of the Interior
Bureau of Ocean Energy Management

November 2011

CONTENTS

VOLUME 1

CONTENTS (Cont.)

CONTENTS (Cont.)

CONTENTS (Cont.)

CONTENTS (Cont.)

CONTENTS (Cont.)

CONTENTS (Cont.)

VOLUME 2

CONTENTS (Cont.)

CONTENTS (Cont.)

VOLUME 3

CONTENTS (Cont.)

CONTENTS (Cont.)

CONTENTS (Cont.)

FIGURES

FIGURES (Cont.)

FIGURES (Cont.)

FIGURES (Cont.)

FIGURES (Cont.)

FIGURES (Cont.)

TABLES

TABLES (Cont.)

TABLES (Cont.)

TABLES (Cont.)

TABLES (Cont.)

TABLES (Cont.)

TABLES (Cont.)

TABLES (Cont.)

TABLES (Cont.)

This page intentionally left blank.

ABBREVIATIONS AND ACRONYMS

ACSAR	Atlantic continental slope and rise
ABC	American Bird Conservancy
ABM	Alabama beach mouse
ACC	Arctic Coastal Current
ACIA	Arctic Climate Impact Assessment
ACP	Arctic Coastal Plain
ADCED	Alaska Department of Community and Economic Development
ADEC	Alaska Department of Environmental Conservation
ADF&G	Alaska Department of Fish and Game
ADNR	Alaska Department of Natural Resources
AEB	Aleutian East Borough
AEWC	Alaska Eskimo Whaling Commission
AFB	Air Force Base
AFN	Alaskan Federation of Natives
AHTS	anchor handling towing supply
Alaska OHA	Alaska Office of History and Archaeology
AMMP	adaptive mitigation and management plan
ANCSA	*Alaska Native Claims Settlement Act* of 1971
ANILCA	Alaska National Interest Lands Conservation Act
ANIMIDA	Arctic Nearshore Impact Monitoring in Development Area
ANSC	Aleutian North Slope Current
ANWR	Arctic National Wildlife Refuge
AO	Arctic Oscillation
BBB	Bristol Bay Borough
Bbbl	billion barrels
bbl	barrels
bbl/yr	barrels per year
BBO	billion barrels of oil
BBOE	billion barrels of oil equivalent
Bcf	billion cubic feet
BCNP	Big Cypress National Preserve
BLM	Bureau of Land Management (USDOI)
BNWR	Breton National Wildlife Refuge
B.P.	before present
bpd	barrels per day
BSAI	Bering Sea and Aleutian Islands, Alaska
BTEX	benzene, toulene, ethylbenzene & xylene
BPXA	British Petroleum (Exploration) Alaska
°C	degrees Centrigrade
^{14}C	carbon-14
CAA	Clean Air Act or conflict avoidance agreement

CAH	Central Arctic Herd
CBM	Choctawhatchee beach mouse
CEC	Commission on Environmental Cooperation
CEI	Coastal Environments, Inc.
CEQ	Council on Environmental Quality
CER	categorical exclusion review
CFC	chlorofluorocarbons
CFR	Code of Federal Regulations
CH_4	methane
CIAP	Coastal Impact Assistance Program
CIRI	Cook Inlet Region, Inc.
cm	centimeter
CMP	coastal management program
cm/s	centimeter per second
CMSP	Coastal and Marine Spatial Planning
CO	carbon monoxide
CO_2	carbon dioxide
COE	Corps of Engineers (U.S. Army)
CPUE	catch per unit effort
CVI	coastal vulnerability index
CWA	Clean Water Act
CWPPRA	Coastal Wetlands Planning, Protection, and Restoration Act
CZM	Coastal Zone Management
CZMA	Coastal Zone Management Act
dB	decibel
dB re 1 µPa-m	dB referenced to 1 micropascal within 1 meter of the source
DDT	dichlorodiphenyltrichloroethane
DHHS	Department of Health and Human Services
DIN	dissolved inorganic nitrogen
DIP	dissolved inorganic phosphorus
DLP	defense of life and property
DOSS	dioctylsulfosuccinate
DPnB	dipropylene glycol n-butyl ether
DPS	distinct population segment
DTNP	Dry Tortugas National Preserve
DWH	Deepwater Horizon
DWH oil spill	Deepwater Horizon MC252 Spill of National Significance
E&D	exploration and development
EA	environmental assessment
ECOS	Environmental Conservation Online System
EDA	estuarine drainage area
EEZ	Exclusive Economic Zone
EFH	essential fisheries habitat
EIA	economic impact area

EIS	environmental impact statement
EJ	environmental justice
ENP	Everglades National Park
ENSO	El Niño-Southern Oscillation
EO	Executive Order
ERS	Economic Research Service (USDOA)
ESA	Endangered Species Act
ESI	Environmental Sensitivity Index
°F	degrees Fahrenheit
FAD	fish aggregation device
FCMA	Fishery Conservation and Management Act of 1976
FDA	fluvial drainage area
FEMA	Federal Emergency Management Agency
FGBNMS	Flower Garden Banks National Marine Sanctuary
FKNMS	Florida Keys National Marine Sanctuary
FLM	Federal land manager
FMC	fishery management council
FMP	fishery management plan
FOSC	Federal On-Scene Coordinator
FPSO	floating production, storage, and offloading
FR	Federal Register
FS	Forest Service (USDOA)
FSB	Federal Subsistence Board
FWPCA	Federal Water Pollution Control Act
FWS	Fish and Wildlife Service (USDOI)
GCCF	Gulf Coast Claims Facility
GINS	Gulf Island National Seashore
GMFMC	Gulf of Mexico Fishery Management Council
GOA	Gulf of Alaska
GOM	Gulf of Mexico
GRS	geographic response strategy
GSA	Geographic Society of America
GWP	global warming potential
H_2S	hydrogen sulfide
ha	hectare
HAPC	habitat area of particular concern
HCA	Habitat Conservation Area
HDDC	high density deepwater communities
HIA	Health Impact Assessment
HPA	Habitat Protection Area
Hz	hertz

IBA	Important Bird Area
IPCC	Intergovernmental Panel on Climate Change
IPHC	International Pacific Halibut Commission
IUCN	International Union Conservation Network
IWC	International Whaling Commission
kHz	kilohertz
KIB	Kodiak Island Borough
km	kilometer
km^2	square kilometer
km/hr	kilometers per hour
KPB	Kenai Peninsula Borough
kwh	kilowatt hours
lb	pounds
LCI	Lower Cook Inlet
LMA	Labor Market Area
LME	Large Marine Ecoregion
LNG	liquefied natural gas
LPB	Lake and Peninsula Borough
LRRS	Long-Range Radar Site
LSU CMI	Louisiana State University Coastal Marine Institute
LCWCRTF	Louisiana Coastal Wetlands Conservation and Restoration Task Force
m	meter
m^3	cubic meter
m^3/s	cubic meter per second
m/s	meters per second
m/yr	meters per year
MAFLA	Mississippi, Alabama, and Florida
MAG-PLAN	MMS Alaska-GOM Modeling Using IMPLAN
MARPOL	International Convention for the Prevention of Pollution from Ships
Mbbl	million barrels
MCF	million cubic feet
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mi^2	square miles
mi^2/yr	square miles per year
ML	Richter low magnitude
ml/L	milliliters per liter
MMbbl	million barrels
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service (USDOI)
MODU	mobile offshore drilling unit
MPA	Marine Protected Area
mph	miles per hour

MPPRCA	Marine Plastic Pollution Research and Control Act
MPRSA	Marine Protection Research and Sanctuaries Act
MRFSS	Marine Recreational Fisheries Statistics Survey (NMFS)
MSA	metropolitan statistical area
MSP	marine spatial planning
M_W	moment magnitude
NAAQS	National Ambient Air Quality Standards
NAFTA	North Atlantic Free Trade Agreement
NAO	North Atlantic Oscillation
NASA	National Aeronautics and Space Administration
NAST	National Assessment Synthesis Team
NDBC	National Data Buoy Center
NEPA	National Environmental Policy Act
NGL	natural gas liquid
NGO	non-governmental organization
NHPA	National Historic Preservation Act
NIC	National Incident Command
NM	nautical miles
NMFS	National Marine Fisheries Service (USDOC, NOAA)
N_2O	nitrous oxide
NO_2	nitrogen dioxide
NO_x	nitrogen oxide
NOAA	National Oceanic and Atmospheric Administration (USDOC)
NOC	National Ocean Council
NORM	naturally occurring radioactive material
NO_x	nitrogen oxides
NP	National Park
NPDES	National Pollutant Discharge Elimination System
NPFMC	North Pacific Fishery Management Council
NPR–A	National Petroleum Reserve–Alaska
NRDA	Natural Resource Damage Assessment
NRDC	National Resources Defense Council
NRHP	*National Register of Historic Places*
NPS	National Park Service (USDOI)
NRC	National Research Council
NSB	North Slope Borough
NSRE	National Survey on Recreation and the Environment (NOAA)
NTL	Notice to Lessees
NWA	national wilderness area
NWR	national wildlife refuge
NWS	National Weather Service
O&G	oil and gas
O_3	ozone

OBIS-SEAMAP	Ocean Biogeographic Information System-Spatial Ecological Analysis of Megavertebrate Populations
OBM	oil-based mud
OCD	Offshore and Coastal Dispersion Model
OCS	Outer Continental Shelf
OCSLA	Outer Continental Shelf Lands Act
OECM	Offshore Environmental Cost Model
OPA 90	Oil Pollution Act of 1990
OPAREA	(military) operating area
OSAT	Operational Science Advisory Team of the Unified Area Command
OSRF	oil-spill financial responsibility
OSV	offshore supply vessel
PAH	polyaromatic hydrocarbons
Pb	lead
PCB	polychlorinated biphenyl
PCH	Porcupine Caribou Herd
PCPI	per capita personal income
PDO	Pacific Decadal Oscillation
PEIS	programmatic environmental impact statement
PICES	North Pacific Marine Science Organization
PINS	Padre Island National Seashore
PKBM	Perdido Key beach mouse
PM	particulate matter
PM_{10}	particulate matter less than 10 microns in diameter
$PM_{2.5}$	fine particulates less than 2.5 microns in diameter
ppb	parts per billion
ppm	parts per million
ppt	parts per thousan
PSD	Prevention of Significant Deterioration
RCRA	Resource Conservation and Recovery Act
ROD	record of decision
ROP	required operating procedure
ROW	right-of-way
SAAQS	State Ambient Air Quality Standards
SABM	St. Andrew’s beach mouse
SBF	synthetic-based drill fluids
SCAT	Shoreline Cleanup Assessment Team
SEED	Shelf Energetics and Exchange Dynamics
SIP	State Implementation Plan
SMB	synthetic-based muds
SO_2	sulfur dioxide
SO_x	sulfur oxides
SST	sea-surface temperature

SSDC	single steel drilling caisson
SUA	Special Use Airspace
SUSIO	State University System of Florida Institute of Oceanography
t	metric ton (tonne)
TAPS	Trans–Alaska Pipeline System
Tbbl	trillion barrels
tcf	trillion cubic feet
TcfG	trillion cubic feet of gas
TcfGE	trillion cubic feel of gas equivalent
TEIA	Transboundary Environmental Impact Assessment
TERA	Troy Ecological Research Associates
Tg	teragram
TLH	Teshekpuk Lake Herd
TMDL	total maximum daily load
TLSA	Teshepuk Lake Special Area
TTI/E	Ten Thousand Islands/Everglades Unit
UCI	Upper Cook Inlet
$\mu g/m^3$	migrograms per cubic meter
µm	micrometer
UNEP	United Nations Environment Programme
µPa	microPascal
µPa-m	microPascal at 1 meter
USCG	U.S. Coast Guard
USDOC	U.S. Department of Commerce
USDOD	U.S. Department of Defense
USDOE	U.S. Department of Energy
USDOI	U.S. Department of the Interior
USDOT	U.S. Department of Transportation
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey (USDOI)
VLOS	very large oil spill
VOC	volatile organic compound
WA	Wilderness Area
WAH	Western Arctic Herd
WBF	water-based fluid
WBM	water-based muds
WEA	Wind EnergyArea
yd^3	cubic yards

This page was intentionally left blank.

SUMMARY

The Proposed Action

The U.S. Department of the Interior (USDOI) proposes 15 lease sales in six of the Outer Continental Shelf (OCS) Planning Areas in the Gulf of Mexico (GOM) and offshore Alaska during the period 2012-2017 (Table S-1). Five area-wide lease sales each would be held in the Central and Western GOM Planning Areas, with one to two lease sales in the extreme western portion of the Eastern GOM Planning Area. Scheduled in the Alaska Region would be one sale with two whaling deferrals in the Beaufort Sea Planning Area, one sale with a 40 km (25 mi) buffer in the Chukchi Sea Planning Area, and one special interest sale in the Cook Inlet Planning Area. No lease sales are proposed off the U.S. east and west coasts. The proposed Program establishes a schedule that the USDOI will use as a basis for considering where and when leasing might be appropriate over a 5-year period (Table S-1). A decision to adopt the Program proposal is not a decision to issue specific leases or to authorize any drilling or development.

Oil and gas activities may occur on OCS leases after a lease sale pursuant to the proposed action, and these activities may extend over a period of 40 to 50 years. These activities may include (1) seismic surveys; (2) drilling oil and natural gas exploration and production wells; (3) installation and operation of offshore platforms and pipelines, onshore pipelines, and support facilities; and (4) transporting oil using ships or pipelines.

TABLE S-1 Proposed 2012-2017 Program Lease Sale Schedule

OCS Planning Area	Proposed Lease Sale Year
Western Gulf of Mexico	Annual sales beginning in 2012
Central Gulf of Mexico	Annual sales beginning in 2013
Eastern Gulf of Mexico	2014, 2016
Cook Inlet	2013
Chukchi Sea	2016
Beaufort Sea	2015

Alternatives

Seven alternatives to the Proposed Action Alternative (Alternative 1) are evaluated in this draft programmatic environmental impact statement (PEIS). Each alternative represents a reduction from the proposed action, differing only in which planning areas (and associated number of lease sales) would be included for possible future lease offerings under the 2012-2017 OCS Oil and Gas Leasing Program (Program).

- Alternative 2 – Exclude the Eastern GOM Planning Area for the duration of the Program. Leasing in the other five planning areas would be the same as Alternative 1.

- Alternative 3 – Exclude the Western GOM Planning Area for the duration of Program. Leasing in the other five planning areas would be the same as Alternative 1.

- Alternative 4 – Exclude the Central GOM Planning Area for the duration of the Program. Leasing in the other planning areas would be the same as Alternative 1.

- Alternative 5 – Exclude the Beaufort Sea Planning Area for the duration of the Program. Leasing in the other planning areas would be the same as Alternative 1.

- Alternative 6 – Exclude the Chukchi Sea Planning Area for the duration of the Program. Leasing in the other planning areas would be the same as Alternative 1.

- Alternative 7 – Exclude the Cook Inlet Planning Area for the duration of the Program. Leasing in the other planning areas would be the same as Alternative 1.

- Alternative 8 – No Action. No lease sales would be conducted in any OCS Planning Area during the period 2012-2017. Exploration, development, and production activities would continue on blocks leased previously.

Principal Issues and Concerns

Risks of Oil Spills. Major regulatory reforms and advances in drilling and containment technology have occurred following the Deepwater Horizon event, reducing the risk of oil spills from OCS operations. The greatest concern related to oil and gas development following lease sales under any of the alternatives addressed in this draft PEIS is that of an accidental oil spill. The magnitude of effects from an accidental spill will depend on the location, timing, and volume of the spill; the environmental setting of the spill (e.g., restricted coastal waterway, deepwater pelagic location); and the species (and their ecology) exposed to the spill. Spill cleanup operations could result in short-term disturbance of fauna in the vicinity of cleanup activities.

Evaluating historical spill data and taking into account the amount of oil production anticipated to occur with development following leasing, spill scenarios were developed for the northern GOM, Cook Inlet, Beaufort Sea, and Chukchi Sea Planning Areas. Most expected spills would be less than 50 bbl in size, and impacts to most resources from such small spills would be minor, as dispersion and natural processes would be expected to quickly disperse and degrade the spill, limiting exposure of, and effects to, resources in the vicinity of the spill. In contrast, a large spill may be expected to affect more resources, do so over a much larger area and for a much longer period of time, and result in potentially major impacts. For analytical purposes, the draft PEIS presents analyses of the effects of varying sizes of oil spills on sensitive resources.

While this analysis provides the Secretary of the USDOI with information about the potential impacts if spills were to occur and contact environmental resources, the analyses cannot predict whether, when, or where specific oil spills will occur or whether any spills will contact environmental resources. The draft PEIS does estimate the number of possible small and large oil spills based on historical oil-spill data, which is independent from the severity of oil-spill impacts.

In all program areas, the analyses considered the occurrence of at least one very large, catastrophic spill event, even if the amounts of oil estimated to be developed suggest the occurrence of such a spill unlikely. The analyses of these spills does not mean the USDOI expects such a catastrophic event to occur under any of the action alternatives considered in this draft PEIS; rather, the analyses identify potential impacts to resources, should such a catastrophic discharge event occur, even if it is unlikely that such an event would occur.

Impact-Producing Factors. It is important to note that establishing a schedule of lease sales by itself will have no direct effects on most resources on the OCS, as the activities that could impact resources would only occur following a lease sale, and then only following approval for exploration and development to be initiated in the lease sale area. Because the nature, location, and level of future project-specific oil and gas activities is unknown at this time, the environmental analyses presented in this draft PEIS are based on reasoned assumptions about future activities, and apply to each of the seven action alternatives under consideration for the Program. Estimates of oil and gas resources that might be found in, and produced from, the areas being considered for leasing provide the basis for making the assumption of the level of development that might occur. Each scenario contains the major elements of activity needed to support exploration, production, and transportation of oil and gas that may be discovered and found to be economically producible.

Several types of routine oil and gas activities were identified that could cause impacts under the proposed action or alternatives (excluding the No Action Alternative) following subsequent lease sale, plan, or permit considerations. None of the action alternatives, if implemented, would authorize oil and gas development activities. These activities were, however, evaluated in the draft PEIS in resource-specific analyses to provide decision makers with information regarding the nature and magnitude of potential impacts that may be incurred with development following a lease sale under any of the seven action alternatives. Location- and resource-specific impacts would be evaluated in subsequent lease sale and plan-specific National Environmental Policy Act (NEPA) analyses and decision-making. The impact-producing factors related to routine OCS activities and evaluated in this draft PEIS include:

- The disposal of liquid wastes, including drilling fluids (i.e., drill muds), produced water, ballast water, and sanitary and domestic wastewater generated by OCS-related activities.

- Solid waste disposal, including material removed from the well borehole (i.e., drill cuttings), solids produced with the oil and gas (e.g., sands), cement residue, bentonite, and trash and debris (e.g., equipment or tools) accidentally lost.

- Gaseous emissions from offshore and onshore facilities and transportation vessels and aircraft.

- Noise from seismic surveys, ship and aircraft traffic, pipeline trenching, drilling and production operations, and explosive platform removals.

- Physical impacts from ship and aircraft traffic and use conflicts with oil tankers and barges, supply/support vessels and aircraft, and seismic survey vessels and aircraft.

- Physical emplacement, presence, and removal of facilities including offshore platforms; seafloor pipelines; floating production, storage, and offloading systems; onshore infrastructure such as pipelines, storage, processing, and repair facilities; ports; pipe coating yards; refineries; and petrochemical plants.

In addition, accidental oil spills were also considered an impacting factor, although not resulting from routine operations. Accidental spills may be associated with a loss of well control, production accidents, transportation failures (e.g., tankers, other vessels, seafloor and onshore pipelines, and storage facilities), and low-level releases from platforms.

Sensitive Biological and Ecological Resources and Critical Habitats

The Program encompasses large areas in the GOM and portions of Alaska. These areas constitute diverse marine and coastal environments that support a tremendous diversity of habitats and biota, including species and habitats protected by the Endangered Species Act and other Federal and State laws and regulations. At this programmatic stage, it is not possible, or appropriate, to conduct site-specific analyses of all the potentially affected resources or identify all relevant mitigation. Therefore, in keeping with NEPA and Council on Environmental Quality regulations, the draft PEIS focuses on those aspects of marine and coastal resources that are unique, ecologically important, or most susceptible to impacts from offshore oil and gas activities. The draft PEIS also concentrates on those life stages and habitats that may be most sensitive to routine oil and gas activities, as well as to accidental oil spills.

The identification and evaluation of potential impacts focused on three main categories: animals, plants, and habitats. Among the animal groups evaluated were marine mammals, birds, fish, sea turtles, and benthic invertebrates. Special attention was drawn to migratory species,

species taken commercially and for Alaska Native subsistence (including whales, fish, and birds), and threatened and endangered species. With respect to habitats, both marine (i.e., corals and "hard bottom" areas) and coastal (i.e., estuaries, wetlands/marshes) areas were identified and evaluated for possible adverse impacts from OCS oil and gas activities.

Social, Cultural, and Economic Resources

Specific concerns regarding social, cultural, and economic resources included potential impacts on tourism, recreation, commercial and recreational fishing, subsistence harvests, aesthetics, local economy (especially the "boom/bust" phenomenon), land and water use conflicts, disproportionate impacts on low income and minority groups, and disproportionate impacts on Alaska Natives. The social, cultural, and economic topics analyzed in the draft PEIS are as follows:

- Population, employment, income, and public service issues from the effects of the Program, including issues of "boom/bust" economic cycles.

- Land use and infrastructure, including construction of new onshore facilities, and land use and transportation conflicts between the oil and gas activities and other uses.

- Sociocultural systems effects, including concerns about the effects on subsistence (e.g., bowhead whale hunting), loss of cultural identity, health impacts including psychological health, and social cost of oil spills.

- Environmental justice (e.g., the potential for disproportionate and high adverse impacts on minority and/or low-income populations [Executive Order 12898]).

- Commercial and recreational fisheries.

- Tourism and recreation, including the use of coastal areas for sightseeing, wildlife observations, swimming, diving, surfing, sunbathing, hunting, fishing, boating, and visual impacts of offshore OCS structures.

- Archaeological resources, including historic shipwrecks and sites inhabited by humans during prehistoric times.

Climate Change

The draft PEIS considers how climate change, based on the observed changes that have been occurring during the past several decades, may affect baseline conditions of resources over the 40 to 50 year period during which oil and gas production could occur following lease sales under the Program. The effects of climate change on ecosystems are complex and non-uniform across the globe and vary among atmospheric, terrestrial, and oceanic systems. Considerations of climate change effects in OCS Planning Areas focus on impacts to marine and coastal systems where environmental sensitivities are typically associated with increasing atmospheric and ocean temperatures, sea level rise, and ocean acidification. These general categories of climate change responses are occurring in addition to human-induced pressures related to coastal population densities (e.g., land use changes, pollution, overfishing) and trends of increasing human use of coastal areas. The draft PEIS presents resource-specific discussions of the affected environment with discussions of the effects of ongoing, observable climate changes for those resources. In addition, the impacts of the continuing trend in climate change during the life of the Program are evaluated as well.

Conclusions

The analyses in this draft PEIS describe in detail the nature and extent of potential impacts of future oil and gas activities on the OCS that may occur under the proposed action or any of the action alternatives. Specifically, the draft PEIS evaluates the potential direct, indirect, and cumulative impacts of routine operations and accidental oil spills. The analyses assume the implementation of all mitigation measures currently required by statute, regulation, or Bureau of Ocean Energy Management (BOEM) policy and practice. One objective of the draft PEIS is to convey to decision makers and the public the relative extent of potential impacts. Conclusions for most analyses generally indicate the ability of most affected resources to recover from impacts that could result from oil and gas development following leasing.

Under the proposed action, or Alternatives 2 through 7, routine operations associated with each of these phases will have the same or similar impact-producing factors associated with them, and these have “typical” types of impacts, regardless of location. The magnitude and importance of those impacts on the resource, however, will be very site- and project-specific. The types of impacts identified and discussed below will be the same for each of the alternatives except the No Action Alternative. The principal difference in potential impacts among the action alternatives will be in where those impacts may be incurred. Each of the alternatives to the proposed action excludes one of the six planning areas included in the proposed action from the Program, and thus most resources in an excluded planning area would not be expected to be affected by routine operations occurring in other planning areas. Because routine operations include some impacting factors (such as seismic survey noise and support vessel traffic) that may extend beyond planning area boundaries, resources in an excluded planning area may be affected by some of the routine operations associated with development in adjacent planning areas. Similarly, accidental oil spills may be transported from the planning area in which the spill occurs to adjacent planning areas, affecting resources in those other areas.

The evaluation of a No Action Alternative is required by the regulations implementing NEPA (40 CFR 1502.14(d)). If the Secretary were to adopt this alternative, it would halt OCS presale planning, sales, and new leasing from 2012 to 2017. However, exploration, development, and production stemming from past sales would continue.

Water Quality

In the GOM and Alaska Planning Areas, routine operations could result in minor to moderate, localized, short-term impacts. Any such impacts would be associated with structure placement and construction (pipelines, platforms) and operational discharges (produced water, bilge water, and drill cuttings) and sanitary and domestic wastes. Structure placement and removal could increase suspended sediment loads, while operational discharges, sanitary and domestic wastes, and deck drainage could affect chemical water quality. Compliance with National Pollutant Discharge Elimination System (NPDES) permit requirements, and U.S. Coast Guard (USGS) regulations would reduce most impacts of routine operations.

The effects of accidental oil spills will depend upon the material spilled, spill size, location, and remediation activities. Small spills would likely result in short-term, localized impacts. Impacts from a large oil spill could persist for an extended period of time if oil were deposited in wetland and beach sediments or low-energy environments because of potential remobilization. The speed of natural recovery in Alaskan waters, as compared to GOM waters, could be slowed by the persistence of oil in cold water temperatures and ice cover. A very large oil spill (especially one associated with a catastrophic discharge event [CDE]) would affect water quality over a much larger area, including possibly in planning areas adjacent to the one where the spill occurs. The potential for more widespread and long-term water quality impacts may be expected to be greater in cold Alaskan waters, especially under ice-cover conditions. In Alaska, winter conditions (e.g., complete ice cover and extremely cold conditions) could substantially complicate spill response given current spill control and remediation technologies.

Air Quality

Routine operations affecting air quality in the GOM and Alaska Planning Areas include emissions from construction equipment, machinery supporting production operations, helicopters, and ships. Only minor impacts to air quality are expected under any of the action alternatives. Emissions during routine operations under any of the action alternatives would cause some slight, localized increases in concentrations of nitrogen dioxide (NO_2), sulfur dioxide (SO_2), particulate matter less than 10 or 2.5 microns in diameter (PM_{10} and $PM_{2.5}$, respectively), and carbon monoxide (CO) in the Planning Areas where such activities would occur. Concentrations would be well within the U.S. Environmental Protection Agency (USEPA) national ambient air quality standards (NAAQS) and the Prevention of Significant Deterioration (PSD) increments. Increases in ozone may occur, but would be less than 1% of total concentrations. Air quality impacts from oil spills and *in situ* burning would be localized and of short duration. Overall, impacts from routine operations, oil spills, and spill response activities are expected to be minor.

Acoustic Environment

Routine operations in the GOM and Alaska OCS Planning Areas could affect ambient noise conditions, with impacts to ambient noise levels expected to be minor. Noise generating sources associated with routine operations include seismic surveys, drilling and production, infrastructure placement and removal, and vessel traffic. Depending on the source and activity, changes in ambient noise levels could be short-term and localized (e.g., from vessel traffic), long-term and localized (from production), or short-term and less localized (from seismic surveys). Seismic surveys could result in short-term changes in ambient noise levels, but the changes could extend well beyond the survey boundary.

Marine and Coastal Habitats

Coastal and Estuarine Habitats. Under any of the action alternatives, coastal and estuarine habitats could incur minor to moderate impacts from routine operations such as pipeline landfall and construction, maintenance dredging of inlets and channels, and vessel traffic. Coastal and estuarine habitats could be disturbed by activities such as pipeline trenching and onshore facility construction. Shoreline habitats may also be affected by wake-induced erosion during routine dredging activities or ship traffic. Habitats potentially affected would include coastal dunes, wetlands, and barrier islands. The magnitude of these impacts would depend on the location of the construction activities, the level of dredging or shipping activity in a specific area, and existing environmental conditions (such as ongoing shoreline degradation).

Coastal and estuarine habitats could also be affected by accidental oil spills. The magnitude of potential impacts to coastal and estuarine habitats will depend on a variety of factors, including the location, size, timing, and duration of the spill, the effectiveness of remediation efforts, existing environmental conditions (e.g., vegetation, substrate type, ice cover), and natural localized erosion and deposition patterns. The effects of small spill would be very localized and relatively short-term. In the event of a large spill or a CDE, habitats over a much greater geographic area may be affected, and may incur more severe impacts where oil is concentrated. In some cases, habitats such as coastal wetlands may not fully recover even following remediation.

Marine Benthic Habitats. Impacts from routine OCS oil and gas activities could result from the construction and removal of infrastructure (wells, platforms, pipelines), vessel traffic, and permitted operational discharges. Construction activities which involve the physical disturbance of the seafloor will result in moderate impacts to benthic habitats within and immediately adjacent to the disturbance footprint. In most cases, disturbed soft-bottom habitats would recover. Protective measures, currently required at the lease sale phase thorugh lease stipulations, exist for seafloor habitats such as live bottom and pinnacle trend areas in the GOM. These measures would help to reduce potential impacts on both nearshore and deeper-water habitats.

Accidental oil spills could affect benthic habitats, and result in minor to moderate impacts to affected habitats. The magnitude of these impacts would depend upon the location, size, timing and duration of the spill; weather conditions; effectiveness of containment and cleanup operations; and other environmental conditions at the time of the spill. Impacts from small spills would be mostly localized and minor. However, if a large spill or a CDE at the seafloor (i.e., from a wellhead or a pipeline) were to occur, a greater amount of habitat could be affected. As a consequence, full recovery of oiled habitats could take many years in some locations.

Marine Pelagic Habitats. Overall, no permanent degradation of pelagic habitat is anticipated and impacts would be negligible to minor in the GOM and Alaska Planning Areas. During routine operations (including routine discharges), marine pelagic habitats could be affected as a result of increased turbidity associated with bottom-disturbing activities, and from operational discharges such as produced water and drilling muds and cuttings. Impacts would be largely localized and short-term in duration.

Small accidental spills may be expected to result in only minor, localized impacts on pelagic habitats. The effects from oil spills would depend on the location, magnitude, duration, and timing of the spill, on environmental factors (e.g., presence of sea ice, storms, ocean currents), and on the habitats affected by the spill. Large spills or a CDE could reduce habitat quality over a larger area, and result in moderate impacts to some habitats. In the GOM, oil contacting *Sargassum* mats could result in complete or partial short-term loss of these unique habitats in some areas and cause localized population-level impacts on associated biota. In Alaska, accidental spills occurring under ice cover or in sea ice habitats could result in small, but long-term impacts to pelagic habitats.

Marine and Coastal Fauna

Mammals. Impacts to marine mammals from routine operations include noise disturbance from seismic surveys, vessels, helicopters, construction and operation of platforms, and removal of platforms with explosives; potential collision with vessels; and exposures to discharges and wastes. Impacts to cetaceans could range from negligible to moderate, with species or stocks inhabiting continental shelf or shelf slope waters most likely to be affected. In Alaska, if the disturbance results in the temporary abandonment of young by adults (e.g., abandonment of pups in Steller's sea lion rookeries), survival of young may be reduced, and moderate impacts to local populations may result. Collisions with OCS-related vessels could also injure or kill some individuals, although the incidence of such collisions is expected to be very low. Meeting the requirements of the Endangered Species Act (ESA) and Marine Mammal Protection Act would reduce the likelihood and magnitude of adverse impacts from routine operations to most marine mammal species. For terrestrial mammals, no impacts are expected from routine operations in the GOM to endangered beach mice subspecies or the Florida salt marsh vole. In Alaska, impacts to terrestrial mammals from routine operations would be negligible to minor.

Accidental oil spills may result in the direct and indirect exposures of mammals and their habitats to the oil. Fouling of fur of some species (e.g., sea otter and fur seal) could affect thermoregulation and reduce survival, while ingestion of oil and oil-contaminated food could have acute and chronic effects. The magnitude of effects from accidental spills will depend on the location, magnitude, duration, timing, and volume of the spills; the habitats affected by the spills (e.g., coastal habitats); and the species exposed. Spills in open waters may be expected to affect the fewest number of individuals. Very large spills, such as a CDE, would affect the greatest number of species and individuals, and have the greatest potential for adversely affecting local mammal populations. In Alaska, the greatest risk to marine mammals would be associated with large spills reaching rookeries and haulout locations where large numbers of individuals could be exposed and population-level impacts on some species (especially the Steller's sea lion) could occur. Overall, small spills would affect relatively few individuals, while large spills could affect many more species, and in some cases (such as a CDE) result in local population-level effects.

***Marine and Coastal Birds*.** Routine operations may result in negligible to moderate, localized, short-term impacts. Impacts would be associated primarily with infrastructure construction, and ship and helicopter traffic. The primary effect would be disturbance of birds in the immediate vicinity of the activity. In most cases, disturbed birds would temporarily leave the area, while in other cases,the displacement could be long-term. Because many birds tend to habituate to human activities and noise, potential impacts from disturbance may be short-term and not expected to result in population-level effects. However, construction activities near coastal habitats could disrupt breeding and nesting activities of colonial nesting birds. Depending on the species, the numbers of birds affected, and the activity disturbed (nesting, molting, feeding, staging), the displacement of disturbed birds could reduce reproductive success, foraging success, and survival. Some collision mortality with offshore platforms would be expected. Loss or alteration of preferred habitat due to pipeline landfalls or other onshore construction could result in the displacement and possible decrease of nesting activities.

Accidental oil spills pose the greatest threat to marine and coastal birds. The magnitude and ecological importance of any effects would depend upon the size, location, duration, and timing of the spill; the species and life stages of the exposed birds; and the size of the local bird population. Exposure to spills in deep water would be largely limited to pelagic birds. Shallow-water spills that reach coastal habitats could affect the greatest variety and number of birds, including shorebirds, waterfowl, wading birds, gulls, and terns. Spills reaching onshore locations have the greatest potential for affecting the greatest number of birds, especially if a spill occurs in or reaches an area where birds have congregated and are carrying out important activities (such as nesting, molting, and staging areas for some of the Alaskan waterfowl and shorebirds). Exposed birds may experience a variety of lethal or sublethal effects, and the magnitude and ecological importance of any such effects would depend upon the size and location of the spill, the species and life stage of the exposed birds, and the size of the local bird population.

Fish Resources and Essential Fish Habitat

Overall, impacts to fish from routine Program activities are expected to range from negligible to minor, and no impacts on threatened or endangered fish species are expected. The primary potential impacts on fish communities from Program activities could result from seismic surveys and bottom-disturbing activities such as drilling, platform placement and mooring, and pipeline trenching and placement, which could displace, injure, or kill fish in the vicinity of the activity. Fixed platforms, particularly the large number projected for the GOM, would also serve as artificial reefs that would attract substantial numbers of fish. Oil and gas activities would be temporary, and no permanent or population-level impacts on fish are expected. Displaced fish and invertebrate food sources would repopulate the area over a short period of time in the GOM, but fish habitat recovery may be long-term in Alaskan waters. The effects of drilling muds and produced water discharge on fish would be localized, and no population-level effects are expected. Drilling waste and produced water discharge would be far less in Alaska because fewer wells would be drilled in Alaska and because it is assumed that drilling muds and cuttings from production wells and all produced water would be reinjected into the wells.

Small spills would be localized and are unlikely to affect a substantial number of fish before dilution and weathering would reduce concentrations of toxic fractions to nontoxic levels. Large spills and a CDE would affect a wider area, with the magnitude of the impacts depending on the location, timing, and volume of spills, distribution and ecology of affected fish species, and other environmental factors. Most adult fish are highly mobile and would likely avoid lethal hydrocarbon exposures, although they may be subjected to sublethal concentrations. Smaller species and egg and larval life stages are more likely to suffer lethal or sublethal exposures from oil contact because of their relative lack of mobility. Under most circumstances, any single large spill would affect only a small proportion of a given fish population; therefore, overall population levels may not be affected. However, fish species that currently have depressed populations or have critical spawning grounds present in the affected area could experience population-level impacts. Oil contacting shoreline areas used for spawning or providing habitat for early life stages of fish could result in large-scale lethal and long-term sublethal effects on fish. In Alaskan waters, where oil may be slow to break down, coastal oiling could measurably depress some fish populations for several years. However, no permanent impacts on fish populations are expected.

Reptiles

Five species of sea turtles occur in the three GOM Planning Areas: green, hawksbill, Kemp's ridley, leatherback, and loggerhead, and all are listed as threatened or endangered under the ESA. All but the hawksbill have been reported to nest on beaches within the GOM Planning Areas. In addition to these turtles, the American crocodile, which is federally endangered, occurs in the Eastern GOM Planning Area along the southern coast of Florida. Routine operations in the GOM are not expected to affect the American crocodile. This species could be affected in the event there is a very large oil spill that reaches the southern Florida coast. In such an event, adults and young could be directly exposed, and nest sites could be fouled. No reptiles occur in the Alaska OCS Planning Areas.

Impacts to reptiles from routine operations associated with the Program are expected to range from minor to moderate. Sea turtles could be directly affected by seismic surveys, vessel traffic, construction of offshore and onshore facilities, operational discharges, and removal of platforms. Noise generated during exploration and production activities and platform removal may result in the temporary disturbance of some individuals, while some turtles may be killed during the use of underwater explosives for platform removal. The construction and operation of new onshore facilities may impact nest sites, possibly result in eggs being crushed, and disturb hatchling movement from the nest sites to the water. Sea turtles may also be injured or killed by collisions with OCS vessels. Permit requirements, ESA regulations and requirements, regulatory stipulations, and BOEM guidelines could limit the seriousness of any potential effects on sea turtles. Therefore, while routine operations could affect individual sea turtles, population-level impacts are not expected.

Oil spills may expose one or more sea turtle life stages to oil or its weathering products. Oil reaching nests may reduce egg hatching and hatchling survival, and inhibit hatchling access to water. Exposed hatchlings, juveniles, and adults may incur a variety of lethal or sublethal effects. The presence of oil on nesting beaches may affect nest site access and use. Small spills are unlikely to affect a large number of sea turtles or their habitats and thus are not expected to have substantial or long-term effects. The magnitude of effects from accidental spills would depend on the location, timing, duration, and volume of the spills; the environmental settings of the spills; and the species and life stages of sea turtle exposed to the spills. A very large spill could affect many more individuals and habitats, including nesting beaches, and potentially lead to population-level effects.

Invertebrates

Routine operations could result in negligible to moderate impacts to invertebrates, especially to benthic invertebrates. The primary impacts of routine Program activities would be from bottom-disturbing activities during the exploration and site development phases. Routine operations involving bottom disturbance (including pipeline trenching) could displace, bury, injure, or kill invertebrates in the immediate vicinity of the activities. Affected invertebrate communities would generally repopulate the disturbed areas over a short period of time (especially soft-bottom communities), although a return to the pre-disturbance community may take longer, particularly in the Arctic. If discharged into open water, the effects of drilling muds and produced water on invertebrates would be localized and no population-level effects are expected. No permanent or population-level impacts on invertebrates are expected from routine operations following lease sales under any of the action alternatives.

Small surface or subsurface oil spills would be rapidly diluted and likely result in only minor localized impacts on invertebrates. Large spills could affect a large number of benthic and pelagic invertebrates and their habitats. The location, size, duration, and timing of the spill would be important determinants of the impact magnitude of large spills. A large spill contacting shoreline areas with sensitive intertidal and shallow subtidal habitats could result in large-scale and long-term sublethal and lethal effects to the benthic communities in those habitats. In Alaska, local populations of intertidal organisms affected by such large spills could be measurably depressed for several years and oil could persist in shoreline sediments for decades.

Areas of Special Concern

Impacts to Areas of Special Concern (AOCs) resulting from routine Program activities are expected to be negligible to moderate because of the existing protections and use restrictions.

Routine operations that could affect AOCs (e.g., National Marine Sanctuaries, National Parks) include the placement of structures, pipeline landfalls, operational discharges, and vessel traffic. However, impacts from these activities are unlikely, as no infrastructure (e.g., pipeline landfalls, shore bases) would be sited in National Parks, National Wildlife Refuges (NWRs), or other AOCs. In Alaska, no OCS-related activities would occur in National Park lands, thereby minimizing the potential for impacts from routine operations to these AOCs, and impacts from routine activities in adjacent areas would be minimal. However, offshore construction of pipelines and platforms could have temporary effects on wildlife due to noise and activity levels and on scenic values for park visitors.

While an oil spill could affect AOCs, the magnitude of the potential impact would depend on the location, size, duration, and timing of a spill; the weather conditions at the time of the spill; the effectiveness of cleanup operations; and other environmental conditions (e.g., presence of sea ice) at the time of the spill. Accidental oil spills reaching AOCs could negatively affect fauna and habitats, subsistence use, commercial or recreational fisheries, recreation and tourism, and other uses.

Impacts on Population, Employment, and Regional Income

The main effect on population and employment of routine operations that could result following leasing will be the employment generated by routine Program activities. In the GOM, direct expenditures associated with routine operations would result in negligible impacts from small increases in population, employment, and income in each region over the duration of the leasing period, corresponding to less than 1% of the baseline. In Alaska, direct expenditures would result in minor impacts from small increases in population, employment, and income in each region over the duration of the leasing period, corresponding to less than 5% of the baseline. Given existing levels of leasing activity, impacts on property values in the GOM and Alaska Planning Areas would be negligible. In planning areas where tourism and recreation provide significant employment, accidental oil spills (especially a low probability CDE) could result in the short-term loss of employment, income, and property values. Expenditures associated with spill cleanup activities would create short-term employment and income in some parts of the affected coastal region(s).

Land Use and Infrastructure

Routine Program activities would result in negligible to minor impacts in the GOM, and minor to moderate impacts in Alaska, on land use, development patterns, and infrastructure. In the GOM, existing infrastructure generally would be sufficient to handle exploration and development associated with potential new leases. In Alaska, additional infrastructure would be necessary to support Program development. Projected impacts in both the GOM and Alaska from an accidental oil spill (especially from a low-probability CDE) would alter land use temporarily but would not likely result in long-term changes. The magnitude of the impacts would depend upon the location, size, timing, and duration of the spill and the existing land use at the spill location.

Commercial and Recreational Fisheries

Following leasing, routine Program operations could have minor impacts on subsistence, commercial, and recreational fisheries. Impacts would be associated primarily with vessel traffic and structure placement, presence, and removal, each of which could temporarily drive fishes away from the area and preclude fishing. However, these impacts would be temporary, and population-level effects on commercial and recreational fishery resources are not anticipated from these routine operations. Once platforms are installed and production activities begin, offshore structures would act as fish attraction devices for both pelagic and reef-associated species; these structures would also be attractive for recreational fishing. Seismic surveys and construction of platforms and pipelines could result in space-use conflicts with commercial and recreational fishing activities, although these effects would be localized. Space-use conflicts, in the case of seismic surveys, would be short-duration.

The level of effects from accidental oil spills on subsistence, commercial, and recreational fisheries would depend on the location, timing, duration, and volume of spills, in addition to other environmental factors. Small spills are unlikely to have a large effect before dilution and weathering reduces concentrations and, therefore, would not have long-term effects on subsistence, commercial and recreational fisheries. If large oil spills were to occur, subsistence, commercial, and recreational fisheries could be affected. The potential for oil-soaked fishing gear and potentially contaminated fish may reduce commercial and recreational fishing efforts and affect subsistence use of the resource. Very large spills could also indirectly affect fisheries by degrading habitats that are critical for the survival of target species, but would only be serious if they led to severe declines in target species' populations. Highly mobile fish species (tunas, sharks, and billfish) could move away from surface oil spills in deep water, disrupting fishing efforts.

Tourism and Recreation

Routine operations would have minor, short-term negative effects on recreation and tourism, with potential adverse aesthetic impacts on beach recreation and sightseeing and potential positive impacts on diving and recreational fishing in the GOM coast; sightseeing, boating, fishing, and hiking activities in the Cook Inlet area; and sightseeing, hiking, and boating activities in the Chukchi Sea and Beaufort Sea Planning Areas.

Potential impacts on recreation and tourism resulting from an oil spill in any of the planning areas would likely include direct impacts (e.g., oil contamination of a beach), access restrictions to a particular area (e.g., no diving or fishing while cleanup is being conducted), and aesthetic impacts. These impacts could persist for several months or more pending cleanup completion and any required habitat restoration. The extent of the impacts would depend on the location, size, duration, and timing of the spill and on the effectiveness of cleanup operations. Since oiled coastal sediments are often removed via mechanical means, such shoreline activity would effectively close the area to public use for the duration of cleanup operations. If restoration is required (i.e., to restore the proper beach profile), additional time may be required before public access is allowed. Historical evidence pertinent to the effects of major oil spills has indicated that spills may prompt either a seasonal decline in tourist visits and/or tourist movement to other coastal areas in the region.

Sociocultural Systems and Environmental Justice

Impacts on sociocultural systems and environmental justice vary across OCS regions. In the GOM and Cook Inlet, where sociocultural systems have a long experience with offshore oil and gas operations, impacts on sociocultural systems would be few and impacts would be minor. The greatest impacts on sociocultural systems in the GOM are expected to result from the ongoing expansion of oil and gas activities in the GOM, especially in expansion to deepwater and ultra-deepwater areas. This expansion of oil and gas activities has contributed to the cultural heterogeneity of the area by drawing the offshore workforce from a wider geographic range. Expansion to deepwater and ultra-deepwater areas has resulted in the creation of jobs that require more specialized skills and in requiring longer, unbroken periods of work offshore. While there is extensive onshore oil development in the vicinity of Prudhoe Bay, there is currently no OCS oil and gas development in the Arctic. Thus, impacts to sociocultural systems from routine Program operations may range from minor to major. Of greatest concern to the Alaska Natives who inhabit the area are threats to their subsistence base and way of life. Noise from seismic surveys and exploratory drilling has the potential to deflect whales and other marine mammals from their accustomed migration routes, making them more difficult to harvest.

A large environmental justice concern is the potential health risk to residents from nearby OCS-related infrastructure, including helipads, heliports, waste management facilities, pipe coating yards, shipyards, platform fabrication yards, supply bases, natural gas storage facilities, repair yards, refineries, port facilities, and terminals. In the GOM, with existing industrial infrastructure, routine Program operations are not expected to significantly change the health risk exposure of nearby residents, and impacts are expected to be negligible. Impacts to environmental justice from routine Program activities in the Cook Inlet and Arctic planning areas are expected to be negligible to minor.

Much of Alaska's Native population, however, resides in coastal areas, and the Arctic areas have a very high Native Alaskan population. The importance of marine mammals (such as the bowhead whale) to subsistence by Alaska Natives (especially in the Arctic) raises particular concerns. Any adverse environmental impacts on fish and mammal subsistence resources from installation of infrastructure and routine operations of these facilities could have disproportionately higher health or environmental impacts on Alaska Native populations. A large oil spill that contacts subsistence resources could also have disproportionately high impacts on the Alaska Native population if the subsistence resources were diminished or tainted as a result of the spill.

Archaeological Resources

Archaeological resources that could be affected by the proposed action include historic shipwrecks and inundated prehistoric sites offshore, and historic and prehistoric sites onshore.

Although shipwrecks tend to concentrate in shallow, nearshore waters in all OCS regions, historic shipwrecks are scattered across the entire continental shelf, and many are found even in deepwater areas. Inundated prehistoric sites may occur on those portions of the continental shelf that were exposed as dry land during the period of lower sea levels of the last ice age. The extent of the continental shelf that was exposed varies from area to area; however, globally, sea levels were approximately 120 m (394 ft) lower than present approximately 21,000 to 19,000 years ago. Onshore historic properties include sites, structures, and objects such as historic buildings, forts, lighthouses, homesteads, cemeteries, and battlefields. Onshore prehistoric archaeological resources include sites, structures, and objects such as shell middens, earth middens, campsites, kill sites, tool manufacturing areas, ceremonial complexes, and earthworks.

Routine operations associated with the proposed action that may affect archaeological resources in all regions include drilling wells, installing platforms, installing pipelines, anchoring, and constructing onshore infrastructure. Existing Federal, State and local laws and regulations require that archaeological surveys be conducted prior to permitting any activity (onshore or offshore) that might disturb a significant archaeological site. Compliance with existing laws and regulations should protect archaeological resources to the maximum extent possible from most impacts associated with routine activities; however, it is still possible that some impacts could occur.

Should a direct physical contact between a routine activity and a shipwreck site occur, it could destroy fragile ship remains and/or disturb the site context, resulting in a loss of data on ship construction, cargo, and the social organization of the vessel's crew, as well as the concomitant loss of information on maritime culture for the time period from which the ship dates. Ferromagnetic debris associated with OCS operations could mask the magnetic signature of historic archaeological resources, making them difficult to detect with magnetometers. Interaction between a routine activity and a prehistoric archaeological site could destroy artifacts or site features and could disturb the stratigraphic context of the site.

Oil spills could affect coastal historic and prehistoric archaeological resources and could result in unavoidable loss of information. The level of this impact would depend on the significance and uniqueness of the information lost. Archaeological resource protection during an oil spill requires specific knowledge of the resource's location, condition, nature, and extent prior to impact; however, the coastal areas of the various OCS regions have not been systematically surveyed for sites. Existing information indicates that prehistoric sites in all regions occur frequently along the mainland coast and barrier islands, and along the margins of estuaries, bays and lagoons; thus, any spill that contacts these areas could involve a potential impact on a prehistoric site.

Alternative 8 – No Action

The evaluation of a No Action Alternative is required by the regulations implementing NEPA (40 CFR 1502.14(d)). If the Secretary were to adopt this alternative, it would halt OCS presale planning, sales, and new leasing from 2012 to 2017, even in the Central and Western

GOM Planning Areas. However, exploration, development, and production stemming from past sales would continue.

This alternative would eliminate new leasing from mid-2012 through mid-2017. The amounts of OCS natural gas (up to 35 trillion cubic feet) and oil (up to 8.1 billion barrels of oil) that could help meet national energy needs would be forgone. That amount of energy would have to be replaced by a combination of imports, alternative energy sources, and conservation.

Market forces are expected to be the most important determinant of the substitute mix for OCS oil and gas. Key market substitutes for forgone OCS oil production would be imported oil, conservation, switching to gas, and onshore production. For OCS natural gas, the principal substitutes would be switching to oil, onshore production, imports, and conservation.

In addition to market-based substitutes, the nation or individual States might choose to encourage or even impose programs designed to deal with the energy shortfall. To replace oil, these programs might favor alternative vehicle fuels such as ethanol or methanol, vehicles with greater fuel efficiency, or alternate transportation methods such as mass transit.

As a partial replacement for the forgone natural gas, governments might mandate increased reliance on coal, nuclear, hydroelectric, or wind-generated electric power. In addition, governments might give more emphasis to programs encouraging more efficient electricity transmission and more efficient use of gas and electricity in factories, offices, and homes.

Conclusions

This PEIS is consistent with the requirements of Outer Continental Shelf Lands Act of 1953 (67 Stat. 462) as amended in 1988 (43 USC 1331 *et seq.*), NEPA (42 USC 4321), as amended, and Council on Environmental Quality regulations for implementing NEPA (40 CFR Part 1500). A scoping process was conducted to obtain input from stakeholders, including individuals, public interest organizations, and governmental agencies, and this input was used to develop the alternatives and issues analyzed in this PEIS.

On the basis of the analyses in this PEIS, the types of impacts that could occur during routine Program activities would be the same among the action alternatives. The alternatives differ primarily on the basis of where the impacts could occur, which is directly related to the planning areas included in each alternative. Routine operations are expected to result in impacts that range from negligible to major, with most being short-term and recovering following completion of the routine activities. The greatest impacts would occur with a low-probability catastrophic discharge event, but the nature and magnitude of impacts would depend on the location, size, duration, and timing of the spill, the resources affected, and the effectiveness of the spill containment and cleanup activities.

This page intentionally left blank.

1 INTRODUCTION

1.1 BACKGROUND

Section 18 of the Outer Continental Shelf Lands Act (OCSLA) of 1953 (67 Stat. 462) as amended in 1988 (43 USC 1331 *et seq.*) requires the U.S. Department of the Interior (USDOI) to prepare a 5-year schedule that specifies, as precisely as possible, the size, timing, and location of areas to be assessed for Federal offshore oil and gas leasing on the U.S. outer continental shelf (OCS). The Federal action being evaluated is the preparation of this 5-year schedule. A schedule is needed to increase the predictability of sales in order to facilitate planning by industry, affected states, and the general public. The OCSLA also requires the 5-year leasing schedule to be developed and maintained in a manner that is consistent with several management principles. Within the USDOI, the Bureau of Ocean Energy Management (BOEM or the Bureau) (formerly the Bureau of Ocean Energy Management, Regulation and Enforcement and prior to that, the Minerals Management Service) must manage the OCS oil and gas program to ensure a proper balance among oil and gas production, environmental protection, and impacts on the coastal zone. OCSLA defines the OCS as all submerged lands lying seaward of State coastal waters which are under U.S. jurisdiction. The BOEM is organized into four regional offices, each of which is responsible for overseeing the safe and environmentally responsible development of traditional and renewable ocean energy and mineral resources in four OCS regions: Alaska, Pacific, Gulf of Mexico (GOM), and Atlantic — for a combined total of 1.7 billion acres of the OCS.

In recent years, the OCS oil and gas resources have been subject to suspensions of activities or moratoria. In 1982, Congress imposed a moratorium on oil and gas leasing for offshore California. Over the next decade, Congress expanded the moratorium to include almost all Atlantic and Pacific planning areas. From 1990 through 2000, an Executive Withdrawal enacted by President George H. Bush was in effect on a portion of the same OCS acreage subject to the 1982 congressional moratorium. Separate and apart from the congressional moratorium, the Executive Withdrawal served to independently limit offshore development. In 1998, President Clinton extended the Executive Withdrawal through 2012. On July 14, 2008, however, President George W. Bush lifted the OCS Executive Withdrawal. On August 1, 2008, the Minerals Management Service (MMS) issued a Request for Comments for the preparation of a new 5-year OCS leasing program to cover 2010 through 2015.

On January 21, 2009, a notice for Request for Comments on the Draft Proposed 5-Year OCS Oil and Gas Leasing Program for 2010-2015 and the Notice of Intent to Prepare an Environmental Impact Statement (EIS) for the Proposed 5-Year Program Draft Proposed Program were published in the *Federal Register* (*Federal Register*, January 21, 2009, Volume 74, Number 12, pages 3631–3635). On February 10, 2010, the Secretary of the Interior extended the comment period by 180 days to September 21, 2009.

As a result of the comment period extension and the Bureau's reconsideration of existing policies and regulations in response to the Deepwater Horizon event on April 20, 2010, the time period to be covered by the new program shifted from 2010-2015 to 2012-2017. The

January 2009 Draft Proposed Plan remains the first of three draft decisions for the program (now for 2012-2017) that will replace the existing 2007-2012 program. However, in response to comments and other considerations, the Secretary has reduced the scope of the 5-year EIS to exclude several planning areas that were originally included in the Draft Proposed Plan decision.

On April 2, 2010, the Bureau issued a Notice of Intent (NOI) to prepare an EIS with respect to the OCS Oil and Gas Leasing Program for 2012-2017 (hereafter referred to as "the Program") and requested comments for the purpose of determining the scope of the EIS. The updated strategy limited lease sales to the following planning areas: Beaufort Sea, Chukchi Sea, Cook Inlet, the Central and Western GOM, and the area of the Eastern GOM excluded from Congressional moratoria (see Figure 1-1). The NOI also announced that scoping meetings would be held during June and early July 2010 in coastal States bordering the Mid- and South Atlantic; Western, Central, and the portion of the Eastern GOM; and at several locations in Alaska. Subsequently, on June 30, 2010, the Secretary announced that the scoping meetings were postponed until later in 2010 because of the need for BOEM to focus on reviewing and evaluating safety and environmental requirements of offshore drilling in response to the Deepwater Horizon event and that a new public comment period would later be announced. On December 1, 2010, the Secretary announced an updated oil and gas leasing strategy for the OCS. Consistent with the Secretary's direction to proceed with caution and to focus on leasing in areas with current active leases, the area in the Eastern GOM that remains under a congressional moratorium and the Mid- and South Atlantic Planning Areas were no longer considered for potential sales and development through 2017. Therefore, scoping meetings were not held in these areas. It was also announced that the Western GOM, Central GOM, and the Cook Inlet, Chukchi Sea, and Beaufort Sea areas offshore Alaska would continue to be considered for potential leasing in the Program.

Congress, in its yearly appropriations to the USDOI, continues to maintain an annual moratorium on OCS oil and gas leasing in the Eastern GOM Planning Area with the exception of a small area along the boundary between the Central and Eastern Planning Areas that was excluded from the moratorium by the GOM Energy Security Act of 2006. Additionally, Presidential moratoria have withdrawn all national marine sanctuaries from leasing through June 30, 2017 (Hagerty 2011). On March 31, 2011, President Obama, under the authority of Section 12(a) of the OCSLA, withdrew the Bristol Bay area of the North Aleutian Basin for consideration of leasing through June 30, 2017. The Congressional and Presidential moratoria prohibit future oil and gas leasing but do not apply to existing leases. Although there are current leases in the Pacific region, no new OCS leasing will take place in the Pacific region under the Program.

The BOEM has prepared this draft programmatic environmental impact statement (PEIS) to assess the environmental, social, and economic impacts associated with the Program. The following Federal, State, and local agencies are serving as cooperating agencies on the development of the PEIS, due to their special expertise:

- U.S. Department of Commerce National Oceanic and Atmospheric Administration (NOAA)

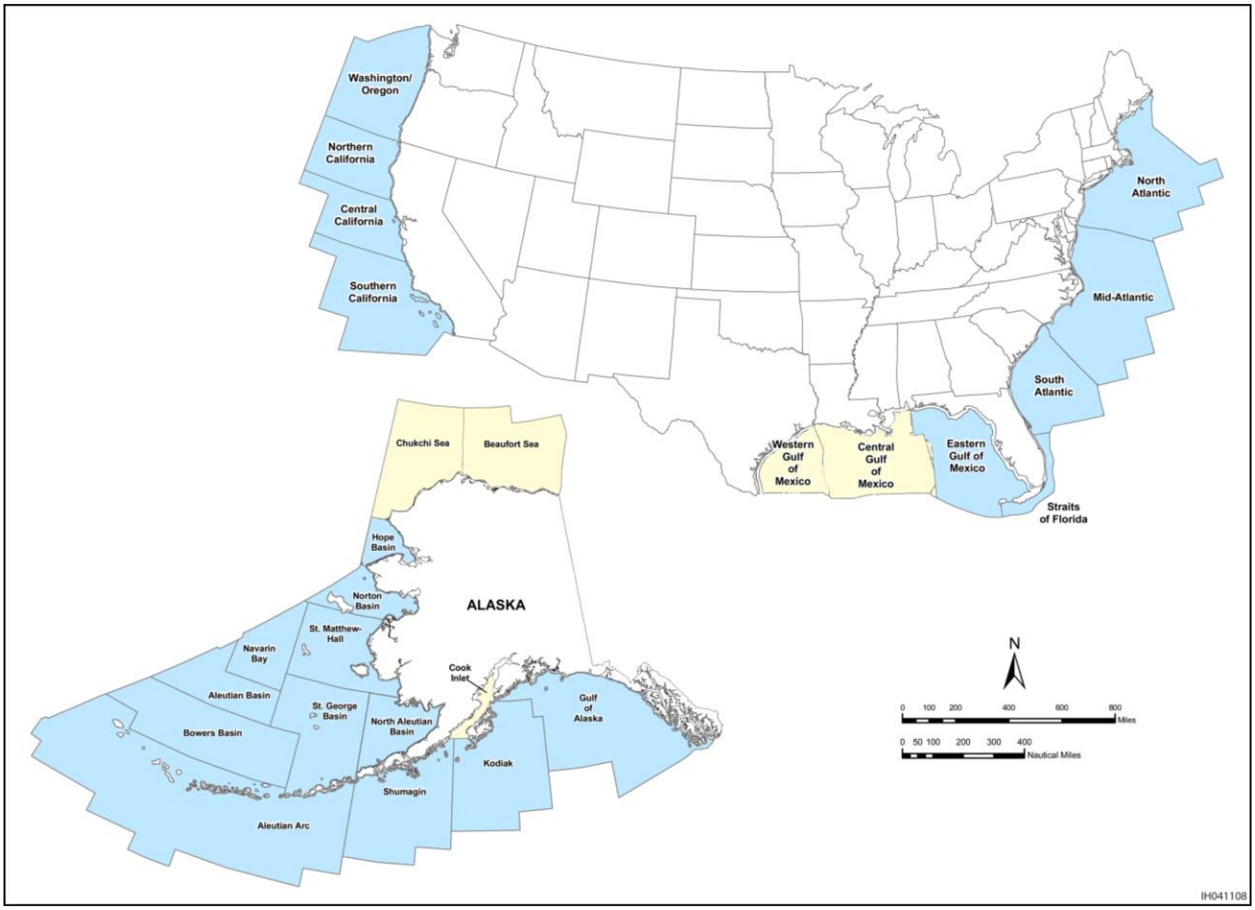

FIGURE 1-1 OCS Planning Areas (planning areas being considered for the Program are shown in yellow) See Figure 1-2 for details on the Eastern GOM Planning Area.

- The State of Alaska

- Alaska North Slope Borough (NSB)

The Program is scheduled to begin in November 2012. The Program consists of a national schedule of potential OCS lease sales within 6 of the 26 OCS Planning Areas (Figures 1-1 and 1-2). The Program will be the eighth such program prepared since Congress passed the OCSLA in 1988. The Program establishes a framework for managing the OCS oil and gas leasing in a manner that accounts for all of the factors required by OCSLA. It also provides the public with a clear statement of the USDOI's OCS leasing intentions during the period from 2012 to 2017.

1.2 PURPOSE OF AND NEED FOR ACTION

The purpose and need of preparing a schedule of potential OCS oil and gas lease sales is to "best meet national energy needs for the 5-year period following its approval" (43 USC 1344)

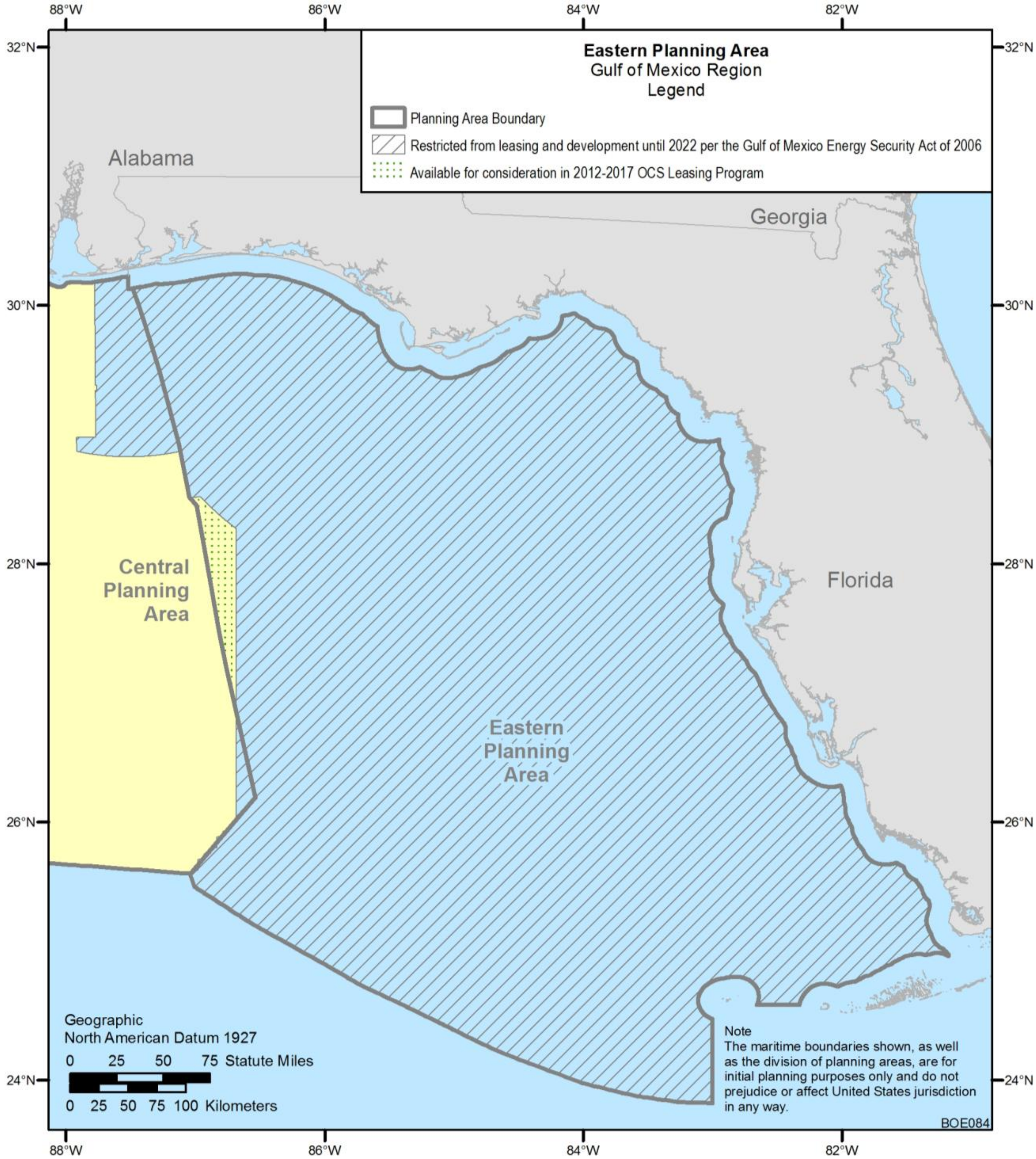

FIGURE 1-2 The Eastern GOM OCS Planning Area Showing the Portion Available for Lease Sale Consideration

by balancing the potential for adverse environmental and societal impacts with the beneficial impacts of the discovery and development of oil and gas. In developing the 5-year leasing schedule, BOEM considers regional and national energy needs; leasing interests as expressed by possible oil and gas producers; applicable laws, goals, and policies of affected States, local governments, and tribes; competing uses of the OCS; relative environmental sensitivity and marine productivity among OCS regions; public input; and the equitable sharing of benefits and risks among stakeholders.

Energy use in the United States is expected to continue to increase from present levels through 2035 and beyond (EIA 2011). For example, the U.S. consumption of crude oil and petroleum products has been projected to increase from about 19.1 million barrels (Mbbl) per day in 2010 to about 21.9 Mbbl per day in 2035 (EIA 2011). Oil and gas reserves in the OCS represent significant sources that currently help meet U.S. energy demands and are expected to continue to do so in the future. The benefits of producing oil and natural gas from the OCS include not only helping to meet this national energy need, but also generating money for public use. In 2009, the OCS produced 2.5 trillion cubic feet (Tcf) of natural gas and more than 590 Mbbl of oil and condensate. These numbers represent 10 and 30%, respectively, of the total U.S. domestic production of oil/condensate and natural gas in 2009. The Federal Government has received, on average, more than $10 billion per year between 2000 and 2010 from OCS bonuses, rental payments, and royalties. The highest revenues per year occurred in 2008, when the government received $23.3 billion in total revenues.

1.3 ENVIRONMENTAL REVIEW UNDER NEPA

Section 18 of the OCSLA directs the USDOI to conduct environmental studies and prepare any EIS required in accordance with the OCSLA and within Section 102(2)(C) of the National Environmental Policy Act of 1969 (NEPA) (42 USC 4332(2)(C)). Under NEPA, Federal agencies are required to prepare a “detailed statement for major Federal actions significantly affecting the quality of the human environment” (NEPA 102(2)). The preparation of this draft PEIS is also consistent with the Council on Environmental Quality (CEQ) regulations (40 CFR 1502.4(b)), which state that “environmental impact statements may be prepared and are sometimes required for broad Federal actions such as the adoption of new agency programs or regulations (Section 1508.18). Agencies shall prepare statements on broad actions so that they are relevant to policy and are timed to coincide with meaningful points in agency planning and decision making.” The preparation of this draft PEIS is thus consistent with, and meets the requirements of OCSLA, CEQ’s regulations for implementing NEPA and USDOI’s regulations implementing NEPA (43 CFR 46).

The OCSLA leasing and development process consists of four major phases. The Secretary first prepares a nationwide 5-year oil and gas leasing program that establishes a schedule of lease sales. Thereafter, individual lease sales scheduled in the 5-year program are held following a series of pre-lease planning actions. Once a lease is issued to an OCS lessee, an Exploration Plan (EP) must be submitted for approval before an operator may begin exploratory drilling on a lease. The EP establishes how the operator will explore the lease and includes all exploration activities, the timing of these activities, information concerning drilling, the location of each well, and other relevant information. If the lessee discovers oil and/or natural gas, a Development and Production Plan (DPP) must be submitted for agency approval. This DPP includes how many wells, where these wells will be located, what type of structure will be used, and how the operator will transport the oil and natural gas. The OCSLA also requires operators to apply for permission prior to drilling wells, pursuant to an EP or, in most areas, a DPP.

In this phased process, the final PEIS may, through tiering, greatly assist subsequent lease sale-specific analyses by allowing incorporation of relevant portions of the final PEIS into those later analyses and NEPA documents. Tiering is defined by the CEQ (40 CFR 1508.28) as "the coverage of general matters in broader environmental impact statements (such as national program or policy statements) with subsequent narrower statements or environmental analyses (such as regional or basin-wide program statements or ultimately site-specific statements) incorporating by reference the general discussions and concentrating solely on issues specific to the statement subsequently prepared."

When a broad NEPA document such as a PEIS or environmental assessment (EA) has been prepared, any subsequent site-specific assessment or evaluation can summarize (and include by reference) the issues discussed in the broader document, and thus the site-specific assessment can focus its analyses on project-specific issues of the particular proposed action (40 CFR 1502.20). Following selection of the Program, any subsequent lease sale-specific NEPA analyses and documentation may tier off the PEIS for the Program.

This draft PEIS is the first of many NEPA analyses that will be done for the activities that occur as a result of the Program. The NEPA assessments, including EISs and EAs associated with various stages of OCS oil and gas development, are shown in Table 1-1.

1.3.1 Scope of the PEIS

This draft PEIS was prepared to evaluate the environmental impacts of alternatives for OCS oil and gas leasing under the Program, and presents those impacts in a comparative manner that provides a clear basis for making a reasoned choice among the alternatives by the decisionmaker. The analyses and evaluations in this draft PEIS and subsequent final PEIS are intended to inform decisions on the size, timing, and location of leasing activity that will be made to create the schedule of lease sales for the Program (43 USC 1344). The OCSLA requires that, for potential leasing to occur in a specific planning area during the applicable 5-year OCS oil and gas leasing program, the specific planning area in which the lease sale would be held must be included in the 5-year program and its associated PEIS. Pursuant to the OCSLA (1344(e)), the Secretary has the discretion to review the leasing program approved at least once each year.

Portions of planning areas can be deferred from leasing during any 5-year oil and gas program because of the presence of sensitive environmental resources, space-use conflicts, or other reasons. The USDOI can also cancel or restrict the area offered in a lease sale based on information, events, and other conditions that arise during any 5-year oil and gas program.

TABLE 1-1 NEPA Assessments Conducted within the OCS Oil and Gas Leasing Program

Program Level	Program Stage	NEPA Analysis[a]	Geographic Scope	Focus and Scope
Planning	Program	Programmatic EIS	Continental	Identification of program areas and number and schedule of lease sales for the Program
	Lease sale	Lease sale EIS or EA	Planning area	Identification of potential impacts and mitigation measures
Project[b]	Exploration Production Decommissioning	CER, EA, or EIS CER, EA, or EIS CER, EA, or EIS	Lease block(s) Portion of lease block Specific facility within a lease block	Application and enforcement of mitigation measures; monitoring of mitigation effectiveness

[a] CER = categorical exclusion review; EA = environmental assessment; EIS = environmental impact statement.

[b] The level of NEPA review at the project level is determined by the complexity of the project, risk factors associated with the project, whether the project occurs in a frontier or mature OCS area, the technologies being used for the project, and other factors.

Examples of the exercise of this authority occurred during the 2007-2012 oil and gas leasing program (the Program) when the single sales scheduled in the North Aleutian Basin and offshore Virginia were cancelled in 2010.

Because portions of planning areas (subareas) can be deferred during a 5-year leasing program, the USDOI is maintaining maximum flexibility in fulfilling its OCSLA mandate to provide for both the nation's energy needs and protect the marine and coastal environment by including in the Program all 6 OCS Planning Areas that were decided upon by the Secretary. If conditions changed during the Program as a result of new information, technologies, or other developments that mitigated the issues responsible for the deferral of a subarea, it would not be possible to restore the subarea for leasing during the existing Program if it were not included in the Program at the outset. There are some exceptions to the approach described above for the 5-year program; for example, the two subsistence deferrals in the Beaufort Sea and the 25-mi no-leasing buffer in the Chukchi Sea have been deferred in past lease sales and have subsequently been incorporated into past 5-year programs. These deferrals (described in detail in Chapter 2 of this PEIS) will be included in the proposed action for the current 5-year leasing program. BOEM may include additional deferral areas in future 5-year programs based on the environmental analysis and regional determination for individual lease sales.

In addition, the detailed information and fine geographic scale needed to evaluate block-by-block deferrals or other mitigations in a specific planning area are not available or appropriate for the PEIS, which needs to adopt a broad geographical scale for its national coverage. Decisions about exclusions and mitigations are premature at the programmatic stage when the focus is the development of a leasing program that identifies how many sales will be included in the program, where to have the sales, and when to schedule the sales. The PEIS informs these decisions by identifying areas, environmental resources, and types of OCS activities that, acting together, suggest the potential for significant interactions between environmental resources and OCS-related activities that could result in significant impacts. In this way, the PEIS identifies the broad issues that will likely require more focused and fine-scale evaluations in subsequent NEPA assessments, leading to the possible development and application of mitigations, should leasing and development actually occur.

1.3.1.1 Incomplete and Unavailable Information

CEQ regulations require an agency to obtain, or explain why it cannot obtain, relevant information about reasonably foreseeable significant adverse impacts that is essential to a reasoned choice among the alternatives presented in an EIS (40 CFR 1502.22). This PEIS provides the level of NEPA analysis corresponding to the first stage of the Program. The PEIS sets forth alternatives for the Secretary to consider and analyzes issues of programmatic concern, which pertain to the Program as a whole.

Programmatic-level analyses and decisions do not require the same detailed analysis that may be necessary at a later stage in the OCS leasing process. Lease sale-specific issues, such as determining which stipulations should apply to a lease sale, are not ripe for analysis at the programmatic stage. Resolving uncertainty related to significant adverse effects on some resources, such as that surrounding global climate change impacts in the Arctic and the potential environmental baseline change brought about by the Deepwater Horizon (DWH) event in the GOM, is not essential at this programmatic stage. In the instances of missing resource-specific information noted in the PEIS, it was determined that the information was not essential to the Secretary’s choice among alternatives at this broad, programmatic decision point because the Secretary is only establishing a schedule of potential lease sales. The Secretary maintains the discretion to delay and cancel lease sales that are part of an approved program. On the other hand, the Secretary will not have the discretion to add program areas that are not included in the Program without program re-approval. It would be imprudent to foreclose program areas at this time based on uncertainty due to incomplete and unavailable information. Over the course of the Program, information relevant to decision making may become available before the decision maker is actually deciding to hold a specific lease sale.

This PEIS presents the information necessary for the Secretary to make a general planning decision, which will be implemented in the future through a series of subsequent, planning area-specific decisions that authorize lease sales and OCS exploration and development activities. To the degree possible, the PEIS uses scientifically credible information and uses accepted scientific methods to make reasoned judgments and arrive at reasoned conclusions. Moreover, some of the missing information, such as definitive information about baseline changes to resources in the GOM resulting from the DWH event, will not be available in a time frame relevant to timely fulfillment of the OCSLA statutory mandate to establish a program every five years.

1.3.2 Public Involvement

As previously discussed, the development of the Program includes preparation of this draft PEIS which, in accordance with NEPA, analyzes the potential effects of the adoption of a schedule of proposed lease sales that identifies the size, timing, and location of proposed leasing activity. The content of a PEIS is based on a process called "scoping." The regulations implementing NEPA require that scoping be included in the environmental analysis process (40 CFR 1501.7). Scoping for this draft PEIS included several key elements: (1) gathering information and ideas from the public and elsewhere about the analytical issues related to the Program; (2) making determinations about which issues should be analyzed; and (3) identifying alternatives to the proposal that warranted analysis. The scoping process is dynamic in that it begins before the draft PEIS analyses are initiated and continues throughout the period of document preparation.

In January 2009, the previous Administration published a Draft Proposed Program and a NOI to prepare an EIS that set out a schedule for scoping meetings in the areas of the Draft Proposed Plan. In February 2009, the Secretary of the Interior extended the comment period on the Draft Proposed Plan and postponed the scoping meetings to allow time to consider further public comment before determining which areas in the Draft Proposed Plan should be scoped and analyzed for consideration in the subsequent program proposals. A preliminary revised program for 2012-2017 was proposed on March 31, 2010, and on April 2, 2010, an NOI to prepare and scope the 2012-2017 OCS oil and gas leasing program PEIS was published in the *Federal Register* (75 FR 16828). That NOI invited the public to provide comments on the scope and content of the PEIS and identified as many as 14 locations where public scoping meetings could be held to obtain comments.

On June 30th, 2010, Secretary of the Interior Salazar announced that the public scoping meetings would be postponed in response to the Deepwater Horizon event. The additional time would be used to evaluate safety and environmental requirements of offshore drilling. On December 1, 2010, Secretary Salazar announced an updated oil and gas strategy for the OCS. The new strategy continued a moratorium for areas in the Eastern GOM (Figure 1-2) and eliminated the Mid-Atlantic and South Atlantic Planning Areas from consideration for potential sales and development through the 2017 planning horizon. The Western GOM, Central GOM, Eastern GOM (only a very small portion thereof), Cook Inlet, Chukchi Sea, and Beaufort Sea OCS Planning Areas (Figure 1-1) would continue to be considered in the PEIS. Subsequently, on January 4, 2011, a Notice of Scoping Meetings for the proposed 2012-2017 OCS oil and gas leasing program PEIS was published in the *Federal Register* (76 FR 376) and a second scoping period was conducted from January 6, 2011, through March 31, 2011. During this scoping period, public scoping meetings were scheduled for 12 locations in Alaska, Texas, Louisiana, Alabama, and Washington, D.C. In addition, BOEM received comments through the mail and maintained a public website to accept electronic scoping comments.

Recent EISs and EAs for GOM and offshore Alaska oil and gas lease sales provided additional scoping information. Many of the analytical issues raised during the lease sale review process are applicable to this draft PEIS for the proposed Program. Subject matter experts at BOEM also identified analytical issues relevant to the draft PEIS analyses. In addition, alternatives developed for past leasing program proposals were reviewed to determine whether it would be appropriate to analyze any of them in detail in this PEIS.

Through the scoping process, the following major issues were identified for consideration in preparing the draft PEIS:

- Oil and gas activities that could cause impacts (termed "impact-producing factors");
- Ecological resources that could be affected by oil and gas activities;
- Social, cultural, and economic resources that could be affected by oil and gas activities;
- Human health;
- Climate change;
- Regulatory oversight and safety; and
- Oil spills.

In addition, comments received through the scoping process provided suggestions for alternatives to be considered in the PEIS. These suggestions fell into the following major categories:

- Prohibiting leasing and development in one or more planning areas;
- Limiting leasing and development to specific areas on the OCS (e.g., no deep water);
- Including more OCS planning areas than the six identified in the proposed action;
- Developing new, or expanding existing, deferral areas; and
- Developing alternative energy sources to replace oil and gas.

The alternatives evaluated in this draft PEIS, as well as those considered but removed from further consideration, are discussed in Chapter 2 of this draft PEIS.

This draft PEIS considers mitigation measures already established and required by existing statutes or regulations, as well as sale-specific measures (stipulations) that were commonly adopted in past sales and that will likely be implemented for any lease sales that would occur under the Program. However, it is at the lease sale stage that more detailed and geographically focused analyses are conducted to evaluate the magnitude of potential impacts and, if needed, to develop effective mitigation strategies to reduce the magnitude of those potential impacts to acceptable levels. Therefore, the impact analyses presented in this PEIS assume implementation of mitigation measures that are required by statute or regulation as well as sale-specific mitigation measures (stipulations) commonly adopted in past sales (see Appendix B: Assumed Mitigation Measures). This draft PEIS also assumes that existing mitigations in areas with currently active leases, such as the GOM and parts of Alaska, will be applied to areas included in the Program that do not have a history of OCS activity.

1.4 ANALYTICAL ISSUES

A number of analytical issues, many of which are addressed in this draft PEIS, were identified during scoping. These include the geographic scope of the PEIS, the analytical scope of the PEIS, the impacting factors to be considered in the analyses, and the resources that may be affected by the Program. These analytical issues are discussed below.

1.4.1 Geographic Scope

There are 26 planning areas on the OCS, and six of these have been identified for leasing consideration as part of the Program (Figure 1-1). Twenty planning areas located along the Atlantic, Pacific, Florida, and Alaskan coasts are neither part of the proposed action nor analyzed in any alternative considered in this draft PEIS.

1.4.2 Analytic Scope

The analyses conducted in preparation of this draft PEIS were based on current, available, and credible scientific data. Interpretation of these scientific data was used to evaluate direct, indirect, and cumulative impacts associated with the proposed action and alternatives. Throughout this PEIS, Alternative 1 (referred to herein as the proposed action) is used as the default scenario on which to base analysis of potential impacts. This does not mean that Alternative 1 has already been chosen as the operative alternative for the Program. Rather, the proposed action includes the largest geographic scope of any of the alternatives contemplated, so using it to analyze impacts results in the most all-inclusive analysis possible, compared to the other alternatives presented. The proposed action is the alternative that has the potential to cause the greatest impacts, with each of the other alternatives representing, in effect, a subset of the proposed action. Therefore, using the proposed action as the basis for analysis provides the most complete and meaningful assessment of potential impacts.

As a programmatic evaluation, this draft PEIS does not evaluate site-specific issues that would be associated with specific lease sales in specific planning areas. As previously discussed, a variety of location-specific factors (such as water depth, sea floor topography, distance from shore, ecological communities, and the presence of threatened and endangered species and cultural resources) may vary considerably, not only between planning areas but also among lease sale blocks within individual planning areas. In addition, variations in project design and study (including the seismic survey approach and technology selected) will influence and/or determine the nature and magnitude of impacts that might occur with a given lease sale. The combined effect of these location-specific and project-specific factors cannot be fully anticipated or addressed in a programmatic analysis, and can only be evaluated at the lease-sale or finer level.

1.4.3 Impact-Producing Factors

Several types of impact-producing factors were identified that warrant consideration. All of the following impact-producing factors are included in the exploration and development scenarios for the proposed action presented in Section 4.4, and are evaluated as applicable in the resource-specific impact evaluations presented elsewhere in Chapter 4. In addition, the cumulative impact analysis includes activities unrelated to OCS development but relevant to assessing cumulative impacts (Section 4.6). The impact-producing factors related to OCS development that were identified include:

- Accidental oil spills including those from loss of well control, production accidents, transportation failures (e.g., from tankers, other vessels, seafloor and onshore pipelines, and storage facilities), and low-level spillage from platforms.

- The offshore and onshore disposal of liquid wastes, including well drilling fluids (i.e., drill muds), produced water, ballast water, and sanitary and domestic wastewater generated by OCS-related activities.

- Solid waste disposal, including material removed from the well borehole (i.e., drill cuttings), solids produced with the oil and gas (e.g., sands), cement residue, bentonite, and trash and debris (e.g., equipment or tools) accidentally lost, including those that contain materials such as mercury that may bioaccumulate.

- Gaseous emissions from offshore and onshore facilities and transportation vessels and aircraft.

- Noise from seismic surveys, ship and aircraft traffic, drilling and production operations, and explosive platform removals.

- Invasive species whose introduction may be facilitated by activities associated with the construction of offshore facilities or with the movement of materials and equipment by way of transportation systems.

- Physical impacts from ship and aircraft traffic and use conflicts with oil tankers and barges, supply/support vessels and aircraft, and seismic survey vessels and aircraft.

- Physical emplacement, presence, and removal of facilities, including offshore platforms; seafloor pipelines; floating production, storage, and offloading systems; onshore infrastructure such as pipelines, storage, processing, and repair facilities; ports; pipe coating yards; refineries; and petrochemical plants.

- Other activities including oil spill response (cleanup), including both response and recovery under extreme sea and ice conditions.

- Interaction of oil and gas industry workers and local residents, including interaction associated with the employment of local residents.

In addition to the activities that may result from the proposed action, the draft PEIS considers natural processes and phenomena that could cause indirect impacts by affecting the safe conduct of OCS oil and gas exploration, production, and transportation activities, or the environmental conditions under which these activities occur. These include geologic hazards such as earthquakes and continental slumping; gas hydrates; physical oceanographic processes such as water currents, sea ice, and waves; subsea permafrost; shoreline erosion; and meteorological and climatic events and processes such as hurricanes and climate change, including global warming and ocean acidification. The draft PEIS also considers space-use conflicts with military operations in designated offshore military areas and potential future alternative uses of the OCS, including the program for alternative energy development and production and alternate use of offshore facilities. It also considers the effects of the OCS oil and gas leasing program on the introduction of invasive species into U.S. waters.

This draft PEIS gives particular attention to the issue of climate change, based on the observed changes that have been occurring during the past several decades, particularly in the Arctic environments in Alaska. Chapter 3 presents a discussion of climate change and baseline conditions (Section 3.3), while many of the subsequent resource-specific discussions of the affected environment include discussions of the effects of ongoing, observable climate changes for those resources. Additional analyses are included in the cumulative analysis (Section 4.6) in which the impacts of the continuing trend in climate change during the life of the proposed action are evaluated along with all other factors affecting the resource.

1.4.4 Potentially Affected Resources

This draft PEIS evaluates resources that may potentially be impacted by oil and gas leasing and development under the Program. The resources evaluated include not only natural resources (physical and biological) but social, cultural, and economic resources as well. The natural resources and topics evaluated in this draft PEIS are as follows:

- *Water Quality (including marine and estuarine areas)*. The water quality issues are related primarily to marine water quality and how changes in water quality caused by OCS activities could affect biological resources (for example, by potentially contributing to the GOM hypoxia zone).

- *Air Quality*. The principal concern is the transport of offshore emissions to onshore areas leading to potential violations of Federal and State air quality standards intended for the protection of human health and welfare.

- *Biologic Resources*. Primary concerns are related to habitat disturbance or loss (including designated critical habitats, pursuant to ESA, and habitat areas of particular concern, pursuant to the Magnuson-Stevens Act), direct physical impacts on biota, and disturbance of normal behaviors (feeding, courtship, migration) by OCS-related activities.

- *Socioeconomic and Sociocultural Resources.* Socioeconomic and sociocultural resources included potential impacts on tourism, recreation, commercial fishing, subsistence harvests, aesthetics, local economy, land and water use conflicts, equitable sharing of program benefits and burdens, disproportionate impacts on Louisiana, and disproportionate impacts on Alaska Natives.

The issues we examine in this draft PEIS regarding possible impacts on biology and ecology fall into three main categories: animals, plants, and habitats or ecological systems. Among the animal groups identified as needing analysis for potential program impacts were marine mammals, birds, fish, and sea turtles. Special attention was drawn to migratory species, species taken commercially and for Alaska Native subsistence (including whales, fish, and birds), and threatened and endangered species. With respect to habitats or systems, both marine (e.g., sanctuaries, marine parks/preserves, seagrasses, mangroves, and “hard bottom” areas) and coastal (e.g., estuaries, wetlands/marsh, intertidal zone, seashore parks) areas were identified as subject to possible adverse impacts. The issue of bioaccumulation is also discussed in this draft PEIS.

The specific biological and ecological resources analyzed in detail are:

- Marine mammals, including a variety of endangered and nonendangered cetaceans (e.g., whales, dolphins, etc.), pinnipeds (seals, sea lions, walruses), sea otters, and polar bears.

- Terrestrial mammals, including caribou and grizzly/brown bear in the Arctic, and five species of federally listed mice and voles that inhabit certain coastal areas of the GOM.

- Birds, including a variety of endangered and nonendangered seabird, shorebird, waterfowl, and raptor species. Particular concern was identified for migratory species, including those taken for Alaska Native subsistence.

- Fish, including a variety of finfish and shellfish species used for commercial or recreational purposes. Particular concern was identified regarding chronic pollution from polycyclic aromatic hydrocarbons. Particular concern was also identified for salmon in Alaska.

- Reptiles, including sea turtles.

- Coastal habitats, including wetlands, estuaries, seagrass and kelp beds, mangroves, dunes, beaches, and barrier islands.

- Lower trophic level organisms and food chains.

- Open water habitats, such as *Sargassum* mats.

- Seafloor habitats, including submarine canyons, topographic features, corals, live bottom areas (benthic environments), and seeps (e.g., brine and oil seeps).

- Areas of special concern, including coastal and marine sanctuaries, parks, refuges, reserves, sanctuaries, and forests. Particular concern was raised in regard to "essential fish habitat" as designated by the U.S. Department of Commerce (USDOC) National Marine Fisheries Service (NMFS).

Specific concerns regarding social, cultural, and economic resources included potential impacts on tourism, recreation, commercial and recreational fishing, subsistence harvests, aesthetics, local economy (especially the "boom/bust" phenomenon), land and water use conflicts, equitable sharing of program benefits and burdens, and disproportionate impacts to certain populations. The social, cultural, and economic topics analyzed in this PEIS are as follows:

- Population, employment, income, and public service issues from the effects of the Program, including issues of "boom/bust" economic cycles.

- Land use and infrastructure, including construction of new onshore facilities, and land use and transportation conflicts between the oil and gas development and other uses.

- Sociocultural systems effects were primarily identified with respect to Alaska. These include concerns about the effects on subsistence (e.g., bowhead whale hunting), loss of cultural identity, psychological health of people, and social costs of lease sales and oil spills.

- Environmental justice (e.g., the potential for disproportionate and high adverse impacts on minority and/or low-income populations [Executive Order 12898]).

- Fisheries; commercial, subsistence, and recreational.

- Tourism and recreation, including the use of coastal areas for sightseeing, wildlife observations, swimming, diving, surfing, sunbathing, hunting, fishing, and boating, as well as visual impacts of offshore OCS structures.

- Archaeological resources, including historic shipwrecks and surface or subsurface sites that had been inhabited by humans during prehistoric times.

1.4.5 Issues Not Analyzed in This PEIS

The following discussions address issues mentioned during scoping that were not analyzed in this PEIS. These issues include concerns about affected resources or analytical techniques employed in the PEIS.

1.4.5.1 Worker Safety

Generally, concerns mentioned regarding worker safety risks from OCS oil and gas development were broad and not defined during scoping. The issue of worker safety is more appropriately considered during the review of individual lease exploration and development proposals. The OCSLA and the implementing regulations require that all drilling and production operations use the best available and safest technologies. A principal reason for this requirement is to minimize the adverse effect of OCS operations on human safety. BOEM considers whether a proposed project would be conducted in a manner that conforms to the many specific requirements developed to protect worker safety during the review of proposals to conduct lease operations. BOEM can best determine at that time whether additional measures are needed to reduce the potential for accidents that affect safety.

1.4.5.2 Proposed Seismic Inventory

Many comments were received through the scoping process on the issue of conducting seismic surveys to identify potential OCS U.S. oil and gas resources. Industry must hold leases before it commits to very expensive exploration drilling activities. Generally, industries, States, and individuals supportive of OCS petroleum development favored this idea, and those against OCS development opposed it. Those in favor argued that it was prescribed in duly enacted law, it would support national energy planning, and it would provide information relevant to the equitable sharing of the benefits and burdens of the OCS leasing program. Those against oil and gas leasing and development on the OCS argued that it would subvert previous laws and policies (e.g., coastal zone management and Congressional moratoria), it might not comply with all NEPA requirements, and it might create pressure to develop areas that are currently under Congressional moratoria and Presidential withdrawals. The procedures under which a seismic inventory for all of the oil and gas resources on the OCS might be conducted are not yet established and are, therefore, unrelated to the Program and not addressed in this PEIS.

1.4.5.3 Neighboring Countries Drilling on OCS Border with the United States

It was suggested that the United States should lease selected tracts on the OCS to counter petroleum development being planned by foreign countries, such as Cuba. It was suggested that this would protect U.S. mineral rights in border areas. The issue of foreign governments exploring and developing petroleum resources in their territorial waters is unrelated to the Program and is, therefore, not addressed by this draft PEIS. This issue of international mineral rights is more appropriately addressed by the U.S. Department of State than by BOEM.

1.4.5.4 Biological Assessment and Opinion for Threatened and Endangered Species

Section 7(a)(2) of the Endangered Species Act (ESA) (16 USC 1536(a)(12)) requires every Federal agency, in consultation with and with the assistance of the Secretary of the Interior and the Secretary of Commerce, to ensure that any action it authorizes, funds, or carries out in the United States or upon the high seas is not likely to jeopardize the continued existence of any listed species or result in destruction or adverse modification of critical habitat. Section 402.02 defines "action" as "all activities or programs of any kind authorized, funded, or carried out in whole or in part." Preparing the Program does not fit the definition of a Federal action because no OCS activities are being "authorized, funded, or carried out" at this Program level. Therefore, ESA Section 7 consultation (whether informal or formal) at the leasing program level is premature.

The OCS oil and gas leasing program, as required by Section 18 of OCSLA (43 USC 1344), identifies a proposed schedule of lease sales and prospective areas of the OCS that the Secretary of the Interior believes will best meet U.S. energy needs. The leasing program process and subsequent Secretarial decisions are based on the four main principles of Section 18 that dictate which areas are reasonable for consideration of leasing in the upcoming 5-year time frame. The Program will define, as broadly as possible, the portion of each planning area that is proposed for subsequent leasing consideration. Decision options for the leasing program are preserved for the Secretary at the time the decision is made for each sale. Therefore, it is at the lease sale stage that BOEM begins ESA Section 7 consultations.

In further support of the position not to consult at the leasing program stage, the U.S. Fish and Wildlife Service (USFWS) and NMFS, in their final rulemaking establishing procedural regulations for Section 7 consultations (51 FR 19926), clarified that informal and formal consultations are a "post-application process when applicants are involved." BOEM would not approach this stage until a lease sale is held and a qualified bid is accepted. Further, we believe the intent of Congress when passing the ESA was to exclude consultations on actions that are remote or speculative in nature. While the following quote addresses ESA Section 7 early consultations (a pre-application process defined in the above-referenced *Federal Register* notice), we believe it clearly expresses Congress' intent and is consistent with our position.

> "The Committee expects that the Secretary will exclude from such early consultation those actions which are remote or speculative in nature and to include only those actions which the applicant can demonstrate are likely to

occur. [. . .] The Committee further expects that the guidelines will require the prospective applicant to provide sufficient information describing the project, its location, and the scope of activities associated with it to enable the Secretary to carry out a meaningful consultation." (H.R. Rep. No. 567, 97th Cong., 2nd Sess. 25 [1982])

Ultimately, decisions regarding the size and configuration of a lease sale area, lease stipulations, and some mitigation measures are determined by the presale process. Prior to the presale process, greater uncertainties exist. Some of the uncertainties may result from an industry firm's interest in a particular area and its willingness to bid, which depend, in part, on continually changing perceptions about potential benefits that might result. Limitations on predicting a firm's investment decisions also limit the ability to predict OCS activities. With so much uncertainty at this Program stage, ESA consultation would be premature.

1.4.5.5 Life Cycle Effects of Oil and Gas Development

A recommendation was made that the PEIS address all reasonable effects of new oil and gas development, production, and consumption. Such "full cycle" effects would include oil and gas exploration, construction and placement of infrastructure, continued drilling, production, processing, treatment, refining, transportation and storage, final decommissioning, and ultimate consumption of the finished product. Additionally, the contribution of OCS development and OCS oil and gas consumption activities to global warming was stressed.

The scope of the proposed action analyzed in this draft PEIS encompasses the exploration, development, production, and transport of crude oil, and decommissioning. The consumption of the refined oil is not considered because the scope of this draft PEIS is limited to issues that have a bearing on the decisions for the proposed leasing program. Consumption of oil and gas is considered at a broader level when decisions are made regarding the role of oil and gas generally, including domestic production and imports, in the overall energy policy of the United States. At the refinery stage, OCS oil is mixed with oil from other sources such that the OCS contribution to subsequent environmental impacts is not separable.

1.4.5.6 Resource Estimates and Impact Analyses

A concern was expressed that petroleum resource reserves should not be linked to conclusions for environmental impacts. It was felt that low oil resource estimates, and subsequent low probabilities of commercial finds, may erroneously be equated with insignificant environmental impacts. The draft PEIS does not equate oil and gas resource estimates and impact significance. We assess the potential impacts of exploration, production, transporting crude oil and gas, and decommissioning on environmental resources, including the potential impacts of a large oil spill, of the proposed action and alternatives, regardless of the oil resource estimate. The analytical conclusions reflect the likely impacts of routine activities as well as those that could occur in the event a large spill contacted the resource. The estimated number of large spills that could occur is a function of the assumptions regarding anticipated (future) production. Therefore, the impacts could be greater on some environmental resources because they could be exposed to more large spills than other environmental resources. If exploration fails to identify oil and gas projects that are commercially feasible, then no development would occur and the only impacts will be associated with exploration activities.

A suggestion was made that the analysis of relative marine productivity should not be limited to a measure of the primary productivity of marine plants. This measure is used because it is well documented and understood. However, we agree that it should not be the only factor used; therefore, BOEM uses other information as well in its consideration of the productivity of marine environments.

A suggestion was made that the environmental cost analysis model should consider the impact of catastrophic events on unique resources. We think that probabilistic models are not an appropriate venue for analyzing events with highly uncertain probabilities. For this reason, catastrophic events are being considered separately.

A suggestion was made in the Alaska region that BOEM use development scenarios that reflect the concerns of affected communities rather than such industry-related factors as water depth and proximity to existing infrastructure. As is the intent of CEQ guidance, our development scenarios are constructed to identify those events that are most likely to happen to better focus the analysis of future activities. However, we address the concerns of affected communities in the analyses of such topics as possible impacts on species and on subsistence.

1.5 ORGANIZATION OF THIS PEIS

This draft PEIS is organized as follows:

- Chapter 1 provides background information, identifies the purpose and need for the action, and discusses scoping and analytical issues.

- Chapter 2 describes the alternatives evaluated in the draft PEIS, identifies alternatives considered but not evaluated in the draft PEIS, and presents a summary comparison of the environmental impacts of the alternatives.

- Chapter 3 provides an overview of the marine and coastal ecoregions where oil and gas development under the Program may occur and presents descriptions of the physical, natural, cultural, and economic resources or conditions that may potentially be affected by the proposed action and other alternatives.

- Chapter 4 describes the impact-producing factors associated with routine operations under each phase of OCS oil and gas development, discusses accidental events and spills, describes the impact analysis approach of the draft PEIS, and defines impact levels. This chapter also discusses the relationship of the physical environment to oil and gas development and identifies issues of programmatic concern. Finally, Chapter 4 presents the exploration and development scenarios, as well as the accidental oil spill scenarios, assumed for this draft PEIS; discusses the potential impacts of these scenarios for each alternative; and discusses the potential cumulative impacts of the alternatives.

- Chapter 5 identifies the unavoidable adverse impacts associated with the alternatives.

- Chapter 6 discusses the relationship between short-term use of the environment and long-term productivity.

- Chapter 7 discusses the significant irreversible and irretrievable commitments of natural and manmade resources.

- Chapter 8 discusses the process used for preparing the Program and the list of agencies, organizations, governments, and individuals that received the draft PEIS.

- Chapter 9 lists the names, education, and experience of the persons who helped to prepare the draft PEIS. Also included are the subject areas for which each person was responsible.

- Appendix A presents a glossary of terms used throughout this draft PEIS.

- Appendix B identifies the mitigation measures that are required by existing statutes or regulations, as well as sale-specific measures (stipulations) that were commonly adopted in past sales and that are assumed will be implemented for any lease sales that would occur under the Program.

- Appendix C identifies all Federal laws and Executive Orders that would apply to leasing under the Program.

1.6 REFERENCES

EIA (U.S. Energy Information Administration), 2011, *Annual Energy Outlook 2011*, Office of Integrated and International Energy Analysis, Washington, D.C.

Hagerty, C.L., 2011, *Outer Continental Shelf Moratoria on Oil and Gas Development*, CRS Report to Congress, 7-5700, R41132, Congressional Research Service, Washington, D.C., May 6.

2 ALTERNATIVES INCLUDING THE PROPOSED ACTION

The Notice of Intent (NOI) for this draft Programmatic Environmental Impact Statement (PEIS), which was published on April 2, 2010 (75 CFR Part 63: 16828–16829), identified eight OCS planning areas for possible inclusion in the 2012-2017 OCS oil and gas leasing program (the Program), but identified no specific lease sale alternatives. The eight planning areas identified in that NOI were as follows:

- The Beaufort Sea, Chukchi Sea, and Cook Inlet Planning Areas in Alaska.

- The Western, Central, and Eastern Gulf of Mexico (GOM) Planning Areas, with the latter focusing on a small area along the western boundary of this planning area.

- The South and Mid-Atlantic Planning Areas.

Subsequently, on December 1, 2010, the Secretary of the Interior announced an updated oil and gas leasing strategy for the OCS (FR Notice; FR Doc. 2010–33149). Consistent with the Secretary's direction to proceed with caution and focus leasing in areas with current active leases, the area in the Eastern GOM Planning Area, which remains under a Congressional moratorium (except for the area not restricted from leasing and development per the Gulf of Mexico Energy Security Act of 2006 as indicated in Figure 1-2 of this PEIS), and the South and Mid-Atlantic Planning Areas were dropped from consideration for potential sales and development through 2017, and thus are no longer under consideration in this PEIS.

The following six OCS planning areas are thus considered in this PEIS.

- The Beaufort Sea, Chukchi Sea, and Cook Inlet Planning Areas in Alaska.

- The Western, Central, and Eastern GOM Planning Areas, with the latter focusing only on a small area along the western boundary of this planning area.

This draft PEIS analyzes eight alternatives for the leasing of Federal offshore lands by the U.S. Department of the Interior (USDOI), Bureau of Ocean Energy Management (BOEM), under the Program.

The draft PEIS analyses assume the implementation of all mitigation measures required by statute, regulation, or lease stipulations. All BOEM sale proposals include rules and regulations prescribing environmental controls applicable to lease operators. Lease stipulations, OCS regulations, and other measures provide a regulatory base for implementing environmental protection on leases issued as a result of a sale. The BOEM Environmental Studies Program and the analyses and monitoring of activities in a sale area provide information used in formulating the Agency's regulatory control over the activities that occur during the life of the leases. This PEIS also assumes that Bureau of Safety and Environmental Enforcement (BSEE, formerly part of BOEMRE will continue to use its broad permitting and monitoring and enforcement authority to ensure safe operations and environmental protection, including use of the best available and safest technologies and requiring existing mitigations. The PEIS assumes that BOEM will continue to monitor operations after drilling has begun and will carry out periodic inspections of facilities (in certain instances, in conjunction with other Federal Agencies such as the U.S. Environmental Protection Agency [USEPA]) to ensure safe and clean operations over the life of the leases. The 7 action alternatives listed below are not mutually exclusive, and the Secretary has the discretion to combine alternatives. These alternatives include the following:

- Alternative 1 – Proposed Action

Under the proposed action, there would be as many as 15 lease sales distributed among the six OCS planning areas, including 12 sales in the GOM and 3 sales in Alaska. The GOM sales include five annual sales in each of the Central and Western Planning Areas and up to two sales in a small area of the Eastern GOM Planning Area that includes 83 lease blocks being considered for this Program (Figure 1-2). The Alaska sales would include one sale in each of the Beaufort Sea and Chukchi Sea Planning Areas and one special interest sale in Cook Inlet. Under the special interest sale process, BOEM issues an annual request for nominations and information and will move forward with the lease sale process only after consideration of the comments received in response to the annual request. If industry interest reflected in the comments is sufficient, the lease sale process will proceed. If interest is not sufficient to support consideration of a sale, the lease sale process will not proceed and another request will be issued the following year and so through the 5-year schedule, until a sale is held or the 5-year period expires.

Neither the proposed action nor any alternative to the proposed action includes consideration of leasing in the Pacific or Atlantic OCS regions. The OCS Planning Areas included in the proposed action are shown in Figure 2-1. All the other "action" alternatives, i.e., Alternatives 2 through 7, are the same as the proposed action, except as specified below.

- Alternative 2 – Exclude the Eastern Planning Area for the duration of the Program

- Alternative 3 – Exclude the Western GOM Planning Area for the duration of the Program

- Alternative 4 – Exclude the Central GOM Planning Area for the duration of the Program

- Alternative 5– Exclude the Beaufort Sea Planning Area for the duration of the Program

- Alternative 6 – Exclude the Chukchi Sea Planning Area for the duration of the Program

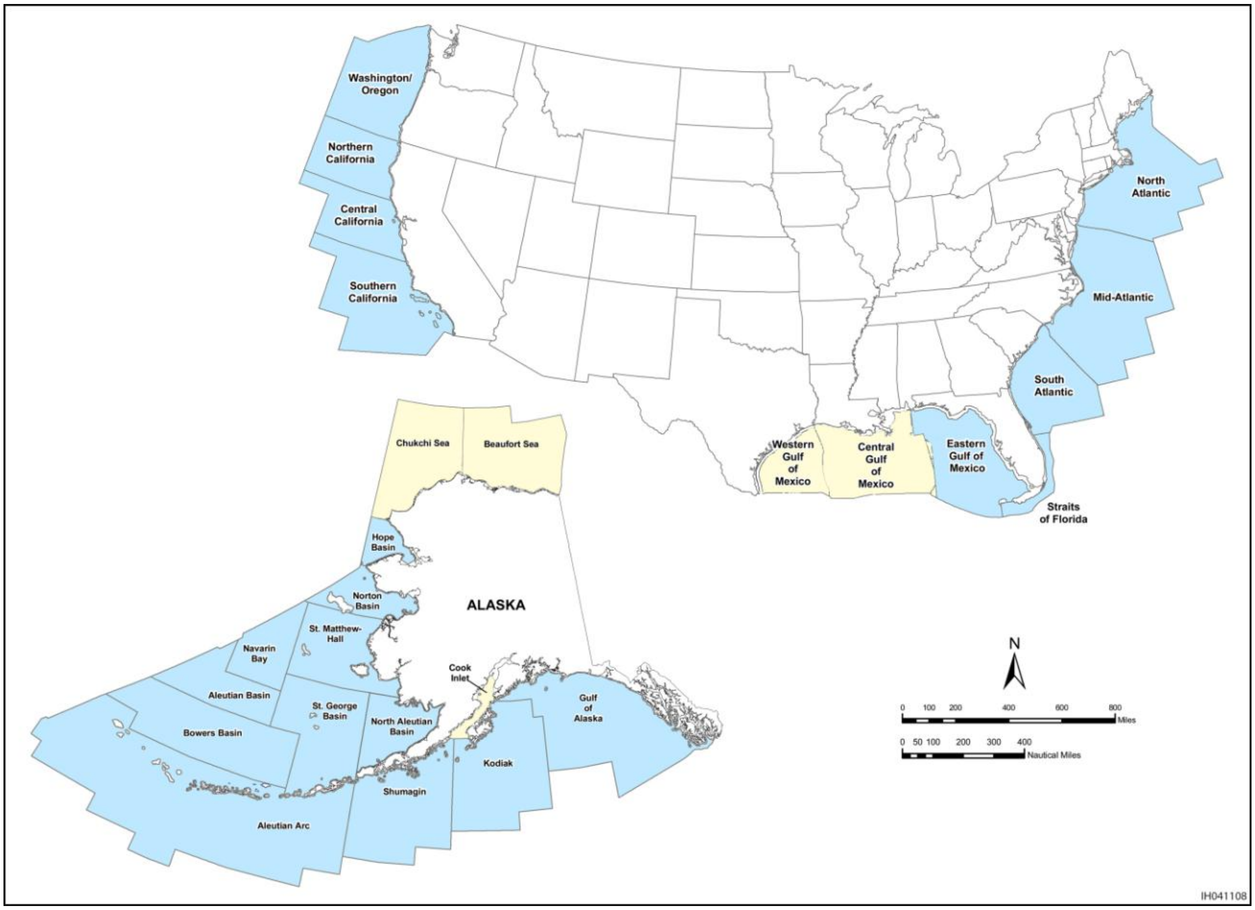

FIGURE 2-1 OCS Planning Areas. Planning Areas in Yellow are under Consideration for Inclusion in the 2012-2017 OCS Oil and Gas Leasing Program

- Alternative 7 – Exclude the Cook Inlet Planning Area for the duration of the Program

- Alternative 8 – No Action.

This chapter describes each alternative and summarizes the potential environmental impacts of the alternatives in comparative form. The summary describes the primary impacts based on the detailed analysis of all potential impacts presented in Chapter 4, Environmental Consequences. The impact analyses presented in this PEIS were generated from exploration, development, transportation, and oil spill scenarios developed specifically for analytical purposes.

2.1 ALTERNATIVE 1 – PROPOSED ACTION

The four OCS regions are divided into 26 OCS Planning Areas (Figure 2-1), and under the proposed action, leasing is considered in two of the four BOEM OCS regions: GOM and

Alaska. Within the GOM OCS region, leasing is being considered in the Central and Western GOM Planning Areas, and in a small extreme western portion of the Eastern GOM Planning Area. Because of the small portion of the Eastern GOM Planning Area under consideration for the program, which contains only 83 of the nearly 11,000 lease blocks in the Eastern GOM Planning Area, and because of the relatively small amount of production that might occur in these blocks, the exploration and development and the oil spill scenarios identified for both one and two sales in the Eastern GOM are analytically identical. Therefore, the impact analysis for a proposed action that includes two eastern GOM sales would also apply to a proposed action that included only a single sale. In addition, the USDOI is considering leasing in 3 of the 15 Alaska region planning areas: Beaufort Sea, Chukchi Sea, and Cook Inlet. No other OCS Planning Areas are analyzed in this PEIS because the USDOI is not considering those areas for leasing under the Program. The proposed action is the USDOI's preferred alternative.

Specifically, the proposed action calls for 15 lease sales under the Program:

- Western Gulf of Mexico Planning Area — five area-wide lease sales; one sale annually beginning in 2012.

- Central Gulf of Mexico Planning Area — five area-wide lease sales; one sale annually beginning in 2013.

- Eastern Gulf of Mexico Planning Area — one to two lease sales in the extreme western portion of the planning area; one sale in 2014 and one sale in 2016.

- Beaufort Sea Planning Area — one sale in 2015 with a bowhead whale migration deferral, which includes the following areas (Figure 2-2):
  - The Barrow Subsistence Whaling area that defers 49 whole or partial blocks located at the western border of the planning area
  - The Kaktovik Subsistence Whaling area that defers 28 whole or partial blocks located offshore of Kaktovik.

- Chukchi Sea Planning Area — one sale in 2016 with a 40 km (25 mi) buffer deferral (Figure 2-2). This alternative considers the impacts associated with not leasing within 25 miles of the Chukchi Sea coast.

- Cook Inlet Planning Area — one special interest sale in 2013.

Activities that could occur as a result of the 15 lease sales under the proposed action may extend over a period of 40–50 years. The impact-causing factors associated with these activities include the placement, use, and decommissioning of offshore infrastructure such as rigs, platforms, and pipelines, and the expansion or construction of, and use of onshore facilities such as support bases and processing plants, and these impacting factors apply to activities in any of the planning areas that are part of the proposed action and alternatives considered in this draft PEIS. Chapter 4, Environmental Consequences, presents the basic assumptions about anticipated production, exploration, development, transportation, and accidental oil spills used to prepare the

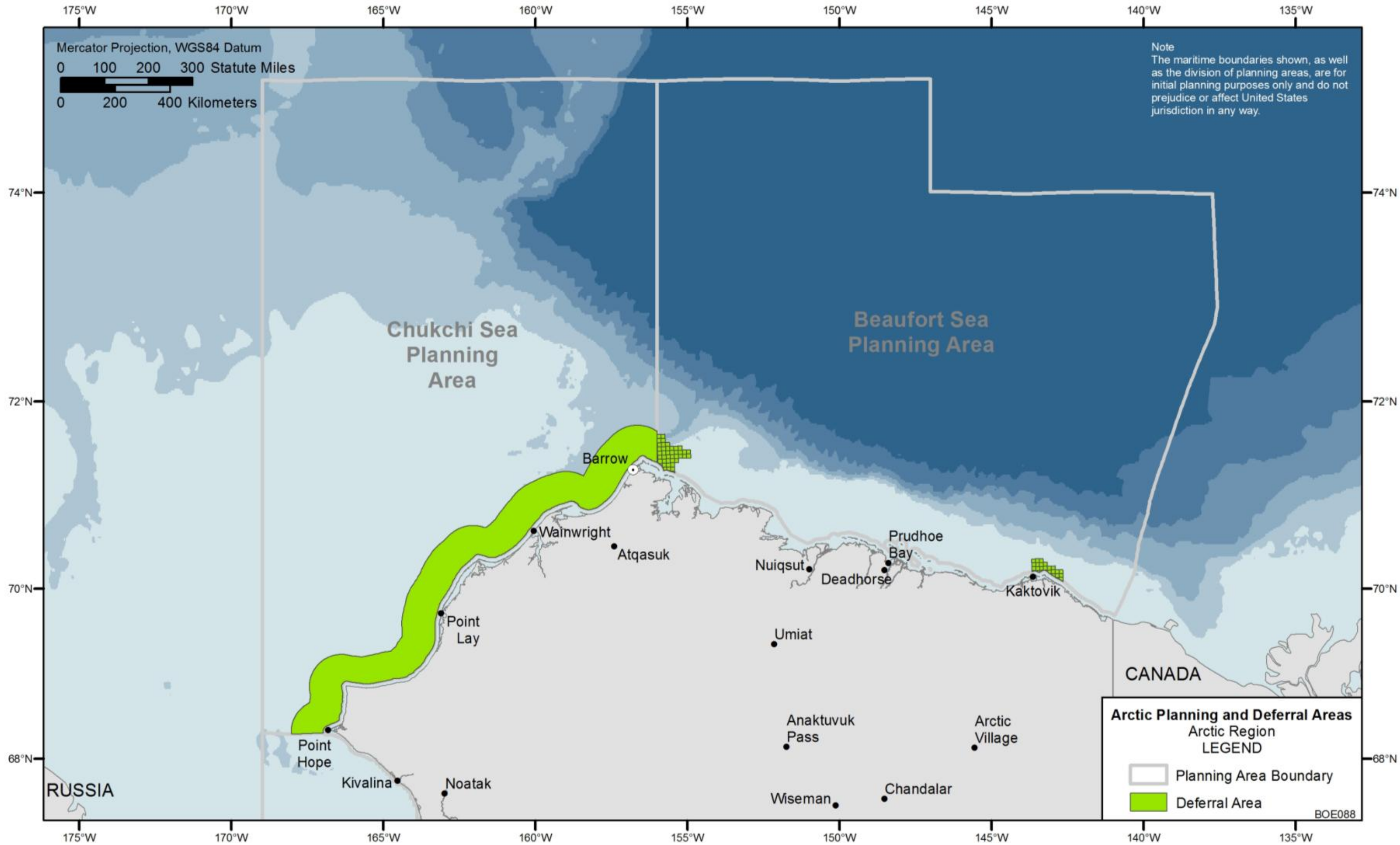

FIGURE 2-2 Deferral Areas in the Beaufort Sea and Chukchi Sea Planning Areas

draft PEIS. The specific estimates of offshore infrastructure required to support exploration and development of the hydrocarbon resources (scenarios) associated with Alternative 1 (the proposed action) are provided in Tables 4.4.1.1-1, 4.4.1.1-3, and 4.4.1.1-4 in Section 4.4.1 of this draft PEIS. Impacting factors and activity-specific impacts are discussed in additional detail in Section 4.1, and in the resource-specific impact discussions presented elsewhere in Chapter 4 of this PEIS.

Transportation for most oil and gas from the GOM Planning Areas would be accomplished by extending and expanding the existing offshore pipeline systems. Some of the oil in deepwater areas and a small amount of the oil from the nearshore areas of the GOM Planning Areas would be transported by barge or shuttle tanker.

In the Alaska OCS region, the lifting of the export ban on Alaskan crude oil has led to infrequent and limited shipments to East Asia. However, the vast majority of oil transported via the Trans-Alaska Pipeline System (TAPS) is still being sent to the U.S. West Coast. Oil and gas from the Beaufort Sea and Chukchi Sea Planning Areas would be transported by new subsea and overland pipelines to the TAPS and delivered to the marine terminal facilities in Valdez, where it would be loaded on tankers and shipped primarily to West Coast ports. Oil and gas from the Cook Inlet Planning Area would be transported to shore using new subsea pipelines, with new onshore common-carrier pipeline systems delivering the oil to existing refineries in Nikiski and gas to transmission facilities in the Kenai area.

2.2 ALTERNATIVE 2 – EXCLUDE THE EASTERN GOM PLANNING AREA FOR THE DURATION OF THE PROGRAM

Under Alternative 2, the Program would not include new leasing in the Eastern GOM Planning Area. This alternative includes 13 lease sales, with the same number of sales in other planning areas and the same exploration and development and oil spill scenarios as identified for the proposed action. The potentially available resources in the Eastern GOM Planning Area available for leasing are estimated to include no more than 0.1 billion barrels (Bbbl) of oil and 0.2 trillion cubic feet (Tcf) of natural gas.

2.3 ALTERNATIVE 3 – EXCLUDE THE WESTERN GOM PLANNING AREA FOR THE DURATION OF THE PROGRAM

Alternative 3 has no lease sales occurring in the Western GOM Planning Area, with the resultant Program having 10 lease sales. The potentially available resources in the Western GOM Planning Area include up to 1.0 Bbbl of oil and 4.6 Tcf of natural gas.

2.4 ALTERNATIVE 4 – EXCLUDE THE CENTRAL GOM PLANNING AREA FOR THE DURATION OF THE PROGRAM

Under this alternative, there would be no lease sales in the Central GOM Planning Area, and only 10 lease sales under the Program. The potentially available resources in the Central GOM Planning Area include as much as 4.3 Bbbl of oil and 19.1 Tcf of natural gas.

2.5 ALTERNATIVE 5 – EXCLUDE THE BEAUFORT SEA PLANNING AREA FOR THE DURATION OF THE PROGRAM

Alternative 5 includes a total of 14 lease sales in all OCS Planning Areas identified for the proposed action except for the Beaufort Sea Planning Area. Under this alternative, OCS oil and gas leasing under the Program, and any subsequent exploration and development in the Arctic region would occur only in the Chukchi Sea Planning Area (except in the deferred area). The potentially available resources in the Beaufort Sea Planning Area that would not be made available under this alternative include as much as 0.4 Bbbl of oil and as much as 2.2 Tcf of natural gas.

2.6 ALTERNATIVE 6 – EXCLUDE THE CHUKCHI SEA PLANNING AREA FOR THE DURATION OF THE PROGRAM

Under Alternative 6, there would be a total of 14 lease sales held under the Program in all OCS Planning Areas included in the proposed action except for the Chukchi Sea Planning Area. Under this alternative, OCS oil and gas leasing under the Program, and any subsequent exploration and development in the Arctic region would occur only in the Beaufort Sea Planning Area (except in the deferred areas). The potentially available resources in the Chukchi Sea Planning Area that would not be made available under this alternative include as much as 2.1 Bbbl of oil and as much as 8.0 Tcf of natural gas.

2.7 ALTERNATIVE 7 – EXCLUDE THE COOK INLET PLANNING AREA FOR THE DURATION OF THE 2012-2017 PROGRAM

Under Alternative 7, no sales would be held in the Cook Inlet Planning Area, resulting in 14 sales in the Program. Under this alternative, OCS oil and gas leasing under the Program, and any subsequent exploration and development in the Alaska region would occur only in the Beaufort Sea and Chukchi Sea Planning Areas, except in the deferred areas. The potentially available resources in the Cook Inlet Planning Area that would not be made available under this alternative include as much as 0.1-0.2 Bbbl of oil and as much as 0.7 Tcf of natural gas.

2.8 ALTERNTIVE 8 – NO ACTION

Alternative 8 is the No Action Alternative. Under this alternative, there would be no lease sales conducted under the Program in any OCS Planning Areas. As much as 8.2 Bbbl of oil and 35 Tcf of natural gas would not be available under this alternative. Energy substitutes are discussed in Section 4.5.6

2.9 ALTERNATIVES CONSIDERED BUT ELIMINATED FROM FURTHER PROGRAMMATIC EVALUATION

Pursuant to the NEPA, BOEM had two public scoping periods, one extending from April 2, 2010, through June 30, 2010, and another from January 6, 2011, through March 31, 2011, to solicit comments for the purpose of determining the scope of the PEIS (see Chapter 1). Comments received through scoping were used to identify issues to be addressed and to provide input into the development of the alternatives considered in this draft PEIS. Additional alternatives suggested through scoping that are different from Alternatives 1–8 above include:

- Expand the oil and gas leasing program to include more or all OCS Planning Areas beyond those identified in the NOI.
- Hold multiple sales in some OCS Planning Areas.
- Delay sales until further data regarding oil spill response and drilling safety are collected and analyzed for the Arctic and GOM areas.
- Develop alternative/renewable energy sources as a substitute for oil and gas leasing on the OCS.
- Add further spatial and temporal deferrals, such as no leasing in parts of planning areas and seasonally limiting activity in other parts of planning areas.
- Reduce the lease sale sizes to smaller than area-wide (less than full planning areas).
- Defer deepwater areas in the GOM planning areas.

These alternatives were considered but eliminated from further evaluation in this PEIS for a variety of reasons, and each alternative is discussed separately below.

2.9.1 Expand the Oil and Gas Leasing Program to Include More or All OCS Planning Areas

Under discretionary authority conferred by Section 18 of OCSLA, the Secretary of the Interior hosted regional public meetings in Atlantic City, NJ, New Orleans, LA, Anchorage, AK, and San Francisco, CA in April 2009 to gather information and public comment to help build a comprehensive energy strategy for the .Outer Continental Shelf. Invited to each of these meetings were regional governors, elected federal officials, private citizens, interested organizations, energy producers, advocacy groups, and local governments. Using the information that was collected from these meetings, and from the extended comment period, the Secretary decided which planning areas to include.

The alternatives considered in this draft PEIS (excluding the No Action Alternative) include oil and gas leasing in as many as 6 of the 26 OCS Planning Areas (Figure 2-1). Alternatives that include more OCS Planning Areas (either adding selected individual areas such as the Atlantic Planning Areas, or including all 26 OCS Planning Areas) were not considered in this PEIS for several reasons.

Most of the Eastern GOM Planning Area, as well as areas of the Central GOM Planning Area within 161 km (100 mi) of the Florida coast, are restricted from leasing and development until 2022 as part of the Gulf of Mexico Energy Security Act of 2006. In Alaska, Bristol Bay in the North Aleutian Basin Planning Area was withdrawn on March 31, 2010, by the President from leasing consideration through June 30, 2017. As a matter of caution, in the aftermath of the DWH event, in April 2010, the Secretary of the Interior announced, on December 1, 2010, a narrowing of the scope of the PEIS by removing the South and Mid-Atlantic Planning Areas from consideration for potential sales and development through 2017. Because of these moratoria and removals, expansion of the Program to all planning areas is not possible, and expanding it to planning areas other than those considered in this draft PEIS is not feasible without further postponement of the Program. Inclusion of all OCS Planning Areas would have been inconsistent with the December 1, 2010, direction of the Secretary of the Interior for the scope of the PEIS to focus on leasing in areas with current active leases. Many of the 26 OCS Planning Areas do not currently have active leases or substantial interest from industry, and were thus not considered for inclusion in the Program, or for evaluation in this draft PEIS.

2.9.2 Hold Multiple Lease Sales in Some OCS Planning Areas

The proposed action identifies 15 lease sales in six planning areas: five sales each in the Western and Central GOM Planning Areas, two sales in the Eastern GOM Planning Area, and one each in the Cook Inlet, Beaufort Sea, and Chukchi Sea Planning Areas. Alternatives with additional sales, such as having more than two sales in the Eastern GOM Planning Area or more than one sale in each of the Alaska Planning Areas, would be inconsistent with the Secretary of the Interior’s Program scoping announcement on December 1, 2010, of an updated oil and gas leasing strategy for the OCS that would proceed with caution and focus on leasing in areas with currently active leases and an existing knowledge base. Holding one sale in each planning area is more consistent with a cautionary approach in the Arctic.

2.9.3 Delay Sales until Further Evaluation of Oil Spill Response and Drilling Safety Is Completed

Following the Deepwater Horizon (DWH) event, there has been considerable activity by not only BOEM but also other Federal and State agencies with regard to the adequacy of past oil spill response plans and drilling safety, as well as the development of new approaches for spill response and increasing drilling safety. BOEM has been active in revising existing regulations and developing new regulations specific to spill response plan requirements and drilling safety, and multiple agencies (including BOEM) are continuing to evaluate these areas. The identification of new approaches to enhance spill response and drilling safety is expected to be an activity that will extend throughout the duration of the Program. Waiting until further evaluation is completed would delay the Program beyond the 5-year revision requirement specified in Section 18 of OCSLA. Inclusion of new information (and any subsequent requirements) related to spill response and drilling safety would be included through the promulgation of regulations, notices to lessees and operators, and site-specific mitigations identified in NEPA analyses at the lease sale and project levels. In addition, at the discretion of the Secretary, any lease sale can be delayed or cancelled for any reason, including a possible need for further evaluation of oil spill response or drilling safety issues.

2.9.4 Develop Alternate/Renewable Energy Sources as a Substitute for Oil and Gas Leasing on the OCS

Energy use in the United States is expected to continue to increase from present levels through 2035 and beyond (EIA 2011). For example, the U.S. Energy Information Administration (EIA) has projected that U.S. consumption of crude oil and petroleum products will increase from about 18.8 million bbl per day in 2009 to about 21.9 million bbl per day in 2035 (EIA 2011). Oil and gas reserves in the OCS (and especially the GOM) represent significant sources that currently help meet U.S. energy demands, and are expected to continue to do so in the future. While alternate/renewable energy sources currently play a role in meeting energy demand in this country, and will continue to do so in the future, such sources could not replace the energy supplied by oil and gas from OCS sources. A more detailed discussion of alternate and other energy substitutes for oil and gas appears in Section 4.5.6, which considers the environmental effects of the No Action Alternative.

The OCSLA, in conjunction with other statutes, extends broad powers to the President and designated Federal Agencies (such as BOEM) over leasing activities on the OCS. Section 18 of the OCSLA specifically directs the Secretary of the Interior to prepare and periodically revise an oil and gas leasing program to implement the policies of OCSLA, and BOEM conducts oil and gas lease sales and executes leases under the OCSLA. Renewable energy projects on the OCS are also managed in conjunction with other Federal and State authorities. Under the OCSLA, Federal planning does not specifically integrate oil and gas leasing with renewable energy leasing. BOEM has, however, issued a final rule specific to the establishment of a program to grant leases, easements, and rights-of-way for renewable energy projects on the OCS (30 CFR Parts 250, 285, and 290).

2.9.5 Add Areal and Temporal Exclusion and Restriction Zones around Sensitive Areas and Resources

BOEM received scoping comments requesting that the PEIS include alternatives that exclude portions of program areas from leasing during the program or that seasonally exclude or restrict drilling in some Arctic areas when ice is present. Specific examples include creating more exclusion areas in the Arctic, particularly in the Hannah Shoals and Camden Bay areas, protecting the Bowhead whale migration corridors, and temporal exclusion or restriction of drilling in the Arctic when ice is present. Other comments suggested exclusion of sensitive areas in the GOM particularly to avoid or minimize contact from a DWH-like discharge event. Specific examples include excluding areas of the GOM OCS in which the Loop Current could transport oil from a large discharge event over great distances, avoiding important ecological areas and features, and developing buffer zones around areas as appropriate, such as coastal migratory corridors, population centers, and critical habitat of listed species.

The Secretary may carve out deferral areas that are based on specific, established need and supported by adequate information, such as deferral areas selected in previous 5-year program alternatives and needed to continue protection of bowhead whale migration in the Beaufort Sea and coastal subsistence uses in the Chukchi Sea. The Bureau indicated in its April, 2010 NOI that other areal or temporal exclusions within planning areas may be considered. After consideration of areas suggested during scoping, BOEM has decided that it is premature to make any decisions as to such exclusions at this early Program stage. The determination of other areal and temporal exclusions and restrictions will depend on the location of specific lease sale areas and whether exploration and development will actually occur in the lease sale area, which is unknown at this time. The exclusion of specific areas or blocks within a planning area is best done at the lease sale stage of the program or when specific OCS projects are being evaluated.

The PEIS is mainly a planning document that informs “big-picture” decisions about the overall size of the program, the planning areas included in the program, and the number of lease sales that could occur during the program. The ecoregional scale used in the draft PEIS to identify areas where OCS effects and vulnerable environmental resources are likely to interact and where mitigations may need to be developed during the program to reduce potential impacts does not provide the fine scale and detailed information needed to develop protected areas on a block-by-block basis. Furthermore, the lease sale process is an evolving process, and additional site-specific studies, consultations, and analyses may be required before effective mitigations and exclusions can be developed. Indeed, it could be almost foolhardy to include areal or temporal exclusions or restrictions now, armed only with inadequate information. By including entire planning areas in the Program, the USDOI is attempting to maintain flexibility in fulfilling its mandate to provide for both U.S. energy needs and to protect the marine and coastal environment.

2.9.6 Reduce the Lease Sale Sizes to Smaller Than Area-Wide (less than full planning areas)

Using an area-wide leasing approach provides greater flexibility to fully consider and balance development, economic, and environmental concerns. While significant domestic energy resources are assumed to be located on the OCS, the precise locations and quantities are unknown because not all promising areas and reservoirs have been fully explored and delineated. One way to optimize discovery of significant oil and gas deposits is to encourage companies to pursue unique and diverse exploration and development strategies based on differing views as to resource location, availability, and extractability. The area-wide process allows lessees to concentrate efforts on tracts they consider most promising as opposed to those pre-identified by the government, unless those areas have been already excluded through pre-lease sale planning and environmental review. The Secretary can reduce the area offered for leasing within a planning area at the lease sale stage of the program based on more information about the location and value of recoverable resources, the potential vulnerability of environmental resources, or other Section 18 concerns. Leasing strategies other than area-wide leasing are described in the Proposed Program.

2.9.7 Defer Oil and Gas Leasing in Deepwater Areas of the Central and Western GOM Planning Areas

During the scoping process, several comments expressed opposition to drilling in deepwater areas. The comments expressed general concerns about deepwater drilling in the GOM after the Deepwater Horizon event that occurred on April 20, 2010, and resulted in a discharge estimated to be 4-9 million barrels of oil. The comments did not specify a definition of deepwater to apply to an alternative that excludes certain areas from leasing to reduce the risk of occurrence of a catastrophic discharge event, nor did the comments identify specific risk factors associated with drilling in “deep” water compared to drilling at other water depths. The Secretary defined deepwater in the context of areas of the GOM with potential for increased drilling risk as water depths of 152 m (500 ft) and deeper when he directed BOEM on May 28, 2010, to exercise its authority under the OCSLA to suspend certain drilling activities for a period of up to 6 months in those water depths. The Secretary later clarified the suspension to cover deepwater operations that involved the use of certain deepwater technology. On October 12, 2011, BOEM lifted the May 28, 2011, drilling suspension on the basis that major issues pertaining to deepwater drilling risk had been addressed through multiple venues in the intervening 5 months.

The PEIS acknowledges the importance of understanding catastrophic discharge event risk for planning, leasing, and regulatory decisions during the Program. To further this understanding, the PEIS includes in Section 4.3, *Assessment of Issues of Programmatic Concern*, a discussion of the current knowledge of the relative importance of catastrophic discharge event risk factors, and a synthesis of this information to identify catastrophic event risk in different program areas. This section identifies water depth as just one of many risk factors that should be considered with other factors when making specific leasing decisions. This section also describes recent regulatory measures that have been promulgated to improve drilling safety and to reduce the risk of occurrence of catastrophic discharge events.

Furthermore, to exclude all deepwater areas in the GOM from potential oil and gas exploration and development would not be reasonable in light of the purpose and need for the oil and gas leasing program, which is to help meet the Nation’s energy needs by developing oil and gas resources in a manner consistent with environmental protection and the laws and policies of affected States. Over the last approximately 20 years, leasing, drilling, and production have moved steadily into deeper waters. As of 2009, there were approximately 7,310 active leases in the U.S. GOM, 58% of which were in deep water. Likewise, deepwater oil production rose about 786% and deepwater gas production increased about 1,067% from 1992 to 2007 (Nixon and Shepard 2009). The leasing schedule must ensure a proper balance between oil and gas production and possible environmental impacts, while also considering relative environmental sensitivity among OCS Regions and competing uses of the OCS. Portions of planning areas, such as deepwater areas, can potentially be deferred from leasing during the program at the lease sale level when such analysis and issues are ripe, if there is, for example, a demonstrated and significant relative risk of a spill or blowout associated with certain deepwater areas, the presence of sensitive environmental resources, space use conflicts, or other reasons.

2.10 SUMMARY OF IMPACTS ANTICIPATED FROM THE PROPOSED ACTION AND ALTERNATIVES

In general, oil and gas development follows a four-phase process, beginning with (1) exploration to locate viable deposits, (2) development of the production well and support infrastructure, (3) operation (oil or gas production), and (4) decommissioning of the offshore facility once it is no longer productive or profitable. Under the proposed action, or Alternatives 2 through 7, routine operations associated with each of these phases will have the same or similar impact-producing factors associated with them (Table 2.10-1), and these have "typical" types of impacts, regardless of location. The magnitude and importance of those impacts on the resource, however, will be very site and project specific. For example, pipeline trenching, regardless of location, will result in disturbance of the sea floor and associated biota and habitats, and generate suspended sediments that will affect local water quality. The importance of such impacts will depend on the types of biota and habitats present (seagrass beds vs. mud bottom; endangered species) and ambient water quality conditions. The types of impacts identified for the proposed action are therefore the same as those expected under each of the alternatives except the No Action Alternative. Table 2.10-2 presents a summary comparison of impacts of all the alternatives, including No Action. The difference in potential impacts among the action alternatives will be in where those impacts may be incurred. Each of the alternatives to the proposed action defers one of the six Planning Areas included in the proposed action from the 2012-2017 OCS leasing program, and most resources in the deferred Planning Area would not be expected to be affected by routine operations in the other Planning Areas. Because routine operations include some impacting factors (such as seismic survey noise and support vessel traffic) that may extend beyond Planning Area boundaries, resources in deferred Planning Areas may be affected by routine operations associated with development in adjacent Planning Areas.

One potential impact-producing factor of oil and gas development under each of the seven action alternatives is an accidental oil spill. The types of effects such accidental spills may have on specific resources will be similar between the proposed action and the other action alternatives, although the duration and magnitude of the impacts will depend on the location, size, timing, and duration of the spill; the effectiveness of spill containment and cleanup operations; and the biological and cultural resources affected by the spill.

The evaluation of a No Action Alternative is required by the regulations implementing the National Environmental Policy Act (40 CFR 1502.14(d)). If the Secretary were to adopt this alternative, it would halt OCS presale planning, sales, and new leasing from 2012 to 2017. However, exploration, development, and production stemming from past sales would continue.

This alternative would shut down the OCS leasing program from mid-2012 through mid-2017. The amounts of OCS natural gas (up to 35 trillion cubic feet) and oil (up to 8.1 billion barrels of oil) that could help meet national energy needs would be forgone. That amount of energy would have to be replaced by a combination of imports, alternative energy sources, and conservation.

Market forces are expected to be the most important determinant of the substitute mix for OCS oil and gas. Key market substitutes for forgone OCS oil production would be imported oil, conservation, switching to gas, and onshore production. For OCS natural gas, the principal substitutes would be switching to oil, onshore production, imports, and conservation.

In addition to market-based substitutes, the Nation or individual States might choose to encourage or even impose programs designed to deal with the energy shortfall. To replace oil, these programs might favor alternative vehicle fuels such as ethanol or methanol, vehicles with greater fuel efficiency, or alternate transportation methods such as mass transit.

As a partial replacement for the forgone natural gas, governments might mandate increased reliance on coal, nuclear, hydroelectric, or wind-generated electric power. In addition, governments might give more emphasis to programs encouraging more efficient electricity transmission and more efficient use of gas and electricity in factories, offices, and homes.

2.11 REFERENCES

EIA (U.S. Energy Information Administration), 2011, *Annual Energy Outlook 2011*, Office of Integrated and International Energy Analysis, Washington, D.C.

Hagerty, C.L., 2011, *Outer Continental Shelf Moratoria on Oil and Gas Development*, CRS Report to Congress, 7-5700, R41132, Congressional Research Service, Washington, D.C., May 6.

MMS (Minerals Management Service), 2007, *Gulf of Mexico OCS Oil and Gas Lease Sales: 2007-2012 Final Environmental Impact Statement*, OCS EIS/EA MMS 2007-018, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans.

Nixon, L.D., and N.K. Shepard, 2009, *Deepwater Gulf of Mexico 2009: Interim Report of 2008 Highlights*, Minerals Management Service, U.S. Department of the Interior, New Orleans, La.

TABLE 2.10-1 Impact-Producing Factors Associated with OCS Oil and Gas Development

	Development Phase				
	Exploration				
Impact-Producing Factor	Seismic Survey	Exploration Well	Development	Operation	Decommissioning
Noise	X	X	X	X	X
Seismic noise	X				
Ship noise	X	X	X	X	X
Aircraft noise		X	X	X	X
Drilling noise		X	X		
Trenching noise			X		
Production noise				X	
Onshore construction			X		
Platform removal					X
Traffic	X	X	X	X	X
Aircraft traffic		X	X	X	X
Ship traffic	X	X	X	X	X
Drilling Mud/Debris		X	X		
Bottom/Land Disturbance		X	X		
Coring and drilling		X	X		
Pipeline trenching			X		
Onshore construction			X		
Air Emissions	X	X	X	X	X
Offshore	X	X	X	X	X
Onshore			X	X	X
Explosives					X
Platform removal					X
Lighting	X	X	X	X	
Offshore	X	X	X	X	
Onshore			X	X	
Visible Infrastructure		X	X	X	
Offshore		X	X	X	
Onshore			X	X	
Space Use Conflicts	X	X	X	X	
Offshore facilities	X	X	X	X	
Onshore facilities			X	X	
Accidental Spills	X	X	X	X	

TABLE 2.10-2 Summary of Potential Environmental Impacts of the Proposed Action and Alternatives for a 2012-2017 OCS Oil and Gas Leasing Program

Resource	Alternative	Potential Impacts
Water Quality	Alternative 1 – Proposed Action	Gulf of Mexico: Routine operations that could result in minor to moderate, localized, short-term impacts include structure placement and construction (pipelines, platforms) and operational discharges (produced water, bilge water, drill cuttings) and sanitary and domestic wastes. Structure placement and removal could increase suspended sediment loads, while operational discharges, sanitary and domestic wastes, and deck drainage could affect chemical water quality. Compliance with NPDES permits and U.S. Coast Guard (USCG) regulations would reduce most impacts of routine operations. The effects of accidental oil spills will depend upon material, spill size, location, and remediation activities. Small spills would likely result in short-term, localized impacts. Impacts from a large oil spill (including those from a very large spill associated with an unlikely catastrophic discharge event [CDE]) could persist for an extended period of time if oil were deposited in wetland and beach sediments or low-energy environments because of potential remobilization. Alaska: Routine operations would result in minor to moderate, short-term, localized impacts such as disturbing sediments and increasing turbidity near construction sites and altering water chemistry from operational discharges. In the Arctic Planning Areas, minor water quality impacts could also occur from fluids entrained in ice roads when they break up in the spring. Compliance with NPDES permits and USCG regulations would reduce impacts of routine operations. The effects of accidental oil spills will depend upon material, spill size, location, season, response, and remediation activities. In the presence of cold temperatures and ice, cleanup activities would be extremely difficult. Small spills would likely result in short-term impacts. Impacts from a large oil spill (including those from a very large spill associated with an unlikely CDE) could persist for an extended period of time if oil were deposited in wetland and beach sediments or low-energy environments because of potential remobilization. Spills under ice could affect water quality for relatively long periods.
	Alternative 2 – Defer the Eastern Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except no impacts to water quality in the Eastern GOM Planning Area from routine operations. Accidental oil spills (especially very large spills) in the other GOM planning areas could potentially affect water quality in the Eastern GOM Planning Area if transported there by GOM currents. Alaska: Same as Alternative 1.
	Alternative 3 – Defer the Western Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except no impacts to water quality in the Western GOM Planning Area from routine operations. Accidental oil spills in the other GOM planning areas could potentially affect water quality in the Western GOM Planning Area if transported there by GOM currents, especially in the event of a very large oil spill. Alaska: Same as Alternative 1.

TABLE 2.10-2 (Cont.)

Resource	Alternative	Potential Impacts
Water Quality (Cont.)	Alternative 4 – Defer the Central Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except no impacts to water quality in the Central GOM Planning Area from routine operations. Accidental oil spills in the other GOM planning areas could potentially affect water quality in the Central GOM Planning Area if transported there by GOM currents, especially in the event of a very large oil spill. Alaska: Same as Alternative 1.
	Alternative 5 – Defer the Beaufort Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1 except that no impacts would be expected in the Beaufort Sea Planning Area. Accidental oil spills in the Chukchi Sea Planning Area could affect water quality in the Beaufort Sea, depending on the location, size, and duration of the spill as well as on the effectiveness of containment and cleanup operations (especially under winter, ice cover conditions).
	Alternative 6 – Defer the Chukchi Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1 except that no impacts would be expected in the Chukchi Sea Planning Area. Accidental oil spills in the western portion of the Beaufort Sea Planning Area could affect water quality in some portions of the eastern Chukchi Sea, depending on the location, size, and duration of the spill as well as on the effectiveness of containment and cleanup operations.
	Alternative 7 – Defer the Cook Inlet Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1 except that no impacts would be expected in the Cook Inlet Planning Area.
	Alternative 8 – No Action[a]	There would be no impacts from a 2012-2017 OCS oil and gas leasing program.
Air Quality	Alternative 1 – Proposed Action	Gulf of Mexico: Routine operations are expected to result in only minor impacts to air quality. Sources of air pollutants (NO_2, SO_2, PM_{10}, and CO) associated with OCS oil and gas development include diesel and gas engines, turbines, and support vessels. Routine operations would not result in exceedance of the NAAQS or impact visibility. Increases of ozone, if they occur, would be about 1% of total concentrations. Small accidental oil spills could have localized and temporary impacts. Pollutant levels from very large spills (including accidental spills associated with an unlikely CDE) and associated *in situ* burning, if used, would generally be small. Plumes from *in situ* burning could temporarily degrade visibility in PSD Class I areas.

TABLE 2.10-2 (Cont.)

Resource	Alternative	Potential Impacts
Air Quality (Cont.)		Alaska: Routine operations are expected to result in only minor impacts to air quality. Routine operations would not result in exceedance of the NAAQS in public access areas or impact visibility. Smaller oil spills could have localized and temporary impacts. Pollutant levels from very large spills (including accidental spills associated with an unlikely CDE) and associated *in situ* burning, if used, could be major during the initial leak and again during cleanup efforts (plumes from *in situ* burning could temporarily degrade visibility), but eventually, air quality is expected to return to normal or near normal. The long-term effects associated with a spill and cleanup would be minor.
	Alternative 2 – Defer the Eastern Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except no impacts to air quality in the Eastern GOM Planning Area from routine operations. Depending on the strength, duration, and direction of prevailing winds, *in situ* burning of a spill in the Central GOM Planning Area could affect air quality in the Eastern GOM Planning Area. Alaska: Same as Alternative 1.
	Alternative 3 – Defer the Western Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except no impacts to air quality in the Western GOM Planning Area from routine operations. Depending on the strength, duration, and direction of prevailing winds, *in situ* burning of a spill in the Central GOM Planning Area could affect air quality in the Western GOM Planning Area. Alaska: Same as Alternative 1.
	Alternative 4 – Defer the Central Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except no impacts to air quality in the Central GOM Planning Area from routine operations. Depending on the strength, duration, and direction of prevailing winds, *in situ* burning of a spill in the other GOM planning areas could affect air quality in the Central GOM Planning Area. Alaska: Same as Alternative 1.
	Alternative 5 – Defer the Beaufort Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1 except no impacts to air quality in the Beaufort Sea Planning Area. Depending on the strength, duration, and direction of prevailing winds, *in situ* burning of a spill in the Chukchi Sea Planning Area could affect air quality in nearby areas of the Beaufort Sea Planning Area.
	Alternative 6 – Defer the Chukchi Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1 except no impacts to air quality in the Chukchi Sea Planning Area. Depending on the strength, duration, and direction of prevailing winds, *in situ* burning of a spill in the Beaufort Sea Planning Area could affect air quality in nearby areas of the Chukchi Sea Planning Area.

TABLE 2.10-2 (Cont.)

Resource	Alternative	Potential Impacts
Air Quality (Cont.)	Alternative 7 – Defer the Cook Inlet Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except that no impacts would be expected in the Cook Inlet Planning Area.
	Alternative 8 – No Action[a]	There would be no impacts from a 2012-2017 OCS oil and gas leasing program.
Acoustic Environment	Alternative 1 – Proposed Action	Gulf of Mexico and Alaska: Routine operations in the GOM and Alaska OCS Planning Areas could affect ambient noise conditions, and impacts to ambient noise levels are expected to be minor. Noise generating sources associated with routine operations include seismic surveys, drilling and production, infrastructure placement and removal, and vessel traffic. Depending on the source and activity, changes in ambient noise levels could be short-term and localized (e.g., from vessel traffic), long-term and localized (from production), or short-term and less localized (from seismic surveys). Seismic surveys could result in short-term changes in ambient noise levels, but the changes could extend well beyond the survey boundary.
	Alternative 2 – Defer the Eastern Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico and Alaska: Same as Alternative 1, except no changes in local ambient sound levels in the Eastern GOM Planning Area from routine operations. Seismic surveys conducted in the eastern portions of the Central GOM Planning Area could temporarily increase ambient sound levels in portions of the Eastern GOM Planning Area.
	Alternative 3 – Defer the Western Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico and Alaska: Same as Alternative 1, except no changes in local ambient sound levels in the Western GOM Planning Area from routine operations. Seismic surveys conducted in the western portions of the Central GOM Planning Area could temporarily increase ambient sound levels in portions of the Western GOM Planning Area.
	Alternative 4 – Defer the Central Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico and Alaska: Same as Alternative 1, except no changes in local ambient sound levels in the Central GOM Planning Area from routine operations. Seismic surveys conducted in the western portion of the Eastern GOM Planning Area or the eastern portion of the Western GOM Planning Area could temporarily increase ambient sound levels in portions of the Central GOM Planning Area.
	Alternative 5 – Defer the Beaufort Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico and Alaska: Same as Alternative 1, except no changes in local ambient sound levels in the Beaufort Sea Planning Area from routine operations. Seismic surveys conducted in the western portion of the Chukchi Sea Planning Area could temporarily increase ambient sound levels in portions of the Beaufort Sea Planning Area.

TABLE 2.10-2 (Cont.)

Resource	Alternative	Potential Impacts
Acoustic Environment (Cont.)	Alternative 6 – Defer the Chukchi Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico and Alaska: Same as Alternative 1, except no changes in local ambient sound levels in the Chukchi Sea Planning Area from routine operations. Seismic surveys conducted in the eastern portion of the Beaufort Sea Planning Area could temporarily increase ambient sound levels in portions of the Chukchi Sea Planning Area.
	Alternative 7 – Defer the Cook Inlet Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico and Alaska: Same as Alternative 1, except that no impacts would be expected in the Cook Inlet Planning Area.
	Alternative 8 – No Action[a]	There would be no impacts from a 2012-2017 OCS oil and gas leasing program.
Coastal and Estuarine Habitats	Alternative 1 – Proposed Action	Gulf of Mexico: Routine operations would result in minor to moderate localized impacts primarily due to facility construction, pipeline trenching and landfalls, channel dredging, and vessel traffic. The effects of accidental oil spills will depend on the specific habitat affected; the size, location, duration, and timing of the spill; and on the effectiveness of spill containment and cleanup activities. Small spills would likely result in short-term impacts while large spills (including CDE-level spills which are not expected) could incur both short-term and long-term impacts depending on habitat type and location and effectiveness of spill containment and cleanup activities. Alaska: Routine operations would be expected to result in minor to moderate localized impacts primarily due to pipeline, road, and onshore facility construction and vessel traffic. These operations could have a major effect on the local indigenous residents most proximate to development if it interferes with their subsistence practices for the greater part of a season. The effects of accidental oil spills will depend on habitats affected; the size, location, duration and timing of the spill; and on the effectiveness of spill containment and cleanup activities. Large (including CDEs which are not expected) and small spills could result in long-term and short-term impacts, depending on the habitats affected; the duration and size of the spill, and on the effectiveness of spill containment and cleanup activities.
	Alternative 2 – Defer the Eastern Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except no impacts to habitats in the Eastern GOM Planning Area from routine operations. Accidental spills in the Central GOM Planning Area could potentially impact habitats in the Eastern GOM Planning Area if carried there by GOM currents. Alaska: Same as Alternative 1.

TABLE 2.10-2 (Cont.)

Resource	Alternative	Potential Impacts
Coastal and Estuarine Habitats (Cont.)	Alternative 3 – Defer the Western Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except no impacts to habitats in the Western GOM Planning Area from routine operations. Accidental spills in the Central GOM Planning Area could potentially impact habitats in the Western GOM Planning Area if carried there by GOM currents. Alaska: Same as Alternative 1.
	Alternative 4 – Defer the Central Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except no impacts to habitats in the Central GOM Planning Area from routine operations. Accidental spills in the other GOM Planning Areas could potentially impact habitats in the Central GOM Planning Area if carried there by GOM currents. Alaska: Same as Alternative 1.
	Alternative 5 – Defer the Beaufort Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except no impacts to habitats in the Beaufort Sea Planning Area from routine operations. Accidental oil spills in the Chukchi Sea Planning Area could potentially impact habitats in the Beaufort Sea Planning Area if carried there by coastal currents.
	Alternative 6 – Defer the Chukchi Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except no impacts to habitats in the Chukchi Sea Planning Area from routine operations. Spills in the Beaufort Sea Planning Area could potentially impact habitats in some portions of the eastern Chukchi Sea Planning Area.
	Alternative 7 – Defer the Cook Inlet Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except no impacts to habitats in the Cook Inlet Planning are expected.
	Alternative 8 – No Action[a]	There would be no impacts from a 2012-2017 OCS oil and gas leasing program.

TABLE 2.10-2 (Cont.)

Resource	Alternative	Potential Impacts
Marine Benthic Habitats	Alternative 1 – Proposed Action	Gulf of Mexico: Routine operations could result in moderate and long-term impacts to benthic habitats, primarily soft sediments. Benthic habitat could be disturbed by platform and pipeline placement, dredging, and operational discharges (produced water and cuttings). Soft sediment habitats can recover within a few years from most disturbances. Existing mitigation measures should eliminate most direct impacts to sensitive and protected benthic habitats. Marine benthic habitat could be affected by a large oil spill, including CDE-level spills which are not expected. Impacts could be long-term and range from small to medium, depending on the habitat affected; the size, duration, timing, and location of the spill; and the effectiveness of spill containment and cleanup activities. Impacts to HDDC from routine operations and accidental spills are unlikely, but may be permanent if they do occur. Alaska: Routine operations associated with platform and pipeline placement could result in moderate and long-term impacts to benthic habitats, primarily soft sediments. Existing mitigation measures should eliminate most direct impacts to sensitive boulder habitats. Accidental releases of oil could be long-term and range from small to medium depending on the habitat affected, cleanup method, and the size, duration, timing, and location of the spill. Impacts to boulder habitats from routine operations could result in moderate and long-term impacts to benthic habitats, primarily soft sediments.
	Alternative 2 – Defer the Eastern Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except that no impacts would be expected in the Eastern GOM Planning Area from routine operations. Marine benthic habitat in the Eastern GOM Planning Area could be affected by a large oil spill in the Central GOM Planning Area. Impacts could be long-term depending on the habitat affected, cleanup method, and the size, duration, timing, and location of the spill. Alaska: Same as Alternative 1.
	Alternative 3 – Defer the Western Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except that no impacts would be expected in the Western GOM Planning Area from routine operations. Marine benthic habitat in the Western GOM Planning Area could be affected by a large oil spill in the Central GOM Planning Area. Impacts could be long-term depending on the habitat affected, cleanup method, and the size, duration, timing, and location of the spill. Alaska: Same as Alternative 1.
	Alternative 4 – Defer the Central Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except that no impacts would be expected in the Central GOM Planning Area from routine operations. Marine benthic habitat in the Central GOM Planning Area could be affected by a large oil spill in the Western or Eastern GOM planning areas. Impacts could be long-term depending on the habitat affected, cleanup method, and the size, duration, timing, and location of the spill. Alaska: Same as Alternative 1.

TABLE 2.10-2 (Cont.)

Resource	Alternative	Potential Impacts
Marine Benthic Habitats (Cont.)	Alternative 5 – Defer the Beaufort Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except that no impacts would be expected in the Beaufort Sea Planning Area. A large oil spill in the eastern portion of the Chukchi Sea Planning Area could affect benthic habitat in the western portion of the Beaufort Sea Planning Area, Impacts could be long-term depending on the habitat affected, cleanup method, and the size, duration, timing, and location of the spill.
	Alternative 6 – Defer the Chukchi Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except that no impacts would be expected in the Chukchi Sea Planning Area. A large oil spill in the western portion of the Beaufort Sea Planning Area could affect benthic habitat in the eastern portion of the Chukchi Sea Planning Area, Impacts could be long-term depending on the habitat affected, cleanup method, and the size, duration, timing, and location of the spill.
	Alternative 7 – Defer the Cook Inlet Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except no impacts would be expected in the Cook Inlet Planning Area.
	Alternative 8 – No Action[a]	There would be no impacts from a 2012-2017 OCS oil and gas leasing program.
Marine Pelagic Habitats	Alternative 1 – Proposed Action	Gulf of Mexico: Routine operations could result in negligible to minor short- and long-term impacts to pelagic habitats, primarily from operational discharges and turbidity generated during infrastructure placement. Effects of accidental oil spills, including CDE-level spills which are not expected, could result in small to large impacts to pelagic habitats, depending on the location, size, duration, and timing of the spill; the habitats affected (e.g., *Sargassum*), and the effectiveness of spill containment and cleanup activities. Alaska: Routine operations could result in negligible to minor, short-term to long-term impacts to pelagic habitat. The effects of accidental releases of oil, including CDE-level spills which are not expected, could result in minor, but long-term impacts to pelagic habitat and sea ice habitat, depending on the size, duration, timing, and location of the spill; the habitat affected; and the effectiveness of spill containment and cleanup activities. Severe winter weather and ice cover may be expected to limit containment and cleanup in winter.

TABLE 2.10-2 (Cont.)

Resource	Alternative	Potential Impacts
Marine Pelagic Habitats (Cont.)	Alternative 2 – Defer the Eastern Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except that no impacts would be expected in the Eastern GOM Planning Area from routine operations. A large oil spill in the Central GOM Planning Area could affect some pelagic habitats in the Eastern GOM Planning Area. Alaska: Same as Alternative 1.
	Alternative 3 – Defer the Western Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except that no impacts would be expected in the Western GOM Planning Area from routine operations. A large oil spill in the Central GOM Planning Area could affect some pelagic habitats in the Western GOM Planning Area. Alaska: Same as Alternative 1.
	Alternative 4 – Defer the Central Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except that no impacts would be expected in the Central GOM Planning Area from routine operations. A large oil spill in the Western or Eastern GOM Planning Areas could affect some pelagic habitats in the Central GOM Planning Area. Alaska: Same as Alternative 1.
	Alternative 5 – Defer the Beaufort Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except that no impacts would be expected in the Beaufort Sea Planning Area. A large oil spill in the eastern portion of the Chukchi Sea Planning Area could affect some pelagic habitats in the western portion of the Beaufort Sea Planning Area.
	Alternative 6 – Defer the Chukchi Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except that no impacts would be expected in the Chukchi Sea Planning Area. A large oil spill in the western portion of the Beaufort Sea Planning Area could affect some pelagic habitats in the eastern portion of the Chukchi Sea Planning Area.
	Alternative 7 – Defer the Cook Inlet Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except no impacts would be expected in the Cook Inlet Planning Area.

TABLE 2.10-2 (Cont.)

Resource	Alternative	Potential Impacts
Marine Pelagic Habitats (Cont.)	Alternative 8 – No Action[a]	There would be no impacts from a 2012-2017 OCS oil and gas leasing program.
Essential Fish Habitat	Alternative 1 – Proposed Action	Gulf of Mexico: Routine operations could result in no more than moderate, short- and long-term impacts to EFH and managed species. Existing mitigation measures should eliminate most direct impacts to coral EFH. Impacts from accidental oil spills, including CDE-level spills which are not expected, could be long-term, depending on the size, duration, timing, and location of the spill; the habitats affected; and the effectiveness of spill containment and cleanup activities.
		Alaska: Routine operations could result in no more than moderate short- and long-term impacts to EFH and managed species. Accidental releases of oil could result in moderate and long-term impacts. Impacts from accidental oil spills, including CDE-level spills which are not expected, could be long-term depending on the size, duration, timing, and location of the spill; the habitats affected; and the effectiveness of spill containment and cleanup activities, which could be hampered by extreme winter conditions and ice cover.
	Alternative 2 – Defer the Eastern Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except that no impacts would be expected in the Eastern GOM Planning Area from routine operations. Some EFH and managed species in the Eastern GOM Planning Area could be affected by a large oil spill in the Central GOM Planning Area. Impacts could be long-term depending on the habitat affected; the size, duration, timing, and location of the spill; and the effectiveness of spill containment and cleanup activities.
		Alaska: Same as Alternative 1.
	Alternative 3 – Defer the Western Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except that no impacts would be expected in the Western GOM Planning Area from routine operations. Some EFH and managed species in the Western GOM Planning Area could be affected by a large oil spill in the Central GOM Planning Area. Impacts could be long-term depending on the habitat affected; the size, duration, timing, and location of the spill; and the effectiveness of spill containment and cleanup activities.
		Alaska: Same as Alternative 1.
	Alternative 4 – Defer the Central Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except that no impacts would be expected in the Central GOM Planning Area from routine operations. Some EFH and managed species in the Central GOM Planning Area could be affected by a large oil spill in the Western or Eastern GOM planning areas. Impacts could be long-term depending on the habitat affected; the size, duration, timing, and location of the spill; and the effectiveness of spill containment and cleanup activities.
		Alaska: Same as Alternative 1.

TABLE 2.10-2 (Cont.)

Resource	Alternative	Potential Impacts
Essential Fish Habitat (Cont.)	Alternative 5 – Defer the Beaufort Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except that no impacts would be expected in the Beaufort Sea Planning Area. A large oil spill in the eastern portion of the Chukchi Sea Planning Area could affect EFH and managed species in the western portion of the Beaufort Sea Planning Area, Impacts could be long-term, depending on the habitats affected; the size, duration, timing, and location of the spill; and the effectiveness of spill containment and cleanup activities, the latter of which could be hampered by extreme winter conditions and ice cover.
	Alternative 6 – Defer the Chukchi Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except that no impacts would be expected in the Chukchi Sea Planning Area. A large oil spill in the western portion of the Beaufort Sea Planning Area could affect EFH and managed species in the eastern portion of the Chukchi Sea Planning Area, Impacts could be long-term depending on the habitat affected; the size, duration, timing, and location of the spill; and the effectiveness of spill containment and cleanup activities, the latter of which could be hampered by extreme winter conditions and ice cover.
	Alternative 7 – Defer the Cook Inlet Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except no impacts would be expected in the Cook Inlet Planning Area.
	Alternative 8 – No Action[a]	There would be no impacts from a 2012-2017 OCS oil and gas leasing program.
Mammals	Alternative 1 – Proposed Action	Gulf of Mexico: Impacts to marine mammals from routine operations include noise disturbance from seismic surveys, vessels, helicopters, construction and operation of platforms, and removal of platforms with explosives; potential collision with vessels; and exposures to discharges and wastes. Impacts to cetaceans could range from negligible to moderate, with species or stocks inhabiting continental shelf or shelf slope waters most likely to be affected. The West Indian manatee and rare or extralimital whale species are not likely to be affected. Meeting the requirements of the ESA and Marine Mammal Protection Act would reduce the likelihood and magnitude of adverse impacts from routine operations to most species. A large accidental oil spill, including CDE-level spills which are not expected, would have minor to moderate impacts to marine mammals; impacts from spill response activities are expected to be minor. No impacts from routine operations to endangered beach mice subspecies or the Florida salt marsh vole are expected. A large oil spill, especially during a tropical storm, could contaminate their habitats.

TABLE 2.10-2 (Cont.)

Resource	Alternative	Potential Impacts
Mammals (Cont.)		Alaska: Impacts to marine mammals, especially cetaceans, from routine operations would be similar to those for the GOM (negligible to moderate). Collisions with OCS-related vessels may injure or kill some individuals, although the incidence of such collisions is expected to be low. Vessels, construction of ice roads, on-ice vehicles, and aircrafts have been known to temporarily disturb some individuals (e.g., polar bears may abandon dens), but these effects would likely be short-term and mitigation can reduce the disturbance. Sea otters appear to habituate to regular human activity, and routine operations would have a negligible impact on their populations. A large oil spill (including CDE-level spills which are not expected) in Cook Inlet Planning Area could cause impacts similar in nature to those which occurred from the *Exxon Valdez* spill. In the Arctic, marine mammals would most likely be impacted by oil-contaminated ice leads, polynyas, rookeries, beaches, and haulouts. Impacts to terrestrial mammals from routine operations would be negligible. Disturbance from noise sources is the most likely impact. Negligible to minor impacts to species occurring along the Beaufort Sea from disturbance or habitat loss from construction and operation of onshore pipeline. A Cook Inlet oil spill that contaminates beaches and shorelines could impact terrestrial mammals such as the grizzly/brown bear and river otter that forage in intertidal habitats. A spill in the Arctic, especially from an onshore pipeline, could contaminate habitats used by caribou, grizzly/brown bears, Arctic foxes, and muskoxen. Coastal beaches are particularly critical to species (including caribou) seeking relief from mosquitoes.
	Alternative 2 – Defer the Eastern Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except no impacts to habitats or individuals in the Eastern GOM Planning Area. A large accidental oil spill in the Central GOM Planning Area could affect mammals and their habitats in the Eastern GOM Planning Area. Impacts to endangered rodent species similar to Alternative 1. Alaska: Same as Alternative 1.
	Alternative 3 – Defer the Western Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except no impacts to habitats or individuals in the Western GOM Planning Area. A large accidental oil spill in the Central GOM Planning Area could affect marine mammals and their habitats in the Western GOM Planning Area. Impacts to endangered rodent species similar to Alternative 1. Alaska: Same as Alternative 1.
	Alternative 4 – Defer the Central Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except no impacts to habitats or individuals in the Central GOM Planning Area. A large accidental oil spill in the Western or Eastern GOM Planning Areas could affect marine mammals and their habitats in the Central GOM Planning Area. Impacts to endangered rodent species similar but less than under Alternative 1, because no large accidental oil spill would occur in the Central GOM Planning Area. Alaska: Same as Alternative 1.

TABLE 2.10-2 (Cont.)

Resource	Alternative	Potential Impacts
Mammals (Cont.)	Alternative 5 – Defer the Beaufort Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Impacts to marine mammals from routine operations similar to Alternative 1, except no impacts would be expected to resident marine mammals or their habitats in the Beaufort Sea Planning Area. No impacts from routine operations would occur to seasonal species while migrating through or inhabiting the Beaufort Sea. Accidental oil spills in the Chukchi Sea Planning Area could impact marine mammals in the Beaufort Sea and affect seasonal migration. Impacts from routine operations and oil spills to terrestrial mammals similar to Alternative 1 except no impacts to species and their habitats along the Beaufort Sea.
	Alternative 6 – Defer the Chukchi Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Impacts to marine mammals from routine operations similar to Alternative 1, except no impacts would be expected to resident marine mammals or their habitats in the Chukchi Sea Planning Area. No impacts from routine operations would occur to seasonal species while migrating through or inhabiting the Chukchi Sea. Accidental oil spills in the Beaufort Sea Planning Area could impact marine mammals in some portions of the eastern Chukchi Sea and affect seasonal migration. Impacts from routine operations and oil spills to terrestrial mammals similar to Alternative 1 except no impacts to species and their habitats along the Chukchi Sea.
	Alternative 7 – Defer the Cook Inlet Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except no impacts would be expected in the Cook Inlet Planning Area.
	Alternative 8 – No Action[a]	There would be no impacts from a 2012-2017 OCS oil and gas leasing program.
Marine and Coastal Birds	Alternative 1 – Proposed Action	Gulf of Mexico: Routine operations may result in negligible to moderate localized short-term impacts; impacts associated primarily with infrastructure construction, and ship and helicopter traffic. Impacts of routine operations to important coastal habitats such as nesting areas and overwintering sites could result in greater, more long-term and potentially population-level impacts should normal breeding and nesting activities be disrupted. Small accidental oil spills are expected to have largely local, small effects. Large spills, including CDE-level spills which are not expected, may result in large, long-term, and possibly population-level effects. The magnitude of the effects will depend on the size, duration, and timing of the spill; the species and habitats affected; and the effectiveness of spill containment and cleanup activities.

TABLE 2.10-2 (Cont.)

Resource	Alternative	Potential Impacts
Marine and Coastal Birds (Cont.)		Alaska: Similar to the impacts identified for the GOM. Because of the importance of certain habitat areas for some migrating and breeding birds, spills affecting those birds and habitats could result in long-term population level impacts for some species if the spills affect important nesting colonies, migratory staging areas, or wintering grounds.
	Alternative 2 – Defer the Eastern Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except that no impacts would be expected in the Eastern GOM Planning Area from routine operations. An accidental spill in the Central GOM Planning Area could affect coastal habitats and birds, as well as sea birds foraging in marine waters, of the Eastern GOM Planning Area. Alaska: Same as Alternative 1.
	Alternative 3 – Defer the Western Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except that no impacts would be expected in the Western GOM Planning Area from routine operations. An accidental oil spill in the Central GOM Planning Area could affect coastal habitats and birds, as well as sea birds foraging in marine waters, of the Western GOM Planning Area. Alaska: Same as Alternative 1.
	Alternative 4 – Defer the Central Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except that no impacts would be expected in the Eastern GOM Planning Area from routine operations. An accidental oil spill in the Eastern or Western GOM Planning Areas could affect coastal habitats and birds, as well as sea birds foraging in marine waters, of the Central GOM Planning Area. Alaska: Same as Alternative 1.
	Alternative 5 – Defer the Beaufort Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except no impacts in the Beaufort Sea Planning Area from routine operations. An accidental oil spill in the western portion of the Chukchi Sea could affect birds and habitats in the Beaufort Sea Planning Area.
	Alternative 6 – Defer the Chukchi Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except no impacts in the Chukchi Sea Planning Area from routine operations. An accidental oil spill in the western portion of the Beaufort Sea could affect birds and habitats in some portions of the eastern Chukchi Sea Planning Area.

TABLE 2.10-2 (Cont.)

Resource	Alternative	Potential Impacts
Marine and Coastal Birds (Cont.)	Alternative 7 – Defer the Cook Inlet Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except no impacts would be expected in the Cook Inlet Planning Area.
	Alternative 8 – No Action[a]	There would be no impacts from a 2012-2017 OCS oil and gas leasing program.
Fish	Alternative 1 – Proposed Action	Gulf of Mexico: Negligible to minor impacts to fish, and negligible impacts to threatened or endangered fish species are expected from routine operations. A large accidental oil, including a CDE-level spill which is not expected, spill is not expected to result in population level impacts except potentially for spills that significantly affect overfished species and their spawning grounds. Oil contacting shoreline areas could result in large-scale lethal and long-term sublethal effects on early life stages of some species, but no permanent population level effects are expected. Alaska: Negligible to minor impacts to fish are expected from routine operations. The impact magnitude of a large oil spill, including a CDE-level spill which is not expected, would depend on the location, timing, and size of the spill, and the distribution and ecology of affected fish species. Oil contacting shoreline areas could result in large-scale lethal and long-term sublethal effects on early life stages, but no permanent population level effects are expected.
	Alternative 2 – Defer the Eastern Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except that no impacts would be expected in the Eastern GOM Planning Area from routine operation. Fish in the Eastern GOM Planning Area could be affected by a large oil spill in the Central GOM Planning Area. Alaska: Same as Alternative 1.
	Alternative 3 – Defer the Western Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except that no impacts would be expected in the Western GOM Planning Area from routine operation. Fish in the Western GOM Planning Area could be affected by a large oil spill in the Central GOM Planning Area. Alaska: Same as Alternative 1.
	Alternative 4 – Defer the Central Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except that no impacts would be expected in the Central GOM Planning Area from routine operation. Fish in the Central GOM Planning Area could be affected by a large oil spill in the Western or Eastern GOM Planning Areas. Alaska: Same as Alternative 1.

TABLE 2.10-2 (Cont.)

Resource	Alternative	Potential Impacts
Fish (Cont.)	Alternative 5 – Defer the Beaufort Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except that no impacts would be expected in the Beaufort Sea Planning Area. A large oil spill in the eastern portion of the Chukchi Sea Planning Area could affect fish in the Beaufort Sea Planning Area.
	Alternative 6 – Defer the Chukchi Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except that no 2012-2017 OCS program-related impacts would be expected in the Chukchi Sea Planning Area. A large oil spill in the western portion of the Beaufort Sea Planning Area could affect fish in the eastern portions of the Chukchi Sea Planning Area.
	Alternative 7 – Defer the Cook Inlet Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except no impacts would be expected in the Cook Inlet Planning Area.
	Alternative 8 – No Action[a]	There would be no impacts from a 2012-2017 OCS oil and gas leasing program.
Reptiles	Alternative 1 – Proposed Action	Gulf of Mexico: Routine operations would result in minor to moderate localized impacts primarily due to seismic exploration, facility construction, pipeline landfalls, channel dredging, and vessel traffic. Accidental oil spills could result in large impacts depending on the size, location, duration and timing of the spill, and on the effectiveness of spill containment and cleanup activities. Small spills would likely result in short-term impacts while large spills (including CDE-level spills which are not expected) could incur both short-term and long-term impacts depending on the species and habitat type affected, and on the size and duration of the spill. Alaska: No impacts.
	Alternative 2 – Defer the Eastern Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except no impacts to reptile species and habitats in the Eastern GOM Planning Area from routine operations. Accidental spills in the Central GOM Planning Area could potentially impact species and their habitats in the Eastern GOM Planning Area. Alaska: No impacts.

TABLE 2.10-2 (Cont.)

Resource	Alternative	Potential Impacts
Reptiles (Cont.)	Alternative 3 – Defer the Western Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except no impacts to reptile habitats in the Western GOM Planning Area from routine operations. Accidental spills in the Central GOM Planning Area could potentially impact species and their habitats in the Western Planning Area. Alaska: No impacts.
	Alternative 4 – Defer the Central Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except no impacts to reptile habitats in the Central GOM Planning Area from routine operations. Spills in the other GOM Planning Areas could potentially impact species and their habitats in the Central Planning Area. Alaska: No impacts.
	Alternative 5 – Defer the Beaufort Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1 Alaska: No impacts.
	Alternative 6 – Defer the Chukchi Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1 Alaska: No impacts.
	Alternative 7 – Defer the Cook Inlet Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except no impacts would be expected in the Cook Inlet Planning Area.
	Alternative 8 – No Action[a]	There would be no impacts from a 2012-2017 OCS oil and gas leasing program.

TABLE 2.10-2 (Cont.)

Resource	Alternative	Potential Impacts
Invertebrates and Lower Trophic Levels	Alternative 1 – Proposed Action	Gulf of Mexico: Routine operations could result in negligible to moderate impacts to primarily benthic invertebrates, primarily from habitat disturbance associated with infrastructure placement, and from routine discharges. Recovery could be short-term to long-term. Large accidental oil spills, including CDE-level spills which are not expected, could measurably depress invertebrate populations especially in intertidal areas, but no permanent impacts are expected. Alaska: Routine operations could result in negligible to moderate impacts to primarily benthic invertebrates. Recovery could be short- to long-term. Large accidental oil spills, including CDE-level spills which are not expected, could measurably depress invertebrate populations, especially in intertidal areas. However, no permanent impacts are expected.
	Alternative 2 – Defer the Eastern Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except that no impacts would be expected in the Eastern GOM Planning Area from routine operations. Invertebrates in the Eastern GOM Planning Area could be affected by a large oil spill in the Central GOM Planning Area. Alaska: Same as Alternative 1.
	Alternative 3 – Defer the Western Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except that no impacts would be expected in the Western GOM Planning Area from routine operations. Invertebrates in the Western GOM Planning Area could be affected by a large oil spill in the Central GOM Planning Area. Alaska: Same as Alternative 1.
	Alternative 4 – Defer the Central Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except that no impacts would be expected in the Central GOM Planning Area from routine operations. Invertebrates in the Central GOM Planning Area could be affected by a large oil spill in the Western or Eastern GOM Planning Areas. Alaska: Same as Alternative 1.
	Alternative 5 – Defer the Beaufort Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except that impacts would be expected in the Beaufort Sea Planning Area. A large oil spill in the eastern portion of the Chukchi Sea Planning Area could affect invertebrates in the Beaufort Sea Planning Area.

TABLE 2.10-2 (Cont.)

Resource	Alternative	Potential Impacts
Invertebrates and Lower Trophic Levels (Cont.)	Alternative 6 – Defer the Chukchi Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except that no impacts would be expected in the Chukchi Sea Planning Area. A large oil spill in the western portion of the Beaufort Sea Planning Area could affect invertebrates in the eastern portion of the Chukchi Sea Planning Area.
	Alternative 7 – Defer the Cook Inlet Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except no impacts would be expected in the Cook Inlet Planning Area.
	Alternative 8 – No Action[a]	There would be no impacts from a 2012-2017 OCS oil and gas leasing program.
Areas of Special Concern (AOC)	Alternative 1 – Proposed Action	Gulf of Mexico: Impacts resulting from routine activities are expected to be negligible to moderate because of the existing protections and use restrictions. Large accidental oil spills, including CDE-level spills which are not expected, reaching AOCs could negatively affect fauna and habitats, subsistence use, commercial or recreational fisheries, recreation and tourism, and other uses. Alaska: Impacts resulting from routine activities are expected to be negligible to moderate because of the existing protections and use restrictions. Impacts from large accidental oil spills, including CDE-level spills which are not expected, reaching AOCs could negatively affect fauna and habitats, subsistence use, commercial or recreational fisheries, recreation and tourism, and other uses.
	Alternative 2 – Defer the Eastern Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except that no impacts would be expected in the Eastern GOM Planning Area from routine operations. AOCs in the Eastern GOM Planning Area could be affected by a large accidental oil spill in the Central GOM Planning Area. Alaska: Same as Alternative 1.
	Alternative 3 – Defer the Western Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except that no impacts would be expected in the Western GOM Planning Area from routine operations. AOCs in the Western GOM Planning Area could be affected by a large accidental oil spill in the Central GOM Planning Area. Alaska: Same as Alternative 1.

TABLE 2.10-2 (Cont.)

Resource	Alternative	Potential Impacts
Areas of Special Concern (AOC) (Cont.)	Alternative 4 – Defer the Central Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico – Same as Alternative 1, except that no impacts would be expected in the Central GOM Planning Area from routine operations. AOCs in the Central GOM Planning Area could be affected by a large accidental oil spill in the Western or Eastern GOM Planning Areas. Alaska – Same as Alternative 1.
	Alternative 5 – Defer the Beaufort Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except that no impacts would be expected in the Beaufort Sea Planning Area. A large accidental oil spill in the eastern portion of the Chukchi Sea Planning Area could affect AOCs in the Beaufort Sea Planning Area.
	Alternative 6 – Defer the Chukchi Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except that no impacts would be expected in the Chukchi Sea Planning Area. A large accidental oil spill in the western portion of the Beaufort Sea Planning Area could affect AOCs in the eastern portions of the Chukchi Sea Planning Area.
	Alternative 7 – Defer the Cook Inlet Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except no impacts would be expected in the Cook Inlet Planning Area.
	Alternative 8 – No Action[a]	There would be no impacts from a 2012-2017 OCS oil and gas leasing program.
Population, Employment, and Income	Alternative 1 – Proposed Action	Gulf of Mexico: Direct expenditures associated with routine operations would result in negligible impacts from small increases in population, employment and income in each region over the duration of the leasing period, corresponding to less than 1% of the baseline. Given existing levels of leasing activity, impacts on property values would be negligible. In areas where tourism and recreation provide significant employment, accidental oil spills, including CDE-level spills which are not expected, could result in the short-term loss of employment, income and property values. Expenditures associated with spill cleanup activities would create short-term employment and income in some parts of the affected coastal region(s).

TABLE 2.10-2 (Cont.)

Resource	Alternative	Potential Impacts
Population, Employment, and Income (Cont.)		Alaska: Direct expenditures associated with routine operations would result in minor impacts from small increases in population, employment and income in each region over the duration of the leasing period, corresponding to less than 5% of the baseline. Given existing levels of leasing activity, impacts on property values would be negligible. In areas where tourism and recreation provide significant employment, accidental oil spills, including CDE-level spills which are not expected, could result in the short-term loss of employment, income and property values. Expenditures associated with spill cleanup activities would create short-term employment and income in some parts of the affected coastal region(s).
	Alternative 2 – Defer the Eastern Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except likely slightly smaller increases in population, employment and income in the Eastern GOM Planning Area, as existing coastal infrastructure could be used to process oil and gas from the other GOM Planning Areas. A large accidental oil spill in the Central GOM Planning Area could affect employment, income, and property values. Alaska: Same as Alternative 1.
	Alternative 3 – Defer the Western Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except likely slightly smaller increases in population, employment and income in the Western GOM Planning Area, as existing coastal infrastructure could be used to process oil and gas from the other GOM Planning Areas. A large accidental oil spill in the Central GOM Planning Area could affect employment, income, and property values. Alaska: Same as Alternative 1.
	Alternative 4 – Defer the Central Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except likely slightly smaller increases in population, employment and income in the Central GOM Planning Area, as existing coastal infrastructure could be used to process oil and gas from the other GOM Planning Areas. A large accidental oil spill in the Western or Eastern GOM Planning Areas could affect employment, income, and property values. Alaska: Same as Alternative 1.
	Alternative 5 – Defer the Beaufort Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except likely slightly smaller increases in population, employment and income in the Beaufort Sea Planning Area, as coastal infrastructure in the corresponding coastal region would be used to process oil and gas from the Chukchi Sea Planning Area. A large accidental spill in the eastern Chukchi Sea Planning Area could affect employment, income, and property values in some portions of the western Beaufort Sea Planning Area.

TABLE 2.10-2 (Cont.)

Resource	Alternative	Potential Impacts
Population, Employment, and Income (Cont.)	Alternative 6 – Defer the Chukchi Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska – Same as Alternative 1, except no increases in population, employment and income in Chukchi Sea Planning Area. A large oil accidental spill in the western portion of the Beaufort Sea Planning Area could affect employment, income, and property values in some portions of the eastern Chukchi Sea Planning Area.
	Alternative 7 – Defer the Cook Inlet Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except no population, employment, and income impacts would be expected in the Cook Inlet Planning Area.
	Alternative 8 – No Action[a]	There would be no impacts from a 2012-2017 OCS oil and gas leasing program.
Land Use and Infrastructure	Alternative 1 – Proposed Action	Gulf of Mexico: Negligible to minor impacts on land use, development patterns, and infrastructure from routine operations. Existing infrastructure generally would be sufficient to handle exploration and development associated with potential new leases. Projected impacts from an accidental oil spill, including a CDE-level spill which is not expected, would likely include stresses of the spill response on existing infrastructure, and restrictions of access to a particular area while the cleanup is being conducted. Impacts would be expected to be temporary and localized. Alaska: Minimal to moderate impacts to land use, development patterns, and infrastructure. The construction and operation of offshore facilities would expand the area potentially at risk from accidental oil spills, along with the requirement to maintain oil-spill response equipment. An accidental oil spill, including a CDE-level spill which is not expected, could alter land use temporarily but would not likely result in long-term changes. The magnitude of the impacts would depend on the size and location of the spill.
	Alternative 2 – Defer the Eastern Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1 except no impacts to land use, development patterns, and infrastructure in the Eastern GOM Planning Area. A large accidental oil spill in the Central GOM Planning Area could affect land use in the Eastern GOM Planning Area; the level and duration of effects will depend on the size, location, duration, and timing of the spill, and on type and effectiveness of spill containment and cleanup activities. Alaska: Same as Alternative 1.

TABLE 2.10-2 (Cont.)

Resource	Alternative	Potential Impacts
Land Use and Infrastructure (Cont.)	Alternative 3 – Defer the Western Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1 except no impacts to land use, development patterns, and infrastructure in the Western GOM Planning Area. A large accidental oil spill in the Central GOM Planning Area could affect land use in the Western GOM Planning Area; the level and duration of effects will depend on the size, location, duration, and timing of the spill, and on type and effectiveness of spill containment and cleanup activities. Alaska: Same as Alternative 1.
	Alternative 4 – Defer the Central Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1 except no impacts to land use, development patterns, and infrastructure in the Central GOM Planning Area. A large accidental oil spill in the Western or Eastern GOM Planning Areas could affect land use in the Central GOM Planning Area; the level and duration of effects will depend on the size, location, duration, and timing of the spill, and on type and effectiveness of spill containment and cleanup activities. Alaska: Same as Alternative 1.
	Alternative 5 – Defer the Beaufort Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except no impacts in the Beaufort Sea Planning Area. An accidental oil spill in the Chukchi Sea Planning Area could affect land use in the Beaufort Sea Planning Area.
	Alternative 6 – Defer the Chukchi Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1 except no impacts in the Chukchi Sea Planning Area. An accidental oil spill in the eastern Beaufort Sea Planning Area could affect land use in the western portion of the Chukchi Sea Planning Area.
	Alternative 7 – Defer the Cook Inlet Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except no land use and infrastructure impacts would be expected in the Cook Inlet Planning Area.
	Alternative 8 – No Action[a]	There would be no impacts from a 2012-2017 OCS oil and gas leasing program.

TABLE 2.10-2 (Cont.)

Resource	Alternative	Potential Impacts
Commercial, Recreational, and Subsistence Fisheries	Alternative 1 – Proposed Action	Gulf of Mexico: Routine operations would have a minor impact on subsistence fishing, the cost of commercial fishing, or on the number of recreation fishing trips, in each region over the duration of the leasing period. Large accidental oil spills (including CDE-level spills which are not expected) may have small to medium, short-term impacts on fisheries resources (lethal and sublethal toxic effects on exposed eggs, larvae, juveniles, and adults) and small to medium impacts on commercial, recreational, and subsistence fishery activities (e.g., trawling, charter fishing). The magnitude and duration of effects will depend on the location, size, duration, and timing of the spill; the fisheries affected, and the duration and effectiveness of spill containment and cleanup activities. Alaska: Similar to the effects for the Gulf of Mexico.
	Alternative 2 – Defer the Eastern Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1 except no impacts in the Eastern GOM Planning Area. An accidental oil spill in the Central GOM Planning Area could reduce or stop commercial, recreational, and subsistence fishery activities in the Eastern GOM Planning Area if the spill enters coastal and marine waters associated with that planning area. Alaska: Same as Alternative 1.
	Alternative 3 – Defer the Western Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1 except no impacts in the Western GOM Planning Area. An accidental oil spill in the Central GOM Planning Area could reduce or stop commercial, recreational, and subsistence fishery activities in the Western GOM Planning Area if the spill enters coastal and marine waters associated with that planning area. Alaska: Same as Alternative 1.
	Alternative 4 – Defer the Central Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1 except no impacts in the Central GOM Planning Area. An accidental oil spill in the Western or Central GOM Planning Areas could reduce or stop commercial, recreational, and subsistence fishery activities in the Central GOM Planning Area if the spill enters coastal and marine waters associated with that planning area. Alaska: Same as Alternative 1.
	Alternative 5 – Defer the Beaufort Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1 except no impacts in the Beaufort Sea Planning Area. An accidental oil spill in the Chukchi Sea Planning Area could affect fisheries resources in the Beaufort Sea Planning Area.

TABLE 2.10-2 (Cont.)

Resource	Alternative	Potential Impacts
Commercial, Recreational, and Subsistence Fisheries (Cont.)	Alternative 6 – Defer the Chukchi Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1 except no impacts in the Chukchi Sea Planning Area. An accidental oil spill in the western portion of the Beaufort Sea Planning Area could affect fisheries resources in the eastern Chukchi Sea Planning Area.
	Alternative 7 – Defer the Cook Inlet Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except no impacts to fisheries would be expected in the Cook Inlet area.
	Alternative 8 – No Action[a]	There would be no impacts from a 2012-2017 OCS oil and gas leasing program.
Tourism and Recreation	Alternative 1 – Proposed Action	Gulf of Mexico: Routine operations would produce minor impacts to beach recreation, sightseeing, boating, and fishing, while offshore structures would create positive impacts to diving and recreational fishing. The impact of an accidental oil spill (including a CDE-level spill which is not expected) on tourism and recreation will depend on the size, location, duration, and timing of the spill, as well as on the effectiveness and timeliness of spill containment and cleanup activities. Alaska: Similar to the impacts identified for the Gulf of Mexico.
	Alternative 2 – Defer the Eastern Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1 except no impacts on tourism and recreation in the Eastern GOM Planning Area. An accidental oil spill in the Central GOM Planning Area could affect tourism and recreation in the Eastern GOM Planning Area and associated coastal areas. Alaska: Same as Alternative 1.
	Alternative 3 – Defer the Western Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1 except no impacts on tourism and recreation in the Western GOM Planning Area. An accidental oil spill in the Central GOM Planning Area could affect tourism and recreation in the Western GOM Planning Area and associated coastal areas. Alaska: Same as Alternative 1.

TABLE 2.10-2 (Cont.)

Resource	Alternative	Potential Impacts
Tourism and Recreation (Cont.)	Alternative 4 – Defer the Central Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1 except no impacts on tourism and recreation in the Central GOM Planning Area. An accidental oil spill in the Western or Eastern GOM Planning Areas could affect tourism and recreation in the Central GOM Planning Area and associated coastal areas. Alaska: Same as Alternative 1.
	Alternative 5 – Defer the Beaufort Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except no impacts on tourism or recreation in the Beaufort Sea Planning Area. An accidental oil spill in the Chukchi Sea Planning Area could affect tourism and recreation in the Beaufort Sea Planning Area.
	Alternative 6 – Defer the Chukchi Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except no impacts on tourism or recreation in the Chukchi Sea Planning Area. An accidental oil spill in the western Beaufort Sea Planning Area could affect tourism and recreation in the Chukchi Sea Planning Area.
	Alternative 7 – Defer the Cook Inlet Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except no impacts on tourism or recreation would be expected in the Cook Inlet.
	Alternative 8 – No Action[a]	There would be no impacts from a 2012-2017 OCS oil and gas leasing program.
Sociocultural Systems	Alternative 1 – Proposed Action	Gulf of Mexico: Because of the well developed and long established oil and gas industry in the Gulf of Mexico, routine operations may be expected to have minor impacts on sociocultural systems of the region. Expansion of deep water development could lead to longer offshore work shifts, which could increase stress to workers, families and communities. Impacts from accidental oil spills would be small, except in the case of very large spills. Very large spills, including CDE-level spills which are not expected, may temporarily halt and impact economies associated with the oil and gas industry, but also in other sectors of the economy. Depending on the duration of such halts and the magnitude of economic impacts, this could result in social and cultural stress, leading to possible social pathologies.

TABLE 2.10-2 (Cont.)

Resource	Alternative	Potential Impacts
Sociocultural Systems (Cont.)		Alaska: Cook Inlet as an established oil and gas industry, and routine operations associated with the proposed action are expected to have no more than minor impacts on social and cultural systems. Potential impacts of routine operations can range from minor to major on sociocultural systems in the Arctic Planning Areas, depending on shore base infrastructure and proximity to existing communities. Accidental oil spills (including CDE-level spills which are not expected) may however, result in more serious impacts, especially in the Arctic where impacts to subsistence could result in large impacts to affected communities.
	Alternative 2 – Defer the Eastern Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1 except no impacts in the Eastern GOM Planning Area. An accidental spill in the Central GOM Planning Area could affect individuals, families, and communities in the Eastern GOM Planning Area. Alaska: Same as Alternative 1.
	Alternative 3 – Defer the Western Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1 except no impacts in the Western GOM Planning Area. An accidental spill in the Central GOM Planning Area could affect individuals, families, and communities in the Western GOM Planning Area. Alaska: Same as Alternative 1.
	Alternative 4 – Defer the Central Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1 except no impacts in the Central GOM Planning Area. An accidental spill in the Western or Eastern GOM Planning Area could affect individuals, families, and communities in the Cemtral GOM Planning Area. Alaska: Same as Alternative 1.
	Alternative 5 – Defer the Beaufort Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1 except no impacts in the Beaufort Sea Planning Area. A large accidental oil spill in the Chukchi Sea Planning Area that enters the Beaufort Sea Planning Area could result in major impacts to individuals, families, and communities that rely on marine resources in those portions of the Beaufort Sea affected by the spill.

TABLE 2.10-2 (Cont.)

Resource	Alternative	Potential Impacts
Sociocultural Systems (Cont.)	Alternative 6 – Defer the Chukchi Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1 except no impacts in the Chukchi Sea Planning Area. A large accidental oil spill in the Beaufort Sea Planning Area that enters the Chukchi Sea Planning Area could result in major impacts to individuals, families, and communities that rely on marine resources in those portions of the Chukchi Sea affected by the spill.
	Alternative 7 – Defer the Cook Inlet Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except no impacts would be expected in the Cook Inlet Planning Area.
	Alternative – No Action[a]	There would be no impacts from a 2012-2017 OCS oil and gas leasing program.
Environmental Justice	Alternative 1 – Proposed Action	Gulf of Mexico: Because of the long-established and well developed oil and gas industry present in the Gulf of Mexico and the non-coastal location of the majority of low income and minority population groups, routine operations are not expected to add additional environmental justice concerns and impacts would be negligible. Impacts of accidental oil spills, including CDE-level spills which are not expected, would be minor, primarily affecting subsistence activities. Alaska: Routine operations could result in negligible to minor impacts depending on the proximity of onshore pipelines or offshore infrastructure to existing communities and/or subsistence harvest areas. Impacts of accidental spills could be large (including CDE-level spills which are not expected), primarily to subsistence resources and users, given the coastal location of the majority of low income and minority population groups and the very heavy reliance of individuals, families, and communities on subsistence resources (especially in Arctic areas).
	Alternative 2 – Defer the Eastern Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. An accidental oil spill in the Central GOM Planning Area could result in environmental justice concerns, associated primarily with a potential reduction of subsistence activities in portions of the Eastern GOM Planning Area affected by the spill. Alaska – Same as Alternative 1.

TABLE 2.10-2 (Cont.)

Resource	Alternative	Potential Impacts
Environmental Justice (Cont.)	Alternative 3 – Defer the Western Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. An accidental oil spill in the Central GOM Planning Area could result in environmental justice concerns, associated primarily with a potential reduction of subsistence activities in portions of the Western GOM Planning Area affected by the spill. Alaska – Same as Alternative 1.
	Alternative 4 – Defer the Central Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. An accidental oil spill in the Western or Eastern GOM Planning Areas could result in environmental justice concerns, associated primarily with a potential reduction of subsistence activities in portions of the Central GOM Planning Area affected by a spill originating in the Central GOM Planning Area. Alaska: Same as Alternative 1.
	Alternative 5 – Defer the Beaufort Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1. An accidental oil spill in the Chukchi Sea Planning Area could result in environmental justice concerns, associated primarily with a potential reduction of subsistence activities in portions of the Beaufort Sea Planning Area affected by the spill.
	Alternative 6 – Defer the Chukchi Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Alaska: Same as Alternative 1. An accidental oil spill in the Beaufort Sea Planning Area could result in environmental justice concerns, associated primarily with a potential reduction of subsistence activities in portions of the Chukchi Sea Planning Area affected by the spill.
	Alternative 7 – Defer the Cook Inlet Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except no impacts would be expected in the Cook Inlet Planning Area.
	Alternative 8 – No Action[a]	There would be no impacts from a 2012-2017 OCS oil and gas leasing program.

TABLE 2.10-2 (Cont.)

Resource	Alternative	Potential Impacts
Archeological and Historic Resources	Alternative 1 – Proposed Action	Gulf of Mexico: Routine operations could affect significant archaeological and historic resources (especially offshore resources), with construction activities such as platform and pipeline construction, and dredging, potentially damaging or destroying affected resources. Onshore impacts (resource damage or loss; visual impacts) are possible from pipeline landfall, onshore pipeline, and road construction. Anchor drags could affect seafloor resources such as shipwrecks. Impacts could range from negligible to major depending on the presence of significant archaeological or historic resources in the area of potential effect. Most resources are expected to be avoided. Accidental oil spills (including CDE-level spills which are not expected) could impact archaeological and historic resources, depending on the spill location, size, and duration, as well on the effectiveness and nature of spill containment and cleanup activities. Alaska: Routine operations could affect significant archaeological and historic resources (especially in offshore locations) through construction activities such as platform and pipeline construction. Onshore impacts (including visual impacts) are also possible from pipeline landfall, onshore pipeline, and road construction. Anchor drags could affect seafloor resources. Impacts could range from negligible to major, depending on the presence of significant archaeological or historic resources in the area of potential effect. Most resources are expected to be avoided. Accidental oil spills, including CDE-level spills which are not expected, could impact archaeological and historic resources, depending on the spill location, size, and duration, as well on the effectiveness and nature of spill containment and cleanup activities.
	Alternative 2 – Defer the Eastern Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except no impacts to archaeological and historic resources in the Eastern Planning Area from routine operations. Accidental oil spills in the Central GOM Planning Area could potentially impact archaeological and historic resources in the Eastern GOM Planning Area. Alaska: Same as Alternative 1.
	Alternative 3 – Defer the Western Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except no impacts to archaeological and historic resources in the Western GOM Planning Area from routine operations. Accidental oil spills in the Central GOM Planning Area could potentially impact archaeological and historic resources in the Western GOM Planning Area. Alaska: Same as Alternative 1.
	Alternative 4 – Defer the Central Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1, except no impacts to archaeological and historic resources in the Central GOM Planning Area from routine operations. Accidental oil spills in the Eastern or Western GOM Planning Areas could potentially impact archaeological and historic resources in the Central GOM Planning Area. Alaska: Same as Alternative 1.

TABLE 2.10-2 (Cont.)

Resource	Alternative	Potential Impacts
Archeological and Historic Resources (Cont.)	Alternative 5 – Defer the Beaufort Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except no impacts to archaeological and historic resources in the Beaufort Sea Planning Area from routine operations. Accidental oil spills in the Chukchi Sea Planning Area could potentially impact archaeological and historic resources in the Beaufort Sea Planning Area.
	Alternative 6 – Defer the Chukchi Sea Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except no impacts to archaeological and historic resources in the Chukchi Sea Planning Area from routine operations. Accidental oil spills in the western portion of the Beaufort Sea Planning Area could potentially impact archaeological and historic resources in the eastern portion of the Chukchi Sea Planning Area.
	Alternative 7 – Defer the Cook Inlet Planning Area for the Duration of the 2012-2017 Program	Gulf of Mexico: Same as Alternative 1. Alaska: Same as Alternative 1, except no impacts would be expected in the Cook Inlet Planning Area.
	Alternative 8 – No Action[a]	There would be no impacts from a 2012-2017 OCS oil and gas leasing program.

[a] Exploration, development, and production would continue under past sales, and could affect resources in the Gulf of Mexico and Alaska. See the 2007- 2012 OCS oil and gas leasing program PEIS (MMS 2007) for a discussion of potential impacts associated with that OCS leasing program.

3 AFFECTED ENVIRONMENT

3.1 INTRODUCTION

The draft programmatic environmental impact statement (PEIS) evaluates eight alternatives: the proposed action, six alternative actions, and a No Action Alternative. The proposed action would establish a 2012-2017 Outer Continental Shelf (OCS) Oil and Gas Leasing Program (the Program) that includes three planning areas in the Gulf of Mexico (GOM) (the Western and Central GOM Planning Areas, as well as a small portion of the Eastern GOM Planning Area), two planning areas in the Arctic (the Beaufort and Chukchi Sea Planning Areas), and Cook Inlet in south central Alaska. Each of the alternatives is identical to the proposed action, except that one of the six planning areas included in the proposed action is deferred from consideration for the duration of the Program; a different planning area is deferred in each alternative. Chapter 3 describes the nature and condition of natural, physical, and socioeconomic resources in these planning areas that may be affected by the Program in these planning areas.

Information regarding each resource presented in Chapter 3 and evaluated for potential impacts in Chapter 4 is presented as follows. Each resource is presented separately. For each resource, the nature and condition of the resource is provided in three groupings, based on the geographic settings of the planning areas included in the proposed action — the GOM, Cook Inlet, and Arctic Alaska. As applicable, the effects of the Deepwater Horizon spill on the baseline conditions of a resource are discussed, and a description is provided of potential changes in baseline conditions from climate change over the 40- to 50-yr expected period of oil and gas activities anticipated for the Program. Some information is currently unavailable, particularly with regard to affected environmental baseline changes; however, this information is not crucial in order to make a reasoned choice among alternatives at this programmatic stage (see Section 1.3.1.1, Incomplete and Unavailable Information).

3.2 MARINE AND COASTAL ECOREGIONS

With the exception of the Cook Inlet Planning Area, the planning areas being considered for leasing under the Program cannot be readily delineated from adjacent planning areas on the basis of clear, distinct geographical or physical boundaries. Except for topographical features associated with coastlines, the boundaries of the OCS planning areas are artificial administrative boundaries on the open oceans (Figure 3.2-1) drawn with no intended relationship to underlying ecologic, oceanographic, or other processes affecting environmental conditions on the OCS and in adjacent coastal areas. Many natural resources, as well as physical features such as currents, freely cross the boundaries of adjacent planning areas, the boundaries between the OCS and adjacent marine waters seaward of the United States Exclusive Economic Zone (EEZ), and the boundaries between coastal waters shoreward of the administrative boundary that separates State and Federal jurisdiction. As a consequence, it would be too restrictive to describe many of the natural and physical resources, or to discuss the potential effects of oil and gas development on those resources, solely on a one-by-one planning area basis. Instead, the PEIS uses marine and coastal ecoregions as a spatial framework to incorporate the areas potentially affected directly by

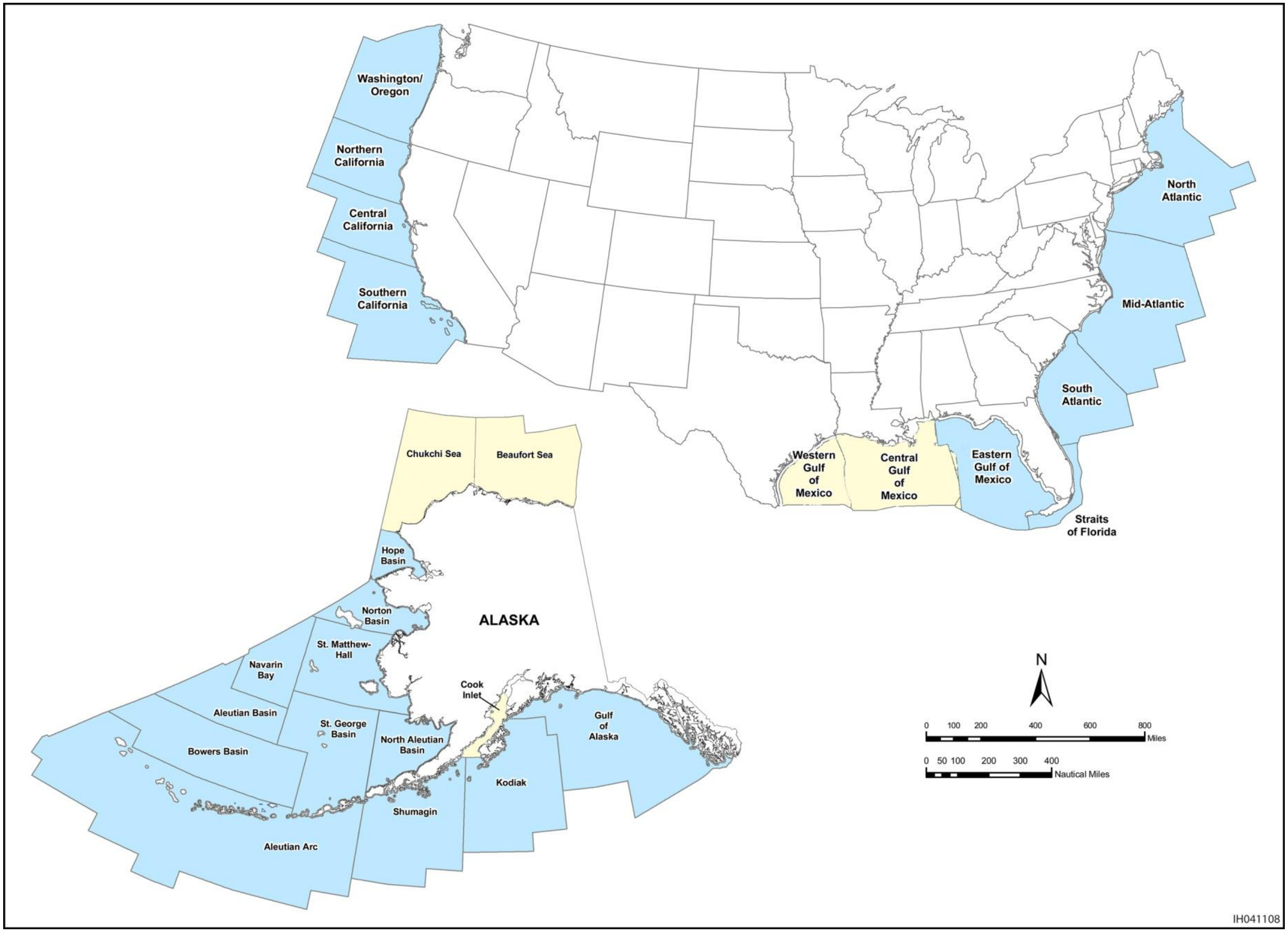

FIGURE 3.2-1 OCS Planning Areas

OCS activities within planning area boundaries as well as areas beyond the planning areas that could be affected by OCS impacts through the action of ecological and physical processes tht operate at an ecoregional scale.

An ecoregion is an ecologically and geographically defined area that contains characteristic geographically distinct assemblages of natural communities and species which tend to be distinct from those in other ecoregions (McMahon et al. 2001; Omernik 2004; Bailey 2005). In terrestrial systems, individual ecoregions are associated with characteristic combinations of land forms and geologic, hydrologic, and climatic conditions (Omernik 1987, 2004). Many Federal agencies and private organizations manage terrestrial resources using land classifications based on the ecoregion concept (e.g., see http://www.fs.fed.us/rm/ecoregions).

The PEIS uses marine and coastal ecoregions to define areas being considered in this and subsequent chapters. Marine ecoregions are defined according to the boundaries of Large Marine Ecosystems (LMEs) developed by the National Oceanic and Atmospheric Administration (NOAA) (LMEW 2009). In particular, this PEIS uses the boundaries of the GOM, Chukchi Sea, Beaufort Sea, and Gulf of Alaska LMEs to define the marine areas that include the OCS Planning Areas considered in Chapters 3 and 4. NOAA developed the LME concept and established the LME program in 1984 as a tool for enabling an ecosystem-based approach to transboundary ecosystem-based science and management. The PEIS uses the LME boundaries to define the areas of analytic interest in the document based on ecologically important distinctions rather than political or administrative boundaries. The PEIS also uses the marine and coastal ecoregions developed by the Commission for Environmental Cooperation (CEC) for North America (Wilkenson et al. 2009) to subdivide the areas defined by the LME boundaries into more localized regional distinctions, where appropriate. The coastal ecoregions are also used to characterize coastal and nearshore areas.

For many environmental resources addressed in this PEIS, the descriptions of the affected environment, as well as the evaluations of possible environmental consequences associated with oil and gas activities, use locations within ecoregions rather than individual OCS planning areas as a spatial reference. The PEIS adopts this approach to facilitate a broader scale ecosystem perspective on the analysis of potential environmental effects of oil and gas activities on the OCS following lease sales under the Proposed Action Alternative. A narrowed planning area perspective is more appropriate for an EIS prepared at the lease sale or project development stages of oil and gas activities on the OCS. Adoption of a broader ecoregional perspective is intended to facilitate the National Environmental Policy Act of 1969 (NEPA) process of tiering by which programmatic analyses are intended to inform and provide context for the more geographically focused and detailed environmental analyses and reviews that will occur later under the Program.

The coastal and marine ecoregions identified in this section make up areas of interest for this PEIS. The evaluations and analyses in this and subsequent chapters will consider the potential effects of oil and gas activities on the OCS within these broad areas. The geographic scope of these analyses will vary depending on the issues being considered. Examples of specific areas of interest that could be applied to different analyses include:

1. Individual OCS Planning Areas and nearby coastal and marine areas where program-related activities could occur and directly affect local natural resource.

   – *Example Issue*: The effects of OCS-related bottom-disturbing activities (such as pipeline trenching) on benthic habitats.

2. Areas outside of OCS Planning Areas where environmental impacts may extend beyond program area boundaries through the action of ecoregion-scale physical and ecological processes.

   – *Example Issue*: Population effects on marine fauna from a very large oil spill as it is transported from a release location by ocean currents and winds.

3. Areas outside the OCS Planning Areas that contribute to and affect marine and coastal environmental baseline conditions and would need to be considered in the analysis of cumulative effects.

   – *Example Issue*: The influence of the Mississippi River drainage basin and discharge on water quality and coastal and marine habitats in the GOM.

3.2.1 Large Marine Ecosystems

Large Marine Ecosystems (LMEs) are relatively large regions of coastal oceans of approximately 200,000 km^2 (77,220 mi^2) that include waters from river basins and estuaries to the seaward boundaries of continental shelves and/or seaward margins of coastal currents and water masses. They are characterized on the basis of ecological (as opposed to political) criteria, including bathymetry, hydrography, productivity, and trophic relationships. Sixty-four distinct LMEs have been delineated around the coastal margins of the Atlantic, Pacific, Arctic, and Indian Oceans (Sherman et al. 2007; LMEW 2009).

The OCS Planning Areas being considered for leasing under the Program addressed in this PEIS occur within four LMEs. The Cook Inlet Planning Area occurs in the Gulf of Alaska LME #2 (Figure 3.2.1-1); the Beaufort Sea Planning Area occurs within the Beaufort Sea LME #55; and the Chukchi Sea Planning Area occurs within the Chukchi Sea LME #54 (Figure 3.2.1-2). The Western, Central, and Eastern GOM Planning Areas occur within the GOM LME #5 (Figure 3.2.1-3). For the purposes of this draft PEIS, the LMEs are used solely to provide a spatial context for the planning areas considered for leasing in the Program. The following sections provide brief summary descriptions of these LMEs.

3.2.1.1 Gulf of Alaska Large Marine Ecosystem

The Gulf of Alaska LME lies along the southern coast of Alaska and the western coast of Canada (Figure 3.2.1-1), and has an area of approximately 1.5 million km^2 (569,450 mi^2), of

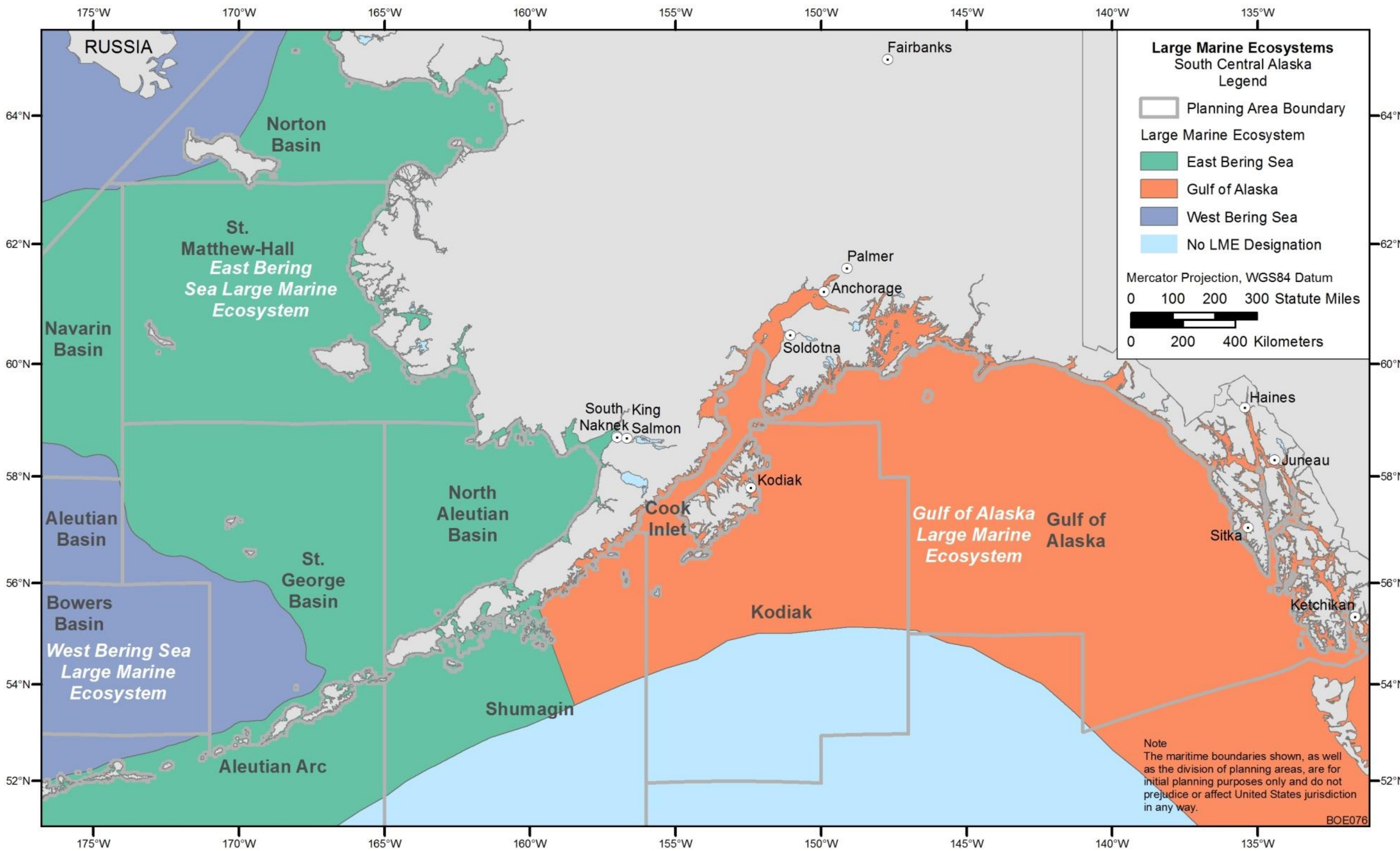

FIGURE 3.2.1-1 Large Marine Ecosystems for Southern Alaska (modified from Wilkenson et al. 2009)

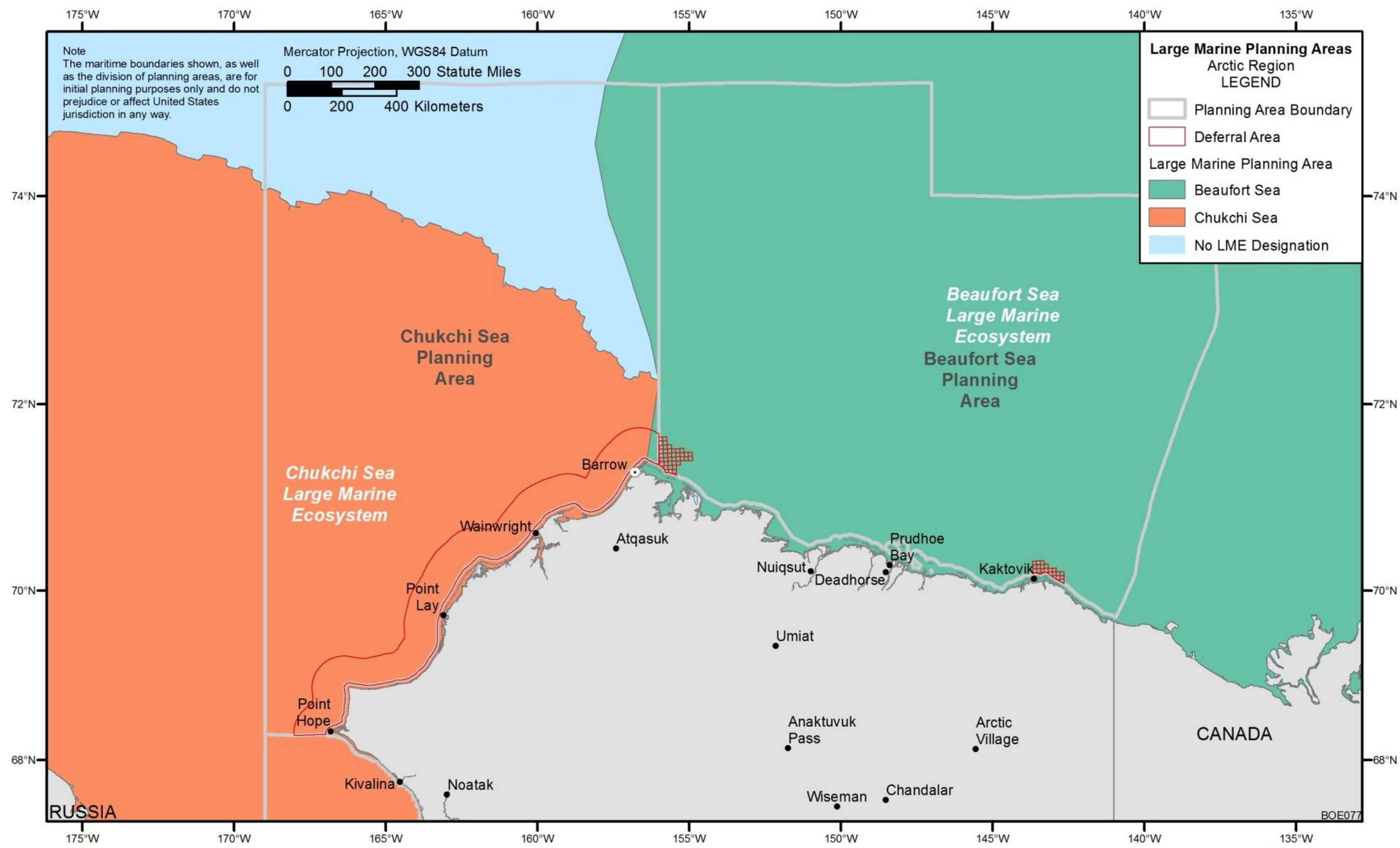

FIGURE 3.2.1-2 Large Marine Ecosystems for Arctic Alaska (modified from Wilkenson et al. 2009)

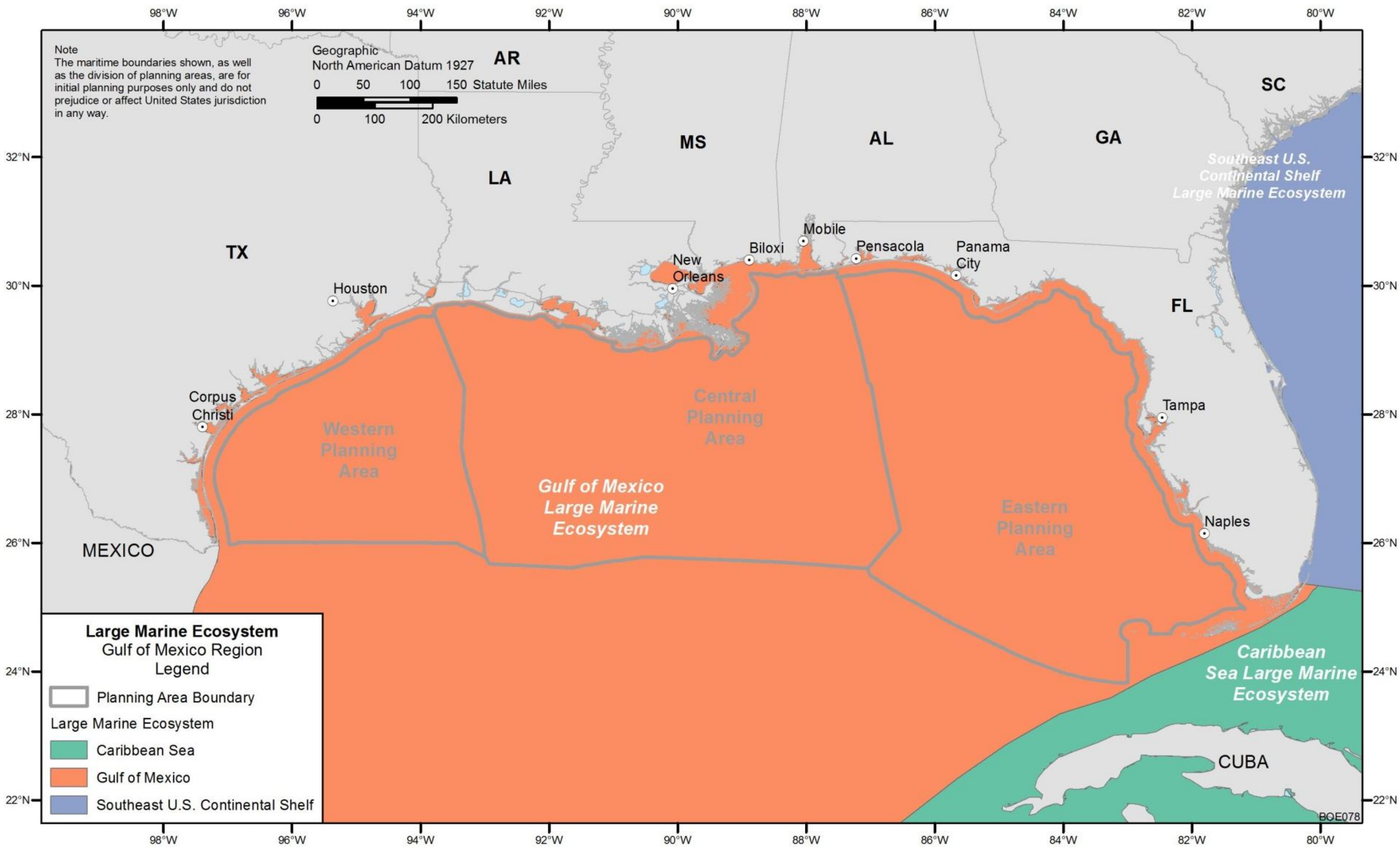

FIGURE 3.2.1-3 Large Marine Ecosystems for the GOM (modified from Wilkenson et al. 2009)

which about 1.5% (22,500 km^2 [8,540 mi^2]) is protected (Aquarone and Adams 2009). The Cook Inlet Planning Area occupies about 1.5% of the Gulf of Alaska LME. This LME is separated to the west from the East Bering Sea LME by the Alaska Peninsula and to the south borders the California Current LME. There are 14 estuaries and river systems, including the Stikine and Copper Rivers, Cook Inlet, and Prince William Sound in the Gulf of Alaska LME.

3.2.1.2 Beaufort Sea Large Marine Ecosystem

The Beaufort Sea LME occurs along the arctic coast of Alaska and northwestern Canada (Figure 3.2.1-2) and covers about 770,000 km^2 (297,300 mi^2), of which about 0.02% (154 km^2 [59 mi^2]) is protected (Belkin et al. 2009). The Beaufort Sea Planning Area occupies about 34% of the Beaufort Sea LME, and future oil and gas leasing activities are anticipated to be restricted to the coastal shelf areas of this LME. The Beaufort Sea LME is characterized by an arctic climate with major annual and seasonal changes, and historically is ice-covered much of the year.

3.2.1.3 Chukchi Sea Large Marine Ecosystem

The Chukchi Sea LME is located off of Russia's East Siberian coast and the northwestern coast of Alaska (Figure 3.2.1-2). This LME is a relatively shallow marginal sea with a surface area of about 776,643 km^2 (299,820 mi^2), of which about 5.4% (42,000 km^2 [16,190 mi^2]) is protected (Heileman and Belkin 2009). The Chukchi Planning Area occupies about 33% of this LME. This LME is characterized by an arctic climate with major seasonal and annual changes, in particular, the annual formation and deformation of sea ice.

3.2.1.4 Gulf of Mexico Large Marine Ecosystem

The GOM LME is a deep marginal sea bordered by Cuba, Mexico, and the United States (Figure 3.2.1-3). The GOM is the largest semi-enclosed coastal sea in the western Atlantic, encompassing about 1,500,000 km^2 (579,150 mi^2) (Heileman and Rabalais 2009). The Central GOM Planning Area comprises about 18%, the Western GOM Planning Area about 8%, and the Eastern GOM Planning Area about 17% of the total area of this LME. About 1.6% (24,000 km^2 [9,090 mi^2]) of the GOM LME is protected, and it contains about 0.5% of the world's coral reefs. The continental shelf comprises about 30% of this LME, and the coastal areas contain more than 750 estuaries, bays, and sub-estuaries that are associated with 47 major estuaries (USEPA 2008; Heileman and Rabalais 2009). This LME is strongly influenced by freshwater input from rivers (especially the Mississippi River), which accounts for about two-thirds of the flows into the GOM (Figure 3.2.1-4), and tropical storms (i.e., hurricanes) (Figure 3.2.1-5) are a major climatological feature of the area (Heileman and Rabalais 2009). Important hydrocarbon seeps occur in the southernmost and northern portions of the LME.

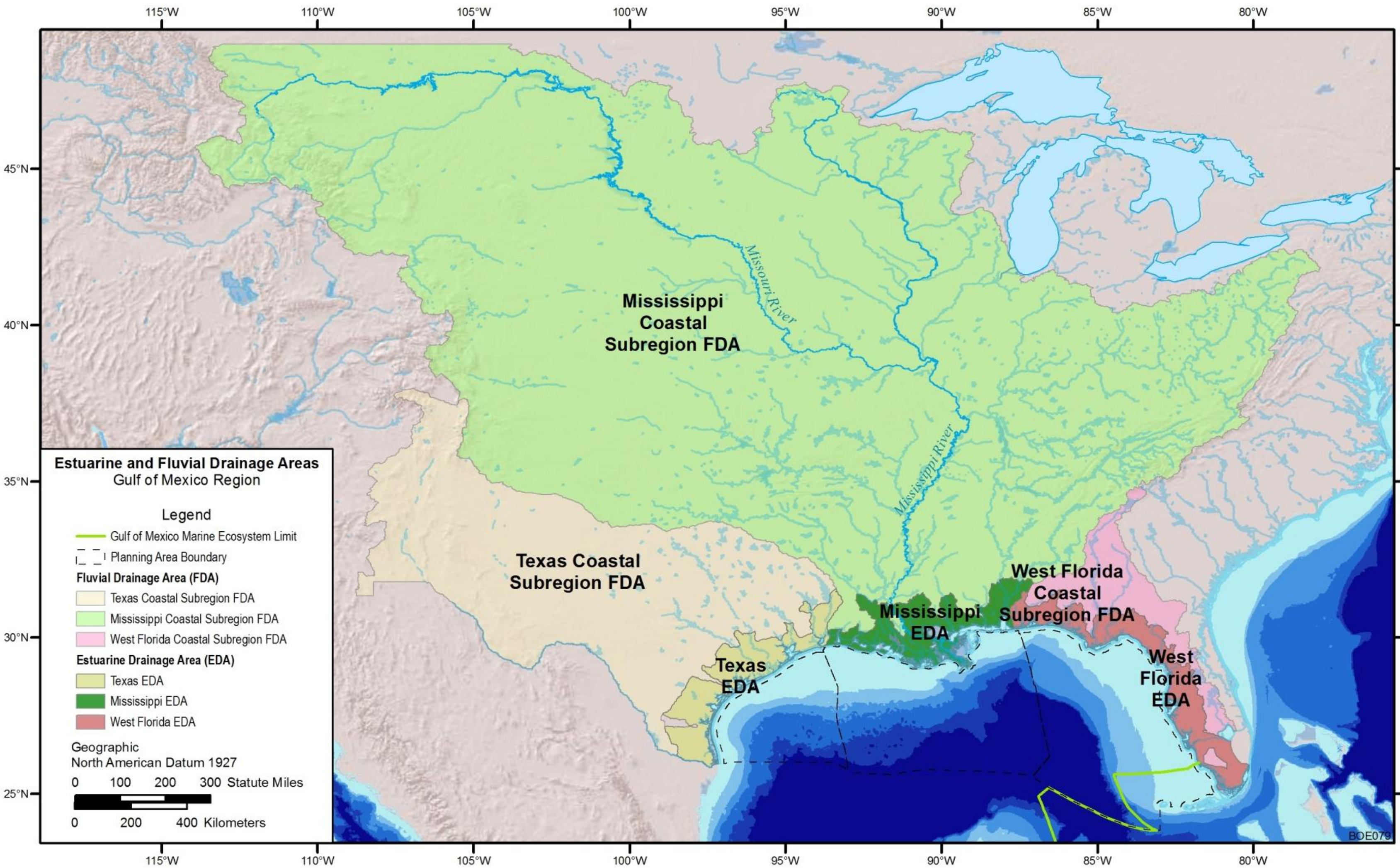

FIGURE 3.2.1-4 Estuarine and Fluvial Drainage Areas of the Northern GOM

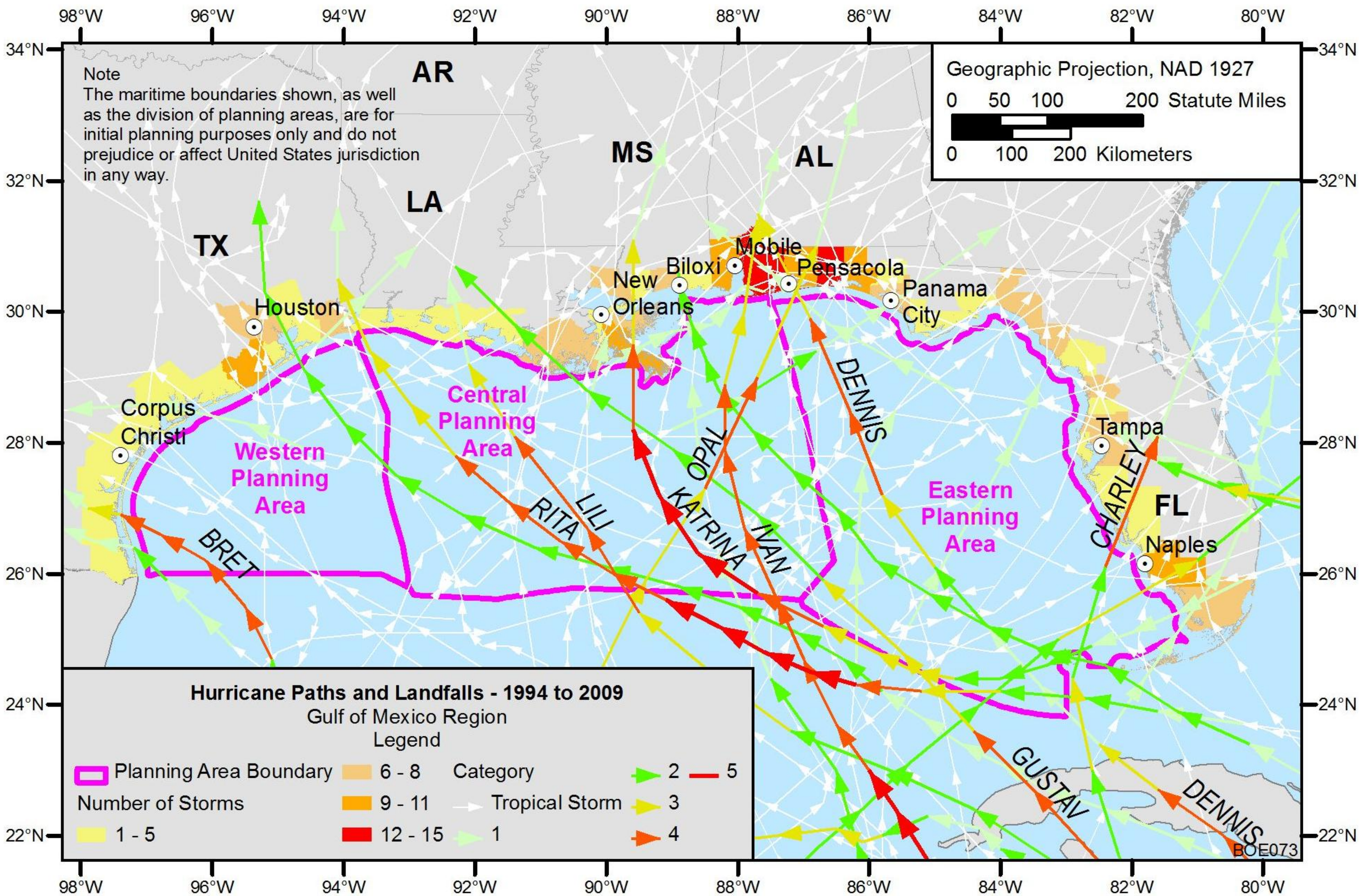

FIGURE 3.2.1-5 Tropical Storm Paths in the Northern GOM

3.2.2 Marine and Coastal Ecoregions of North America

As shown in Figures 3.2.1-1, 3.2.1-2, and 3.2.1-3, the four LMEs that encompass the OCS Planning Areas addressed in this draft PEIS are very large, and reflect marine ecosystem differences at their largest scale. Thus, their use in assessing the potential effects of oil and gas development activities to marine resources within individual LMEs would be similarly restricted to very large scale evaluations. The LMEs may be further examined on finer scales that distinguish ecosystems on the basis of larger physiographic features (e.g., continental slope, shelf, and abyssal plain) as well as on more locally significant conditions (such as local water characteristics, regional landforms, and biological communities). One such sub-LME classification has been developed by the CEC, a tri-national partnership comprised of government agencies, organizations, and researchers from the United States, Canada, and Mexico (see http://www.cec.org). The CEC has classified North American oceanic and coastal waters into 24 marine ecoregions according to oceanographic features and geographically distinct assemblages of species (Wilkinson et al. 2009). The Level II and Level III marine ecoregions developed by the CEC for North America are used in this draft PEIS to help identify and describe the marine ecosystems and resources that occur in the OCS Planning Areas that may be affected by OCS oil and gas activities under the Program.

Level II ecoregions capture the division between neritic (coastal areas out to a depth of about 200 m [600 ft]) and oceanic areas, and are determined by large-scale physiography (continental shelf, slope, and abyssal plain and also areas of islands and major trenches, ridges, and straits). The Level II classifications reflect the importance of depth as a determinant of benthic marine communities as well as the importance of major physiographic features in determining current flows and areas of upwelling. The Level III ecoregions reflect differences within the neritic areas, and are based on more locally significant variables such as local characteristics of the water mass, regional landforms, and biological community type. The Level III ecoregions are limited to the continental shelf, as only these areas have sufficient information to support finer-scale ecoregion delineations (Wilkinson et al. 2009). The CEC Level II and III marine ecoregions relevant to this draft PEIS are shown in Figure 3.2.2-1 for the GOM Planning Areas, Figure 3.2.2-2 for the Cook Inlet Planning Area, and Figure 3.2.2-3 for the Chukchi and Beaufort Seas Planning Areas, and are discussed below.

Other efforts have been directed toward developing ecoregions for coastal areas within LMEs (e.g., Yanez-Arancibia and Day 2004). The coastal ecoregions of Yanez-Arancibia and Day (2004) and the CEC marine ecoregions are used together in this PEIS to present an integrated ecosystem-based view of the areas that could be affected by oil and gas activities on the OCS.

The following sections identify the CEC ecoregions associated with each of the OCS Planning Areas addressed in this draft PEIS. Descriptions of the physical environment and ecological resources in these ecoregions are discussed in the subsequent resource-specific descriptions of the affected environment later in this chapter.

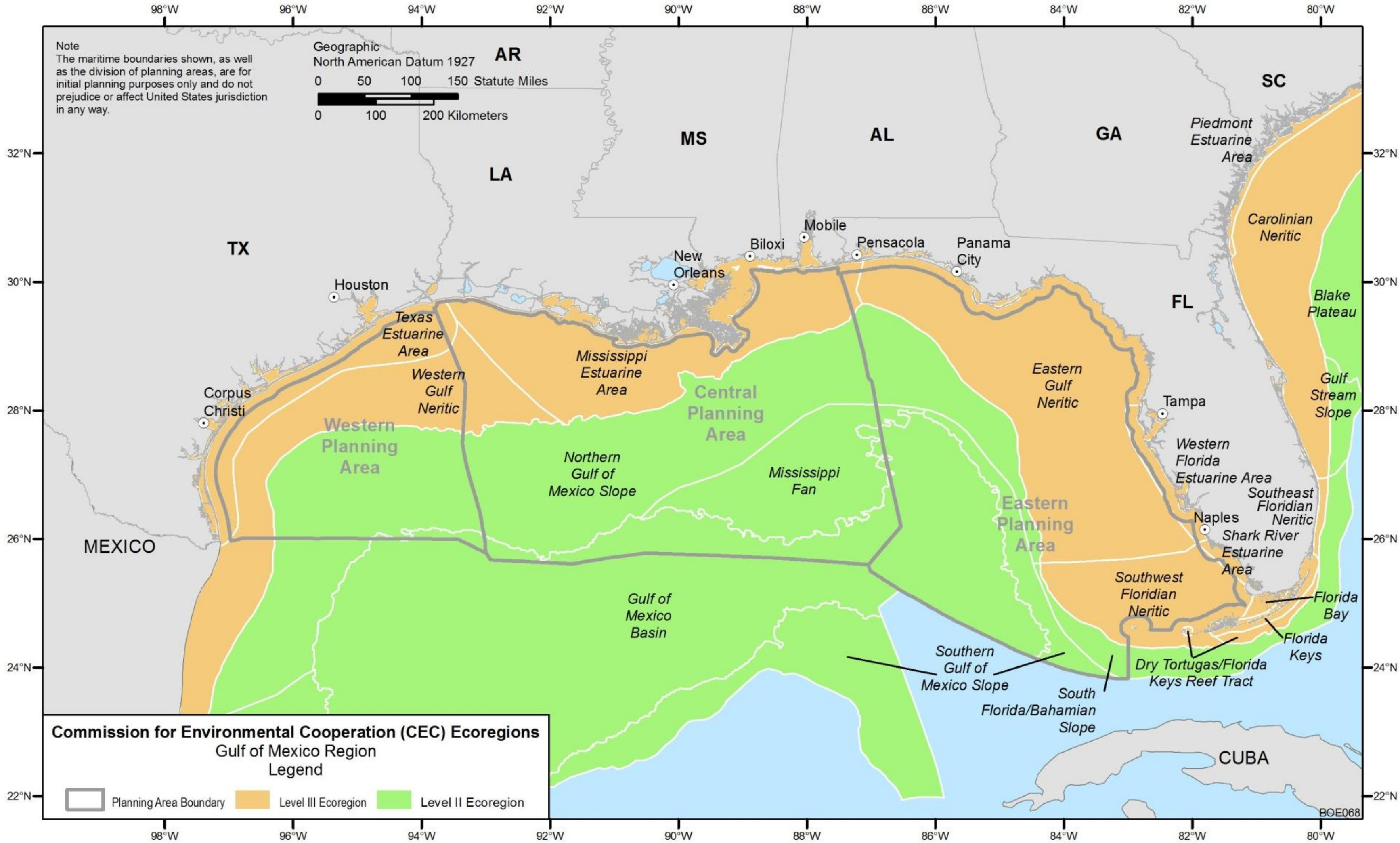

FIGURE 3.2.2-1 CEC Level II and III Marine Ecoregions of the Northern GOM

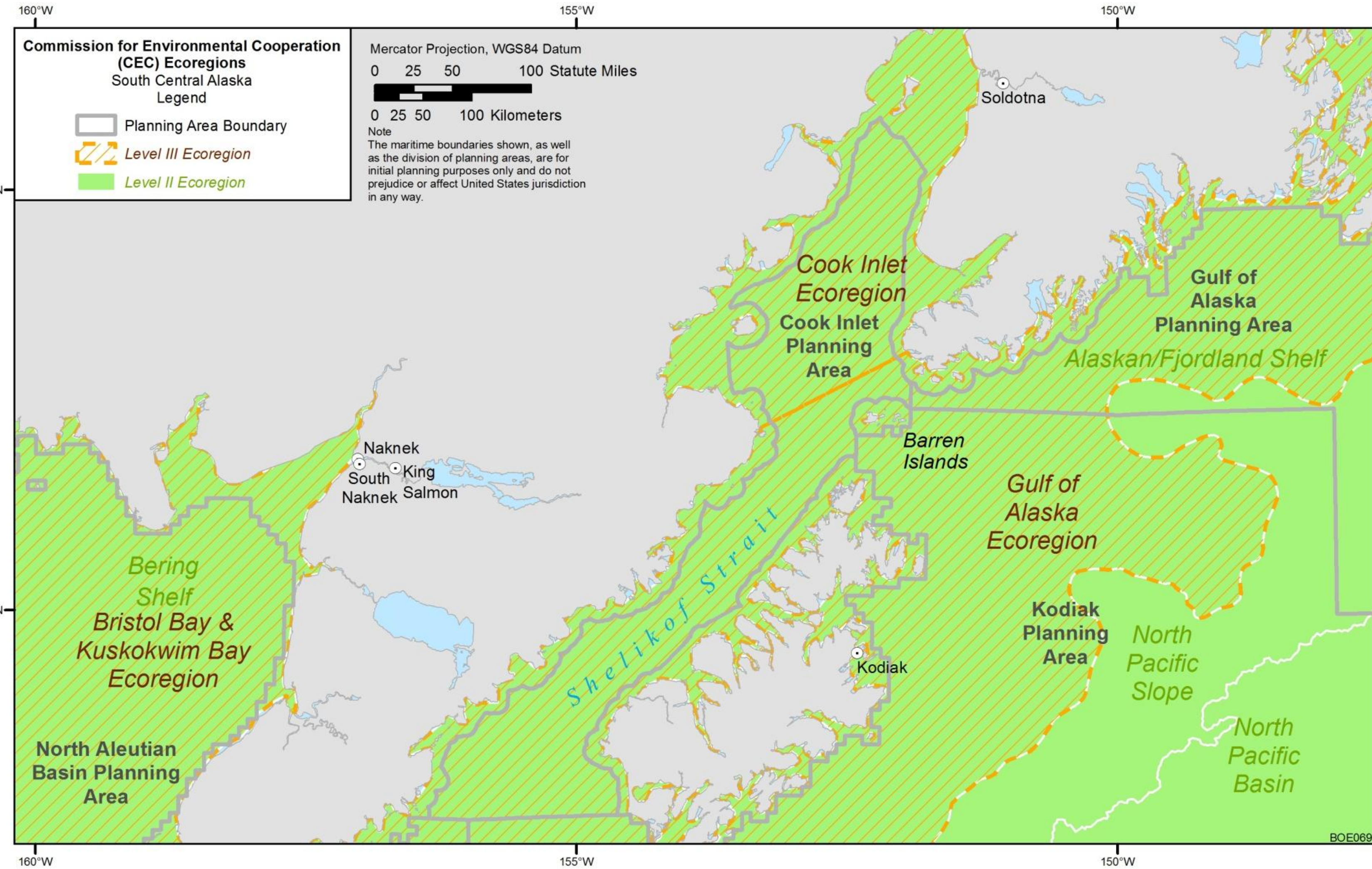

FIGURE 3.2.2-2 CEC Level II and III Marine Ecoregions of South Central Alaska

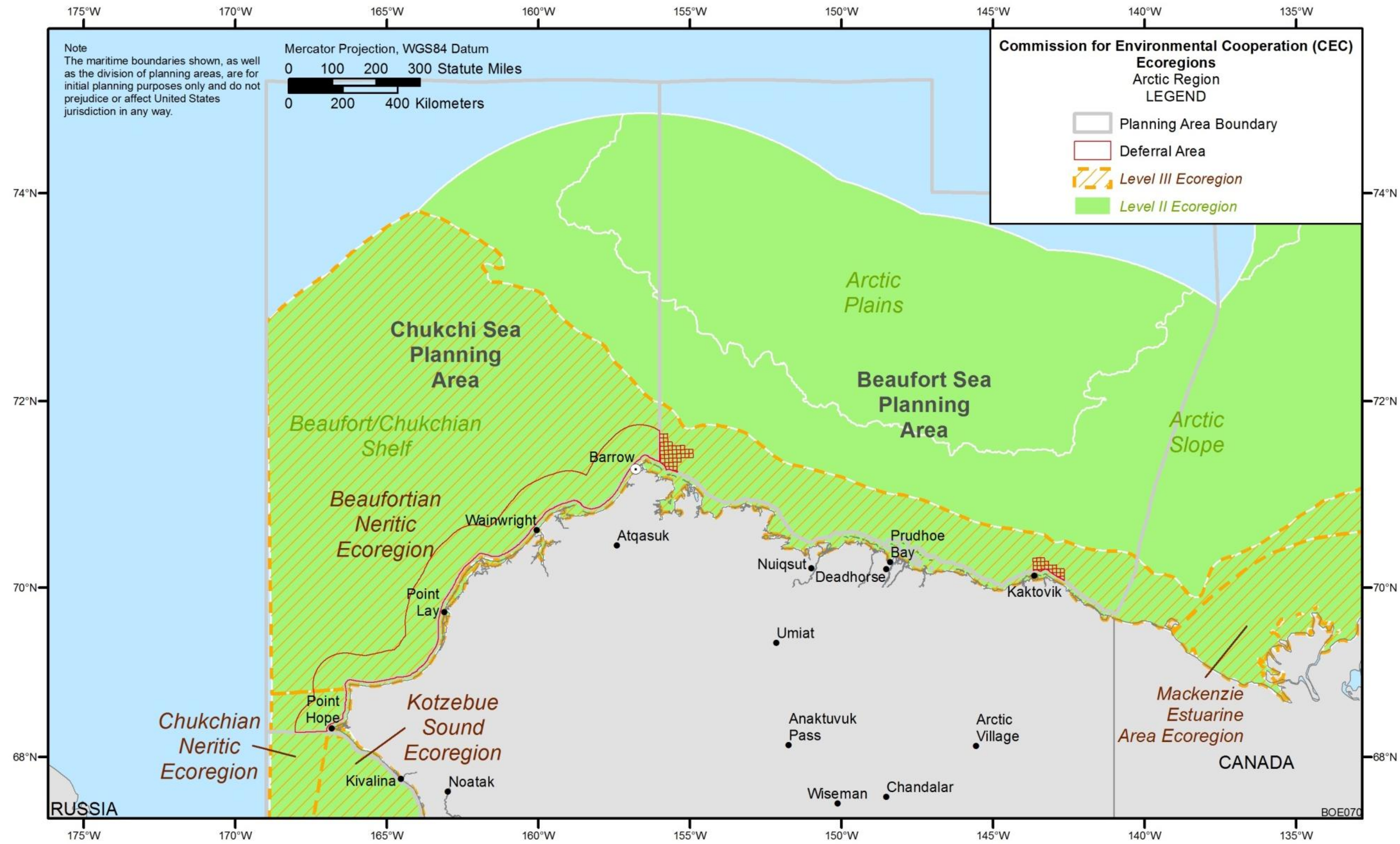

FIGURE 3.2.2-3 CEC Level II and III Marine Ecoregions of Northern Alaska

3.2.3 Ecoregions of the Northern Gulf of Mexico

As previously discussed, the GOM Planning Areas addressed in this draft PEIS occur within the GOM LME (see Section 3.2.2), which can be subdivided into finer-scale marine ecoregions as described by the CEC and others (Wilkenson et al. 2009). On a geomorphological basis, the GOM Planning Areas include the Northern GOM Shelf and Slope, the Mississippi Fan, and the GOM Basin Ecoregions (Figure 3.2.2-1) (Wilkinson et al. 2009). The following sections present brief overviews of these ecoregions, with more detailed discussions of physical and biological conditions and resources discussed in later sections.

3.2.3.1 Northern Gulf of Mexico Shelf Ecoregion

As indicated by its name, this ecoregion encompasses the continental shelf of the northern GOM and includes about half of the Western, Central, and Eastern GOM Planning Areas (Figure 3.2.2-1). This ecoregion varies in width across the three planning areas, extending as much as 250 km (155 mi) from the coastline in some areas, being narrowest in the vicinity of the Mississippi River Delta eastward to the Florida Panhandle. Water depth extends down to about 200 m (660 ft). Coastal areas of this ecoregion may be further delineated into three estuarine areas, the Texas, Mississippi, and Western Florida Estuarine Areas, and three neritic areas, the Western GOM, Eastern GOM, and Southwest Florida Neritic Areas (Figure 3.2.2-1). These estuarine areas contain as much as 60% of the tidal marshes of the United States and receive inputs from 37 major rivers. Freshwater input (with associated sediment loads) from three major estuarine drainage areas (Figure 3.2.1-4) strongly influences the nature and distribution of habitats and associated biota along the GOM coast.

The physiological and ecological conditions of the shelf in the central portion of the northern GOM are strongly influenced by the Mississippi River and its tributary, the Atchafalaya River (Wilkenson et al. 2009). Drainage from more than 55% of the conterminous United States enters the GOM from the Mississippi River, affecting water quality and substrates of this and other ecoregions (see Section 3.4.1). Increased nutrient and sediment loads from the Mississippi River result in the annual appearance of a large “dead zone” — an area of extremely low oxygen concentration.

Habitats include coastal lagoons and estuaries, tidal freshwater grasses, salt marsh, tidal freshwater marsh flats, intertidal scrub forest, beaches, and barrier islands. The nature and extent of these habitats and the biota they support vary, depending upon location (e.g., western Texas coastline vs. the Chenier Plain, Louisiana, vs. the west coast of central Florida).

3.2.3.2 Northern Gulf of Mexico Slope Ecoregion

This ecoregion extends from the edge of the Northern GOM Shelf Ecoregion to the start of the GOM Basin, with depths ranging from 200 to 3,000 m (660 to 9,800 ft) (Figure 3.2.2-1). This ecoregion extends through all three planning areas, comprising more than half of the Western and Central GOM Planning Areas and about a quarter of the Eastern GOM Planning Area.

3.2.3.3 Mississippi Fan Ecoregion

The Mississippi Fan Ecoregion extends from the Mississippi River Delta to the central abyssal plain (Figure 3.2.2-1), and is strongly influenced by the outflow of the Mississippi River. The upper part of the fan (to a water depth of about 2,500 m [8,200 ft]) has a complex and rugged topography attributed to salt diapirism,[1] slumping, and current scour; the lower part of the fan by contrast is smooth, with a gently sloping surface that merges with the abyssal plain to the southeast and southwest.

3.2.3.4 Gulf of Mexico Basin Ecoregion

The GOM Basin Ecoregion contains the deepest waters and habitats within the GOM LME. Water depths range from 3,000 to more than 4,300 m (9,800 to more than 14,100 ft). Only a very small portion of the Western GOM Planning Area overlies this ecoregion (Figure 3.2.2-1). In contrast, about a quarter of the Central GOM Planning Area (primarily in its southeastern portion) and about a third of the Eastern GOM Planning Area (primarily its southwestern portion) overlay the GOM Basin Ecoregion.

3.2.4 Ecoregions of the Gulf of Alaska

As discussed earlier, the Cook Inlet Planning Area is located within the Gulf of Alaska LME (Figure 3.2.1-1). Cook Inlet itself is associated with the Alaskan/Fjordland Pacific Level II Ecoregion, which extends from the westernmost end of the Aleutian Islands southward to the northern end of Vancouver Island (Wilkinson et al. 2009). The Cook Inlet Planning Area includes two Level III ecoregions: the Cook Inlet Ecoregion in the upper portion of the planning area and the Gulf of Alaska Level III ecoregion in the lower portion of the planning area (Figure 3.2.2-2). These ecoregions are strongly influenced by the Alaska Current and the Alaska Coastal Current.

3.2.4.1 Alaskan/Fjordland Shelf Level II Ecoregion

The Alaskan/Fjordland Shelf Level II Ecoregion includes fjords, islands, and straits along the Pacific coast from the north end of Vancouver Island to the end of the Alaska Peninsula. The shelf is generally narrow, ranging from about 20 km (12 mi) at its southern end to about 160 km (96 mi) along portions of the Alaska Peninsula, and is very narrow in some areas (such as around the Queen Charlotte Islands). The shelf is widest in the vicinity of the Cook Inlet Planning Area. This ecoregion has one of the most productive marine ecosystems in the northern Pacific, primarily as a result of the upwelling of nutrients by the Alaska Gyre (Wilkenson et al. 2009).

[1] Salt diapirism refers to a process by which natural salt (mainly halite but also including anhydrite and gypsum) in the subsurface deforms and flows in response to loading pressures from overlying sediments. Because of its low density, salt tends to flow upward from its source bed, forming intrusive bodies known a salt diapirs. Salt diapirs are common features of sedimentary basins such as the GOM (Nelson 1991).

3.2.4.2 Gulf of Alaska Level III Ecoregion

The Gulf of Alaska Level III Ecoregion extends about 1,860 km (1,160 mi) along the Gulf of Alaska coast from about the vicinity of Juneau westward to the end of the Alaskan Peninsula at Unimak Pass, and has a width of about 170 km (105 mi) in the vicinity of the Cook Inlet Planning Area. This ecoregion encompasses the lower portion (the Shelikof Strait) of the Cook Inlet Planning Area, from the approximate vicinity of the Barren Islands through the Shelikof Strait to the southern end of Kodiak Island (Figure 3.2.2-2). This ecoregion is strongly influenced by the Alaska Current. The Shelikof Strait portion of this ecoregion and the planning area is about 240 km (150 mi) in length with a width of about 40–50 km (25–30 mi). Physiography of the ecoregion includes rocky coastlines and numerous fjords, islands, and embayments.

3.2.4.3 Cook Inlet Level III Ecoregion

The Cook Inlet Level III Ecoregion includes the northern portion of the Cook Inlet Planning Area, northward from the mouth of Cook Inlet proper (Figure 3.2.2-2). The inlet is about 290 km (180 mi) in length, with a watershed of about 100,000 km^2 (39,000 mi^2). Major tributaries based upon size include the Susitna, Little Susitna, Kenai, Matanuska, Eagle, Crescent, and Johnson Rivers.

3.2.5 Ecoregions of the Alaska Arctic Coast

The Beaufort and Chukchi Sea Planning Areas occur within the two LMEs that encompass the arctic coast of Alaska (Figure 3.2.1-2). While the two planning areas occur within the similarly named LMEs, the Level II and III CEC ecoregions actually cross LME and planning area boundaries (Figure 3.2.2-3). The following sections identify and describe the CEC Level II and III ecoregions where OCS oil and gas leasing may occur under the proposed action.

3.2.5.1 Arctic Slope and Arctic Plains Level II Ecoregions

These two Level II ecoregions are characterized by relatively constant covers of ice sheets and ice packs (Wilkenson et al. 2009). Water depths on the Arctic Slope may range from 200 to 3,000 m (660 to 9,800 ft) and are deeper on the Arctic Plains. Most of these two ecoregions occur in the Beaufort Sea Planning Area (Figure 3.2.2-3). While ice may cover 90–100% of these ecoregions in any given year, ice cover throughout the year is not continuous; numerous leads of open water occur and are very important to ecological resources of these ecoregions.

3.2.5.2 Beaufort/Chukchian Shelf Level II Ecoregion

Within the Arctic Planning Areas, this Level II ecoregion extends along the Arctic coast from the eastern boundary of the Beaufort Sea Planning Area westward almost to Point Hope (Figure 3.2.2-3). In the Beaufort Sea Planning Area, this ecoregion is relatively narrow (about 80 km [50 mi]), and widens considerably in the Chukchi Sea Planning Area to as much as 390 km (240 mi). Water depths may reach 100 m (330 ft) (Wilkenson et al. 2009). Coastal areas include barrier beaches, extensive deltas, lagoons, estuaries, tidal flats, and narrow sand and gravel beaches, with low coastal relief. From October to June, this ecoregion is covered by a combination of landfast ice (extending 20 to 80 km [12 to 50 mi]) and pack ice. In summer, there is a coastal ice-free zone that may be as much as 200 km (120 mi) in width.

3.2.5.3 Beaufortian and Chukchian Neritic Level III Ecoregions

These Level III ecoregions occur within and comprise all of the Beaufort/Chukchian Shelf Level II Ecoregion (discussed above) that occurs within the two Arctic Planning Areas considered in this draft PEIS (Figure 3.2.2-3). The Beaufortian Neritic Level II Ecoregion accounts for the vast majority of the Beaufort/Chukchain Shelf, while the Chukchian Neritic Level II Ecoregion occurs only along a small portion of the Chukchi Sea coast in the vicinity of Point Hope. Both ecoregions (and especially the Chukchi Neritic Ecoregion) are strongly influenced by circulation flowing from the Bering Sea (Wilkenson et al. 2009).

3.3 CONSIDERATIONS OF CLIMATE CHANGE AND THE BASELINE ENVIRONMENT

Several natural and anthropogenic factors affect climate variability, but scientific evidence has led to the conclusion that current climate warming trends are linked to human activities, which are predominantly associated with greenhouse gas emissions (e.g., NRC 2010). Climate change effects have been observed to be occurring on all continents and oceans, and these observations have provided insights on relationships among atmospheric concentrations of carbon dioxide and other greenhouse gases, mean global temperature increases, and observed effects on physical and biological systems (IPCC 2007a). There are many impacts associated with climate change processes that have been observed in U.S. coastal regions that include changing air and water temperatures, rising sea levels, more intense storms, ocean acidification, coastal erosion, sea ice loss, declining coral reef conditions, and loss of critical habitats such as estuaries, wetlands, barrier islands, and mangroves (e.g., Boesch et al. 2000; ACIA 2005; Titus et al. 2009; Morel et al. 2010; Pendleton et al. 2010; Blunden et al. 2011).

The global climate system is driven largely by incoming solar energy that is reflected, absorbed, and emitted within the Earth’s atmosphere, and the resulting energy balance determines atmospheric temperatures (Solomon et al. 2007). Atmospheric concentrations of greenhouse gases (carbon dioxide, methane, nitrous oxide, and halocarbons) increase absorption and emission of energy, resulting in a positive radiative forcing to the climate system and warmer global mean temperatures; this process is often described in general terms as the greenhouse effect. Global concentrations of greenhouse gases in the atmosphere have increased from pre-industrial times and by 70% from 1970 to 2004; these emission increases are linked to human activity sectors such as energy, industry, transportation, and agriculture (IPCC 2007a; Rogner et al. 2007). The climate system response to this positive radiative forcing is complicated by a number of positive and negative feedback processes among atmospheric, terrestrial, and oceanic ecosystems, but overall the climate is warming, as is evident by observed increases in air and ocean temperatures, melting of snow and ice, and sea level rise (IPCC 2007a).

Global mean atmospheric temperatures have risen by 0.74 ± 0.18°C (1.33 ± 0.32°F) between 1905 and 2005, and the rate of warming for the past 50 yr has been almost double the rate for the past 100 yr (0.13°C [0.23°F] per decade) (Trenberth et al. 2007). Atmospheric warming has not been spatially uniform, and in particular arctic temperatures have increased about twice as much as those in lower latitudes (ACIA 2005). Preferential warming in the Arctic is partially the result of the ice-albedo effect, which occurs when highly reflective ice is replaced by less reflective water and land surfaces, resulting in more heat being absorbed by the land and water rather than being reflected back to the atmosphere (Perovich et al. 2007). About 80% of the warmth caused by greenhouse gases has been absorbed in the oceans (NRC 2010). Long-term observations of oceanic temperatures have revealed considerable inter-annual and inter-decadal variability. Between 1961 and 2003, oceanic warming was widespread in the upper 700 m (2,300 ft) of oceans, where the global mean ocean temperature has risen by 0.10°C (0.18°F) (Bindoff et al. 2007).

The effects of climate change on ecosystems are complex and nonuniform across the globe and vary among atmospheric, terrestrial, and oceanic systems (e.g., IPCC 2007a; Blunden et al. 2011). Considerations of climate change effects in OCS planning areas focus on impacts on marine and coastal systems where environmental sensitivities are typically associated with increasing atmospheric and ocean temperatures, but they can also be categorized as responses to sea level rise, coastal erosion, and ocean acidification. These general categories of climate change responses are occurring in addition to human-induced pressures related to coastal population densities (e.g., land use changes, pollution, overfishing) and trends of increasing human use of coastal areas (Nicholls et al. 2007).

Environmental Sensitivity to Atmospheric and Oceanic Temperature Increases. Environmental responses to warming atmospheric and oceanic temperatures include changes to species composition, coral reef damage, permafrost thawing, increased occurrences of storm events, loss of sea ice, and changes in ocean dynamics.

Species Composition. Effects of warming temperatures have already been seen in the form of changes in species location ranges, changes in migration patterns and timing, changes in location and timing of reproduction, and increases in disease (Perry et al. 2005; Rosenzweig et al. 2007; Simmonds and Isaac 2007). As species extend their spatial ranges, there can be negative consequences related to non-native and invasive species (Twilley et al. 2001). Climate change impacts on aquatic environments have the potential to affect species composition within an ecosystem according to species-specific thresholds, as well as species characteristics such as mobility, lifespan, and availability to use available resources (e.g., Chapin et al. 2000;

Levinsky et al. 2007). These variations in species-specific thresholds and characteristics result in the breakup of existing ecosystems and the formation of new ones in response to climate change, with unknown consequences (Perry et al. 2005; Simmonds and Isaac 2007; Karl et al. 2009).

Coral Reef Damage. Warmer water temperatures or increases in ultraviolet light penetration cause coral to lose their symbiotic algae, a process called bleaching. Intensities and frequencies of bleaching events have increased substantially over the past 30 yr, resulting in the death of or severe damage to about one third of the world's shallow water corals (Karl et al. 2009). In addition to coral bleaching, there has been a rise in the occurrence of excessive algal growth on reefs, as well as the presence of predatory organisms and reports of diseases related to bacterial, fungal, and viral agents (Boesch et al. 2000; Twilley et al. 2001). Additional discussion of coral reef damage is presented in Section 3.7.2.1.7.

Permafrost Thawing. Permafrost degradation affects terrestrial and hydrologic conditions in Arctic regions where the temperature at the top of the permafrost layer has increased by up to 3°C (5.4°F) since the 1980s, and in the Alaskan Arctic the permafrost base has been thawing at a rate of up to 0.04 m/yr (0.13 ft/yr) (Lemke et al. 2007). Recent data collected in 2010 suggest that trends in permafrost warming have begun to propagate southward nearly 200 km (124 mi) inland from the North Slope region (Richter-Menge and Jeffries 2011). Thawing of permafrost near coastal regions is expected to result in more rapid rates of shore erosion, increases in stored-carbon releases (Schuur et al. 2009), and damage to infrastructure such as roads and pipelines (Karl et al. 2009). These effects are expected to be compounded by reduced duration and extent of shoreline protection provided by landfast ice and more exposure to ocean storms.

Increases in Major Storm Frequency and Intensity. Regional weather conditions are influenced by modal climatic variability patterns such as the El Niño-Southern Oscillation (ENSO), Arctic Oscillation (AO), North Atlantic Oscillation (NAO), and the Pacific Decadal Oscillation (PDO) that act as connection pathways between regional atmospheric conditions and the world's oceans (NRC 1998; Liu and Alexander 2007). Major storms in low- to mid-latitude regions (e.g., cyclones, hurricanes, and typhoons) are largely controlled by the ENSO phase (Trenberth et al. 2007). In the northern hemisphere, there is a general northward shift in cyclone activity that is correlated with AO and NAO phases (ACIA 2005). Climate change affects water temperatures and wind patterns that interact to either enhance or work against storm formation, making it difficult to predict climate change effects on major storm events (Karl et al. 2009). However, a number of studies have concluded that cyclonic activity has changed over the second half of the 20th century with evidence suggesting that since the 1970s there has been a substantial upward trend toward longer-lasting and more intense storms (Trenberth et al. 2007).

Sea Ice Biome. The presence of sea ice and landfast ice in the marine environment of the Arctic creates a productive marine ice biome essential for the survival and flourishing of marine animals and supports traditional subsistence communities (e.g., Berkes and Jolly 2001; Simmonds and Isaac 2007; Arp et al. 2010). These environments provide hunting, resting, and birthing platforms along the ice-water interface, generate local upwelling responsible for high productivity in polynyas, and release large quantities of algae growing beneath the ice surface into the food chain at ice melt (ACIA 2005). Polar bear populations are strongly correlated with regional characteristics of sea ice and vary seasonally and with respect to specific requirements for reproduction (Durner et al. 2004). The Iñupiat Eskimos, Alaska Native people of coastal villages of northwestern Alaska and the North Slope, use sea ice for hunting and fishing grounds, as well as seasonal whaling camps that are vital to support their subsistence lifestyle (Braund and Kruse 2009). The greatest threat to the sea ice biome is the loss of sea ice due to climate change. Sea ice extent, as observed mainly by remote sensing methods, has decreased at a rate of approximately 3% per decade starting in the 1970s with larger decreases occurring in summer months (Parkinson 2000). Multi-year sea ice has decreased at a rate of nearly 9 to 12% per decade since the 1980s (Comiso 2002; Perovich et al. 2010), but more recent studies have shown a loss of multi-year ice area of 42% from 2005 to 2008 (Kwok and Cunningham 2010).

Ocean Dynamics. While large-scale trends in ocean salinity suggest certain regions have been experiencing changes in salinity that in combination with the warming of the atmosphere and oceans can change the dynamic properties of the ocean circulation patterns, there is currently no clear evidence for suggesting significant changes to major ocean circulation patterns as a result of climate change (Bindoff et al. 2007). However, there have been more regional studies that have suggested potential mechanistic changes to ocean circulations. For example, Bakun (1990) presented evidence on the effects of altered wind patterns that could enhance coastal upwelling along the western coast of the United States, which could increase productivity in these regions as nutrient-rich bottom water ascends to the ocean surface. There has also been interest in understanding the effect of increased freshwater inputs from the Greenland Ice Sheet on overturning the North Atlantic Current (Church 2007; Rabe et al. 2011). One of the largest obstacles for understanding climate change effects on ocean currents is the lack of long-term measurements, which makes it difficult to decipher climate change responses from inter-decadal variability (Bryden et al. 2003).

Environmental Sensitivity to Sea Level Rise and Coastal Erosion. The recent global sea level rise has been caused by warming-induced thermal expansion of the oceans and accelerated melting of glaciers and ice sheets. The global mean sea level has risen at a mean rate of 1.8 ± 0.5 mm/yr from 1961 to 2003 with considerable variability spatially, as well as considerable decadal time-scale variability (Bindoff et al. 2007). Predictions in sea level rise are as much as 0.6 m (2 ft) by 2100 (Nicholls et al. 2007). The amount of relative sea level rise along different parts of the U.S. coast depends not only on thermal expansion and ice sheet melting, but also on the changes in elevation of the land that occur as a result of subsidence or geologic uplift (Karl et al. 2009). Submergence hotspots can occur as a result of local subsidence in combination with sea level rise such that the rate of rise of sea level relative to the land is expected to be higher than in other parts of the area.

Certain areas along the Atlantic and GOM coasts are undergoing relatively rapid inundation and landscape changes because of the prevalence of low-lying coastal lands (Titus et al. 2009). Barrier islands in the northern GOM have been losing land areas and changing habitat conditions because of decreased sediment supplies from rivers, sea level rise, and intense storms (Lucas and Carter 2010). Coastal erosion rates over the past couple of decades averaged 3.7 m/yr (12 ft/yr), but storm events such as Hurricane Rita have caused erosion rates of 12 to 15 m (39 to 49 ft) in a single event (Park and Edge 2011). The coasts of the Beaufort and Chukchi Seas consist of river deltas, barrier islands, exposed bluffs, and large inlets and inland are characterized by low-relief lands underlain by permafrost (Jorgenson and Brown 2005). The combination of wind-driven waves, river erosion, sea level rise, and sea ice scour with highly erodible coastal lands creates the potential for high erosion rates along the Beaufort and Chukchi Sea coasts (Proshutinsky et al. 2001; Mars and Houseknecht 2007). In addition to coastal erosion along the arctic coast, storm surge flooding has converted freshwater lakes into estuaries, affecting habitat conditions (Arp et al. 2010).

Environmental Sensitivity to Ocean Acidification. Ocean acidification refers to the decrease in the pH of the oceans and its buffering capacity caused by the uptake of carbon dioxide from the atmosphere that reacts with seawater to form carbonic acid, leading to decreasing pH values in the oceans. Predictions of future ocean water pH levels vary somewhat, but predicted decreases range from 0.14 to 0.4 pH units over the 21st century (Caldeira and Wickett 2005; Orr et al. 2005; IPCC 2007a). Factors such as water temperatures, salinity, sea ice, and ocean mixing processes affect the amount of carbon dioxide absorbed by oceans, so climate change effects on storms, river discharge, and precipitation patterns all affect ocean acidification (IPCC 2007). The mechanisms that lead to ocean acidification also affect estuarine and coastal waters, although their impacts on estuarine ecosystems are not well known because of the multitude of processes affecting pH levels in these systems (Feely et al. 2010).

Ocean acidification affects the ability of certain organisms to create shells or skeletons by calcification, which can be especially harmful to mollusks, corals, and certain plankton species that are important to oceanic food chains (Orr et al. 2005; Karl et al. 2009). However, several laboratory experiments conducted under elevated carbon dioxide conditions have shown mixed calcification rates in many organisms (including positive responses to ocean acidification), which suggests complex mechanisms by which organisms respond to ocean acidification (Doney et al. 2009; Ries et al. 2009). Coral reefs are highly dependent on calcified structures for survival and both warm-water and cold-water corals are negatively impacted by ocean acidification (Royal Society 2005). Ocean waters in Arctic regions are highly susceptible to ocean acidification resulting from increased carbon dioxide solubility, freshwater inputs, and increased primary productivity, and these factors relating to ocean acidification are enhanced by current climate change trends and loss of sea ice (Fabry et al. 2009; Steinacher et al. 2009).

Climate Change Predictions and Uncertainties. Climate change predictions are based on a variety of models that simulate all relevant physical processes affecting interactions among the atmosphere, oceans, and biosphere, which are driven by a variety of projected greenhouse gas emission scenarios. Global climate models generate projected changes in atmospheric, ocean, and land surface climate variables at scales on the order of one degree in latitude and longitude, which are not sufficient for making regional-scale climate assessments. Downscaling global climate models and coupling them with more localized regional climate models is an active area of current research (Christensen et al. 2007; Randall et al. 2007). The complexity of modeling global and regional climate systems is great, so it is important to consider measures of uncertainty, which is typically done using a multi-model ensemble approach (Krishnamurti et al. 2000). It is important to recognize that despite new climate model developments, uncertainty in climate projections can never be entirely eliminated (McWilliams 2007).

The Intergovernmental Panel on Climate Change (IPCC) has summarized climate change predictions over the next two decades and over the 21st century, using climate model predictions and evidence from various scientific disciplines (IPCC 2007a). The IPCC uses a 10-fold likelihood scale ranging from virtually certain (>99% probability of occurrence) to exceptionally unlikely (<1% probability) to define consistent terminology for climate change projections where uncertainty can be assessed by statistical analyses, and a 10-point scale (10 being the most confident) for projections where uncertainty was qualitatively assessed by expert judgment. The most recent climate change projections summarized by the IPCC (2007a) include some of the following:

- An increase in atmospheric temperatures of approximately 0.2°C (0.4°F) per decade is predicted over a range in projected greenhouse gas emission scenarios;

- Warming is expected to be greatest over land and at higher latitudes;

- Model estimates of sea level rise vary from 0.18 to 0.59 m (0.6 to 2 ft) by the end of the 21st century, but information on important feedback processes to sea level rise do not allow for determining a best estimate;

- Polar regions are projected to have continued reductions in sea ice, glaciers, and ice sheets;

- Projection models suggest that ocean pH values decreasing between 0.14 and 0.35 over the 21st century;

- It is likely (>66%) that tropical cyclones will become more intense;

- Increased precipitation is very likely (>90%) to occur at high-latitudes;

- There is high confidence (8 out of 10) that annual river runoff will increase by 10 to 40% at high latitudes and decrease by 10 to 30% in dry regions of mid-latitudes;

- Net carbon uptake by terrestrial ecosystems is likely (>66%) to peak during this century as natural carbon sequestration mechanisms reach their capacity; and

- There is medium confidence (5 out of 10) that predicted temperature increases will result in approximately 20 to 30% of plant and animal species that have been assessed likely (>60%) being at an increased risk of extinction.

3.3.1 Gulf of Mexico

Climate change in the GOM is expected to affect coastal ecosystems, forests, air and water quality, fisheries, and business sectors such as industry and energy (Ning et al. 2003). The GOM region has experienced increasing atmospheric temperatures since the 1960s, and from 1900 to 1991 sea surface temperatures have increased in coastal areas and decreased in offshore regions (Twilley et al. 2001). In addition to temperature changes, the northern coast of the GOM is experiencing impacts associated with sea level rise that include the loss of coastal wetland and mangrove habitats, salt water intrusion into coastal aquifers and forests, and increases in shoreline erosion (Williams et al. 1999; Pendleton et al. 2010). Climate change associated sea level rise is occurring in combination with altered hydrology and land subsidence that has resulted in measures of relative sea level rise ranging between 0.002 m/yr (0.007 ft/yr) along Texas and up to 0.01 m/yr (0.03 ft/yr) along the Mississippi River Delta (Twilley et al. 2001).

Climate models generally predict a rise in temperatures in the GOM Coastal States this century; however, predictions of precipitation are more problematic due to model uncertainties (Karl et al. 2009). Predictions of precipitation among various modeling studies for the GOM region have generally predicted a slight decrease in precipitation in coastal areas, as well as more intense rainfall events and longer periods of drought, but models vary widely in upland areas, which affect river discharges (Mulholland et al. 1997; Boesch et al. 2000; Twilley et al. 2001).

Significant increases or decreases in precipitation and river runoff would affect salinity and water circulation, as well as water quality. Increased runoff would likely deliver increased amounts of nutrients (such as nitrogen and phosphorous) to estuaries, increase the stratification between warmer fresher and colder saltier water, and potentially lead to eutrophication of estuaries and increase the potential for harmful algal blooms that can deplete oxygen levels (Justic et al. 1996; Karl et al. 2009). Reductions of freshwater flows in rivers or prolonged drought periods could substantially reduce biological productivity in Mobile Bay, Apalachicola Bay, Tampa Bay, and the lagoons of Texas and could increase the salinity in coastal ecosystems, resulting in a decline in mangrove and sea grass habitats (Twilley et al. 2001). Decreased runoff could also diminish flushing of the estuaries, decrease the size of estuarine nursery zones, and allow an increase in predators and pathogens (Boesch et al. 2000).

Sea level rise along parts of the northern GOM coast are as high as 0.01 m/yr (0.03 ft/yr), which is much greater than globally averaged rates (Twilley et al. 2001; IPCC 2007a). The combination of sea level rise and land subsidence is resulting in the loss of coastal wetlands and mangroves, which is damaging to habitat functions to many important fish and shellfish populations. Future sea level rise is expected to cause additional saltwater intrusion into coastal aquifers of the GOM, potentially making some unsuitable as potable water supplies (Karl et al. 2009). Saltwater intrusion and sea level rise are damaging coastal bottomland forests (primarily along the western GOM coast) and mangroves through soil salinity poisoning, increased hydroperiods, and coastal erosion (Williams et al. 1999). Additionally, climate change model predictions suggest that there will be an increase in the intensity of hurricanes (IPCC 2007a), and coastal regions may potentially have fewer barrier islands, coastal wetlands, and mangrove forests to buffer the resulting storm surges as a result of sea level rise.

Marine biota in the GOM are influenced by changes in temperature, salinity, and ocean acidification, as well as their biological environment including predators, prey, species interactions, disease, and fishing pressure (Karl et al. 2009). Projected changes in physical oceanographic conditions can affect the growth, survival, reproduction, and spatial distribution of marine fish species and of the prey, competitors, and predators that influence the dynamics of these species. However, impacts on marine biota associated with climate change need to be considered against natural variation (Rosenzweig et al. 2007).

3.3.2 Alaska Region

The Arctic climate system is complex and has varied considerably over geologic time scales (ACIA 2005). Over the last 100 yr, mean Arctic temperatures have increased at a rate nearly double that of global mean temperatures (IPCC 2007a). The ice-albedo feedback mechanism has the potential to enhance the effects of warming trends as the loss of sea ice leads to more heat absorption by ocean waters, which affects both sea ice melt and regional atmospheric circulation patterns important to the global heat budget (ACIA 2005; Overland and Wang 2011). However, it is important to recognize that climate conditions in the Arctic experience strong decadal variability in relation to modal climatic variability patterns such as the AO, PDO, and NAO (ACIA 2005). A recent modeling study has suggested that Arctic regions are nearing a threshold, where amplified greenhouse effect warming is likely to overpass decadal climate variability patterns (Serreze and Francis 2006). The impacts of climate change on the Arctic include warming ocean temperatures, reductions in sea ice, permafrost thawing, and coastal erosion, which all affect terrestrial, coastal, and marine ecosystems (Hopcroft et al. 2008). In addition to ecosystem impacts, the loss of sea ice contributes to an ice-albedo feedback process that affects regional atmospheric circulation patterns and global heat budgets (ACIA 2005; Overland and Wang 2011).

Changes to the Arctic climate, as well as the sea ice and permafrost biomes, have been documented in several studies (Parkinson 2000; Comiso 2002; Rothrock and Zhang 2005; ACIA 2005; Anisimov et al. 2007; Hopcroft et al. 2008; Perovich et al. 2010; Richter-Menge and Jeffries 2011) and include:

- Atmospheric temperatures have increased by 1–2°C (2–4°F) since the 1960s;

- Atmospheric temperatures increasing at a rate of 1°C (2°F) per decade in winter and spring;

- Precipitation has increased by approximately 1% per decade;

- March sea ice extent has decreased at a rate of approximately 3% per decade starting in the 1970s;

- Multi-year sea ice has decreased at a rate of approximately 9 to 12% per decade since the 1980s;

- Sea ice volumes have decreased by 4% per decade since the 1950s;

- Temperatures at the top of the permafrost layer have increased by up to 3°C (5°F) since the 1980s;

- Permafrost base has been thawing at a rate of up to 0.04 m/yr (0.13 ft/yr).

Impacts of current and projected climate changes have the potential to affect sea ice (most importantly multi-year sea ice) and permafrost biomes, as well as coastal erosion rates, animal populations, and subsistence livelihoods. Retreat of sea ice would increase impacts on coastal areas from storms. Furthermore, coastlines where permafrost has thawed are more vulnerable to erosion from wave action, which can affect both erosion rates as well as change freshwater lakes into estuarine habitats (Mars and Houseknecht 2007; Arp et al. 2010). An aerial photo comparison has revealed total erosive losses up to 457 m (1,500 ft) over the past few decades along some stretches of the Alaskan coast (Alaska Regional Assessment Group 1999). At Barrow, Alaska, coastal erosion has been measured at the rate of 1–2.5 m/yr (3–8 ft/yr) since 1948 (ACIA 2005), and it has been causing severe impacts on the community. Maximum coastal erosion rates of up to 13.3 m/yr (43.6 ft/yr) have occurred near Cape Halkett and Cape Simpson during the time period of 1980–2000 (Ping et al. 2011).

Changes in permafrost have caused failure of buildings and costly increases in road damage and road maintenance in Alaska (Alaska Regional Assessment Group 1999; Hinzman et al. 2005). Present costs of thaw-related damage to structures and infrastructure in Alaska have been estimated at $35 million per year (NAST 2001). A continued warming of the permafrost is likely to increase the severity of permafrost thaw-related problems. Thawing of any permafrost increases groundwater mobility, reduces soil bearing strength, and increases the susceptibility to erosion and landslides. Thawing could disrupt petroleum exploration and production by shortening the availability of time for minimal-impact operations on ice roads and pads (ACIA 2005).

Loss of sea ice, especially multi-year ice that lasts through summer months, could cause large-scale changes in marine ecosystems and could threaten populations of marine mammals such as polar bears, walruses, and seals that depend on the ice for habitat, hunting, and transportation (Boesch et al. 2000; NAST 2001; Durner et al. 2004; Hopcroft et al. 2008; Karl et al. 2009). With studies examining the impacts of climate change on arctic biota, there have been reported changes in abundance, range shifts, growth rates, behavior, and community dynamics for both terrestrial and marine species (Belkin 2009; Mueter et al. 2009; Wassmann et al. 2011). Seals and polar bears regularly use landfast sea ice as habitat, which is particularly susceptible to climate warming (Boesch et al. 2000). Ice edges are biologically productive systems in which ice algae form the base of the food chain, which has implications for higher trophic levels (Moline et al. 2008). The sea ice algae are crucial to arctic cod, which is an important species to the diets of seabirds and marine animals in Arctic regions (Bradstreet and Cross 1982; Gradinger and Bluhm 2004). As ice melts, there is concern that there would be loss of prey species of marine mammals, such as arctic cod and amphipods, which are associated with ice edges, and these impacts can propagate through food webs associated with the sea ice biome (ACIA 2005).

Ocean fisheries are highly vulnerable to changes in climatic conditions such as sea temperature and sea ice conditions (Karl et al. 2009), and fisheries in the Alaska region have experienced decadal-scale variability in climate due to modal patterns of oceanic and atmospheric interactions (Schwing et al. 2010). For example, Pacific salmon populations have shown decadal variability over the past 300 yr, which spans the timeframe of before and after commercial fishing, suggesting the strong coupling of ocean conditions and salmon populations (Finney et al. 2000). In 1977, warmer sea surface temperatures and reduced sea ice conditions generated a “regime shift” in the fisheries of the Gulf of Alaska that carried over into the 1980s, producing large salmon, pollock, and cod populations with a reduction in populations of forage fishes (Boesch et al. 2000; NAST 2001). Evidence of climate change warming effects on fisheries is difficult to detect with respect to decadal variability patterns. However, current trends of increased freshwater inputs, increased ultraviolet radiation, warmer sea surface temperatures, ocean acidification, and reduced sea ice are driving biodiversity changes across trophic levels for marine and freshwater fish of the Alaska region with both positive and negative effects depending on tolerance levels and the ability to adapt to changing habitats of the various fish populations (Reist et al. 2006; Anisimov et al. 2007; Bates and Mathis 2009). In addition to temperature and sea ice changes, permafrost thawing and alterations to terrestrial hydrology have the potential to increase sediment and nutrient availability in estuarine and nearshore habitats, which have a mixture of positive and negative impacts on marine and anadromous fish populations (ACIA 2005; Hopcroft et al. 2008).

Alaska Native subsistence communities have adapted to climate variability in the past, but current warming trends may produce uncharacteristic and extreme environmental conditions that can adversely affect these communities (Berkes and Jolly 2001; Anisimov et al. 2007). Climate change effects such as sea ice melt, permafrost loss, and sea level rise may alter traditional hunting locations and cause shifts in game patterns and quality, travel routes, and inter-community trading and social mechanisms (Alaska Regional Assessment Group 1999; ACIA 2005). In addition to climate change impacts, Alaska Native subsistence communities have been adapting to economic development and modernization occurring in Arctic regions (ACIA 2005; Braund and Kruse 2009). Alaska Native subsistence communities have experienced and are currently experiencing impacts on subsistence activities caused by a combination of environmental, social, and cultural changes. The Alaska Native subsistence communities will find it more difficult to adapt or relocate than they did in the past because most now live in established communities, which will make adaptation to climate change effects problematic in the future (ACIA 2005).

3.4 WATER QUALITY

3.4.1 Gulf of Mexico

The term water quality describes the overall condition of water, reflecting its particular biological, chemical, and physical characteristics. It is an important measure for both ecological and human health. Water quality is most often discussed in reference to a particular purpose or use of the water, such as recreation, drinking, or ecosystem health. This usage divides the analysis area into coastal and marine waters and includes human uses of water for recreation and food harvest along with industrial and domestic uses. Coastal waters include all bays and estuaries from the Rio Grande River to the Florida Bay. Marine water includes both State offshore water and Federal outer continental shelf (OCS) waters extending from outside the barrier islands to the Exclusive Economic Zone. The inland extent is defined by the Coastal Zone Management Act. A further distinction within the marine water areas is between continental shelf water and deep water. Figure 3.4.1-1 illustrates this distinction within marine water areas and the OCS Planning Areas for the GOM.

In general, coastal water quality is influenced by the rivers that drain into the area, the quantity and composition of wet and dry atmospheric deposition, and the influx of constituents from sediments. Human activities influence the waters closest to the land. Circulation or mixing of the water may either improve the water quality through dilution or degrade the quality by introducing factors that contribute to water quality decline.

Marine water composition in the GOM has two primary influences. These are the configuration of the GOM Basin, which controls the oceanic waters that enter and leave the GOM, and runoff from the land masses, which controls the quantity of freshwater input into the GOM. The GOM receives oceanic water from the Caribbean Sea through the Yucatan Channel and freshwater from major continental drainage systems such as the Mississippi River system. Estuarine and fluvial drainage areas in the GOM region are shown in Figure 3.2.1-4. The three major fluvial drainage areas (FDAs) drain a total of 4.1 million square kilometers (km^2) (1.6 million square miles [mi^2]) of the inland continental United States, and have a large influence on water quality in the GOM. The large amount of freshwater runoff mixes into the GOM surface water, producing a different composition on the continental shelf from that in the open ocean.

3.4.1.1 Coastal Waters

The GOM coast contains one of the most extensive estuary systems in the world. This system extends from the Rio Grande River in Texas eastward to Florida Bay in Florida. Estuaries, semi-enclosed basins within which the freshwater of rivers and the higher salinity waters offshore mix, are influenced by both freshwater and sediment influx from rivers and the tidal actions of the oceans. The primary variables that influence coastal water quality are water temperature, total dissolved solids (salinity), suspended solids (turbidity), and nutrients. An estuary’s salinity and temperature structure are determined by hydrodynamic mechanisms governed by the interaction of marine and terrestrial influences. Hydrodynamic influences include tides, nearshore circulation, freshwater discharges from rivers, and local precipitation. Tidal mixing within GOM estuaries is limited by the small tidal ranges that occur along the GOM coast. The shallowness of most GOM estuaries, however, tends to amplify the mixing effect of the small tidal range. GOM coast estuaries exhibit a general east-to-west trend in selected attributes of water quality associated with changes in regional geology, sediment loading, and freshwater inflow. For example, the estuarine waters in Florida generally have greater clarity and lower nutrient concentrations than those in the central and western areas of the GOM coast.

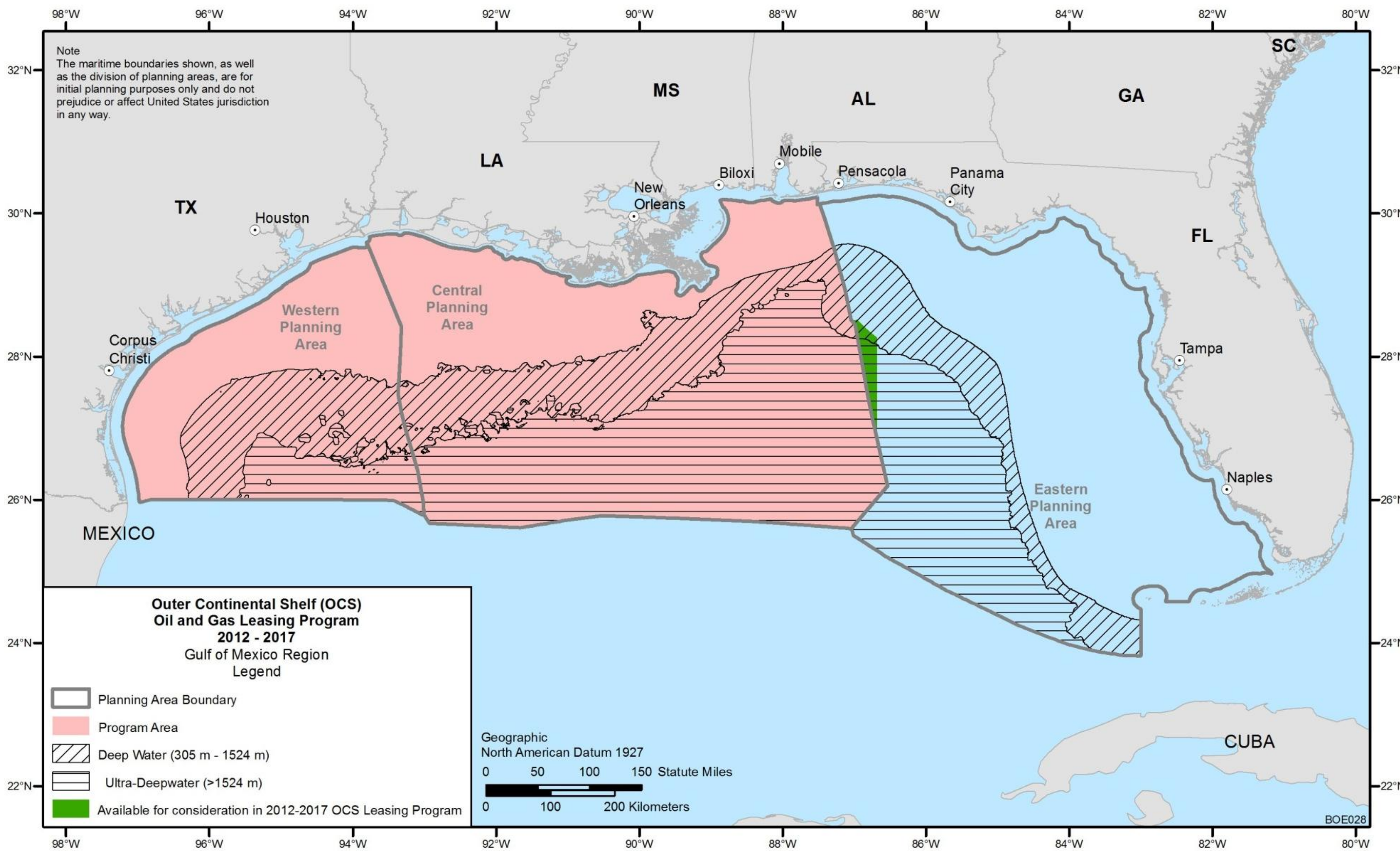

FIGURE 3.4.1-1 Depth Zones within GOM Planning Areas and Program Areas for the OCS Oil and Gas Leasing Program 2012-2017

The primary factors that affect estuarine water quality include upstream withdrawals of water for agricultural, industrial, and domestic purposes; contamination by industrial and sewage discharges; agricultural runoff carrying fertilizer, pesticides, and herbicides; upstream land use; redirected water flows; and habitat alterations (e.g., construction and dredge-and-fill operations). Because drainage from more than 55% of the conterminous United States enters the GOM primarily from the Mississippi River, a large area of the nation contributes to coastal water quality conditions in the GOM (see Figure 3.2.1-4). There are also three major estuarine drainage areas (EDAs) that drain approximately 250,000 km^2 (95,000 mi^2) of coastal areas along the GOM, strongly influencing water quality in the estuarine environments (NOAA 1999).

Population growth results in additional clearing of the land, excavation, construction, expansion of paved surface areas, and drainage controls. These activities alter the quantity, quality, and timing of freshwater runoff. Stormwater runoff that flows across impervious surfaces is more likely to transport contaminants associated with urbanization including suspended solids, heavy metals and pesticides, oil and grease, and nutrients (U.S. Commission on Ocean Policy 2004). Additional information on factors that contribute to coastal water quality can be found in the sociocultural systems section of this chapter.

Coastal water quality is also affected by the loss of wetlands, which is discussed in detail in Section 3.7.1. Wetlands improve water quality through filtration of runoff water and provision of valuable habitat. Suspended particulate material is trapped and removed from the water, resulting in greater water clarity. Nutrients may also be incorporated into vegetation and wetland sediments and removed from the water that passes through the wetlands.

The first USEPA National Coastal Condition Report summarized coastal conditions with data collected from 1990 to 1996 (USEPA 2001). The USEPA updated this information in a third report (USEPA 2008). The first report rated the overall condition of the GOM coastal region as fair to poor. The third report ranked the water quality index fair and the overall condition fair to poor (USEPA 2008). The water quality ranking used five factors: (1) dissolved oxygen, (2) dissolved inorganic nitrogen, (3) dissolved inorganic phosphorus, (4) chlorophyll *a*, and (5) water clarity. Contaminated sediments pose an immediate threat to benthic organisms and an eventual threat to estuarine ecosystems as a whole. Contaminants in sediments may be resuspended into the water by anthropogenic activities, storms, or other natural events, where they can expose organisms in the water column and can accumulate and move up the food chain, eventually posing health risks to humans (USEPA 2011g). The sediment quality index of the GOM coast region was ranked as poor (USEPA 2008). Sediments in the GOM coast region have been found to contain pesticides, metals, polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs) (USEPA 2008).

Hurricanes Katrina and Rita resulted in a number of impacts on water quality conditions in the GOM as a result of storm damage to pipelines, refineries, manufacturing and storage facilities, sewage treatment facilities, and other facilities and infrastructure. For example, Katrina damaged 100 pipelines, which resulted in approximately 211 minor pollution reports to the former Minerals Management Service (MMS) (now the BOEM), while Rita damaged 83 pipelines, resulting in 207 minor pollution reports (MMS 2006a). Flood waters pumped into Lake Pontchartrain contained a mixture of contaminants, including sewage, bacteria, heavy metals, pesticides, and other toxic chemicals, and as much as 24,600 cubic meters (m^3) (6.5 million gal) of oil (Sheikh 2006). Sources of these contaminants include damaged sewage treatment plants, refineries, manufacturing and storage facilities, and other industrial and agricultural facilities and infrastructure (Sheikh 2006). The flood waters of New Orleans were oxygen depleted and contained elevated bacterial levels, but the pollutants occurred at about the same concentrations as typical stormwater runoff (Pardue et al. 2005). Testing following the storm identified low levels of fecal coliform in Mississippi Sound and Louisiana coastal waters. Very few toxics resulting from the hurricanes were detected in estuarine or coastal waters (USEPA 2010).

The heavy rainfall associated with Katrina increased agricultural runoff of nutrients into the GOM and decreased salinity of nearshore waters (NOAA and NMFS 2007). Storm surges as a result of the hurricanes caused temporary saltwater intrusion in some estuarine areas (NOAA and NMFS 2007). The release of contaminated Lake Pontchartrain waters into the GOM, as well as releases from damaged pipelines, caused short-term impacts on water quality in the GOM. Tidal action and normal current patterns in the GOM resulted in the dilution and dispersal of any heavily contaminated waters, potentially limiting any long-term effects on GOM water quality (Congressional Research Service 2005). Levels of contamination in oyster populations in coastal Louisiana and Mississippi after hurricane Katrina were measured and compared to the 20-yr record of contamination. Levels of organochlorine compounds and PAHs were found to be below normal, and levels of metals/trace elements were found to be elevated at most sites, compared to the historical record (NCCOS 2006).

3.4.1.2 Marine Waters

Within the GOM, marine waters occur in three regions: (1) the continental shelf west of the Mississippi River (primarily the Western GOM Planning Area and the western half of the Central GOM Planning Area), (2) the continental shelf east of the Mississippi River (the eastern half of the Central GOM Planning Area and the Eastern GOM Planning Area), and (3) deep water (>310 m). Figure 3.4.1-1 illustrates the marine water areas and the OCS Planning Areas for the GOM.

3.4.1.2.1 Continental Shelf West of the Mississippi River. The water quality in this area is highly influenced by input of sediment and nutrients from the Mississippi and Atchafalaya Rivers (Murray 1997). The Mississippi-Atchafalaya River Basin drains about 41% of the conterminous United States (see Mississippi Coastal Subregion FDA in Figure 3.2.1-4). A turbid surface layer of suspended particles is associated with the freshwater plume from these rivers. The river system supplies nitrate, phosphate, and silicate to the shelf. During summer months, the low-salinity water from the Mississippi River spreads out over the shelf, resulting in a stratified water column. While surface oxygen concentrations are at or near saturation, hypoxia, defined as oxygen concentrations less than 2 milligrams per liter (mg/L), is observed in bottom waters during the summer months in waters of the continental shelf west of the Mississippi River.

The Hypoxic Zone. Hypoxic, or low-oxygen, conditions occur on the continental shelf in the northern part of the GOM in areas where the dissolved oxygen level is below 2 mg/L. Hypoxia in the GOM is attributed to large nutrient influxes from the rivers draining the continental United States and stratification of GOM waters from differences in temperature and density (Mississippi River/GOM Watershed Nutrient Task Force 2009). The average size of the hypoxic zone over the period of measurement (1985–2011) is 13,600 km^2 (5,300 mi^2) (LUMCON 2011). Over the 5-yr period between 2006 and 2010, the hypoxic zone had an average size of 17,300 km^2 (6,700 mi^2), and in 2010, the hypoxic zone was measured to be 17,520 km^2 (6,765 mi^2) (USEPA 2011?). The hypoxic zone increased from an average size of 8,300 km^2 (3,200 mi^2) in the 1985−1992 period to more than 16,000 km^2 (6,200 mi^2) in the 1993−1997 period (Rabalais et al. 2002), and it reached a record 22,000 km^2 (8,500 mi^2) in 2002. The size of the hypoxic zone is directly correlated with the flux of nitrogen from the Mississippi River and river discharge (Scavia et al. 2003). Veil et al. (2005) evaluated the loading of nutrients and other oxygen-demanding materials in produced water discharged from offshore oil and gas platforms located in the hypoxic zone. Veil et al. (2005) found that the nitrogen and phosphorus loading in produced water discharges were about 0.16% and 0.013%, respectively, of the nutrient loading entering the GOM from the Mississippi and Atchafalaya Rivers.

Pollutant Sources. Analysis of shelf sediments off the coast of Louisiana has found trace organic pollutants including PAHs, herbicides such as Atrazine, chlorinated pesticides, PCBs, and trace inorganic (metal) pollutants (Turner et al. 2003). The detection of organochlorine pesticides and PAHs in sediment cores collected in water depths of 10 to 100 m (33 to 330 ft) off the southwest pass of the Mississippi River increased in sediments deposited after the 1940s (Turner et al. 2003). The river was identified as the primary source of both organochlorine and the pyrogenic PAHs, which are associated with the burning of fossil fuels; however, higher concentrations of petrogenic PAHs, associated with natural seeps and/or oil and gas exploration, were found farther from the mouth of the river (Turner et al. 2003).

The offshore oil and gas industry operates hundreds of platforms throughout this portion of the GOM. Many platforms have discharges of drilling wastes, produced water, and other industrial wastewater streams that have adverse impacts on water quality. The USEPA regulates the discharge of these wastes through an NPDES permit. Except in shallow waters, the effects of these discharges are generally localized near individual points of discharge (Neff 2005).

3.4.1.2.2 Continental Shelf East of the Mississippi River. Water quality on the continental shelf from the Mississippi River Delta to Tampa Bay is influenced by river discharge, runoff from the coast, and eddies from the Loop Current. The Mississippi River accounts for 72% of the total discharge onto the shelf (SUSIO 1975). The outflow of the Mississippi River generally extends 75 km (45 mi) to the east of the river mouth (Barry A. Vittor & Associates, Inc. 1985), except under extreme flow conditions. Mobile Bay and several smaller rivers east of the Mississippi River including the Apalachicola and Suwannee Rivers also contribute runoff to the area (Jochens et al. 2002). The Loop Current intrudes in irregular intervals onto the shelf, and the water column can change from well mixed to highly stratified very rapidly. Discharges from the Mississippi River can be easily entrained in the Loop Current.

Hypoxia is rarely observed on the Mississippi-Alabama shelf, although near-hypoxic conditions have been observed in the spring and summer during research cruises in 1987 through 1989 (Brooks and Giammona 1991) and 1998 through 2000 (Jochens et al. 2002).

The Mississippi-Alabama shelf sediments are strongly influenced by fine sediments discharged from the Mississippi River. The shelf area is characterized by a bottom nepheloid layer and surface lenses of suspended particulates that originate from river outflow. The West Florida Shelf receives very little sediment input. The water clarity is higher toward Florida, where the influence of the Mississippi River outflow is rarely observed.

Pollutant Sources. Analysis of water, sediments, and biota for hydrocarbons between 1974 and 1977 indicated that the Mississippi, Alabama, and Florida (MAFLA) area is pristine, with some influence of anthropogenic and petrogenic hydrocarbons from river sources (SUSIO 1977; Dames and Moore, Inc. 1979). Analysis of trace metal contamination for the nine trace metals analyzed (barium, cadmium, chromium, copper, iron, lead, nickel, vanadium, and zinc) also indicated no contamination sources (SUSIO 1977; Dames and Moore, Inc. 1979). A study done between 1987 and 1989 indicated that high molecular-weight hydrocarbons can come from natural petroleum seeps at the seafloor or recent biological production as well as input from anthropogenic sources (Brooks and Giammona 1991). The primary source of petroleum hydrocarbons and terrestrial plant material on the Mississippi-Alabama shelf is the Mississippi River. Higher levels of hydrocarbons were observed in late spring, coinciding with increased river influx. The sediments, however, are washed away later in the year, as evidenced by low hydrocarbon values in winter months. Contamination from trace metals was not observed (Brooks and Giammona 1991).

Several small rivers and the Loop Current are the primary influences on water quality on the shelf from DeSoto Canyon to Tarpon Springs and from the coast to a 200-m (656-ft) water depth (SAIC 1997). Because there is very little onshore development in this area, the waters and surface sediments are uncontaminated. The Loop Current flushes the area with clear, low-nutrient water (SAIC 1997).

Deep Water. Limited information is available on the deepwater environment of the GOM. Water at depths greater than 1,400 m (4,600 ft) is generally relatively homogeneous with respect to temperature, salinity, and oxygen (Nowlin 1972; Pequegnat 1983; Gallaway and Kennicutt 1988). A dissolved-oxygen low appears to occur at water depths of between 250 and 750 m (820 and 2,460 ft), depending upon the location within the GOM (Nowlin 1972). Pequegnat (1983) has pointed out the importance of the flushing time of the GOM. Jochens et al. (2005) provided a summary of estimated flushing rates presented in the literature, which range from 3 to 270 yr for different areas of the GOM. The waters of the western and southwestern GOM are estimated to have longer flushing times than the rest of the GOM; however, flushing rates are uncertain and are not well understood in the deepwater zone (Jochens et al. 2005). Investigations of historical oxygen data for the GOM and modeling of the distribution indicate that oxygen levels in the deep GOM would suffer only localized impacts from activities, but basin-wide decreases in oxygen would not occur (Jochens et al. 2005).

Limited analyses of trace metals and hydrocarbons for sediments exist, and water column measurements are primarily limited to salinity, temperature, and nutrients (Trefry 1981; Gallaway and Kennicutt 1988; CSA 2006; Rowe and Kennicutt 2009). Between 2000 and 2002, the MMS completed two studies to measure concentrations of organics, metals, and nutrients in sediments in the deepwater zone (CSA 2006; Rowe and Kennicutt 2009). These studies helped to create a baseline of information related to the ecological function of these sediments, the extent of naturally occurring organics, and the impacts seen from OCS oil and gas activities.

Hydrocarbon (oil) seeps are extensive throughout the continental slope and naturally contribute hydrocarbons to the sediments and water column (Sassen et al. 1993a). Remote sensing techniques have identified approximately 350 natural seeps in the northern half of the GOM (Kvenvolden and Cooper 2003). Estimates of the total volume of seeping oil in the northern half of the GOM vary widely from 29,000 barrels per year (bbl/yr) (MacDonald 1998) to 520,000 bbl/yr (Kvenvolden and Cooper 2003). When combined with estimates of oil seeping into the southern portion of the GOM, the estimated volume of oil seeping into the GOM is approximately 1.0 million bbl/yr (Kvenvolden and Cooper 2003). These estimates used satellite data and an assumed slick thickness. At hydrocarbon seeps, pore water of three different origins has been identified to leak out in addition to hydrocarbons: (1) seawater trapped during the settling of sediments, (2) briny fluid that is associated with the dissolution of underlying salt deposits, and (3) highly saline deep-seated formation waters (Fu and Aharon 1998; Aharon et al. 2001). The first two fluids leak out in the vicinity of carbonate deposits, while the third is rich in barium and is associated with barite deposits such as chimneys (Fu and Aharon 1998).

3.4.1.3 Climate Change Effects

Water quality in the GOM is expected to be affected by climate change (Ning et al. 2003). A thorough discussion of the impacts of climate change to the baseline environment can be found in Section 3.3. Anticipated sea-level rise would cause salinity increases in estuaries and lead to increases in coastal erosion (Nicholls et al. 2007). Changes in precipitation in the large fluvial drainage areas that contribute to the GOM (see Figure 3.2.1-4) are anticipated to change the quantity and timing of runoff that enters into the GOM. Significant changes in runoff would impact salinity in the coastal waters of the GOM, change coastal water circulation, and also impact the quantities of contaminants carried to the GOM, including suspended solids, heavy metals, pesticides, oil and grease, and nutrients. Increased runoff would likely deliver increased amounts of nutrients, increase the stratification between warmer fresher and colder saltier water, and potentially lead to eutrophication of estuaries and increase the potential for harmful algal blooms that can deplete oxygen levels (Justic et al. 1996; Karl et al. 2009). Reductions of freshwater flows in rivers or prolonged drought periods could increase the salinity in coastal ecosystems (Twilley et al. 2001). Ocean temperatures in the upper 700 m (2,300 ft) increased by 0.10°C (0.18°F) between 1961 and 2003 (Bindoff et al. 2007). Future sea surface temperature increases are anticipated and would affect chemical and microbial processes in coastal and marine environments. Rising temperatures are anticipated to lead to increased thermal stratification, increased coral bleaching and moratlity, and increased algal blooms, but other impacts are difficult to predict, due to the complexity of ecological processes (Nicholls et al. 2007). In addition, ocean pH values are anticipated to decrease by up to 0.35 pH units over the 21st century, leading to ocean acidification (IPCC 2007a).

3.4.1.4 Deepwater Horizon Event

On April 20, 2010, the Deepwater Horizon drilling platform collapsed leading to the largest offshore oil spill in U.S. history, the Deepwater Horizon event (DWH event) (OSAT 2010). It is estimated that between April 22 and July 15, 2010, approximately 4.9 million barrels (with an uncertainty of plus or minus 10%) of oil leaked into the GOM from the DWH event (Lubchenco et al. 2010; TFISG 2010). Analysis of event video footage led scientists to conclude that the the majority of the volume of the release of the DWH event was hydrocarbon gases, and oil was only 44% of the volume of the release (TFISG 2010). In addition, approximately 7,000 m^3 (1.84 million gal) of the chemical dispersants COREXIT 9500 and COREXIT 9527 were used on the DWH event (Oil Spill Commission 2011). Of the total volume, approximately 2,900 m^3 (771,000 gal) of chemical dispersants were applied directly to the DWH wellhead at a depth of about 5,000 ft below the water surface, which was the first application of dispersants at the source of a subsea spill (Kujawinski et al. 2011). An estimate of the fate of the oil was released by the National Incident Command (NIC) in August 2010; findings were as follows: 25% of the oil was estimated to be removed by burning, skimming, and direct recovery from the wellhead; 25% was estimated to have evaporated or dissolved; 24% was estimated to be dispersed; and 26% was estimated to remain as oil on or near the water surface, onshore oil that remains or has been collected, and oil that is buried in sand and sediments (Lubchenco et al. 2010). As of August 2010, oil that was reported to be dissolved or was dispersed into the water column, and thus remaining in the environment, was estimated to be between 2.9 and 3.2 million bbl by a group of academics organized by the Georgia Sea Grant (Hopkinson 2010).

The principal impacting factors to GOM water quality from the DWH event were (1) the release of oil, (2) the release of gas, and (3) the use of chemical dispersants. Impacts of the DWH event on water quality have been monitored by various Federal and State agencies and by the academic community. The December 17, 2010, report released by the Operational Science Advisory Team of the Unified Area Command (OSAT) summarized water and sediment quality data measuring concentrations of oil- and dispersant-related chemicals collected from the start of the DWH event through October 23, 2010 (OSAT 2010). The OSAT is a group of Federal scientists and stakeholders that was put together by the Unified Area Command to collect data to inform cleanup operations, restoration activities, research, and the Natural Resources Damage Assessment (NRDA) process (OSAT 2010). As of January 20, 2011, a total of 13,677 water samples and 4,506 sediment samples had been taken to support the NRDA process (NOAA 2011g). Shoreline Cleanup Assessment Team (SCAT) observations indicated that oiling along barrier islands and coastal areas in Louisiana, Mississippi, Alabama, and Florida during and after the DWH event persisted as of January 2011 (Geoplatform 2011a,b).

The oil that leaked during the DWH event is known as light sweet crude oil and has many chemical constituents. To evaluate the impacts of the DWH event on the environment, the

USEPA has set "benchmark" concentrations of 41 compounds found in the oil from the DWH event for human health, aquatic health, and sediment (OSAT 2010). The compounds include 7 volatile organic compounds (VOCs), 16 parent PAHs, and 18 derivative compounds of the PAHs (OSAT 2010). The composition of the oil from the DWH event varies with the state of weathering of the oil; as the lighter-end components are removed from weathering processes, only the heavier-end components remain (Core and Technical Working Groups 2010). Some of the constituents released during the DWH event evaporated at the surface or rapidly dissolved into the GOM waters before the oil reached the surface. Evidence from the DWH event indicates that methane gas released from the well was rapidly broken down by bacterial action with little oxygen drawdown (Camilli et al. 2010; Kessler et al. 2011). Other constituents remained in the water column and bottom sediments for longer periods (OSAT 2010). In addition, the chemical dispersant used during the spill has been tracked in the GOM by measuring concentrations of 2-butoxyethanol, dipropylene glycol n-butyl ether (DPnB), propylene glycol, and dioctylsulfosuccinate (DOSS) — its four major constituents — and comparing those concentrations to water quality aquatic life benchmarks set by the USEPA (OSAT 2010). Areas contacted by the event were identified by tracking certain constituents. Other chemicals associated with the event include other surface washing agents, which are used to lift oil off of shoreline surfaces and further prevent those surfaces from becoming sources of pollution (NOAA 2011a).

Both short-term and long-term impacts from the DWH event on water quality in the GOM are currently being assessed. The current understanding of the status of water quality in coastal and marine areas as a result of the event will be discussed below.

3.4.1.4.1 Effects of Deepwater Horizon Event on Coastal Water Quality. As a result of the DWH event, oil was present on the surface as well as dispersed and in suspension below the surface in coastal areas (OSAT 2010). The NRDA process has collected a large amount of data, and as of December 1, 2010, approximately 6,400 linear km (4,000 linear mi) of shoreline had been assessed by NRDA teams for oil contamination (NOAA 2010a). Data from regional SCAT teams indicates that oil contamination persisted on GOM shorelines as of December 2010 and January 2011. As of December 20, 2010, the Louisiana SCAT team observations indicated tar balls and varying degrees of oiling were still present on the shoreline and barrier islands of Louisiana. As of January 5, 2011, Mississippi, Alabama, and Florida SCAT team observations indicated varying degrees of oiling were present on the barrier islands and shoreline in Mississippi, Alabama, and western Florida (Geoplatform 2011a,b). As of January 20, 2011, 134 km (83 mi) of shoreline were classified as heavily or moderately oiled (NOAA 2011c).

OSAT reported that all water samples collected after August 3, 2010 (in waters deeper than 10 ft), indicated that oil- and dispersant-related chemicals were below levels set by the USEPA to be chronically toxic to humans and aquatic life. Within 3 km (2 mi) of the wellhead, however, concentrations of oil-related chemicals in the deepwater sediments were still found to be elevated above benchmark concentrations for aquatic life (OSAT 2010). The OSAT report also identified some residual contamination remaining in shallow waters in the form of tar mats, defined as "submerged sedimented oil," located in the sub-tidal zone and reported that sampling to date had not been adequate to define the extent of the tar mats. The OSAT (2010) report indicated the need to further define the tar mats and evaluate them as a potential source of shoreline contamination through "re-oiling."

OSAT (2010) defined nearshore waters as those within 5.6 km (3 nautical mi; 3.5 linear mi) of the coastline, which are also defined as "State" waters in most cases. Visible oil was first found in nearshore waters on approximately May 15, 2010, in Louisiana and June 1, 2010, for Alabama, Mississippi, and Florida. Nearshore water and sediment quality were sampled before oil reached the nearshore zone, starting in late April, to create a baseline/ reference dataset (OSAT 2010). Concentrations of oil-indicator and dispersant chemicals were measured in samples to determine the presence or absence of impacts from the event. The concentrations of those chemicals were then compared with the human health and ecological health benchmarks set by the USEPA as indicators of health risks. Findings of indicator concentrations of oil- and dispersant-related chemicals were also compared to the composition of the oil from the DWH event to rule out samples that may have been contaminated by other sources (e.g., oil leaks from boats). Samples that were found to be of indeterminate origin were considered to be the oil from the DWH event. Results of the water and sediment quality sampling are detailed in Table 3.4.1-1 and indicate that there were very few exceedances of the benchmarks set by the USEPA. No exceedances of the human health benchmark for oil-related chemicals or the aquatic life benchmark for dispersant-related chemicals were measured in samples. Sampling after August 3, 2010, found traces of oil and dispersant remaining in the nearshore zone, but all samples that exceeded water and/or sediment quality benchmarks were not consistent with the oil from the DWH event (OSAT 2010).

3.4.1.4.2 Effects of Deepwater Horizon Event on the Continental Shelf. The December 17, 2010, OSAT report summarized data collected measuring concentrations of oil- and dispersant-related chemicals in water and sediment from the start of the event through October 23, 2010. The OSAT (2010) report defined the offshore zone as those waters between 5.6 km (3 nautical mi) of the coastline (boundary of "State" waters) to the 200-m (656-ft) bathymetric contour. Concentrations of oil- and dispersant-indicator chemicals were measured in samples to determine the presence or absence of impacts from the event. The concentrations of those chemicals were then compared with the human health and ecological health benchmarks set by the USEPA as indicators of health risks. Findings of indicator concentrations of oil- and dispersant-related chemicals were also compared to the composition of the oil from the DWH event to rule out samples that may have been contaminated by other sources (e.g., oil leaks from boats). Results of the water and sediment quality sampling are detailed in Table 3.4.1-1 and indicate that there were very few exceedances of the benchmarks set by the USEPA. No exceedances of the human health benchmark for oil-related chemicals or the aquatic life benchmark for dispersant-related chemicals were measured in water samples, and no exceedances of the aquatic life benchmark for oil-related chemicals were measured in sediment samples. Sampling after August 3, 2010, found traces of oil and dispersant remaining in the offshore zone, but no samples taken after this time had concentrations that exceeded water quality benchmarks (OSAT 2010).

3.4.1.4.3 Effects of Deepwater Horizon Event on Deep Water. The December 17, 2010, OSAT report summarized oil- and dispersant-related chemical concentrations in water and sediment from the start of the DWH event through October 23, 2010. The OSAT (2010) defined the deepwater zone as those waters beyond the 200-m (656-ft) bathymetric contour. Concentrations of oil- and dispersant-indicator chemicals were measured in samples to determine the presence or absence of impacts from the DWH event. The concentrations of those chemicals were then compared with the human health and ecological health benchmarks set by the USEPA as indicators of health risks. Findings of indicator concentrations of oil- and dispersant-related chemicals were also compared to the composition of the oil from the DWH event to rule out samples that may have been contaminated by other sources (e.g., oil leaks from boats). Results of the water and sediment quality sampling (Table 3.4.1-1) indicate that there were very few exceedances of the benchmarks set by the USEPA. No exceedances of the human health benchmark for oil-related chemicals or the aquatic life benchmark for dispersant-related chemicals were measured in samples. Sampling after August 3, 2010, found traces of oil and dispersant remaining in the deepwater zone, and seven sediment samples taken within 3 km (2 mi) of the wellhead exceeded the aquatic life sediment quality benchmark and were consistent with the oil from the DWH event (OSAT 2010).

Camilli et al. (2010) conducted a subsurface hydrocarbon study two months after the DWH event (depth 1,500 m [4,921 ft]) in the GOM. They found a continuous oil plume at a depth of approximately 1,100 m (3,609 ft) that extended for 35 km (22 mi) from the DWH event site. The plume consisted of monoaromatic hydrocarbons (benzene, toluene, ethylbenzene, and xylene) at concentrations greater than 50 micrograms per liter. The plume persisted for months at this depth with no substantial biodegradation. They also measured concentrations throughout the water column and found similarly high concentrations of aromatic hydrocarbons in the upper 100 m (328 ft). Polycyclic aromatic hydrocarbons were found at very high concentrations (reaching 189 micrograms per liter) by Diercks et al. (2010) after the DWH event at depths between 1,000 and 1,400 m (3,281 and 4,593 ft) extending as far as 13 km (8 mi) from the subsurface DWH event site.

Joye et al. (2011) estimated that the DWH event released 500,000 tons of hydrocarbon gases at depth. They found high concentrations of dissolved hydrocarbon gases (methane, ethane, propane, butane, and pentane) in a water layer between 1,000 and 1,300 m (3,281 and 4,265 ft) (Joye et al. 2011). These concentrations exceeded the background concentration of hydrocarbon gases by up to 75,000 times. Results from a study by Yvon-Lewis et al. (2011) showed that, beginning 53 days after the DWH event and for 7 days of continuous chemical analysis at sea, there was a low flux of methane from the DWH event to the atmosphere. Based on these methane measurements at the surface water and concurrent measurements at depth, they concluded that the majority of methane from the DWH event remained dissolved in the deep ocean waters (Yvon-Lewis et al. 2011). Valentine et al. (2010) reported that two months after the DWH event, propane and ethane gases at depth were the major gases driving rapid respiration by bacteria. They also found these gases at shallower depths but at concentrations that were orders of magnitude lower (Valentine et al. 2010).

Methane release in the DWH event and biodegradation by deepwater methanotrophs were studied by Kessler et al. (2011). They found that a deepwater bacterial bloom respired the

TABLE 3.4.1-1 Summary of Results of Water and Sediment Quality Sampling from the Deepwater Horizon Event as of October 23, 2010[a]

Sample Type	Total Samples	Number of Detects	Samples Exceeding Benchmark[b]	Exceedances Consistent with Oil from DWH Event
Nearshore Zone[c]				
Oil-Related Chemicals				
Water quality sample compared to human health benchmark[b]	6,090	2,685	0	0
Water quality sample compared to aquatic life benchmark	5,773	395	41	22
Sediment quality sample compared to aquatic life benchmark	1,136	441	24	13
Dispersant-Related Chemicals				
Water quality sample compared to aquatic life benchmark	5,262	60	0	0
Sediment quality sample	412	6	NA[d]	NA
Offshore Zone[e]				
Oil-Related Chemicals				
Water quality sample compared to human health benchmark[b]	750	242	0	0
Water quality sample compared to aquatic life benchmark	481	283	6	6
Sediment quality sample compared to aquatic life benchmark	268	207	0	0
Dispersant-Related Chemicals				
Water quality sample compared to aquatic life benchmark	440	199	0	0
Sediment quality sample	242	1	NA	NA
Deepwater Zone[f]				
Oil-Related Chemicals				
Water quality sample compared to human health benchmark[b]	4,794	673	0	0
Water quality sample compared to aquatic life benchmark	3,612	821	70	63
Sediment quality sample compared to aquatic life benchmark	120	114	7	7
Dispersant-Related Chemicals				
Water quality sample compared to aquatic life benchmark	4,114	353	0	0
Sediment quality sample	120	1	NA	NA

[a] Data as presented in OSAT (2010).

[b] Values of the USEPA benchmarks are presented in the report by OSAT (2010).

[c] Nearshore zone is defined as coastal waters out to 5.6 km (3 nautical mi) from the shoreline (State waters).

[d] NA = No sediment quality benchmarks were established for dispersant-related chemicals.

[e] Offshore zone is defined as waters from 5.6 km (3 nautical mi) of the shoreline to a depth of 200 m (656 ft).

[f] Deepwater zone is defined as waters deeper than 200 m (656 ft).

majority of the methane in approximately 120 days. Similarly, Hazen et al. (2010) found indigenous bacteria at 17 deepwater stations biodegrading oil 2–3 months after the DWH event. The fate of 771,000 gallons of chemical dispersants injected at the DWH wellhead near the seafloor (1,500 m [4,921 ft]) was studied by Kujawinski et al. (2011). Their results show that the dispersants injected at the wellhead were concentrated in hydrocarbon plumes at 1,000–1,200 m (3,281–3,937 ft) depth 64 days after dispersant application was stopped and as far away as 300 km (186 mi). They concluded that the chemical dispersants at this depth underwent slow rates of biodegradation (Kujawinski et al. 2011).

3.4.2 Alaska – Cook Inlet

The term water quality describes the overall condition of water, reflecting its particular biological, chemical, and physical characteristics. It is an important measure for both ecological and human health. Water quality is most often discussed in reference to a particular purpose or use of the water, such as recreation, drinking, or ecosystem health. Alaska State and Federal laws define the type of water quality that must be maintained for these purposes.

Alaska marine waters are a mixture of several sources — atmospheric (precipitation), rivers, streams, groundwater, snowmelt, glacier-melt, ice-melt, and oceanic sources such as vents on the deep seafloor. Constituents in marine waters come into the system naturally (biogenic) and are introduced by humans (anthropogenic). Climate change is affecting the sources and constituents of marine water as increasing carbon dioxide and increasing air temperatures force changes in seawater acidification, seawater temperature, and related water quality variables.

Precipitation, snowmelt, glaciers, and groundwater springs feed the many lakes, streams, ponds, and wetlands throughout Alaska. High tundra, muskeg, willow-alder habitats, and alpine bedrock feed constituents into these freshwater systems. Rivers originating in headwaters introduce and transport sediment into the drainage basins on a seasonal basis. Volcanic eruptions have also played an important role in contributing chemical constituents to the freshwater systems of Alaska.

In Alaska, there are several seasonal or occasional natural events that contribute to water quality and to which natural systems are adapted. Examples of these events include hydrocarbons from natural oil seeps, sediment from coastal erosion, sediment derived from glacial-fed rivers, natural levels of nutrients from river flooding, and metals from volcanic eruptions and rock erosion (AMAP 1997, 2002, 2007). Several metals, such as zinc and iron, in natural low concentrations are essential for life processes in the marine environment (Ezoe et al. 2004).

The Alaska OCS water quality to date has had relatively little exposure from the more common land-based and marine anthropogenic pollution found in the Lower 48 States. The rivers that flow into coastal marine waters remain relatively unpolluted by human activities. Industrial and shipping impacts on water quality have been and are relatively low at this time, with some notable exceptions of events such as the *Exxon Valdez* oil spill and the *Selengdang Ayu* and other ship groundings or accidents.

There are, however, several sources of anthropogenic contaminants in the Alaska marine environment. They travel through pathways to the arctic marine ecosystem including deposition from the atmosphere, discharges to the sea, drifting sea ice, or directly from accidental or intentional dumping of pollutants. Water quality pollutants arrive in Alaska from sources both within and outside the circumpolar environment. The types of pollutants that come from these near and distant sources include oil-based hydrocarbons, manufactured chemicals, metals (e.g., mercury, lead, cadmium), nutrients loads, high sediment loads (nonpoint runoff of disturbed lands), organic waste (e.g., seafood processing), and radionuclides (from radioactive materials).

Persistent organic pollutants (POPs) are a category of anthropogenic pollutants that are particularly resistant to degradation in the environment. POPs have a potential for long-range transport, and they accumulate in concentrations in aquatic species. Polyaromatic hydrocarbons (PAHs), a byproduct of burning hydrocarbon fuel, and polychlorinated biphenyls (PCBs), used in manufacturing products, are two persistent organic pollutants found in the Alaska (AMAP 2004).

Many of these pollutants concentrate in animals and bioaccumulate as they move through the food web. Contaminated animals can then transport the pollutant into or away from the Arctic (AMAP 2004). Migratory whales, migratory seabirds, and salmon species are examples of pollutant transporters through the marine aquatic system.

Human society sometimes discharges into the environment constituents that also occur naturally in the ecosystem. These anthropogenic discharges, however, are different than the biogenic sources because they occur in greater concentrations and often suddenly; the chemical bondings are different than what is found in the natural system; the discharges occur outside the area that they would naturally occur; or they occur out of phase of the natural cycle of the same biogenic contributions to the system. Examples of anthropogenic constituents include sediment, metals, and hydrocarbons.

The Cook Inlet Planning Area is located in south central Alaska and has a watershed of approximately 100,000 km^2 (38,600 m^2) (Saupe et al. 2005). The continental shelf off of south central Alaska supports a productive ecosystem that includes numerous species of fishes, marine mammals, sea birds, and invertebrates. Degradations of water quality, where they occur, are largely related to seasonal biological activity and naturally occurring processes. The Cook Inlet watershed is home to two thirds of the population of the State of Alaska; therefore, runoff in the watershed is influenced by human activity more than in any other region in Alaska (Saupe et al. 2005). The principal point sources of anthropogenic contaminants in Cook Inlet are discharges from municipalities, seafood processors, and the petroleum industry (MMS 1995). Point source pollution is rapidly diluted by the energetic tidal currents in the Cook Inlet, and it is estimated that 90% of the water in the Cook Inlet is flushed every 10 months (MMS 2003a). The State of Alaska has identified several coastal impaired water bodies throughout the south central coastal area that have total maximum daily load (TMDL) restrictions implemented or remain on the Clean Water Act 303(d) list of impaired water bodies with TMDLs planned to be implemented by 2013 (ADEC 2010a). The impaired areas are all relatively small and are mainly affected by urban runoff, timber harvest, or seafood processing (ADEC 2010a). These small impaired areas would not have an appreciable effect on marine water quality. The coastal waters of south central Alaska have recently been assessed to be in good condition by the USEPA National Coastal Condition Report, and were deemed to be in better condition than any other U.S. coastal waters assessed for the report (USEPA 2008).

Cook Inlet waters are influenced by riverine and marine inputs. During summer and fall, surface salinity varies from 32% at the entrance to lower Cook Inlet to approximately 26% at the West Forelands (Rosenberg et al. 1967; Kinney et al. 1970; Wright et al. 1973; Gatto 1976; Muench et al. 1978). Oxygen levels measured in May 1968 in the surface waters of Cook Inlet ranged from about 7.2 to 11.0 mL/L (Kinney et al. 1970). None of the waters in the inlet were found to be oxygen depleted, because of the strong tidal currents in the inlet that mix the entire water column (Kinney et al. 1970).

The distribution of suspended particulate matter in Cook Inlet shows horizontal gradients in both the longitudinal and cross-inlet directions (Feely and Massoth 1982). The suspended particulate matter concentrations are higher (up to 2,000 parts per million [ppm]) in the northeastern end of upper Cook Inlet and decrease through the lower inlet (up to 100 ppm) depending on inputs from rivers at the time of measurement (Kinney et al. 1970; Wright et al. 1973; Sharma 1979; Feely and Massoth 1982; Saupe et al. 2005).

The activities associated with petroleum exploitation in State waters that are most likely to affect water quality in the Cook Inlet are (1) the permitted discharges from exploration drilling units and production platforms and (2) petrochemical plant operations. The USEPA compared pollutant concentrations resulting from an estimated Cook Inlet discharge of cuttings generated while drilling with synthetic-based fluid to both Federal criteria and State water quality standards (because the projected discharges occur in State waters). There was no predicted exceedance of the Federal criteria or State water quality standards in the Cook Inlet (USEPA 2000). The National Research Council (NRC 2003b) estimated that the total amount of produced water being released into Cook Inlet waters was 45.7 million bbl/yr in the 1990s. Produced water can contain hydrocarbons, salts, and metals at levels toxic to marine organisms. Before being discharged into the ocean, produced water is typically treated and must meet NPDES requirements regarding discharge rate, contaminant concentration, and toxicity, thereby reducing the potential for water column and sediment contamination.

Sediment sampling for sediment quality was conducted in depositional areas in the outer portion of Cook Inlet in 1997 and 1998 (Boehm et al. 2001a). Analysis of dated sediment cores demonstrated that the concentration of hydrocarbons has not increased appreciably over the past few decades (since before State offshore oil exploration and production in Cook Inlet). The concentrations of total PAHs found by Boehm et al. (2001a) in the outer portion of Cook Inlet range from less than 120 to 490 parts per billion (ppb). The highest concentrations tend to occur in the southeast corner of Cook Inlet. These concentrations are the result of a combination of eroded coal and oil sources, plus seep oil being deposited in sediments by the coastal current entering Cook Inlet from the eastern Gulf of Alaska (Boehm et al. 2001a). The concentrations downcurrent of Cook Inlet are actually diluted up to several-fold by Cook Inlet discharges. This results in the highest concentrations of hydrocarbons existing in coastal sediments where the influence of estuarine Cook Inlet discharges is smallest, particularly in eastern lower Cook Inlet

(Boehm 2001). Water and sediment quality were also sampled in 2002 by the USEPA and the Alaska Department of Environmental Conservation (ADEC) for the National Coastal Assessment Program (Saupe et al. 2005). Total PAH concentrations in sediments of Cook Inlet ranged from less than 10 ppb to 840 ppb, with the majority of samples having concentrations less than 150 ppb (Saupe et al. 2005). No persistent organic contaminants, such as PCBs or dichlorodiphenyltrichloroethanes (DDTs) were detected in sediments during sampling in 2002 (Saupe et al. 2005). Sampling for metals concentrations in sediment indicate that levels of most metals are below a range to produce effects (as defined by the ADEC); however, concentrations of nickel and chromium in sediments were found to exceed the threshold for effects at three stations and one station, respectively, within the Cook Inlet (Saupe et al. 2005). Measurements of sediment total organic carbon taken in 1971 were found to be low and suggestive of an unpolluted environment (MMS 2003a).

Hydrocarbons are found throughout the waters of Cook Inlet in generally low concentrations. Natural oil seeps occur on the west side of the Cook Inlet, which release hydrocarbons from biogenic sources (Saupe et al. 2005). Concentrations generally are similar to those found in other unpolluted coastal areas.

3.4.2.1 Climate Change Effects

Climate change is anticipated to impact water quality of the Cook Inlet. A thorough discussion of the impacts of climate change to the baseline environment can be found in Section 3.3. Anticipated sea-level rise would cause salinity increases in estuaries and lead to increases in coastal erosion (Nicholls et al. 2007). Increases in precipitation are anticipated to increase the quantity of runoff that enters into Cook Inlet (IPCC 2007a). Significant changes in runoff would impact salinity in Cook Inlet, change water circulation and stratification in Cook Inlet, and also impact the quantities of suspended solids and nutrients delivered to Cook Inlet (ACIA 2005). In addition, anticipated thaw of permafrost would increase susceptibility to erosion and landslides, which could lead to increased input of suspended solids to Cook Inlet (ACIA 2005). Ocean temperatures in the upper 700 m (2,300 ft) increased by 0.10°C (0.18°F) between 1961 and 2003 (Bindoff et al. 2007). Future sea surface temperature increases are anticipated and would affect chemical and microbial processes in coastal and marine environments (Nicholls et al. 2007). Coastal erosion is anticipated to increase due to climate change (Alaska Regional Assessment Group 1999). In addition, ocean pH values are anticipated to decrease by up to 0.35 pH units over the 21st century, leading to ocean acidification (IPCC 2007a).

3.4.3 Alaska – Arctic

The term water quality describes the overall condition of water, reflecting its particular biological, chemical, and physical characteristics. It is an important measure for both ecological and human health. Water quality is most often discussed in reference to a particular purpose or use of the water, such as recreation, drinking, or ecosystem health. Alaska State and Federal laws define the type of water quality that must be maintained for these purposes. General characteristics of water quality in Alaskan waters are presented above in Section 3.4.2.

Because of limited municipal and industrial activity around the Arctic Ocean coast, most pollutants occur at low levels in the Arctic. The rivers that flow into the Alaskan arctic marine environment remain relatively unpolluted by human activities, but they carry into the marine environment suspended sediment particles with trace metals and hydrocarbons. Winds and drifting sea ice may play a role in the long-range redistribution of pollutants in the Arctic Ocean. The broad arctic distribution of pollutants is described in a report by the Arctic Monitoring and Assessment Program (AMAP 1997) entitled *Arctic Pollution Issues: A State of the Arctic Environmental Report*.

The areas of the Arctic region in the proposed action are in the Beaufort and Chukchi Sea Planning Areas (Figure 3.4.3-1). Under Alternatives 5 and 6, leasing activity would be deferred in the Beaufort and Chukchi Sea, respectively. In both seas, the water quality is relatively pristine. Degradation of water quality, where it occurs in the Arctic, is largely related to localized anthropogenic pollution from, for example, mining facilities and former military facilities (ADEC 2010a).

Water quality in the nearshore Arctic Ocean (landward of the 40-m [131-ft] water depth line) may be slightly affected locally by both anthropogenic and natural sources. Most detectable pollutants occur at very low levels in the arctic waters and/or sediments and do not pose an ecological risk to marine organisms (MMS 2003a). The State of Alaska does not identify any Clean Water Act Section 303(d) impaired water bodies within the Arctic region (ADEC 2010a). However, some annual water quality monitoring (temperature and total dissolved solids) is required for the Nearshore Beaufort Lagoons as a condition for oil and gas operations. The Nearshore Beaufort Lagoons were on the Clean Water Act 303(d) list for impaired water bodies between 1996 and 1998 for temperature and salinity, but mitigation measures have brought water quality into compliance with Alaska standards since 2002 (ADEC 2010a).

The primary rivers that flow into the arctic marine environment remain relatively unpolluted by human activities. They do, however, carry into the marine environment suspended sediment particles with some trace metals, hydrocarbons, and other pollutants. Suspended sediment concentrations are highest during the spring runoff, when rivers flow into the Arctic under landfast ice (Alkire and Trefry 2006). Plumes of river water can extend to 20 km (12.4 mi) under the ice, as mixing and wave action are low under the seasonal ice (Alkire and Trefry 2006).

Suspended sediment concentrations in the Beaufort Sea under summer conditions are usually low, but can be elevated by wind-wave activity in shallow waters closer to shore (less than 10 m [33 ft] deep) (Boehm et al. 2001b). Suspended sediment concentrations in the Beaufort Sea are estimated to be at background levels (Trefry et al. 2009). Water quality also is affected by natural erosion of organic material along the shorelines. The Chukchi is a high-energy shore once the ice is gone (MMS 2008b). Erosion and flooding occur with autumn and spring storms and ice movement (MMS 2008b). The increased oxygen demand of these inputs

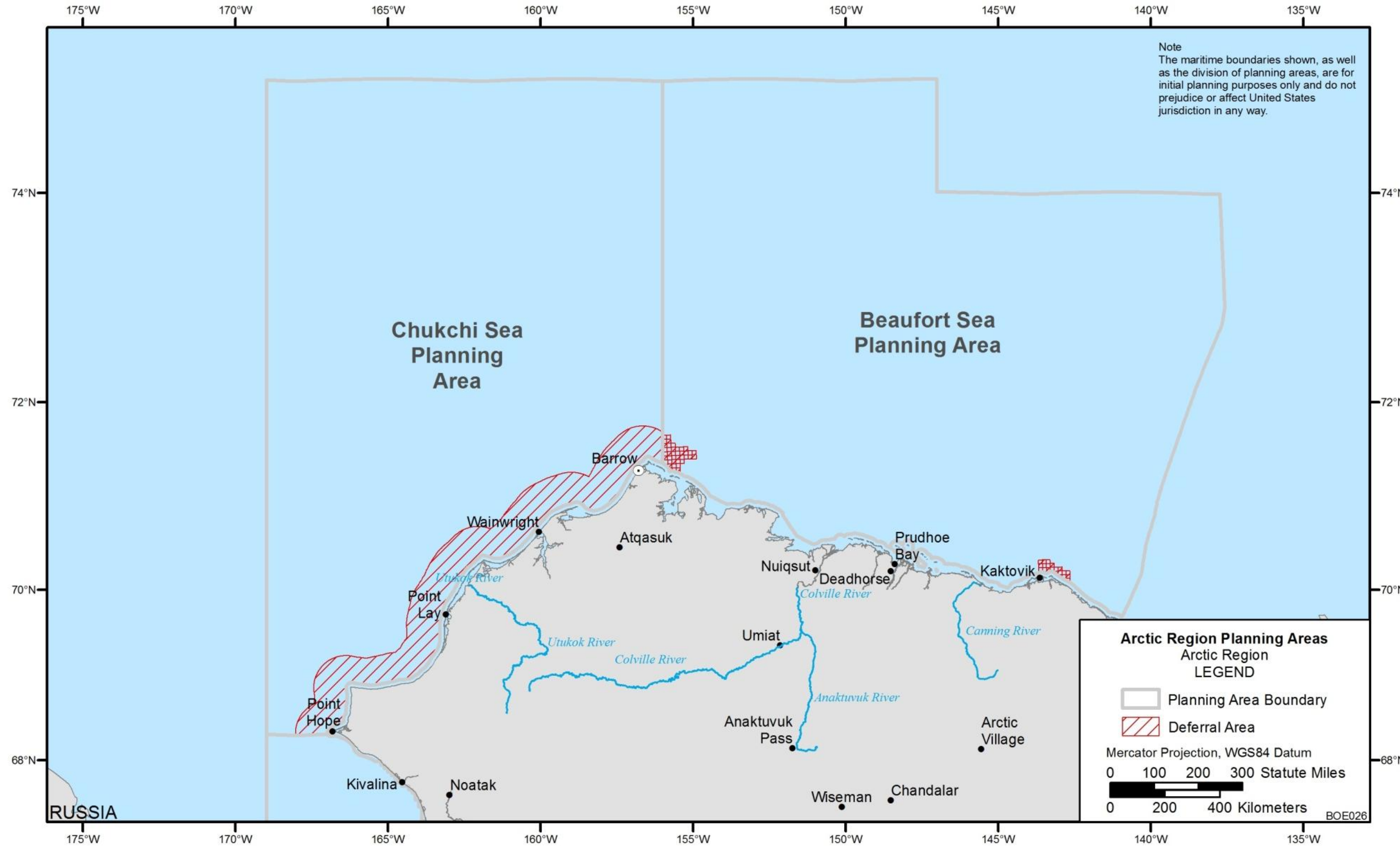

FIGURE 3.4.3-1 Beaufort and Chukchi Sea Planning Areas

may marginally lower oxygen levels and locally increase turbidity. These effects usually occur in waters less than 5 m (16.4 ft) deep and do not generally extend seaward of the barrier islands. Another cause of altered water quality is sea ice cover (MMS 2008b). As sea ice forms during the fall, particulates are removed from the water column by ice crystals and are locked into the ice cover. The result is very low turbidity levels during the winter.

Dissolved and particulate trace metal concentrations in sediments of the Beaufort nearshore do not show evidence of significant impact from the nearby oil and gas activities in Prudhoe Bay (Naidu et al. 2001, 2005; Trefry et al. 2009). However, elevated concentrations of copper, lead, cadmium, silver, arsenic, antimony, nickel, mercury, and cobalt have been measured at a monitoring station near the West Dock in Prudhoe Bay and are assumed to be related to construction activity in the area (Boehm et al. 2001b). Results of monitoring activities around the Northstar site and the original proposed Liberty site also indicate that hydrocarbon and metals concentrations in sediments are not significantly influenced by anthropogenic input (Brown 2003). Trace-metal concentrations in the Chukchi are elevated compared to those in the eastern portions of the Arctic Ocean. The higher concentrations are thought to come from Bering Sea water that passes first through the Chukchi Sea and then through the Beaufort Sea (MMS 2008b). These waters, however, are considerably lower in trace-metal concentrations than the USEPA criteria for the protection of marine life (MMS 2008b). One potential source of anthropogenic input of trace metals is the Red Dog Mine. A study for the National Park Service (Hasselbach et al. 2005) showed extensive airborne transport of cadmium and lead; although the study was focused only on the Cape Krusenstern National Monument, these contaminants are probably carried out into the Chukchi Sea (Hasselbach et al. 2005).

Background hydrocarbon concentrations in Beaufort Sea waters appear to be biogenic and on the order of less than 1 ppb (Trefry et al. 2004). No seafloor oil seeps have been identified in the Beaufort or Chukchi Sea (Becker and Manen 1988). However, naturally occurring oil seeps have been identified onshore above the low-tide line along the coast of the Beaufort Sea (Becker and Manen 1988). Recent studies of sediments in Beaufort Lagoon, located in the eastern portion of the Alaskan arctic coast, have indicated that no anthropogenic hydrocarbon or metals contamination exists (Naidu et al. 2005). These sediment data will serve as a baseline against which to evaluate impacts to nearshore sediments from anthropogenic activities (Naidu et al. 2005). Hydrocarbon concentrations in sediments of the Beaufort Sea are relatively high compared with other undeveloped marine areas (Steinhauer and Boehm 1992). Total hydrocarbon concentrations in sediments range from 2 to 85 milligrams per kilogram (mg/kg) (Steinhauer and Boehm 1992; Naidu et al. 2001; Brown 2003). PAH concentrations in the sediments range from 0.3 to 2 mg/kg, which are well below levels that have detrimental effects on the environment (Brown 2003). Examination of sediment cores gives little indication that oil and gas activities in the area have measurably contaminated the sediments (Brown 2003), and molecular markers do not indicate input from oil and gas industrial activities (Naidu et al. 2001). However, concentrations of hydrocarbons at a sampling site near West Dock in Prudhoe Bay show signs of elevated hydrocarbons when compared to the other sampling stations (Boehm et al. 2001b). Considering the limited sources of anthropogenic input to the area, concentrations of hydrocarbons in the Chukchi Sea are expected to be at background levels.

3.4.3.1 Climate Change Effects

Climate change is anticipated to impact water quality of the Beaufort and Chukchi Seas. A thorough discussion of the impacts of climate change to the baseline environment can be found in Section 3.3. Anticipated sea-level rise would cause salinity increases in estuaries and lead to increases in coastal erosion (Nicholls et al. 2007). Increases in precipitation are anticipated to increase the quantity of runoff that enters arctic waters (IPCC 2007a). Significant changes in runoff would impact salinity and also impact the quantities of suspended solids and nutrients delivered to the Beaufort and Chukchi Seas (ACIA 2005). In addition, anticipated thaw of permafrost would increase the susceptibility to erosion and landslides, which could lead to increased input of suspended solids to arctic waters (ACIA 2005). Ocean temperatures in the upper 700 m (2,300 ft) increased by 0.10°C (0.18°F) between 1961 and 2003 (Bindoff et al. 2007). Future sea surface temperature increases are anticipated and would affect chemical and microbial processes in coastal and marine environments (Nichols et al. 2007). Coastal erosion is anticipated to increase due to climate change, due to permafrost thaw (Alaska Regional Assessment Group 1999). Retreat of sea ice would increase impacts to coastal areas from storms, change the sea surface temperature and salinity, and alter ocean stratification (ACIA 2005). In addition, ocean pH values are anticipated to decrease by up to 0.35 pH units over the 21st century, leading to ocean acidification (IPCC 2007a).

3.5 METEROLOGY AND AIR QUALITY

3.5.1 Climate

3.5.1.1 Gulf of Mexico

Most of the southern States, including the coastal areas along the GOM, have humid subtropical climates characterized by hot summers and mild winters, with high humidity in all seasons. These climates are classified as Cfa under the Köppen-Geiger climate classification system (Peel et al. 2007). The GOM is influenced by a maritime subtropical climate controlled mainly by the clockwise wind circulation around a semipermanent, high barometric pressure area alternating between the Azores and Bermuda Islands. The circulation around the western edge of the high pressure cell results in the predominance of moist southeasterly wind flow in the region. However, winter weather is quite variable. During the winter months, December through March, cold fronts associated with outbreaks of cold, dry continental air masses influence mainly the northern coastal areas of the GOM. Tropical cyclones may develop or migrate into the GOM during the warmer season, especially in the months of August through October. In coastal areas, the land-sea breeze is frequently the primary circulation feature in the months of May through October. Note that the following discussion is limited to the Western and Central Planning Areas and westernmost part of the Eastern Planning Area. Meteorological data summaries are based on two primary references: (1) local climatological data (NCDC 1995, 2011a) for coastal cities along the GOM and (2) meteorological data collected from the shoreline stations and buoy stations over open waters of the GOM (NDBC 2011).

For the coastal areas along the GOM, prevailing wind directions are generally from the southeast and the south, except for the coastal areas stretching from Alabama to the Florida Panhandle, where the prevailing wind is from the north (NCDC 1995, 2011a). Along the southern tip of Texas, southerly and southeasterly winds prevail throughout the year. Along the eastern coastal area (e.g., Pensacola, Florida), these wind components are limited to spring and early summer, and more northerly winds prevail during the rest of the year. Based on the National Data Buoy Center (NDBC) data in the Western and Central Planning Areas, southeasterly winds prevail (NDBC 2011). However, easterly winds are more frequent in the Eastern Planning Area. Near the coastal area in Alabama and the Florida Panhandle, the prevailing wind direction is from the north, the same as that for coastal cities (NCDC 2011a). Average wind speeds from the shoreline and buoy stations are relatively uniform, ranging from 5.2 to 6.4 m/s (11.6 to 14.3 mph), although anemometer heights vary from 5.0 to 30.5 m (16.4 to 100.1 ft). In general, wind speeds are highest in the winter months and lowest in the summer months, except for the shoreline stations in Texas where they are highest in May.

Ambient temperatures in the coastal areas and open waters of the GOM depend primarily on latitude and secondarily on proximity to the coastline. In the warmest month in the summer, average temperatures in the GOM coastal cities are relatively uniform, ranging from about 28 to 29 degrees Celsius (°C) (82 to 85 degrees Fahrenheit [°F]) (NCDC 1995, 2011a). During the warm months, there is little diurnal or spatial variation in temperature. Average temperatures for the coldest month in winter range from about 11°C (51°F) in the northern coastal cities to about 16°C (61°F) in the southernmost city in Texas. Ambient temperatures over the open GOM exhibit much smaller daily and seasonal variations due to the moderating effects of large bodies of water. Annual average temperatures range from 20°C (69°F) at the shoreline stations to 25°C (77°F) at open water buoy stations (NDBC 2011). Irrespective of the locations of NDBC stations, highest monthly temperatures, which occur mostly in August, are relatively uniform, ranging from about 28 to 29°C (82 to 84°F), which are similar to those in the coastal cities (NCDC 1995, 2011a). The lowest monthly temperatures occur mostly in January and vary depending on the location, ranging from 11°C (52°F) at the shoreline stations to 21°C (71°F) at open water buoy stations.

Humid subtropical climates exhibit abundant and fairly well-distributed precipitation throughout the year. Precipitation in the coastal cities along the GOM tends to peak in the summer months; lowest precipitation can occur in any of non-summer seasons. Annual mean precipitation tends to be heavier to the east than to the west of the GOM (NCDC 1995, 2011a). Annual precipitation ranges from 70.0 cm (27.55 in.) in Brownsville, Texas, to 168.4 cm (66.29 in.) in Mobile, Alabama. Rainfall in the warmer months is usually associated with convective cloud systems that produce showers and thunderstorms. Winter rains are associated with the passage of frontal systems through the area. Snowfall along the GOM is uncommon: highest annual snowfall along the coastal cities is about 1.0 cm (0.4 in.) (NCDC 1995, 2011a).

Due to the proximity of the GOM, the relative humidity over the coastal areas is high, especially for the northern coastal areas during the warmer months. Lower humidities in the winter season are associated with outbreaks of cool, dry continental air from the interior. Annual average relative humidities range from 75 to 79% for the coastal cities along the GOM (NCDC 1995, 2011a). Typically, the highest relative humidity occurs during the coolest part of the day (around sunrise), while the lowest relative humidity occurs during the warmest part of the afternoon.

Fog occurs occasionally in the cooler season as a result of warm, moist GOM air blowing over cool land or water surfaces. The number of days with heavy fog (visibility of 0.4 km [0.25 mi] or less) occur from 21 to 47 days per year along the GOM coastal cities (NCDC 1995, 2011a). The poorest visibility conditions occur from November through April. During air stagnation, industrial pollution and agricultural burning can also impact visibility.

Atmospheric stability plays an important role in dispersing gases or particulates emitted into the atmosphere. Vertical motion and pollution dispersion are enhanced in an unstable atmosphere and are suppressed in a stable atmosphere. Over land, the atmospheric stability is more variable, depending on the time of day, cloud cover, and wind speed. Under calm to low winds, the atmosphere tends to be unstable during the daytime due to surface heating by solar insolation and stable at night due to radiative cooling. Under higher wind speeds and/or greater cloud cover, the atmosphere tends to be neutral irrespective of time of day. For coastal areas along the GOM, unstable conditions occur about 20% of the time, while neutral and stable conditions each occur about 40% of the time (Doty et al. 1976). Different from overland behavior, there is no large sensible heat flux driven by solar radiation over water. In addition, heating and cooling of the water surface takes place slowly due to its high heat capacity. In general, the atmosphere over water tends to be neutral to slightly unstable, since there are usually positive heat and moisture fluxes.

The mixing height is the height above the surface through which relatively vigorous vertical mixing occurs, primarily through the action of atmospheric turbulence. When the mixing height is low (i.e., very little vertical motion), ground-level concentrations of pollutants will be relatively high because the pollutants are prevented from dispersing upward. Mixing heights commonly go through large diurnal variations due to solar heating and surface cooling. Mixing heights are generally lowest around sunrise and highest during mid- to late afternoon. By season, mixing heights are typically the highest in summer and the lowest in winter. Near large water bodies (e.g., the GOM), diurnal and seasonal variations in mixing heights are relatively small compared with those at inland stations due to the moderating effects of the water. For coastal areas along the GOM, the mean annual morning mixing heights range from 500 to 900 m (1,640 to 2,950 ft), while the mean afternoon mixing heights range from 1,000 to 1,400 m (3,280 to 4,590 ft) (Holzworth 1972). Over water, the absence of a strong sensible heat flux to drive the marine mixed layer and the small surface roughness of sea results in relatively low mixing heights. LeMone (1978) indicated that typical marine mixing height is about 500 m (1640 ft) over low-latitude oceans.

In the GOM region, severe weather events such as thunderstorms, lightning, floods, tornadoes, and tropical cyclones are common. Thunderstorms occur from 26 days per year in Brownsville, Texas, to 80 days per year in Mobile, Alabama (NCDC 1995, 2011a). Thunderstorms occur most frequently in summer months and are least frequent in winter months. The number of lightning strikes per km^2-yr is as low as one at the southern tip of Texas and as high as 14 (NOAA 2011b). During the 1980–1999 period, tornadoes occurred from about

0.2 days per year[2] at the southern tip of Texas up to 1.2 days per year in the southeastern Texas, Louisiana, and Mississippi along the GOM (NSSL 2003). While tornadoes and floods are the primary weather hazards in the southern States, the GOM coastal zone is most vulnerable to hurricanes and their accompanying impacts such as storm surges.

Tropical cyclones affecting the GOM originate over the tropical portions of the Atlantic basin, including the Atlantic Ocean, the Caribbean Sea, and the GOM. Tropical cyclones occur as early as May and as late as December, but most frequently from mid-August to late October (NHC 2011a). On average, about 11 tropical cyclones occur in the Atlantic Basin, many of which remain over the ocean and never impact the U.S. coastlines. About six of these storms become hurricanes each year (NHC 2011b). Coastal counties adjacent to the Western and Central Planning Areas could expect return periods, ranging from 3.6 to 7.0 yr, for hurricanes passing within 139 km (86 mi) of a given location (NHC 2011a). Figure 3.5.1-1 shows landfalling hurricanes in the continental U.S. for the period 1994–2009. Tropical cyclones cause damage to physical, economic, biological, and social systems in the GOM, but the severest effects tend to be highly localized. The GOM is also periodically affected by wintertime extratropical cyclones generated when continental, cold air outbreaks interact with the warm GOM waters. These storms can produce gale force winds and high seas, and are hazardous to shipping due to their sudden onset and rapid formation. For a discussion of the effects of tropical cyclones and severe storms on OCS oil operations in the GOM, see previous EISs prepared for OCS oil and gas activities in the GOM (MMS 2007a, 2008a).

3.5.1.2 Alaska – Cook Inlet

Climate in Alaska depends primarily on three factors: latitude, continentality, and elevation (ACRC 2011). The climate of the southern coastal Alaska including the Cook Inlet Planning Area is marine, characterized by short and cool summers and mild winters. The climate is moderated due to marine influences; however, the upper reaches of the Cook Inlet see more continental effects. Although the Cook Inlet Planning Area is relatively small compared to the other two planning areas, weather patterns significantly vary over a relatively short distance due to nearby complex terrains. The following discussion for wind, ambient temperature, and precipitation is based on data from primarily two National Weather Service (NWS) first-order stations: Homer, which is located on the southwest side of the Kenai Peninsula, and Kodiak, which is located on the east side of Kodiak Island. Homer and Kodiak are located in the upper and lower portions of the Cook Inlet Planning Area, which represent a wide spectrum of variations in climate around the area.

Winds are strongly influenced by local topography and mostly blow parallel to nearby mountain ranges. In Cook Inlet, the general prevailing wind direction is from the northeast. However, wind direction and speed at any location in Cook Inlet vary greatly depending on the orientation and elevation of and proximity to nearby mountain ranges/valleys and the openness to the Gulf of Alaska. At Homer, the prevailing wind direction is from the northeast during September through March, while winds blow more frequently from the west during April

[2] The mean number of days with one or more events occurring within 40 km (25 mi) of a point.

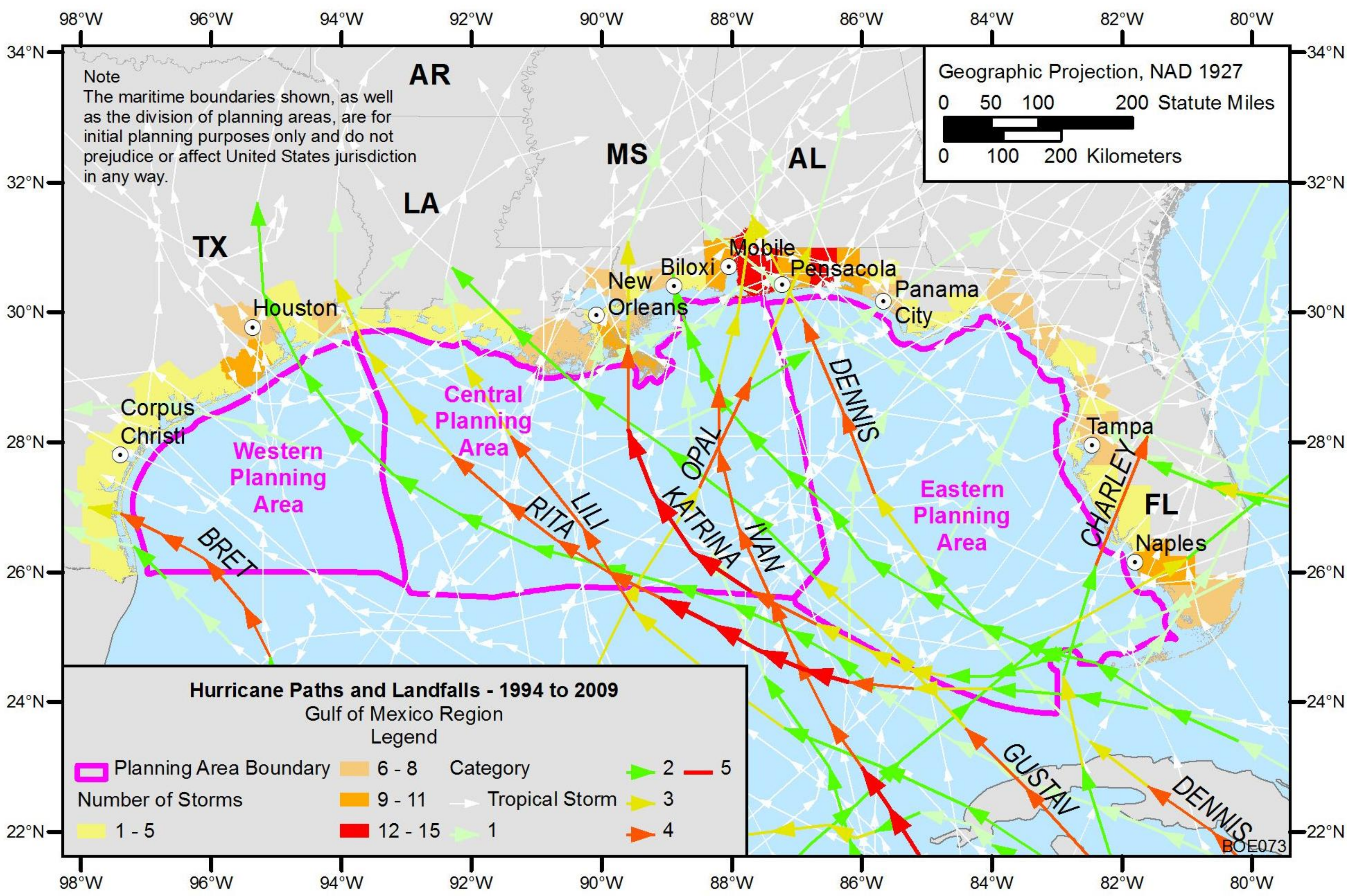

FIGURE 3.5.1-1 U.S. Landfalling Hurricanes, 1994–2009 (NHC 2011a)

through August (NCDC 2011b). The average wind speed at Homer is about 3.3 m/s (7.3 mph), with a slightly higher value in spring and a slightly lower value in summer. At Kodiak, the prevailing wind direction is from the northwest throughout the year, except in June and July when east-northeast winds blow more frequently (NCDC 2011b). The average wind speed at Kodiak is about 5.0 m/s (11.1 mph), with the highest reading in winter and the lowest in summer. At the NDBC buoy and coastal stations scattered within the Cook Inlet Planning Area, prevailing wind directions vary clockwise from the west to the northeast (NDBC 2011). Average wind speeds from NDBC stations range from 4.4 to 7.4 m/s (9.9 to 19.6 mph), with the highest reading in winter and the lowest in summer.

During the normal period (1970–2000), the average temperature at Homer was about 3.4°C (38.1°F) (NCDC 2011b). January was the coldest month, with a mean daily minimum of –8.1°C (17.5°F); August was the warmest month, with a mean daily maximum of 16.1°C (61.0°F). In summer, maximum temperatures go over 21.1°C (70°F) about 2 days per year, while about 178 and 10 days have minimum temperatures at or below freezing and at –17.8°C (0°F) or below, respectively (NCDC 2011b). The highest temperature, 27.2°C (81°F), was reached in July 1993, and the lowest, –31.1°C (–24°F), in January 1989. For the same period, the average temperature at Kodiak was about 4.7°C (40.5°F), with the lowest mean daily minimum of –4.3°C (24.3°F) in February and the highest mean daily maximum of 16.3°C (61.4°F) in August (NCDC 2011b). About 8 days annually exceed 21.1°C (70°F), while about 131 days and 1 day have minimum temperatures at or below freezing and at –17.8°C (0°F) or below, respectively. Extreme temperatures at Kodiak range from –26.7°C (–16°F) to 30.0°C (86°F). Temperature patterns from NDBC stations are similar to those at Homer and Kodiak, except for a little higher annual average temperature range of about 0.5°C (0.9°F) at NDBC stations (NDBC 2011).

The amount of precipitation depends strongly on the surrounding topographic features. During the normal period (1970–2000), annual precipitation at Homer averaged about 64.6 cm (25.45 in.) (NCDC 2011b). An annual average of 148 days have measurable precipitation (0.025 cm [0.01 in.] or higher). Precipitation is recorded throughout the year but is the highest in fall, followed by winter, and lowest in spring. Snow starts as early as October and continues as late as May. Most of the snow falls from November through March. The annual average snowfall at Homer is about 158.2 cm (62.3 in.). For the same period, annual precipitation at Kodiak averages about 191.4 cm (75.35 in.), and an annual average of 201 days have measurable precipitation (NCDC 2011b). By season, precipitation is the highest in fall, followed by winter, and lowest total in summer. Snow starts as early as October and continues as late as May. Most of the snow falls from November through April. The annual average snowfall at Kodiak is about 181.6 cm (71.5 in.).

Severe weather events, such as floods, hail, high winds, and winter events (such as heavy snow, ice storms, winter storms, blizzards), have been reported in the area surrounding Cook Inlet (NCDC 2011c). A normal storm track along the Aleutian chain, the Alaska Peninsula, and all of the coastal area of the Gulf of Alaska exposes these parts of the State to a large majority of the storms crossing the North Pacific, resulting in a variety of wind-related issues (NCDC 2011d). Wind velocities exceeding 45 m/s (100 mph) are not common but do occur, usually associated with mountainous terrain and narrow passes. In 2006, Kodiak experienced a wind gust estimated at 59 m/s (131 mph) that caused minor property damage. Intense coastal winds occur as a result of atmospheric pressure differentials between interior Alaska and the Gulf of Alaska. Higher interior atmospheric pressure also promotes periodic, local offshore winds that are orographically funneled, attaining velocities up to 42 m/s (93 mph) and extending up to 30 km (19 mi) offshore (Lackmann 1988).

Atmospheric stability provides a measure of the amount of vertical mixing and dispersion of air pollutants. Along the Gulf of Alaska, atmospheric stability is predominantly neutral. This is due to the frequent occurrence of relatively high wind speeds and cloud cover. Stable conditions are found about 15–25% of the time, while unstable conditions occur less than 10% of the time. Neutral conditions prevail for the rest of the time. The stable conditions are associated with clear, calm conditions at night. Over open water in the wintertime, unstable conditions are expected to be more frequent. More stable conditions are expected over water in the summer season because of the relatively colder temperature of the sea surface in relation to the ambient air.

3.5.1.3 Alaska – Arctic

As discussed above, climate in Alaska depends primarily on three factors: latitude, continentality, and elevation (ACRC 2011). The climate of the land mass bordering the Beaufort and Chukchi Seas is classified as tundra, characterized by a lack of warm summers (average temperature for the warmest month is less than 10°C (50°F) but above freezing (>0°C [32°F]), and scant (or trace) precipitation.

3.5.1.3.1 Winds. In general, wind patterns at the coastal stations along the Beaufort and Chukchi Sea Planning Areas are characterized by (1) relatively high average wind speeds, about 5.4 m/s (12.0 mph) at stations in the Beaufort Sea, ranging from 4.7 m/s (10.5 mph) at Point Lay to 6.5 m/s (14.6 mph) at Point Hope in the Chukchi Sea; (2) frequent extreme winds; and (3) higher easterly wind components (NCDC 2011e).

The eastern Beaufort Sea coastal winds are strongly influenced by channeling due to the Brooks Range to the south. In the eastern Beaufort Sea around Barter Island, westerly and west-northwesterly winds become more frequent in the winter months, with prevailing easterly and east-southeasterly winds in other months (NCDC 2011e). These bimodal wind direction patterns are also observed in central Beaufort Sea around Prudhoe Bay, but prevailing and secondary wind directions are shifted to east-northeast and west-southwest, respectively.

Along the coast of the Chukchi Sea from Barrow to Cape Lisburne, surface winds commonly blow from the east-northeast and the east (NCDC 2011e). At these stations, northeasterly to east-southeasterly wind components prevail almost every month without any comparable westerly components. However, the prevailing wind direction at Point Hope (the westernmost coastal station of the Chukchi Sea) is from the north, but winds there blow from the southeast and south-southeast a considerable amount of the time. At this station, south-southeasterly winds prevail in June and July, while north-northwesterly to northeasterly winds prevail in all other months.

During the winter, northerly winds prevail in the Chukchi Sea, with directions ranging from northwest in the western part of the sea to northeast in the eastern part (Proshutinsky et al. 1999). During the summer, the Chukchi Sea exhibits a more complicated wind regime, with alternating northerly and southerly winds.

3.5.1.3.2 Ambient Temperature. Along the Beaufort Sea, the average temperature ranges from –12.3°C (9.8°F) at Barter Island to –11.2°C (11.8°F) at Kuparuk (WRCC 2011). February is the coldest month, with a mean monthly minimum temperature ranging from –31.2°C (–24.2°F) to –32.4°C (–26.3°F); July is the warmest month, with a mean monthly maximum ranging from 7.4°C (45.4°F) to 13.3°C (55.9°F). In summer, maximum temperatures seldom go over 21.1°C (70°F). Daily maxima above freezing have been recorded only one-third of the days. Freezing temperatures have been observed every month of the year (about 287–310 days per year); more than half of the days (about 163–167 days per year) have minimum temperatures of –17.8°C (0°F) or below (WRCC 2011). The highest temperature, 28.3°F (83°F), was reached at Kuparuk and Prudhoe Bay, and the lowest, –52.2°C (–62°F), at Prudhoe Bay.

Along the Chukchi Sea, the average temperature ranges from –12.0°C (10.4°F) at Barrow to –8.1°C (17.5°F) at Cape Lisburne (WRCC 2011). February is the coldest month, with a mean monthly minimum temperature ranging from –25.7°C (–14.3°F) to –34.7°C (–30.5°F), and July is the warmest month, with a mean monthly maximum ranging from 7.6°C (45.7°F) to 10.9°C (51.6°F). Freezing temperatures have been observed every month of the year (about 264–316 days per year); about half of the days (about 125–165 days per year) have minimum temperatures of –17.8°C (0°F) or below (WRCC 2011). Both the highest temperature of 26.7°F (80°F) and the lowest of –48.9°C (–56°F) were recorded at Wainwright.

3.5.1.3.3 Precipitation. Precipitation on the tundra is generally meager; thus the tundra is desert-like in terms of precipitation. Along the Beaufort Sea, the average annual precipitation ranges from 10.1 cm (3.97 in.) at Kuparuk to 15.7 cm (6.19 in.) at Barter Island (WRCC 2011). Annual average measurable precipitation (0.025 cm [0.01 in.] or higher) ranges from 62 days at Kuparuk to 87 days at Barter Island. Precipitation is recorded throughout the year, mostly as rainfall, with the lowest amounts in spring and the highest in late summer. Snow falls every month of the year but approximately half falls in fall months. The annual average snowfall ranges from 82.0 cm (32.3 in.) at Kuparuk to 106.2 cm (41.8 in.) at Barter Island (WRCC 2011).

Along the Chukchi Sea, the average annual precipitation ranges from 11.7 cm (4.62 in.) at Barrow to 28.8 cm (11.34 in.) at Cape Lisburne (WRCC 2011). The annual average measurable precipitation ranges from 66 days at Point Lay to 112 days at Cape Lisburne. The annual average snowfall ranges from 43.2 cm (17.0 in.) at Point Lay to 105.2 cm (41.4 in.) at Cape Lisburne (WRCC 2011).

3.5.1.3.4 Severe Weather. Storms (wind velocities of greater than 15 m/s [34 mph]) are observed more often in winter than in summer. In the Chukchi Sea, 6–10 storm days occur per month. The duration of storms ranges from 6 to 24 hours in 70–90% of cases, but stormy weather can last 8–14 days (Proshutinsky et al. 1999).

On October 3, 1963, an intense storm that hit Barrow with little warning and caused more damage than any other storm in Barrow's historical records is described in detail by Brunner et al. (2004). Wind gusts as high as 34–36 m/s (75–80 mph) may have been reached, and the highest official observation of sustained winds was 25 m/s (55 mph). The resulting storm surge (or rise in sea level) reached 3.0 m (10 ft), and may have been as high as 3.7 m (12 ft). The storm surge and wave action caused extensive flooding in coastal areas, and more than 150,000 m^3 (200,000 yd^3) of sediment transport caused bluffs in the Barrow area to retreat as much as 3.0 m (10 ft) (Brunner et al. 2004). Since this episode, at least 30 storms have produced severe winds at Barrow and along the Chukchi Sea coast. Lynch et al. (2001) document high-wind events at Barrow for the period 1960–2000 and concluded that high-wind events are common in fall and winter, but rare in summer. It remains uncertain whether the more frequent storms and the summer storms seen in the past few years are part of a new pattern.

Since 2001, severe weather events, such as floods, storm surges, hail, high winds, winter events (such as heavy snow, winter storms, extreme windchills, blizzards), have been reported in the coastal areas surrounding the Beaufort and Chukchi Seas (NCDC 2011c). In 2005, Cape Lisburne, (nearly the westernmost point of the Chukchi Sea Planning Area) experienced a wind gust estimated at 40 m/s (89 mph) that caused no property damage.

3.5.1.3.5 Atmospheric Stability. Atmospheric stability provides a measure of the amount of vertical mixing and dispersion of air pollutants. Along the Arctic Ocean, the atmosphere is predominantly neutral, due to the frequent occurrence of high wind speeds and cloud cover. Stable conditions are found about 15–25% of the time, while unstable conditions occur less than 10% of the time. Netural conditions prevail for the rest of the time. Stable conditions are usually associated with clear, calm conditions at night. The presence of sea ice tends to result in more stable conditions, but also greater winds speeds, which could lead to a neutral atmosphere. Stable conditions also tend to be favored in the summertime due to the relatively colder temperatures of the sea surface in relation to the ambient air.

3.5.2 Air Quality

3.5.2.1 Gulf of Mexico

Under the Clean Air Act (CAA), which was last amended in 1990, the USEPA has set National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to public health and the environment (USEPA 2011a). NAAQS have been established for six criteria pollutants — carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), particulate matter (PM; PM_{10}, PM with an aerodynamic diameter of 10 μm or less; and $PM_{2.5}$, PM with an aerodynamic diameter of 2.5 μm or less), ozone (O_3), and sulfur dioxide (SO_2), as shown in Table 3.5.2-1. The CAA established two types of NAAQS: primary standards to protect public health including sensitive populations (e.g., asthmatics, children, and the elderly) and secondary standards to protect public welfare, including protection against degraded visibility and damage to animals, crops, vegetation, and buildings. Any individual State can have its own State Ambient Air Quality Standards (SAAQS) but SAAQS must be at least as stringent as the NAAQS. If a State has no standard corresponding to one of the NAAQS or the SAAQS is not as stringent as the NAAQS, then the NAAQS apply. Currently, all GOM States except Florida have adopted NAAQS. The State of Florida has ambient standards for 24-hour and annual average SO_2 that are more stringent than the NAAQS.

Areas considered to have air quality as good as or better than NAAQS are designated by the USEPA as attainment areas. Areas where air quality does not meet the NAAQS are designated by the USEPA as nonattainment areas. Nonattainment areas where air quality has improved to meet the NAAQS are redesignated as maintenance area and are subject to an air quality maintenance plan. The CAA requires each State to develop and regularly update a State Implementation Plan (SIP) to demonstrate how it will attain and maintain the NAAQS. SIPs include the regulations, programs, and schedules that a State will impose on sources and must demonstrate to the USEPA that the NAAQS will be attained and maintained.

In general, ambient air quality on coastal counties along the GOM is relatively good. Currently, all of the coastal counties along the GOM are in attainment for all criteria pollutants except 8-hour ozone (USEPA 2011b). For 8-hour ozone, all coastal counties in Mississippi, Alabama, and Florida are classified as in attainment, but a number of counties in Texas and Louisiana are designated as nonattainment or maintenance areas. Eight counties in the Houston-Galveston-Brazoria designated area in southeast Texas are classified as severe (maximum attainment date no later than June 2019) nonattainment areas, while three counties in the Beaumont/Port Arthur designated area are classified as moderate maintenance areas. In Louisiana, five parishes in the Baton Rouge designated area are classified as moderate (maximum attainment date no later than June 2010) nonattainment areas. For the Houston-Galveston-Brazoria and Baton Rouge nonattainment areas, 8-hour ozone concentrations have had a general downward trend since 1998 but ozone concentrations frequently exceed the NAAQS (USEPA 2011c). During the 2004–2008 period, the highest of the annual fourth-highest daily maximum 8-hour ozone concentrations were 0.106 ppm and 0.097 ppm, recorded in the Houston-Galveston-Brazoria and Baton Rouge nonattainment areas, respectively.

This region has several favorable conditions for the photochemical production of ozone. Precursor emissions of ozone, such as nitrogen oxides (NO_x) and VOCs, are abundant in the region due to a huge population, the oil and gas industry, and the petrochemical industry, including electricity generating facilities, chemical plants, petroleum refining facilities, oil and gas storage and transportation industries, and associated onroad vehicles and nonroad equipment. In addition, considerable emissions of biogenic VOCs are widespread and ubiquitous in the region. The subtropical climate of the region (characterized by relatively high temperature and intense solar radiation, despite frequent occurrences of precipitation) plays a role in establishing conditions conducive to high ozone episodes.

TABLE 3.5.2-1 National Ambient Air Quality Standards (NAAQS) and Maximum Allowable Prevention of Significant Deterioration (PSD) Increments

		NAAQS[b]		PSD Increment (µg/m^3)[d]		
Pollutant[a]	Averaging Time	Value	Type[c]	Class I	Class II	Class III
CO	8-hour	9 ppm (10 mg/m^3)	P	–[e]	–	–
	1-hour	35 ppm (40 mg/m^3)	P	–	–	–
Pb	Rolling 3-month average	0.15 µg/m^3	P, S	–	–	–
	Quarterly average	1.5 µg/m^3	P, S	–	–	–
NO_2	Annual (arithmetic average)	53 ppb	P, S	2.5	25	50
	1-hour	100 ppb	P	–	–	–
PM_{10}	Annual (arithmetic average)	–	–	4	17	34
	24-hour	150 µg/m^3	P, S	8	30	60
$PM_{2.5}$	Annual (arithmetic average)	15.0 µg/m^3	P, S	1	4	8
	24-hour	35 µg/m^3	P, S	2	9	18
O_3	8-hour	0.075 ppm (2008 standard)	P, S	–	–	–
	8-hour	0.08 ppm (1997 standard)	P, S	–	–	–
	1-hour	0.12 ppm[f]	P, S	–	–	–
SO_2	Annual (arithmetic average)	0.03 ppm	P	2	20	40
	24-hour	0.14 ppm	P	5	91	182
	3-hour	0.5 ppm	S	25	512	700
	1-hour	75 ppb	P	–	–	–

[a] CO = carbon monoxide; NO_2 = nitrogen dioxide; O_3 = ozone; Pb = lead; $PM_{2.5}$ = particulate matter ≤2.5 µm; PM_{10} = particulate matter ≤10 µm; and SO_2 = sulfur dioxide.

[b] Refer to 40 CFR Part 50 for detailed information on the attainment determination and reference method for monitoring.

[c] P = primary standards, which set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly; S = secondary standards, which set limits to protect public welfare, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings.

[d] The final rule for PSD increments for $PM_{2.5}$ is effective on December 20, 2010 (75 FR 64864).

[e] A dash denotes that no standard exists.

[f] The USEPA revoked the 1-hour ozone standard in all areas, although some areas have continuing obligations under that standard ("anti-backsliding").

Source: 40 CFR 52.21; 75 FR 64864; USEPA 2011a.

In recent years, four revisions to NAAQS have been promulgated. Effective May 27, 2008, the USEPA revised the 8-hour ozone standards from 0.08 ppm to 0.075 ppm (73 FR 16436). Effective January 12, 2009, the USEPA revised the Pb standard from a calendar-quarter average of 1.5 $\mu g/m^3$ to a rolling 3-month average of 0.15 $\mu g/m^3$ (73 FR 66964). Effective April 12, 2010, the USEPA established a new 1-hour primary NAAQS for NO_2 at 100 ppb (75 FR 6474), while, effective August 23, 2010, the USEPA established a new 1-hour primary NAAQS for SO_2 at 75 ppb (75 FR 35520). It takes several years to establish monitoring plans and collect data to determine whether an area is in compliance with a new standard.

The Prevention of Significant Deterioration (PSD) regulations (see 40 CFR 52.21), which are designed to limit the growth of air pollution in clean areas, apply to major new sources or modifications of existing major sources within an attainment or unclassified area. While the NAAQS (and SAAQS) place upper limits on the levels of air pollution, PSD regulations place limits on the total increase in ambient pollution levels above established baseline levels for NO_2, PM_{10}, $PM_{2.5}$, and SO_2, thus preventing "polluting up to the standard" (see Table 3.5.2-1). All State air quality jurisdictions are divided into three classes of air quality protection. These allowable increases are smallest in Class I areas, special areas of natural wonder and scenic beauty, such as National Parks (NPs), National Monuments, and Wilderness Areas (WAs), where air quality and air quality-related values (such as visibility and acid deposition) should be given special protection. The rest of the country is subject to larger Class II increments. States can choose a less stringent set of Class III increments, but none have done so. Major (large) new and modified stationary sources must meet the requirements for the area in which they are locating and any areas they impact. Thus, a source locating in a Class II area near a Class I area would need to meet the more stringent Class I increment in the Class I area and the Class II increment elsewhere, as well as any other applicable requirements.

As a matter of policy, the USEPA recommends that the permitting authority notify the Federal land managers (FLMs) when a proposed PSD source would locate within 100 km (62 mi) of a Federal Class I area. If the source's emissions are considered large, the USEPA recommends that sources beyond 100 km (62 mi) of a Federal Class I area be brought to attention of the FLM. There are several Class I areas in the GOM coastal zones, in Louisiana and Florida, as shown in Figure 3.5.2-1. In Louisiana, there is one Federal Class I area, while Florida has four. The Federal Class I area offshore of Louisiana consists of the Breton Wildlife Refuges, located on Breton Island and on many of the Chandeleur Islands (40 CFR 81.412). Federal Class I areas in Florida, such as Bradwell Bay WA,[3] Everglades NP, Chassahowitzka WA, and St. Marks WA (40 CFR 81.407), are located more than 250 km (155 mi) from the eastern boundary of the Central Planning Area. In addition, these Class I areas are not located downwind of prevailing winds in the Western and Central Planning Areas, and thus are not much affected by any current activities occurring in the Western or Central Planning Areas.

3 In 1980, Bradwell Bay WA along with Rainbow Lake in Wisconsin were excluded for purposes of visibility protection as Federal Class I areas.

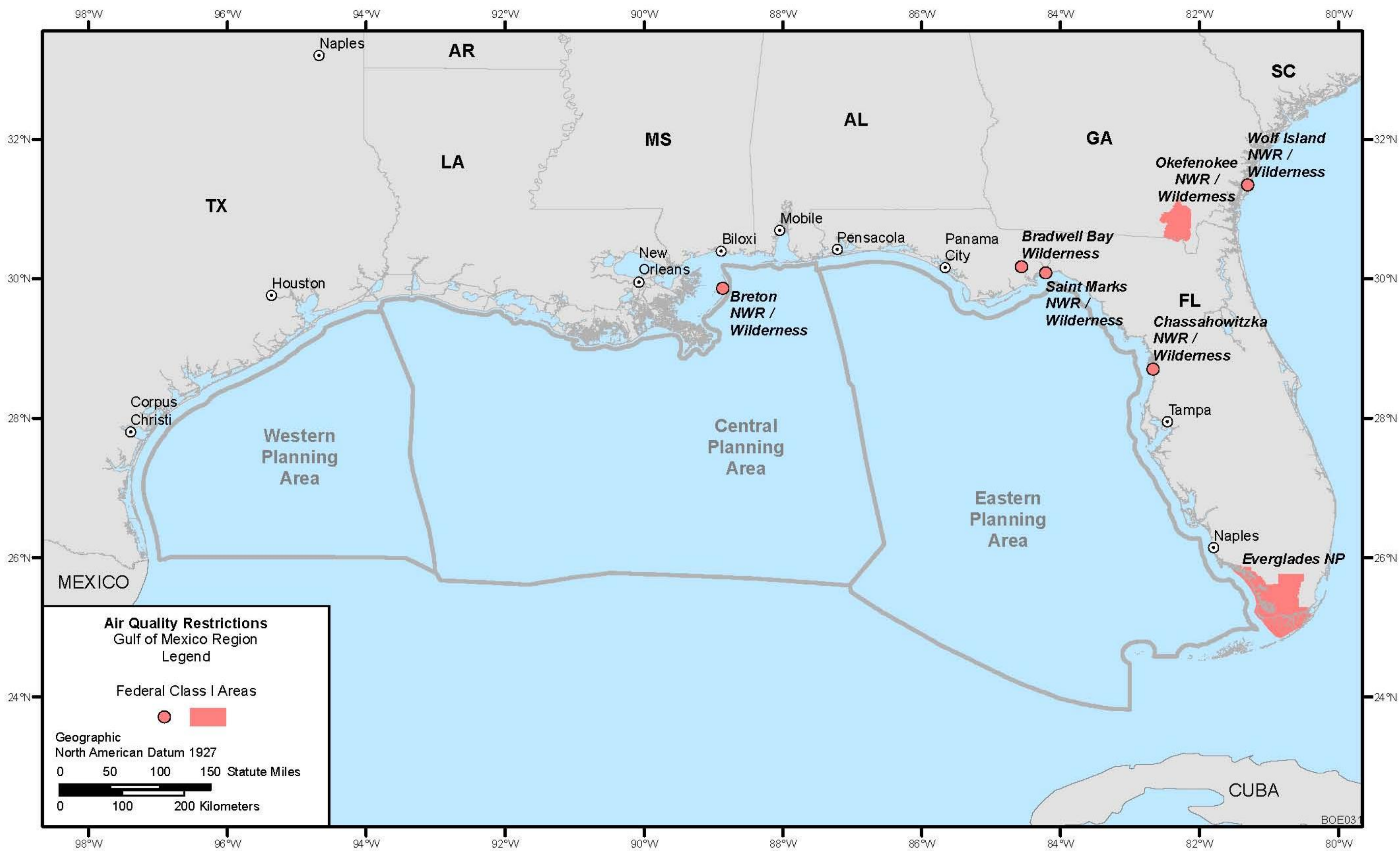

FIGURE 3.5.2-1 Mandatory Class I Federal Areas along the GOM

Deepwater Horizon Event

On April 20, 2010, the explosion and subsequent fire of the British Petroleum (BP) DWH platform in the GOM caused estimated 4.9 million barrels (Mbbl) of oil to be released into the GOM until July 15, 2010, when the wellhead was capped. The BP spill is by far the world's largest accidental release of oil into marine waters. It is estimated that burning, skimming, and direct recovery from the wellhead removed one quarter (25%) of the oil released from the wellhead (Lubchenco et al. 2010). One quarter (25%) of the total oil naturally evaporated or dissolved, and slightly less than one quarter (24%) was dispersed (either naturally or chemically) as microscopic droplets into GOM waters. The residual amount — just over one quarter (26%) — is either on or just below the surface as light sheen and weathered tar balls, has washed ashore or been collected from the shore, or is buried in sand and sediments. In summary, a third (33%) of the total leaked oil in the BP spill was captured or mitigated by the unified command recovery operations, including burning, skimming, direct recovery from the wellhead, and chemical dispersion. Half of the total leaked oil (naturally and chemically dispersed and residual) is currently being degraded naturally.

Evaporation from the oil spill itself would result in VOCs in the atmosphere. The VOC concentrations would occur anywhere there is an oil slick, and downwind of the slick. VOC concentrations would decrease with downwind distance. The lighter portions of VOCs would be most abundant in the immediate vicinity of the spill site. The heavier compounds would be emitted over a longer period of time and over a larger area. The formation of large concentrations of secondary organic aerosol (SOA), which affects air quality and climate change, was observed downwind from the DWH oil spill (de Gouw et al. 2011). This SOA plume was formed from unmeasured, less volatile hydrocarbons that were emitted from a wider area around DWH. Some of the compounds emitted could be hazardous to workers in the vicinity of the spill site. The hazard to workers can be reduced by monitoring and using protective gear, including respirators. During the DWH incident, air samples collected by individual offshore workers by BP, the Occupational Safety and Health Administration (OSHA), and the USCG showed levels of BTEX that were mostly under detection levels. All samples had concentrations below the OSHA Occupational Permissible Exposure Limits (PELs) and the more stringent American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs) (BOEMRE 2011a).

At present, a number of scientists, physicians, and health care experts are concerned with potential public health effects as a result of DWH event in the GOM; they found that the VOC benzene, a cancer-causing agent, has been found to be above Louisiana's ambient air quality standards (BOEMRE 2011a). However, while benzene in several samples related to the DWH oil spill was indeed above the Louisiana annual standard of 12 $\mu g/m^3$ (or 3.76 ppb), the long-term average in the monitoring period was well below the standard (Liu 2011).

Climate Change Effects

Climate changes are under way in the United States and globally, and are projected to continue to grow substantially over next several decades unless intense, concerted measures are taken to reverse this trend. Climate-related changes include rising temperature and sea level, increased frequency and intensity of extreme weathers (e.g., heavy downpours, floods, and droughts), earlier snowmelts and associated frequent wildfires, and reduced snow cover, glaciers, permafrost, and sea ice. A thorough discussion of the impacts of climate change to the baseline environment can be found in Section 3.3. In this section, potential impacts of climate change on meteorology and air quality specific to the GOM are discussed based on the report released by U.S. Global Change Research Program (USGCRP) in June 2009 titled, *Global Climate Change Impacts in the United States* (USGCRP 2009), unless otherwise noted.

Overall, the annual average temperature in the Southeast, which encompass the GOM coastal areas, did not change significantly over the past century. However, since 1970, the annual average temperature has risen about 1.6°F (0.9°C), with the highest seasonal increase of 2.7°F (1.5°F) in winters. Recently, heat waves and extreme temperatures have been common, especially in the southern States. For example, the average temperature for the summer in Texas at 86.8°F (30.4°C) exceeded the previous seasonal statewide average temperature record for any State during any season (NCDC 2011x). In summer of 2011, persistent heat engulfed the nation and the number of daily maximum temperatures over 100°F (37.8°C) were recorded to range from 10 days to more than 70 days in most of Texas, with a maximum of 90 days at Laredo Airport located in the southernmost Texas. In the near term (2010–2029) and mid-century (2040–2059), projected average temperature changes along the GOM coastal areas range 1–3°F (0.6–1.7°C) and 2–4°F (1.1–2.2°C), respectively, from 1961–1979 baseline.

Over the century, precipitation in the Southeast has increased by an average of 6% but has decreased by about 8% since 1970, with a maximum decrease of about 29% in spring. Model predictions indicated that, due to the northward shift of storm tracks, northern areas will become wetter and southern areas, especially in the West, will become drier. Accordingly, most of the GOM coastal area is predicted to experience reductions in precipitation and increases in drought severity and duration in the future. The destructive potential of Atlantic hurricanes has increased since 1970 and is correlated with the increase in sea surface temperature. Anticipated future changes for the U.S. and surrounding coastal waters include more intense hurricanes with related increases in wind, rain, and storm surges, but the frequency of landfalling hurricanes has not been established.

The two criteria air pollutants of most concern for public health and the environment are surface ozone and particulate matter. Air quality in the GOM is anticipated to be affected by climate change. While the Clean Air Act has improved air quality, higher temperatures and associated stagnant air masses due to a weaker global circulation and a decreasing frequency of mid-latitude cyclones (Jacob and Winner 2009) are expected to make it more challenging to meet air quality standards, particularly for ground-level ozone (a component of smog). A warmer climate is projected to increase the natural emissions of VOCs, accelerate ozone formation, and increase the frequency and duration of stagnant air masses that allow air pollutants to accumulate. This will worsen air quality, exacerbate respiratory diseases, and cause decreased crop yields.

Wildfires in the U.S. are already increasing due to warming. In GOM coastal areas, rising temperature and less precipitation (and thus prolonged droughts) have caused drying of soils and vegetation, which increase the potential for wildfires. More wildfires would result in air emissions, including criteria pollutants and toxic air pollutants, which could adversely impact air quality, visibility, and human health. In addition, greenhouse gas (GHG) emissions released from wildfires and associated loss of vegetation acting as a GHG sink could accelerate climate changes.

3.5.2.2 Alaska – Cook Inlet

For more detailed information on Federal air regulations and programs, please see Section 3.5.2.1.

The Alaska SAAQS are identical to the NAAQS (18 AAC 50.010). In addition, Alaska has set standards for some pollutants that are not addressed by the NAAQS, that is, reduced sulfur compounds and ammonia.

Except for a few population centers such as Anchorage, Fairbanks, and Juneau, the existing air quality in Alaska is relatively pristine with pollutant concentrations that are well within the ambient standards. Currently, Kenai Peninsula and Kodiak Island Boroughs, which surround the Cook Inlet Planning Area, have no air monitoring stations for criteria pollutants but are in unclassifiable/attainment for all criteria pollutants (40 CFR 81.302).

Eagle River in the Municipality Anchorage and Juneau are currently in nonattainment for the PM_{10} NAAQS, while Fairbanks is in nonattainment for $PM_{2.5}$ NAAQS. Although $PM_{2.5}$ is still a problem, recent air monitoring data indicated that neither Eagle River nor Juneau continues to violate the PM_{10} standard. The Alaska Department of Environmental Conservation (ADEC), together with the USEPA and related boroughs, are currently in the process of changing the status from nonattainment to maintenance. The most important sources of particulate matter in Alaska include volcanic ash, windblown dust from dry glacial riverbeds, wildfires during summertime, fugitive dust from unpaved roads, re-entrainment of winter sanding materials from paved roads, and wood smoke as well as fuel combustion (ADEC 2010b). In particular, increased exposure to particulate matter occurs during extended wintertime temperature inversions. In addition, Anchorage and Fairbanks are designated as maintenance areas for CO NAAQS.

There are four PSD Class I areas in Alaska (40 CFR 81.402): the Bering Sea WA in the St. Mathew Island group off southwestern Alaska; the Denali NP in south central Alaska; the Simeonof WA in the Shumagin Islands off the Alaska Peninsula; and the Tuxedni WA in Cook Inlet. All WAs are administered by the U.S. Fish and Wildlife Service (USFWS), while the Denali NP is administered by the National Park Service. The Tuxedni WA is the only Class I area that is located in close proximity to the northern portion of Cook Inlet Planning Area (about 10 km [6 mi] away), as shown in Figure 3.5.2-2. All other Class I areas in Alaska are located beyond 100 km (61 mi) from the Cook Inlet Planning Area.

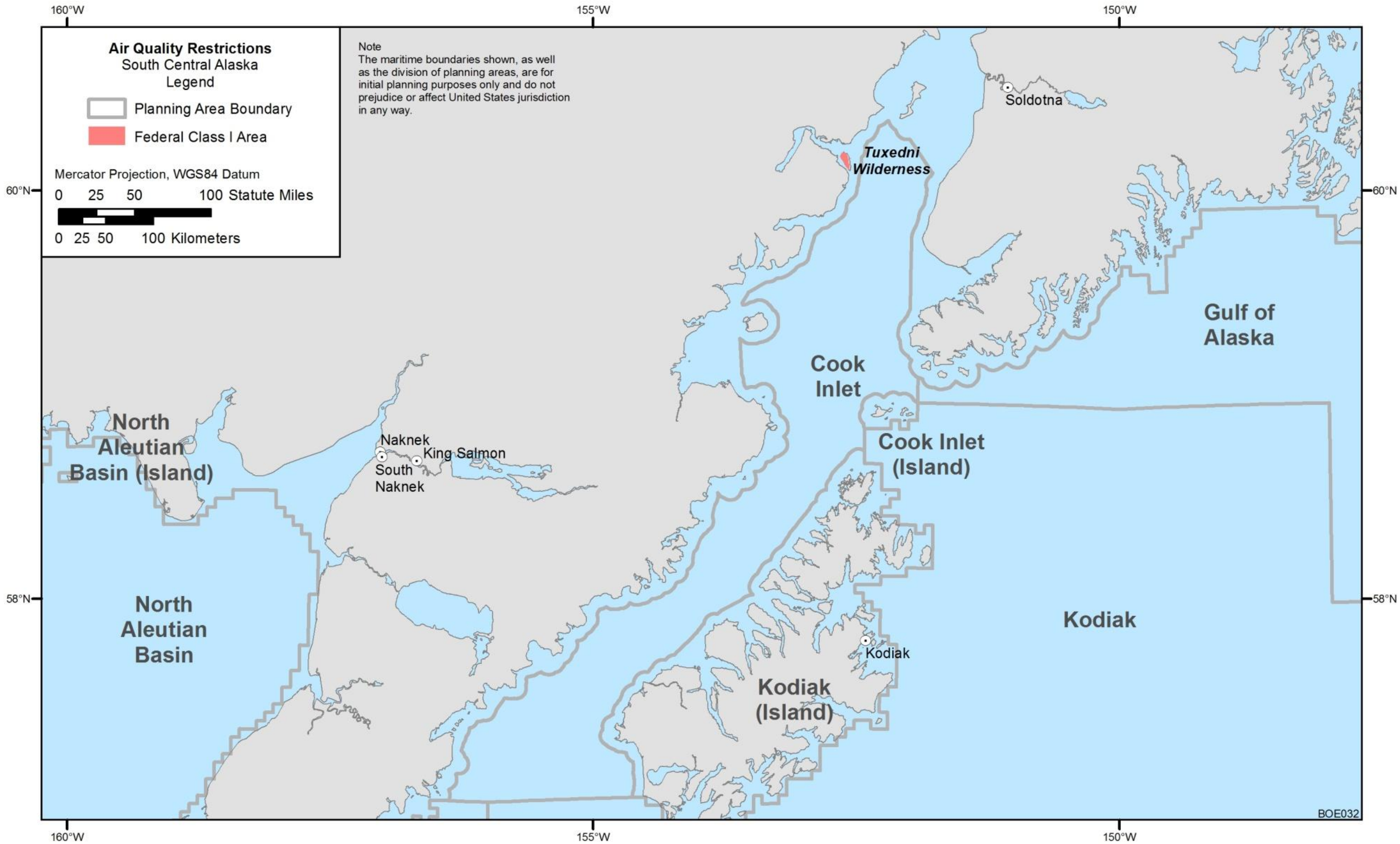

FIGURE 3.5.2-2 Mandatory Class I Federal Area in Cook Inlet, Alaska

Climate Change Effects

Climate changes are under way in the U.S. and globally, and are projected to continue to grow substantially over next several decades unless intense concerted measures are taken to reverse this trend. Climate-related changes include rising temperature and sea level, increased frequency and intensity of extreme weathers (e.g., heavy downpours, floods, and droughts), earlier snowmelts and associated frequent wildfires, and reduced snow cover, glaciers, permafrost, and sea ice. A thorough discussion of the impacts of climate change to the baseline environment can be found in Section 3.3. In this section, potential impacts of climate change on meteorology and air quality specific to the Cook Inlet are discussed based on the report released by U.S. Global Change Research Program (USGCRP) in June 2009 titled, *Global Climate Change Impacts in the United States* (USGCRP 2009).

In particular, Alaska has many resources vulnerable to climate change, such as sea ice, glaciers, permafrost, and thus may be subject to more pronounced potential impacts than any other parts of U.S. Over the past 50 yr, Alaska experienced more temperature increases than the rest of U.S. Its annual average temperature has increased by 3.4°F (1.9°C), with the highest seasonal increase of 6.3°F (3.5°C) in winters. By the middle of the century, the annual average temperature in Alaska is projected to rise about 3.5 to 7°F (1.9 to 3.9°C). The higher temperatures are already contributing to earlier snowmelt, reduced sea ice, widespread glacier retreat, and permafrost warming. This warming could produce benefits in some sectors, such as longer growing season, a longer period of outdoor and commercial activity such as tourism, increased shipping, and resource extraction, and detriments in others, such as increased likelihood of summer drought and wildfires due to longer summers and higher temperatures, coastal erosion, and flooding associated with coastal storms, and major shifts of biota habitats. Open water with a lower albedo absorbs sunlight better than the reflective surface of ice with a higher albedo. Albeit limited to northern Cook Inlet, any decrease in sea ice due to warming could lead to an decrease in albedo and thus an increase in ocean surface temperature, which causes sea ice to melt more, the so-called ice-albedo positive feedback.

Over the past 50 yr, precipitation has increased an average of 5% in the U.S. Model predictions indicate that, due to northward shift of storm tracks, northern areas will become wetter and southern areas, especially in the West, will become drier. Over this century, the temperature rise in sea surface temperature and reduced ice cover are likely to lead to northward shifts in Pacific storm tracks and increased impacts on Alaskan coastlines, many of which are low in elevation.

Two criteria air pollutants of most concern for public health and the environment are surface ozone and particulate matter. Air quality in the Cook Inlet is anticipated to be affected by climate change. Associated with climate change, more wildfires would result in air emissions, including criteria pollutants and toxic air pollutants, which could adversely impact air quality, visibility, and human health. In addition, greenhouse gas (GHG) emissions released from wildfires and associated loss of vegetation as a GHG sink could accelerate climate changes. To some degree, higher temperatures could increase ground-level ozone levels, which are primarily related to ambient temperature. Ozone level increases can worsen air quality, exacerbate respiratory diseases, and cause decreased crop yields. However, this minimal increase in ozone due to climate change is not anticipated to be high enough to contribute to exceeding the NAAQS.

3.5.2.3 Alaska – Arctic

Please see Section 3.5.2.1 for more detailed information on Federal air regulations and programs and 3.5.2.2 for Alaska-specific information.

Alaska has low air emissions. There are few industrial emission sources and, outside of Anchorage and Fairbanks, no sizable population centers. Barrow with a year 2010 population of about 4,600 is the largest city in North Slope Borough (USCB 2011i). The primary industrial emissions are associated with oil and gas production, power generation, small refineries, paper mills, and mining. The existing air quality in Alaska is considered to be relatively pristine, with pollutant concentrations in most areas that are well within the NAAQS. Currently, North Slope Borough, which borders the Beaufort and Chukchi Sea Planning Areas, has no continuous air monitoring stations for criteria pollutants but is designated as an unclassifiable/attainment area for all criteria pollutants (40 CFR 81.302).

All four Class I areas in Alaska are located more than 690 km (430 mi) from the Beaufort and Chukchi Sea Planning Areas (40 CFR 81.402). The entire Arctic region is classified Class II under Federal PSD regulations.

Over most of the onshore areas bordering the Arctic Ocean, there are only a few small, widely scattered emission sources. The only major local sources of industrial emissions are in the Prudhoe Bay-Kuparuk-Endicott oil production complex. The offshore Northstar facility located on an artificial island was the greatest single source of vented/flared gas on the North Slope in 2002 (Alaska Department of Administration 2004). However, repairs during 2004 resulted in a significant decrease of flaring at Northstar Island. This area was the subject of monitoring programs during 1986–1987 (ERT Company 1987; Environmental Science and Engineering, Inc. 1987) and from 1990 through 1996 (ENSR Consulting and Engineering 1996; USACE 1999). Five monitoring sites were selected — three were considered subject to maximum air pollutant concentrations, and two were considered more representative of the air quality of the general Prudhoe Bay area. The more recent observations are summarized in Table III.A-6 in MMS (2003b). All the values meet the NAAQS and SAAQS. The results demonstrate that ambient pollutant concentrations meet the ambient standards, even for sites subject to maximum concentrations.

Aside from notable warming trends and their associated impacts, the Arctic region experiences air pollution problems due to long-range transport of air pollutants from industrial northern Eurasia and North America, including arctic haze followed by acidic depositions, tropospheric ozone, and buildup of toxic substances such as mercury or persistent organic compounds (Law and Stohl 2007). Local shipping emissions and summertime boreal forest fires may also be important pollution sources in the Arctic. In addition, large haze events in the Arctic can be caused by Asian dust originating from the Gobi and Taklamakan Deserts in Mongolia and northern China in springtime, as identified in Rahn et al. (1977).

During the winter and spring, winds transport pollutants to Arctic region across the Arctic Ocean from industrial Europe and Asia (Rahn 1982). These pollutants, primarily from coal burning and metal smelting, cause a phenomenon known as arctic haze, a visible reddish-brown haze. The composition of aerosols producing regional haze consists of approximately 90% sulfate aerosols and 10% soot (Wilcox and Cahill 2003). Pollutant sulfate due to arctic haze in the air in Barrow (that in excess of natural background) averages 1.5 $\mu g/m^3$. The concentration of vanadium, one of signature elements that fingerprint fossil fuel combustion, averages up to 20 times the background levels in the air and snowpack. Observations of the chemistry of the snowpack in the Canadian Arctic also provide evidence of long-range transport of small concentrations of organochlorine pesticides (Gregor and Gummer 1989). Concentrations of arctic haze during winter and spring at Barrow are similar to those over large portions of the continental United States, but they are considerably higher than levels south of the Brooks Range in Alaska. Any ground-level effects of arctic haze on the concentrations of regulated air pollutants in the Prudhoe Bay area are included in the monitoring data given in Table III.A-6 in MMS (2003b). Model calculations indicate that less than 10% of the pollutants emitted in the major source regions are deposited in the Arctic (Pacyna 1995). Maximum concentrations of some pollutants, sulfates and fine particles, were observed during the early 1980s and decreases in concentrations were observed at select stations at the end of the 1980s due to emissions decreases in some source regions and a meteorological shift. However, the decline in emissions from Russia may be reversing as a consequence of economic revitalization and an increasing reliance on coal, as natural gas becomes more valuable for export (Wilcox and Cahill 2003). Despite this seasonal, long-distance transport of pollutants into the Arctic, regional air quality still is far better than ambient air quality standards.

Climate Change Effects

Climate changes are underway in the U.S. and globally, and are projected to continue to grow substantially over next several decades unless intense concerted measures are taken to reverse this trend. Climate-related changes include rising temperature and sea level, increased frequency and intensity of extreme weathers (e.g., heavy downpours, floods, and droughts), earlier snowmelts and associated frequent wildfires, and reduced snow cover, glaciers, permafrost, and sea ice. A thorough discussion of the impacts of climate change to the baseline environment can be found in Section 3.3. In this section, potential impacts of climate change on meteorology and air quality specific to the Arctic are discussed based on the report released by U.S. Global Change Research Program (USGCRP) in June 2009 titled, *Global Climate Change Impacts in the United States* (USGCRP 2009).

In particular, Alaska has many resources vulnerable to climate change, such as sea ice, glaciers, permafrost, and thus may be subject to more pronounced potential impacts than any other parts of U.S. Over the past 50 yr, Alaska experienced more temperature increase than the rest of U.S. Its annual average temperature has increased by 3.4°F (1.9°C), with highest seasonal increase of 6.3°F (3.5°C) in winters. By the middle of the century, annual average temperature in Alaska is projected to rise about 3.5 to 7°F (1.9 to 3.9°C). The higher temperatures are already contributing to earlier snowmelt, reduced sea ice, widespread glacier retreat, and permafrost warming. This warming could produce benefits in some sectors, such as longer growing season, a longer period of outdoor and commercial activity such as tourism, increased shipping, and resource extraction, and detriments in others, such as increased likelihood of summer drought and wildfires due to longer summers and higher temperatures, coastal erosion, and flooding associated with coastal storms, and major shifts of biota habitats. Open water with a lower albedo absorbs sunlight better than the reflective surface of ice with a higher albedo. Any decrease in Arctic sea ice due to warming could lead to a decrease in albedo and thus an increase in ocean surface temperature, which causes sea ice to melt more, the so-called ice-albedo positive feedback.

Over the past 50 yr, precipitation has increased an average of 5% in the U.S. Model predictions indicate that, due to northward shift of storm tracks, northern areas will become wetter and southern areas, especially in the West, will become drier. Over this century, temperature rise in sea surface temperature and reduced ice cover are likely to lead to northward shifts in Pacific storm tracks and increased impacts on Alaskan coastlines, many of which are low in elevation.

Two criteria air pollutants of most concern for public health and the environment are surface ozone and particulate matter. Air quality in the Beaufort and Chukchi Seas is anticipated to be affected by climate change. Associated with climate change, more wildfires would result in air emissions, including criteria pollutants and toxic air pollutants, which could adversely impact air quality, visibility, and human health. In addition, greenhouse gas (GHG) emissions released from wildfires and associated loss of vegetation as a GHG sink could accelerate climate changes. To some degree, higher temperatures could increase ground-level ozone levels, which are primarily related to ambient temperature. Ozone level increases can worsen air quality, exacerbate respiratory diseases, and cause decreased crop yields. However, this minimal increase in ozone due to climate change is not anticipated to be high enough to contribute to exceeding the NAAQS.

3.6 ACOUSTIC ENVIRONMENT

3.6.1 Gulf of Mexico

For a more detailed discussion on the acoustic environment of the GOM, please see MMS (2004), which is incorporated here for reference.

3.6.1.1 Sound Fundamentals

Light does not travel far in the ocean due to its absorption or scattering. Even in the clearest water most light is absorbed within a few tens of meters, and visual communication is very limited in water, especially in deep or murky water, and/or at night. Accordingly, auditory capabilities have evolved to overcome this limitation of visual communication for many marine animals. Sound, which is mostly used by marine animals for such basic activities as finding food or a mate, navigating, and communicating, plays a crucial role in their survival in the marine environment. The same advantages of sound in water have led humans to deliberately introduce sound into the ocean for many valuable purposes, e.g., communication (e.g., submarine-to-submarine), feeding (e.g., fish-finding sonar), and navigation (e.g., depth-finders and geological and geophysical surveys for minerals) (Hatch and Wright 2007). However, some sounds, such as the noise generated by ships and by offshore industrial activities, including oil and gas activities, are also introduced into the ocean as a byproduct.

Any pressure variation that the human ear can detect is considered as sound, and noise is defined as unwanted sound. Sound is described in terms of amplitude (perceived as loudness) and frequency (perceived as pitch). The ear can detect pressure fluctuations changing over seven orders of magnitude. The ear has a protective mechanism in that it responds logarithmically, rather than lineally. To deal with these two realities (wide range of pressure fluctuations and the response of the ear), sound pressure levels[4] are typically expressed as a logarithmic ratio of the measured value to a reference pressure, called a decibel (dB). By convention, the reference pressures are 20 micropascal (µPa) for airborne sound, which corresponds to the average person's threshold of hearing at 1000 Hz, and 1 µPa for underwater sound. Accordingly, sound intensity in dB in water is not directly comparable to that in dB in air.

There are primarily three ways to characterize the intensity of a sound signal (OMP 2010). The "zero-to-peak pressure" denotes the range between zero and the greatest pressure of the signal, while "peak-to-peak pressure" denotes the range between negative and positive extremes of the signal. The "root-mean-square (rms) pressure" is the square root of the average of the square of the pressures of the sound signal over a given duration. Due to the sensitivity of marine animals to sound intensity, the rms pressure is most widely used to characterize underwater sound waves. However, for impulsive sounds, rms pressure is not appropriate to use because it can vary considerably depending on the duration over which the signal is averaged. In this case, peak pressure of impulsive sound, which could be associated with the risk of causing physical damage in auditory systems of marine animals, is more appropriately used (Coles et al. 1968). Unless otherwise noted, *source levels* of underwater sounds are typically expressed in the notation "dB re 1 µPa-m," which is defined as the pressure level that would be measured at a reference distance of 1 m from a source. In addition, zero-to-peak and peak-to-peak sound pressure levels are denoted as $dB_{0\text{-}p}$ and $dB_{p\text{-}p}$ re 1 µPa-m, respectively. In addition, the *received levels* (estimated at the receptor locations) are presented as "dB re 1 µPa" at a given location (e.g., 5 km [3 mi]).

[4] There are two primary but different metrics for sound measurements: sound pressure level (SPL) and sound exposure level (SEL). SPL is the root mean square of the sound pressure over a given interval of time, given as dB re 1 µPa for underwater sound. In contrast, SEL is the total noise energy from a single event and is the integration of all the acoustic energy contained within the event. SEL takes into account both the intensity and the duration of a noise event, given as dB re 1 $\mu Pa^2 \times s$ for underwater sound. In consequence, SEL is similar to SPL in that total sound energy is integrated over the measurement period, but instead of averaged over the entire measurement period, a reference duration of 1 s is used.

3.6.1.2 Sound Propagation

Understanding the impact of sound on a receptor requires a basic understanding of how sound propagates from its source. Underwater sound spreads out in space, is reflected, refracted, and absorbed. Sound propagates with different geometries under water, especially in relatively shallow nearshore environments. Vertical gradients of temperature, pressure, and salinity in the water as well as wave and current actions can also be expected to constrain or distort sound propagation geometries. Several important factors affecting sound propagation in water include spreading loss, absorption loss, scattering loss, and boundary effects of the ocean surface and the bottom (Malme 1995).

Among these, spreading loss, which does not depend on frequency, is the major contributor to sound attenuation. As propagation of sound continues, its energy is distributed over an ever-larger surface area. Spherical and cylindrical spreading are two simple approximations used to describe the sound levels associated with sound propagations away from a source. In spherical propagation, sound from a source at mid-depth in the ocean (i.e., far from the sea surface or sea bottom) propagates in all directions with a 6-dB drop per doubling of distance from the source. In cylindrical spreading, sound propagates uniformly over the surface of a cylinder, with sound radiating horizontally away from the source, and sound levels dropping 3 dB per doubling of distance. The surface of the water and the ocean floor are effective boundaries to sound propagation, acting either as sound reflective or absorptive surfaces. Consequently, underwater sound originating as a point source will initially propagate spherically over some distance until the sound pressure wave reaches these boundary layers; thereafter, the sound will propagate cylindrically. Therefore, sound levels tend to diminish rapidly near the source (spherical propagation) but slowly with increasing distances (cylindrical propagation).

Directionality refers to the direction in which the signal is projected. Many underwater noises are generally considered to be omnidirectional (e.g., construction, dredging, explosives). However, geophysical surveys, such as seismic air gun arrays, are focuses downward, while some geological surveys are fanned. Although air gun arrays are designed to direct a high proportion of the sound energy downward, some portion of the sound pulses can propagate horizontally in the water, depending on array geometry and aspect relative to the long axis of the array (Greene and Moore 1995). In any case, sound attenuation of directional sound with distance is lower than the spreading loss for omnidirectional sources discussed above.

As sound travels, some sound energy is absorbed by the medium such as air or water (so-called absorption losses) which represents conversion of acoustic energy to heat energy. Absorption losses depend strongly on frequency, becoming greater with increasing frequencies, and vary linearly with increasing distance, and are given as dB/km. Sound scattering is affected by bubbles, suspended particles, organisms, or other floating materials. Like absorption losses, scattering losses vary linearly with distance, and are given as dB/km.

Whenever sound hits the ocean surface or seafloor, it is reflected, scattered, or absorbed and mostly loses a portion of its sound energy. Hard materials (like rocks) will reflect or scatter more sound energy, while soft materials (like mud) will absorb more sound energy.

Accordingly, the seafloor plays a significant role in sound propagation, particularly in shallow waters.

Typically, a high-frequency sound cannot travel as far as a low-frequency sound in water because higher frequencies are absorbed more quickly. An exception is the rapid attenuation of low frequencies in shallow waters (Malme 1995). Shallow water acts as a waveguide bounded on the top by the air and on the bottom by the ocean bottom. The depth of the water represents the thickness of the waveguide. Sound at long wavelengths (low frequencies) does not fit in the waveguide and is attenuated rapidly by the effects of interference at the boundaries.

3.6.1.3 Ambient Noise

Ambient noise is defined as typical or persistent environmental background noise lacking a single source or point. In the ocean, there are numerous sources of ambient noise, both natural and anthropogenic, which are variable with respect to season, time of day, location, and noise characteristics (e.g., frequency). Natural sources include wind and waves, seismic noise from volcanic and tectonic activity, precipitation, marine biological activities, and sea ice (Greene 1995) while anthropogenic sources include transportation, dredging and construction, oil and gas drilling and production, geophysical surveys, sonars, explosions, and ocean scientific studies (Greene and Moore 1995). Depending on the ambient noise levels and their frequency distributions, basic activities by marine animals or specific human activities could be significantly hampered. As the ambient noise level increases, sounds from a specific source disappear below the ambient level and become undetectable due to loss of prominence of the signal at shorter ranges. In particular, anthropogenic sound could have effects on marine life, including behavior changes, masking, hearing loss, and strandings. Due to its importance to the sensitivity of instrumentation for research and military applications, ambient noise has been of considerable interest to oceanographers and naval forces. Recent concerns over potential impacts of strong sources of sound from scientific and military activities have driven considerable public and political interest in the issue of noise in the marine environment (NRC 2003; Greene 1995).

For most of the world oceans, shipping and seismic exploration noise dominate the low-frequency portion of the spectrum (Hildebrand 2009). In particular, noise generated by shipping has increased as the number of ships on the high seas has increased (Andrew et al. 2002). Along the west coast of North America, long-term monitoring data suggest an average increase of about 3 dB per decade in low-frequency ambient noise.

Various activities and processes, both natural and anthropogenic, combine to form the sound profile within the ocean. Except for sounds generated by some marine animals using active acoustics, most ambient noise is broadband (composed of a spectrum of numerous frequencies without a differentiating pitch). Virtually the entire frequency spectrum is represented by ambient noise sources.

According to the Office of Marine Programs (OMP 2010) of the University of Rhode Island, distant shipping is the primary source of ambient noise in the 20- to 500-Hz range. Spray and bubbles associated with breaking waves are the major contributions to ambient noise in the 500- to 100,000-Hz range. At frequencies greater than 100,000 Hz, "thermal noise" caused by the random motion of water molecules is the primary source. Ambient noise sources, especially noise from wave and tidal action, can cause coastal environments to have particularly high ambient noise levels. Ice movements are a large source of noise in the Arctic and in Cook Inlet.

Per classical Wenz curves (Wenz 1962), which are plots of average ambient noise spectra, seismic background and turbulent-pressure fluctuations are prevailing noises in the frequency range of 1 to 100 Hz. Ocean traffic has noise between 10 and 1,000 Hz. Bubble and spray resulting from sea surface agitation (such as breaking waves, spray, bubble formation and collapse, and rainfall), whose noise increases with wind speed, accounts for the frequency range of 100 to 20,000 Hz. With peaks ranging between 100 and 1,000 Hz, Wenz curves provided noise spectrum level distributions for varying sea states.[5] At frequencies greater than 10,000 Hz, thermal noise contributes increasingly to ambient levels with frequency, but absolute levels are much lower than those below these frequencies. As intermittent and local effects, earthquakes and explosions consist of noise signals from 1 to 100 Hz. Volcanic and tectonic noise generated by earthquakes on land or in water propagates as low-frequency, locally generated "T-phase" waves, with energy levels generally below 100 Hz (Greene 1995). Biota, such as fishes, certain shrimps, and marine mammals, can produce signals ranging from less than 10 Hz to well over 100,000 Hz. Shipping and industrial activities along with sea ice have signals between 10 and 10,000 Hz. In addition to noise caused by breakup, sea ice makes noise when temperature changes result in cracking. Underpressure from wind and currents also results in significant low-frequency noise, and iceberg melting results in "seltzer" noise. Precipitation covers the frequency range of 100 to 25,000 Hz.

Sources of ambient noise in the OCS include wind and wave activity, including surf noise near the land-sea interface; precipitation noise from rain and hail; lightning; biological noise from marine mammals, fishes, and crustaceans; and distant shipping traffic (Greene 1995). Several of these sources may contribute significantly to the total ambient noise at any one place and time, although ambient noise levels above 500 Hz are usually dominated by wind and wave noise. Consequently, ambient noise levels at a given frequency and location may vary widely on a daily basis. A wider range of ambient noise levels occurs in water depths less than 200 m (shallow water) than in deeper water. Ambient noise levels in shallow waters are directly related to wind speed and indirectly to sea state (Wille and Geyer 1984).

3.6.1.4 Anthropogenic Noise

Table 3.6.1-1 summarizes the various types of man-made noises in the ocean. Sources include transportation, dredging, construction, hydrocarbon and mineral exploration, geophysical

---

5 Sea state is a measure of the intensity of the ocean's movement and is characterized by such parameters as wind speed, wave height, wave periodicity, and wave length. Sea states vary from "0," which represents calm conditions, to "9," which is characterized by wind speeds of more than 33 m/sec (108 ft/sec) and wave heights of more than 14 m (46 ft).

TABLE 3.6.1-1 General Types of Anthropogenic Sound in the Ocean and Estimated Levels of Maritime Activity

Activity	Sources	Source Level[a] (dB re 1 μPa-m)	Frequency Range (Hz)[b]	Gulf of Mexico Level of Activity
Transportation	Aircraft (fixed-wing and helicopters)	156–175	45–7,070	Moderate flight activity, estimated to be in the range of several hundred flights annually (most low-level flights for oil and gas support, aerial surveys)
	Small vessels (boats, ships)	145–170	37–6,300	High activity level; hundreds to thousands of fishing vessels, pleasure craft, small ships daily; millions of angler trips per year (MMS 2004: Appendix F, Section II.B); oil and gas support vessel activity, estimated to be 304,807 to 319,921 trips per year, with most concentrated in the Central Planning Area.
	Large vessels (commercial vessels, supertankers)	169–198	6.8–428	In the U.S. GOM in 1999, tankers and other freight vessels completed a total of approximately 279,000 vessel trips in the GOM and Gulf Intracoastal Waterway waters
	Ice breakers	171–191	10–1,000	None
	Hovercraft and vehicles on ice	130	224–7,070	None; related watercraft would include "jet skis," whose numbers are estimated to range into the thousands
Dredging and construction	Dredging	150–180	10–1,000	Precise levels unknown, although harbor maintenance activity is very common for major GOM ports; very limited in shipping channels
	Tunnel boring	Low	10–500	Unknown; expected to be rare in the GOM
	Other construction operations	Low	<1000	Unknown; expected to be limited in the GOM
	Pile driving	228	Broadband (peak at 100–500 Hz)	Precise levels unknown; used to set platforms

TABLE 3.6.1-1 (Cont.)

Activity	Sources	Source Level[a] (dB re 1 µPa-m)	Frequency Range (Hz)[b]	Gulf of Mexico Level of Activity
Oil and gas drilling and production	Drilling from islands and caissons	140–160	20–1,000	None in the GOM
	Drilling from bottom-founded platforms	119–127 (received)	5–1,200	Variable; may range from tens to hundreds of wells drilled from GOM platforms annually; January 2001 drilling activity levels: 61 wells. MMS notes 40,361 approved applications to drill in the GOM Federal waters
	Drilling from vessels	154–191	10–10,000	Low level of activity, on the order of tens of drill ships operating in GOM waters annually
	Offshore oil and gas production	Low	50–500	4,019 production platforms on 7,564 active leases in Federal waters of the GOM, as of July 31, 2001; as of September 2, 2003, there were 3,476 active offshore production platforms in the GOM Federal waters
	Support activity	See small vessels	See small vessels	304,807 to 319,921 trips per year, with most (~90%) concentrated in the Central Planning Area; ~10% of support vessel activity occurs in the Western Planning Area, while 0.2 to 0.3% is projected for the Eastern Planning Area
Geophysical surveys	Air guns	216–259[c]	<120	Tens to 30+ surveys per year, may have as many as five surveys running concurrently (MMS 2004: Appendix D, Section V)
	Sleeve exploders and gas guns	217[c]	Low	Unknown; expected to be very rare

TABLE 3.6.1-1 (Cont.)

Activity	Sources	Source Level[a] (dB re 1 µPa-m)	Frequency Range (Hz)[b]	Gulf of Mexico Level of Activity
Geophysical surveys (Cont.)	Vibroseis	187 to 210[c] instantaneous level dependent upon sweep length (i.e., ~18–22 dB less than an air gun pulse)	10–70	Estimated to be rare (MMS 2004: Append D, Section II.D)
	Other techniques (sparkers, boomers)	212–221[c]	Not applicable	Estimated to be rare
Navigation and target detection (sonars, pingers)	Fathometers	180+	12,000+	Potentially high, given the presence of thousands of ships and boats in the GOM
	Military active sonars	230+	2,000–57,000	Unknown; expected to be periodic, infrequent (e.g., tens to 100 or more annually)
	Transponders	180–200	7,000–60,000	Unknown; expected to be periodic, infrequent (e.g., several hundred per year)
Explosions	Military ordinance	>279[c]	Peak	Low; live fire testing very limited in the GOM
	Ship and weapons testing	>294[c] (10,000 lb charge)	Broadband	Periodic, infrequent
	Offshore demolition (structure removals)	267–279[c] (based on charge weights)	Peak	53–130 removals per year

TABLE 3.6.1-1 (Cont.)

Activity	Sources	Source Level[a] (dB re 1 µPa-m)	Frequency Range (Hz)[b]	Gulf of Mexico Level of Activity
Ocean science studies	Seismology	Not applicable	Not applicable	Unknown, expected to be very limited study of earthquakes in the GOM, if any
	Acoustic propagation	220	50–64	Unknown, expected to be very limited
	Acoustic tomography	Not applicable	Not applicable	None expected
	Acoustic thermometry	195	57.5–92.5	None expected

[a] Root mean square pressure level unless otherwise noted.

[b] Frequency range represents the lowest and highest frequencies over which the estimated source level data (reported either for dominant tones or center frequency of the 1/3 octave bands) are available.

[c] Zero-to-peak pressure level.

Source: Adapted from Greene and Moore (1995) and various sources including MMS (2004), as noted.

surveys, sonar, explosions, and ocean science studies. Noise levels from most human activities are greatest at relatively low frequencies (<500 Hz).

3.6.1.4.1 Transportation. Transportation-related noise sources include aircraft (both helicopters and fixed-wing aircraft) and surface and subsurface vessels. While icebreakers, snowmobiles (snowmachine traffic), and hovercrafts are operating in the Arctic region, of these three, only hovercrafts are used in Cook Inlet, and none are used in the GOM.

Aircraft. The primary sources of aircraft noise are their engine(s) (either reciprocating or turbine) and propellers or rotors. Sound energy from both helicopters and propeller-driven aircraft concentrates at relatively low frequencies (usually below 500 Hz) due to dominant tones, which are harmonics of the blade rates[6] of the propellers and rotors (Hubbard 1995). Sounds from jets (i.e., turbojet or turbofan) that do not drive propellers or rotors do not include prominent tones at low frequencies but broadband noise across a wide range of frequencies.

In general, large, multi-engine aircraft tend to be noisier than small aircraft. Broadband (45–7,070 Hz) source levels from aircraft flyovers range from 156 dB re 1 μPa-m for Twin Otter with two turboprops to 175 dB re 1 μPa-m for C-130 military transport aircraft with four turboprops. A four-engine P-3 Orion with multi-bladed propellers has estimated source levels of 160–162 dB re 1 μPa-m in the 56–80 Hz band and 148–158 dB re 1 μPa-m in the 890–1,120 Hz band. A Twin Otter generates source levels of 147–150 dB re 1 μPa-m at the 82 Hz tone. Helicopters are typically noisier and produce a larger number of acoustic tones and higher broadband noise levels than do fixed-wing aircraft of similar size. Estimated source levels for a Bell 212 helicopter are about 149–151 dB re 1 μPa-m at the 22 Hz tone (Greene and Moore 1995).

Underwater sounds from passing aircraft are transient. Levels and durations of sounds received underwater from passing aircraft depend on the noise strength of the aircraft, the altitude and aspect of the aircraft, water depth, bottom conditions, the temperature-salinity profile of the water column, and receiver depth. The peak received noise level in water, as an aircraft passes directly overhead, decreases with increasing altitude and increasing receiver depth. At incident angles greater than 13° from the vertical, much of the incident noise from passing aircraft is reflected and does not penetrate the water with calm seas, deep water, or shallow water with a nonreflective bottom. However, some airborne sound may penetrate water at angles greater than 13° from the vertical when rough seas provide suitable angles for additional transmission, but only above certain frequencies (Lubard and Hurdle 1976). Accordingly, the duration of audibility of a passing aircraft is far longer in air than in water. As explained previously, bottom type and water depth may strongly affect the level and frequency content of aircraft noise by either reflectivity or absorption of sound. Due to multiple reflections, lateral propagation underwater during aircraft flyover is better in shallow than in deep water, especially in the case of a reflective bottom (e.g., basalt); thus, its noise can be heard longer in shallow than in deep water.

---

[6] The blade rate is defined as the number of turns of a propeller or turbine per second multiplied by the number of blades.

Small and Large Vessels. Vessels are primary contributors to overall background noise in the sea, given their large numbers, wide distribution, and mobility (Greene and Moore 1995). Sound levels and frequency characteristics of vessel noises underwater are generally related to vessel size, speed, and mode of operation, although there exist wide variations among vessels of similar classes depending on vessel design. Larger vessels generally emit stronger and lower-frequency sounds than smaller vessels do because of their greater power, large drafts,[7] and slow-turning engines and propellers, and those underway with a full load or those pushing or towing a load are noisier than unladen vessels. The primary noise sources from all machine-powered vessels are related to propeller, propulsion, and other machinery. Propeller cavitation is usually the dominant underwater noise source of many vessels (Ross 1976). In general, propeller cavitation produces most of the broadband noise, with dominant tones resulting from the propeller blade rate. Propeller singing, typically a result of resonant vibration of the propeller blade(s) with a strong tone between 100 and 1,000 Hz, is an additional source of propeller noise. Cavitation bubbles absorb vibrational energy, so propeller singing ceases in case of strong cavitation. Noise from propulsion machinery is generated by engines, transmissions, rotating propeller shafts, and mechanical friction. These sources reach the water through the vessel hull. Other sources of vessel noise include a diverse array of auxiliary machinery, flow noise from water dragging along a vessel's hull, and bubbles breaking in the vessel's wake (Greene and Moore 1995).

Small boats produce noise of about 150–170 dB re 1 μPa-m at frequencies mostly below 1,000 Hz. At the 1/3 octave-band's center frequency of 1,000 Hz, a tug pulling a barge generates 164 dB re 1 μPa-m when empty and 170 dB re 1 μPa-m when loaded. A tug and barge underway at 18 km/hr (11 mph) can generate broadband (45–7,070 Hz) source levels of 171 dB re 1 μPa-m. A small crew boat produces 156 dB re 1 μPa-m at the 90 Hz tone. A small boat with an outboard engine generates 156 dB re 1 μPa-m at the 1/3 octave-band's center frequency of 630 Hz, with almost the same levels as that ranging from 400 to 800 Hz. An inflatable boat with a 25 horsepower outboard engine produces 152 dB re 1 μPa-m at the 1/3 octave-band's center frequency of 6,300 Hz (Greene and Moore 1995).

Fishing in coastal regions also contributes sound to the overall ambient noise. Sound produced by these smaller boats is typically at a higher frequency, around 300 Hz. A 12-m (39-ft) long fishing boat, underway at 7 knots, generates a broadband source level of 151 dB re 1 μPa-m in the 250–1,000 Hz range. Trawlers generate source levels of 158 dB re 1 μPa-m at the 1/3 octave-band's center frequency of 100 Hz, with almost the same levels as that ranging from 100 to 250 Hz (Greene and Moore 1995).

Few data on 1-m (3-ft) source levels are available for small ships, such as support and supply ships. A supply ship underway can generate broadband (45–7,070 Hz) source levels of 181 dB re 1 μPa-m. In general, broadband (20-1000 Hz) source levels for most small ships are about 170 to 180 dB re 1 μPa-m (Greene and Moore 1995), which is for ships between boats and large vessels.

[7] The draft denotes the vertical distance between the waterline and the bottom of the ship's hull.

Shipping traffic, including large commercial vessels and supertankers, is most significant at frequencies from 20 to 300 Hz. Source levels from a freighter can be 172 dB re 1 μPa-m in the dominant tone of 41 Hz. Large vessels such as tankers, bulk carriers, and container ships can range from 169 dB (at the 428 Hz tone) to 181 dB (at the 33 Hz tone) re 1 μPa-m, while a very large container ship generates as much as 181–198 dB re 1 μPa-m (at tones below 40 Hz). Supertankers generate peak source levels of 185–190 dB re 1 μPa-m at about a 7 Hz tone. Noise levels of supertankers are highest at the lowest frequency measured (near 2 Hz), while strong broadband components caused by propeller cavitation are centered at frequencies ranging from 40 to 100 Hz (Greene and Moore 1995).

In shallow water, shipping traffic located more than 10 km (6 mi) away from a receiver generally contributes only to background noise. However, in deep water, low-frequency components of traffic noise up to 4,000 km (2,485 mi) away may contribute to background noise levels (Greene 1995).

3.6.1.4.2 Dredging and Construction. Marine dredging and construction activities are common within the coastal waters of the OCS. Underwater noises from dredge vessels are typically continuous in duration (for periods of days or weeks at a time) and strongest at low frequencies. Marine dredging sound levels vary greatly, depending upon the type of dredge (such as transfer, hopper, and clamshell dredges), and hopper dredges were noisier than transfer dredges (Greene 1985a, 1987). Transfer dredges can generate broadband (45–890 Hz) source levels of 172 to 185 dB re 1 μPa-m, and 1/3 octave-band (between 10 and 1,000 Hz) source levels ranging from 150 to 180 dB re 1 μPa-m with peaks in the 100–200 Hz range (Greene and Moore 1995). A clamshell dredge generates broadband (20–1,000 Hz) source levels of about 167 dB re 1 μPa-m while pulling a loaded clamshell back to the surface. Because of rapid attenuation of low frequencies in shallow water, dredging noise can diminish below typical broadband ambient levels of about 100 dB re 1 μPa within 25 km (16 mi) of dredges, but stronger tones from some dredges can be detectable beyond 25 km (16 mi) under certain conditions (Greene and Moore 1995).

Sounds from various onshore construction activities vary greatly in levels and characteristics. These sounds are most likely within shallow waters. Onshore construction activities may also propagate into coastal waters, depending upon the source and ground material (Greene and Moore 1995).

Pile driving during construction activities is of special concern because it generates signals with a very high source level and broad bandwidth. In general, the source level and frequency content of the sounds produced by pile driving depend on a variety of factors, including the type and size of the impact hammer and the pile, the properties of the seafloor, and the depth of the water. Thus, the actual sounds produced would vary from location to location.

Pile driving is expected to generate sound levels in excess of 200 dB and to have a relatively broad bandwidth from 20 Hz to the ultrasonic range above 20 kHz, with peak energy between 100 and 500 Hz (Madsen et al. 2006; Thomsen et al. 2006). Due to the impulsive nature of the sound, the radiation pattern is assumed to be rather omnidirectional

(Madsen et al. 2006). Measurements from offshore wind farms in German Bight indicated that the broadband peak sound pressure level during pile driving were 189 dB_{0-p} re 1 μPa (SEL = 166 dB re 1 $\mu Pa^2 \cdot s$) at 400 m (1,300 ft) distance, resulting in a peak broadband source level of 228 dB_{0-p} re 1 μPa-m (SEL = 206 dB re 1 $\mu Pa^2 \cdot s$-m) (Madsen et al. 2006). The 1/3 octave-band sound pressure level was highest at 315 Hz (peak = 218 dB_{0-p} re 1 μPa-m) with considerable sound energy above 2 kHz.

Sound propagation modeling for three projects predicted underwater noise levels greater than 160 dB re 1 μPa (NMFS threshold for behavioral disturbance/harassment from a noncontinuous noise source) at distances ranging from 3.4 to 7.2 km (2.1 to 4.5 mi) (BOEMRE 2011b). Pile-driving noise can travel a long distance; even at 80 km (50 mi) distance, the sound pressure levels at frequencies below 4 kHz are well above background noise, about 40–50 dB (Thomsen et al. 2006).

3.6.1.4.3 Oil and Gas Drilling and Production. Offshore drilling and production involve a variety of activities that produce underwater noises. Offshore drilling can be, in large part, made from three types of facilities: (1) natural or manmade islands; (2) bottom-founded platforms; and (3) drilling vessels, including semisubmersibles and drillships. Irrespective of type of facilities, most noises associated with offshore oil drilling and gas production are generally below 1,000 Hz (Greene and Moore 1995).

Compared with other drilling facilities, underwater noise emanating from drilling on natural or manmade islands is generally low, primarily due to poor transmission of sound through the rock and fill islands. And thus noise is inaudible at ranges beyond a few kilometers. During drilling operations at the Sandpiper Island, Miles et al. (1987) estimated the source level of 145 dB re 1 μPa-m at a predominant 40-Hz tone, which is presumed related to diesel electric generator operation.

Underwater noises emanating from drilling activities from fixed, metal-legged platforms are considered weak due to noise sources on decks well above the water and small surface areas in contact with water. The strongest tones are generally at very low frequencies, near 5 Hz, for which received levels of 119 to 127 dB re 1 μPa at near-field measurement locations were reported (Gales 1982).

Drillships show somewhat higher noise levels than semisubmersibles as a result of mechanical noises generated through the hull of a drillship that is well coupled to the water. The drillship *Canmar Explorer II* generated broadband (45–7,070 Hz) source levels of 174 dB re 1 μPa-m. The specialized ice-strengthened floating platform *Kulluk* is by far the noisiest among drillships, producing broadband (45–1,780 Hz) source levels of 185 dB re 1 μPa-m (Greene and Moore 1995). Across the 20 to 1,000 Hz range, its 1/3 octave-band source levels are higher than that for *Canmar Explorer II*, with a maximum difference of about 15 dB. Measurements from *Kulluk* operating in another area indicated that it produced broadband (10–10,000 Hz) source levels of 191 dB re 1 μPa-m while drilling and 179 dB re 1 μPa-m while tripping (extracting or lowering the drillstring) (Hall et al. 1994).

In the shallow waters, the overall noise (20 to 1,000 Hz band) from most drilling operations would be at levels below the median ambient noise (about 100 dB re 1 μPa) at ranges greater than 30 km (19 mi) (Greene 1987).

Offshore oil and gas production is made from natural/manmade islands or from bottom-standing metal platforms. Sounds from production on islands or platforms can attenuate rapidly due to the reasons explained above for platforms and islands. Underwater sound levels from these activities are relatively low compared with other manmade activities. In addition, support activities associated with oil and gas operations such as supply/anchor handling and crew boats and helicopters also contribute to the noise from offshore activities.

3.6.1.4.4 Geophysical Surveys. Marine geophysical (seismic) surveys are commonly conducted to delineate oil and gas reservoirs below the surface of the land and seafloor. These operations direct high-intensity, low-frequency sound waves through layers of subsurface rock, which are reflected at boundaries between geological layers with different physical and chemical properties. The reflected sound waves are recorded and processed to provide information about the structure and composition of subsurface geological formations (McCauley 1994). In an offshore seismic survey, a high-energy sound source is towed at a slow speed behind a survey vessel. Until the mid-1960s, explosive charges were the standard sources for marine seismic exploration, but nonexplosive seismic survey sources, such as air guns, sleeve exploders, gas guns, and Vibroseis®, are currently in use, among which air guns are commonly used (Greene and Moore 1995). An air gun is a pneumatic device that produces acoustic output through the rapid release of a volume of compressed air, which forms bubbles. The air gun is designed to direct the high-energy bursts of low-frequency sound (termed a “shot”) downward toward the seafloor. Air guns are usually used in sets, or arrays, rather than singly (McCauley 1994). Reflected sounds from below the seafloor are received by an array of sensitive hydrophones on cables (collectively termed “streamers”) that are either towed behind a survey vessel or attached to cables placed on or anchored to the seafloor.

Air gun arrays are the most common source of seismic survey noise. Air guns produce energy primarily at 10–120 Hz, with some energy up to 500–1,000 Hz, which is lower than low-frequency energy but much higher than ambient noise levels. A typical full-scale air gun array produces a broadband source level of 248–255 $dB_{0\text{-}p}$[8] re 1 μPa-m (Johnston and Cain 1981; Greene 1985b), with the most powerful air gun array producing 259 $dB_{0\text{-}p}$ re 1 μPa-m (Parrott 1991). Typical seismic arrays being used in the GOM produce source levels (sound pressure levels) of approximately 240 $dB_{0\text{-}p}$ re 1 μPa-m. Despite downward focusing of the seismic air gun pulses toward the ocean bottom, portions of their energy propagate horizontally, which is of greater concern. In waters 25–50 m (82–164 ft) deep, sound produced by air guns can be detected 50–75 km (31–47 mi) away, and these detection ranges can exceed 100 km (62 mi) during quiet times with efficient propagation, or in deeper water (Greene and Moore 1995).

[8] For an ideal sinusoid, the zero-to-peak value is about 6 dB lower than peak-to-peak value and about 3 dB higher than the rms value.

3.6.1.4.5 Navigation and Target Detection. Active sonar systems are used for the detection of objects underwater. These range from depth-finding sonars (fathometers), found on most ships and boats, to powerful and sophisticated units used by the military. Sonars emit transient, and often intense, sounds that vary widely in intensity and frequency. Unlike most other manmade noises, sonar sounds are mainly at moderate to high frequencies, ranging from a few hundred hertz for long-range search sonar to several hundred kilohertz for side-scan sonars and military sonars, which attenuate much more rapidly than lower frequencies (Greene and Moore 1995). Acoustic pingers used for locating and positioning of oceanographic and geophysical equipment also generate noise at high frequencies.

Source levels of depth sounders are over 180 dB re 1 μPa-m at over 12 kHz, while those of bottom profilers are about 200–230 dB re 1 μPa-m in the 0.4–30 kHz range. Military sonars for search and surveillance operate at 2–57 kHz, with source levels of over 230 dB re 1 μPa-m (Watts 1994).

3.6.1.4.6 Explosions. Underwater explosions in open waters are the strongest point sources of anthropogenic sound in the sea. Sources of explosions include both military testing and non-military activities, such as offshore structure removals. Explosives produce rapid onset pulses (shock waves) followed by a succession of oscillating low-frequency bubble pulses, if the explosion occurs sufficiently deep from the surface (Staal 1985). Shock waves change to conventional acoustic pulses as they propagate.

High-explosive detonations have velocities of 5,000–10,000 m/s with pulse rise times of about 20 μsec and short-pulse durations of 0.2–0.5 ms. Although the wave is initially supersonic, it is quickly reduced to a normal acoustic wave. Bubble-pulse frequency decreases as charge mass increases and as charge depth decreases. The spectra are dominated by a broad peak over a lower frequency band (<100 Hz), with strong infrasonic (<20 Hz) energy. Even a small 0.5-kg (1-lb) charge of TNT generates source levels of 267 $dB_{0\text{-}p}$ re 1 μPa-m, while a 20-kg (44-lb) charge of TNT produces 279 $dB_{0\text{-}p}$ re 1 μPa-m, with dominant frequencies below 50 Hz. Detonation of very large charges during ship shock tests with a 4,536-kg (10,000-lb) charge produces source levels of more than 294 $dB_{0\text{-}p}$ re 1 μPa-m (Greene and Moore 1995; MMS 2005a).

3.6.1.4.7 Ocean Science Studies. Ocean science studies examine characteristics of the water masses and ocean bottom layer. In addition to the seismic surveys that are mentioned above, these include investigating sound transmission and the properties of ocean water masses (acoustic oceanography), the latter of which include tomographic studies.

Two notable closely related ocean science studies are presented to describe typical source levels. In January 1991, the Heard Island Feasibility Test (HIFT) in the southern Indian Ocean was carried out to establish the limits of usable, long-range acoustic transmissions (Munk et al. 1994). In the study, a vertical array of five sources, centered at 57 Hz (bandwidth 14 Hz), generated broadband source levels of about 220–221 dB re 1 μPa-m. These signals were detected halfway around the world (at ranges of up to ~20,000 km [12,427 mi]). The Acoustic

Thermometry of Ocean Climate (ATOC) study was made in the northern Pacific Ocean over the decade 1996–2006, and was designed to monitor long-term ocean temperature trends. The coded signals with a source level of 195 dB re 1 μPa-m transmitted broadband signals centered at 75 Hz (bandwidth 35 Hz) to receivers scattered in the northern Pacific Ocean at a maximum range of about 5,500 km (3,418 mi) (Dushaw et al. 2009).

3.6.1.4.8 Snowmachines and Ice Roads. The two principal sources of transportation activity on the North Slope are the oil industry and the Iñupiat communities (MMS 2008b). Small snowmobiles have high-speed two-cycle engines. These are noisy in air and create sounds at higher frequencies than larger, slower machinery. The amount of sound passing through ice into the water below is expected to vary greatly depending on snow, ice, and temperature conditions. The spectrum of snowmobile sound as received under the ice includes much energy near 1–1.25 kHz, but levels vary widely: spectrum levels about 90 dB re 1 $\mu Pa^2/Hz$ at a range of 148 m (486 ft) in one study, versus only 55-60 dB at range of about 200 m (656 ft) in another (Greene and Moore 1995).

The oil industry builds ice roads in winter to access areas that otherwise would be inaccessible to large equipment. Fresh water from local streams and ponds is used to build a thick, flat road surface capable of supporting large machinery. Ice-road construction begins after freezeup and after there is a minimum of 6 in. of base snow. Ice roads are built over tundra and shorefast ice to facilitate exploration and development while minimizing impacts (MMS 2008b).

3.6.1.5 Climate Change Effects

Potential impacts of climate change on the acoustic environment are relatively minor. Since the sound attenuation rate depends on seawater acidity, it has been suggested that increasing ocean acidification resulting from rising anthropogenic CO_2 emissions will result in decreased sound absorption (Hester et al. 2008). Increases in ambient low-frequency noise have already been reported, attributable largely to an overall increase in human activities, such as shipping that are unrelated to climate change (Andrews et al. 2002). Due to the combined effects of decreased absorption and anticipated increases in overall human activities, ambient noise levels will increase considerably within the auditory range of 10–10,000 Hz, which are critical for environmental, biota, military, and economic interests (Hester et al. 2008). There will also be changes in frequency spectrum distributions.

3.6.2 Alaska – Cook Inlet

For a more detailed discussion on the acoustic environment of Cook Inlet, please see MMS (2003a), which is incorporated here for reference.

General underwater noise sources are covered in detail in Section 3.6.1, Acoustic Environment: Gulf of Mexico, while those limited to Arctic Alaska are discussed in

Section 3.6.3, Acoustic Environment: Alaska – Arctic. In this section, noise sources specific to Cook Inlet will be presented.

3.6.2.1 Sources of Natural Sound

In Cook Inlet, underwater sound is generated by a variety of natural sources, such as ice, the action of wind, waves, and biological activity. Ambient noise levels and the acoustic environment in the Cook Inlet vary greatly among seasons and even daily. To a lesser degree than in the Arctic, ice plays a role in the ambient noise levels. In contrast to the Arctic environment, strong tidal fluctuations and currents function as additional sources of ambient noise in Cook Inlet. Cook Inlet has one of the largest tides in the North American continent, and thus tidal noises can be important contributors to ambient levels, especially at low frequencies. Wind and wave action also contribute to ambient noise. Measurements at several seaward locations around Anchorage that are removed from industrial activities indicated that the mean ambient underwater broadband (10–20,000 Hz) levels span a fairly wide range, from 95 to 120 dB re 1 µPa (Blackwell and Greene 2002).

Marine mammals in Cook Inlet also contribute to ambient noise.

Echolocation clicks have the highest source levels among marine mammal sounds. The echolocation signals from beluga whales have source levels of about 206–225 dB re 1 µPa-m, with peak frequencies between 40 and 60 kHz and between 100 and 120 kHz (Au et al. 1985, 1987; Au 1993). Under controlled conditions, a trained beluga had good echolocation abilities at distances up to at least 80 m (262 ft) (Au et al. 1987). However, maximum distances at which echolocation pulses can be detectable by hydrophone (one-way travel) are much greater than the maximum target distance at which the emitting animal can detect echoes (two-way travel).

Humpback whales in southeast Alaskan waters produce five categories of sounds, with frequencies ranging between 20 and 2,000 Hz (Thompson et al. 1986). Source levels ranged from 162 (low-frequency pulse trains) to 192 dB (surface impacts resulting from fluke or flipper slaps), re 1 µPa-m.

Fin whales typically produce calls around 20 Hz, which have source levels of about 160–186 dB re 1 µPa-m with extremes of 200 dB and ≤140 dB (Patterson and Hamilton 1964; Northrop et al. 1968, 1971; Watkins 1981; Watkins et al. 1987; Cummings and Thompson 1994). Calls at 20 Hz can be transmitted up to 185 km (115 mi) away (Cummings and Thompson 1971).

There are many other species of marine mammals in the marine environment of Cook Inlet whose vocalizations contribute to ambient sound. These include but are not limited to, other whales (such as gray whales), dolphins, sea lions, sea otters, and seals (see Section 3.8.1.2). Sea lions, sea otters, seals, and marine and coastal birds all produce sound that can be heard above water.

3.6.2.2 Sources of Anthropogenic Sound

The primary sources of anthropogenic sounds in the Cook Inlet include aircraft overflights, vessel activities and traffic, oil and gas activities, including seismic surveys and production operations and other miscellaneous human activities such as construction of pipelines and production facilities, pile driving for a new dock at Anchorage port, and possibly new bridge construction. Port of Anchorage and Anchorage International Airport, which are important transportation and distribution hubs, and Elmendorf Air Force Base are located more than 145 km (90 mi) northeast of the Cook Inlet Planning Area (see Figure 3.2.1-1). Cook Inlet experiences considerable aircraft traffic throughout the year, including commercial passenger, cargo, private, and military aircraft (Moore et al. 2000). In particular, Kenai and Homer airports, located east of the planning area, processed about 114,000 flight operations in 2001, about half of which were attributable to air-taxi operations. More than 10 helicopters are also based at these two airports. In Cook Inlet, significant noise originates from heavy vessel traffic, including cargo vessels, freighters, tankers, supply ships, support vessels, tugboats, barges, seismic-survey vessels, and fishing boats (for recreational, commercial, subsistence, and personal use). As for natural sound, anthropogenic sound varies spatially and temporally within the Cook Inlet.

Considering the size and/or traffic volume of vessels, noise from boat traffic associated with oil and gas activities is likely less than that from the fishing and commercial traffic occurring within the Cook Inlet. However, shipping traffic is more pronounced in Cook Inlet than in the Arctic Ocean. Shipping traffic dominates the spectra of ambient noise between 20 and 300 Hz. Fishing vessels produce high-frequency sound peaking at 300 Hz, whereas larger cargo vessels produce more lower frequency sounds (Greene and Moore 1995).

Sounds produced by offshore oil and gas platforms in Cook Inlet have not been well studied. However, drilling platforms and combined drilling/production platforms in California produce little underwater sound because of the small surface area in contact with the water and the placement of machinery on decks well above the water (Gales 1982).

3.6.2.3 Climate Change Effects

Potential impacts of climate change on the acoustic environment are relatively minor. Since the sound attenuation rate depends on seawater acidity, it has been suggested that increasing ocean acidification resulting from rising anthropogenic CO_2 emissions will result in decreased sound absorption (Hester et al. 2008). Increases in underwater low-frequency noise have already been reported, attributable largely to an overall increase in human activities, such as shipping that are unrelated to climate change (Andrews et al. 2002). Although sea ice is limited to northern Cook Inlet during winter through early spring, reduced sea ice associated with climate change could provide a longer open water season for shipping and resource extraction, which could increase sound levels in Cook Inlet. Due to the combined effects of decreased absorption, the anticipated increase in overall human activities, and the longer open water season, ambient noise levels will increase considerably within the auditory range of 10–10,000 Hz, which are critical for environmental, biota, military, and economic interests (Hester et al. 2008). There will also be changes in frequency spectrum distributions.

3.6.3 Alaska – Arctic

For a more detailed discussion on the acoustic environment of the Arctic region, please see MMS (2008b) and MMS (2006c), which are incorporated here for reference.

General underwater noise sources are covered in detail in Section 3.6.1, Acoustic Environment: Gulf of Mexico, while those limited to Cook Inlet are discussed in Section 3.6.2, Acoustic Environment: Alaska – Cook Inlet. In this section, noise sources specific to Arctic Alaska will be presented.

In the Arctic Project Areas including the Beaufort and Chukchi Seas, underwater sound is generated by a variety of natural and anthropogenic sources. The arctic waters are a unique acoustic environment mainly due to the presence of ice, which can contribute significantly to ambient sound levels and affects sound propagation.

3.6.3.1 Sources of Natural Sound

Natural sound in the Alaskan Arctic predominantly originates from ice and the action of wind, waves, and biological activity (Greene 1995). Ambient levels of natural sound can vary dramatically between and within seasons at a particular location and can vary from location to location. As an example, Burgess and Greene (1999) found that ambient sound in the Beaufort Sea in September 1998 ranged widely, between about 63 and 133 dB re 1 μPa. The presence, thickness, and movement of sea ice significantly influence the ice's contribution to ambient sound levels, as does the period of open water when wind and waves contribute to ambient sound levels.

Sea Ice. The Arctic waters are a unique acoustic environment mainly due to the presence of ice, which can contribute significantly to ambient sound levels and affects sound propagation. Ice cracking due to thermal stresses caused by temperature changes generates noise, and ice deformation under pressure from wind and currents produces significant low-frequency noise (Greene 1995). Data are limited, but in at least one instance it has been shown that ice-deformation sounds had frequencies of 4–200 Hz (Greene 1981). While sea ice can produce significant sound, it also can also function to dampen ambient sound.

Ambient noise levels in the project area can vary drastically between seasons and can also vary with sea ice conditions. In winter and spring, shore-fast ice produces significant thermal cracking sounds (Milne and Ganton 1964). The spectrum of cracking noise typically displays a broad range from 100 to 1000 Hz, and the spectrum level has been observed to vary as much as 15 dB within 24 hours due to the diurnal change of air temperature. The NRC (2003; citing Urick 1984) reported that variability in air temperature over the course of the day can change received sound levels by 30 dB between 300 and 500 Hz. Spring noise spectra peaked at about 90 dB re 1 $\mu Pa^2/Hz$ at infrasonic frequencies (0.5–2 Hz) (Milne and Ganton 1964). In the 2–20 Hz range, noise spectra decrease with increasing frequency, while in the 20–8,000 Hz range, the levels of 50 dB re 1 $\mu Pa^2/Hz$ remain constant. Winter noises include wind-induced noise as well as thermal cracking sounds. Winter noise, equivalent to Knudsen spectrum for sea state three, is higher than during any other season. For late summer ice, relative motion of the floes is the primary factor for ambient sound. As icebergs melt, they produce additional background noise with a spectrum level flat at about 62 dB re 1 μPa^2/Hz at a range of 180 m from an iceberg, decreasing to about 58 dB at 10 kHz (Urick 1971). In addition to noise caused by breakup, sea ice makes noise when temperature changes result in cracking. Underpressure from wind and currents also results in significant low-frequency noise, and iceberg melting results in "seltzer" noise.

The Arctic Ocean is almost uniformly cold from top to bottom, and pressure always increases with depth. Thus, sound speed is the lowest at or near the surface. All sound rays in the arctic surface channel are refracted upward and are then reflected from the under-ice surface (Richardson et al. 1995). Low-frequency noise loses its energy by conversion of acoustic waves into flexural waves of the ice sheet. At higher frequencies, under-ice roughness plays a primary role in sound propagation. Smooth annual ice may enhance propagation as compared with open water conditions. However, increased cracking, ridging, and other forms of roughness generally cause more transmission losses than under open water conditions. As ice forms, especially in very shallow water, the sound propagation properties of the underlying water are affected in a way that can reduce the transmission efficiency of low-frequency sound (Blackwell and Greene 2002). At frequencies less than 500 Hz, where most acoustic energy from aircraft and surface vehicles is concentrated, the ice layer is acoustically thin and causes little attenuation of sound (Malme 1995).

The presence of sea ice also affects the timing, nature, and possible locations of human activities such as shipping; research; barging; whale hunting; oil- and gas-related exploration (e.g., seismic surveys and drilling); military activities; and other activities that introduce noise into the marine environment. Because of sea ice and its effects on human activities, ambient sound levels in the Beaufort and Chukchi Seas can vary dramatically between seasons and with sea ice conditions. The presence of ice also impacts which marine species are present, another factor that influences ambient sound levels.

There is some concern that climate change will alter the acoustic environment in the Arctic drastically. Arctic sea ice is declining rapidly. Its extent has fallen at a rate of 3 to 4% per decade over the last three decades, and this trend is very likely to continue (USGCRP 2009). If Arctic warming continues, it is likely that changes in the acoustic environment also will occur in many parts of the waters off Alaska (Tynan and DeMaster 1997; Brigham and Ellis 2004). Climate warming potentially could: (1) increase noise and disturbance related to increased shipping and other vessel traffic and possibly increased seismic exploration and development; (2) expand commercial fishing and/or cause a change in areas where intensive fishing occurs; (3) decrease year-round ice cover; (4) change subsistence-hunting practices; and (5) change the distribution of marine mammal species (MacLeod et al. 2005).

Wind and Waves. During the open water season **i**n the Arctic, wind and waves are important interrelated sources of ambient sounds with levels tending to increase with increased wind (and thus sea state) and wave height, all other factors being equal (Greene 1995). Areas of water with 100% sea ice cover can reduce or completely eliminate sounds from waves or surf. However, the marginal ice zone in the area near the edge of large sheets of ice usually is characterized by quite high levels of ambient sound compared to other areas, in large part due to the impact of waves against the ice edges and the breaking up and rafting of ice flows (Milne and Ganton 1964).

Marine Mammals (and Birds). Marine mammals can contribute significantly to the background sounds in the acoustic environment of the Beaufort and Chukchi Seas; however, frequencies and levels depend highly on seasons. For example, bearded seal sounds dominate ambient noise in many Arctic areas during spring; source levels of bearded seal songs have been estimated to be up to 178 dB re 1 μPa-m, with dominant frequencies of 1–2 kHz (Cummings et al. 1983). Parts of some calls were recorded up to a distance of 25 km (16 mi) underwater (Cleator et al. 1989). Ringed seal calls have a source level of 95–130 dB re 1 μPa-m, with the most energy below 5 kHz (Thomson and Richardson 1995). Its source levels are low compared with those of other marine mammals and the detection range may not exceed 1 km (0.6 mi) (Cummings et al. 1984). Bowhead whales, which are present in the Arctic region from early spring to mid- to late fall, produce sounds with estimated source levels ranging 128 to 189 dB re 1 μPa-m in frequency ranges from 20 to 3,500 Hz. Thomson and Richardson (1995) summarized that most bowhead whale calls are "tonal frequency modulated (FM)" sounds at 50–400 Hz. A few callings of bowhead whales are detectable up to 20 km (12 mi) away, although most localizable whales are ≤ 10 km (6.2 mi) away (Cummings and Holliday 1985; Davis et al. 1985; Clark et al. 1986; LGL and Greeneridge 1987).

There are many other species of marine mammals in the arctic marine environment whose vocalizations contribute to ambient sound including, but not limited to, the gray whale, walrus, beluga whale, spotted seal, fin whale (in the southwestern areas), and, potentially but less likely, the humpback whale. Walruses, seals, and seabirds (especially in the Chukchi Sea near colonies) all produce sound that can be heard above water.

3.6.3.2 Sources of Anthropogenic Sound

The primary sources of anthropogenic sounds in the Arctic include vessel activities and traffic, oil and gas activities, including seismic surveys, production, and other miscellaneous activities. During much of the year in many marine areas, there are few near-field marine noise sources of human origin and limited, but increasing, land-based and nearshore-based sources of noise.

Anthropogenic sources of sound in the project area include vessels; navigation and scientific research equipment; airplanes and helicopters; human settlements; military activities; and marine development, including those sounds from the oil and gas activities. Ambient sound levels from anthropogenic sources can also fluctuate temporally and spatially as much as variations in natural sounds. Table 3.6.1-1 provides a comparison of man-made sound levels from various sources and their typical source levels associated with the marine environment.

Vessel Activities and Traffic. The types of vessels that typically produce noise in the Beaufort and Chukchi Seas include barges, skiffs with outboard motors, icebreakers, tourism and scientific research vessels, and vessels associated with oil and gas exploration, development, and production. In the Beaufort and Chukchi Seas, vessel traffic and associated noise presently is limited primarily to open water season between late spring and early autumn.

In shallow water, vessels more than 10 km (6.2 mi) away from a receiver generally contribute only to background noise levels (Greene 1995). In deep water, traffic noise up to 4,000 km (2,485 mi) away may contribute to background noise levels. Shipping traffic is most significant at frequencies from 20 to 300 Hz (Greene 1995). Barging associated with activities such as onshore and limited offshore oil and gas activities, fuel and supply shipments, and other activities contributes to overall ambient noise levels in some regions of the Arctic. Smaller boats, such as aluminum skiffs with outboard motors during fall subsistence whaling and fishing also generate noise, typically at a higher frequency around 300 Hz (Greene and Moore 1995).

Icebreaking vessels used in the Arctic for activities including research and oil and gas activities produce louder, but also more variable, sounds than those associated with other vessels of similar power and size (Greene and Moore 1995). Icebreaking noise is up to 15 dB higher than when the same ship is underway in open water, primarily due to strong propeller cavitation. However, physical crushing of ice contributes little to the overall increase in noise. In general, spectra of icebreaker noise are wide and highly variable over time. Icebreaking generates broadband (10–1,000 Hz) source levels of 184 and 191 dB re 1 µPa-m during movement ahead and astern, respectively (Greene and Moore 1995). Even with rapid attenuation of sound under heavy ice conditions, the elevation in noise levels attributed to icebreaking can be substantial out to at least 5 km (3 mi). In some instances, icebreaking sounds are detectable from more than 50 km (31 mi) away.

Hovercraft can operate on open water or ice, and tracked or standard vehicles can often operate on shore-fast ice. Recordings indicated that the hovercraft operating around the Northstar Island generate strong in-air sounds, but were considerably quieter underwater than conventional vessels of similar size (Blackwell and Greene 2005). Hovercraft have replaced much of the helicopter traffic to the Northstar facility. At the closest point of approach (6.5 m [21 ft]), underwater broadband (10–10,000 Hz) levels reached 133 and 131 dB re 1 µPa at depths of 1 and 7 m (3 and 23 ft), respectively, with the peak near 87 Hz, which corresponds to the blade rate of the thrust propeller.

In general, noise generated on ice is transmitted into the water directly below but does not propagate well laterally (Greene and Moore 1995). For sources on ice, sound levels are affected by ice conditions (temperature, snow cover) and are generally much lower than those generated by vessels on water. Snow absorbs sound, and thus transmits less sound energy to water, and water depth also affects sound transmission from sources on ice.

Northstar is the first offshore oil production island in the Beaufort Sea, which is located about 19 km (12 mi) northwest of the Prudhoe Bay. Around the Northstar Island, vessels were the main contributors to the underwater sound field. During both the ice-covered and the open water seasons, helicopters and a hovercraft were used to transport personnel and equipment to and from the Northstar Island (Richardson 2011). During the ice-covered season, tracked vehicles and standard vehicles were additional modes of transportation over an ice road to the Northstar Island. During the open water season, vessels such as tugs, self-propelled barges, crew boats, and other vessel operations (e.g., oil spill-response training) were additional modes of transportation. Broadband sounds from vessel traffic were often detectable as much as 30 km offshore. Sound measurements for the entire 2001–2010 late summer/early fall seasons indicated that broadband (10–450 Hz) ambient levels ranged from 81 to 141 dB re 1 μPa at about 450 m (1,476 ft) north to northeast of Northstar.

Seismic Noise. The oil and gas industry in Alaska conducts marine (open water) surveys (e.g., air gun array) in the summer and fall, and on-ice seismic surveys (e.g., Vibroseis) in the winter to locate geological structures potentially capable of containing petroleum accumulations and to better characterize ocean substrates or sub-sea terrain.

Air gun arrays are the most common source of seismic survey noise. Air guns produce energy primarily at 10–120 Hz, with some energy up to 500–1,000 Hz, which is lower than low-frequency energy but much higher than ambient noise levels. A typical full-scale air gun array produces a broadband source level of 248–255 dB_{0-p} re 1 μPa-m (Johnston and Cain 1981; Greene 1985b), with the most powerful air gun array of 259 dB_{0-p} re 1 μPa-m (Parrott 1991). Typical seismic arrays being used in the Arctic produce source levels (sound pressure levels) as high as 248 dB_{0-p} re 1 μPa-m (Greene and Richardson 1988).

While the seismic air gun pulses are directed toward the ocean bottom, sound propagates horizontally for several kilometers (Greene and Richardson 1988; Hall et al. 1994). In waters 25–50 m deep, sound produced by air guns can be detected 50–75 km (31–47 mi) away, and these detection ranges can exceed 100 km (62 mi) in deeper water (Greene and Moore 1995) and, particularly during summer, over 3,000 km (1,864 mi) in the open ocean (Nieukirk et al. 2004).

Vibroseis is a method of seismic profiling on shore-fast ice, usually over shallow water, which propagates energy into the earth over an extended period of time, in contrast to the near-instantaneous energy provided by impulsive sources. In this activity, hydraulically driven pads mounted beneath a line of trucks are used to vibrate, and thereby energize, the ice. Noise incidental to the activity is introduced by the vehicles associated with this activity. Greene and Moore (1995) summarized that typical signals associated with the vibroseis sound source used for an on-ice seismic survey sweep from 10 to 70 Hz, but harmonics extend to about 1.5 kHz. Vibroseis produces source levels of about 187–210 dB_{0-p} re 1 μPa-m and would reduce to the ambient level at distances of 3.5–5 km (2–3 mi) (Holliday et al. 1984).

Noise from Other Oil and Gas Activities. Offshore exploration and production drilling platforms (freestanding or drill ships) use machinery and equipment that emit noise into the marine environment. While most of this noise is relatively localized, organisms can be attracted to or be displaced away from these sites.

Onshore oil production facilities (and associated buildings, pipelines, roads, etc.) have equipment (machinery and vehicles) or people that generate noise. As of 2008, there is no oil production facilities in the Chukchi Sea. There is one operating oil production facility on an artificial island and several others in planning and construction stages in the Beaufort Sea. There are two other developments on causeways. While sounds originating from drilling activities on islands can reach the marine environment, noise typically propagates poorly from artificial islands, as it must pass through gravel into the water (Greene and Moore 1995). During unusually quiet periods, drilling noise from icebound islands with a low source level and low frequency would be audible at a range of about 10 km (6 mi), when the usual audible range would be about 2 km (1 mi). Broadband noise reduced to ambient levels within about 1.5 km (0.9 mi), and low-frequency tones were measurable to about 9.5 km (6 mi) under low ambient noise conditions, but were essentially undetectable beyond about 1.5 km (0.9 mi) with high ambient noise. Much of the production noise from oil and gas operations on gravel islands is substantially attenuated within 4 km (2.5 mi) and often not detectable beyond 9.3 km (6 mi) away.

Based on sounds measurements of noise from Northstar obtained during March 2001 and February–March 2002 (during the ice-covered season), Blackwell et al. (2004) found that background levels were reached underwater at 9.4 km (6 mi) during drilling and at 3–4 km (2–2.5 mi) without. Depending on the wind but irrespective of drilling, in-air background levels were reached at 5–10 km (3–6 mi) from Northstar. Without vessels and under calm sea (sea state ≤ 1), median underwater sound from a gravel island like Northstar generally reached background levels at about 2–4 km (1.2–2.5 mi) from Northstar (Richardson 2011).

3.6.3.2.3 Miscellaneous Sources. Acoustical systems are associated with some research, military, commercial, or other vessel use of the Beaufort or Chukchi Seas. Such systems include multi-beam sonar, sub-bottom profilers, and acoustic Doppler current profilers. Active sonar is used for the detection of objects underwater. These systems range from depth-finding sonar, found on most ships and boats, to powerful and sophisticated units used by the military. Sonar emits transient, and often intense, sounds that vary widely in intensity and frequency. Although not commonly used in the Arctic, acoustic pingers used for locating and positioning oceanographic and geophysical equipment also generate noise at frequencies greater than about 10–20 kHz. LGL Ltd. (2005) describes many examples of acoustic navigational equipment.

Small snowmobiles are used for transportation on the North Slope (MMS 2008b). These are noisy in air and create sounds at higher frequencies than larger, slower machinery. The amount of sound passing through ice into the water below is expected to vary greatly depending on snow, ice, and temperature conditions (Greene and Moore 1995).

The oil industry builds ice roads in winter to access areas that otherwise would be inaccessible to large equipment. Ice-road construction begins after freezeup and is built over tundra and shorefast ice to facilitate exploration and development while minimizing impacts (MMS 2008b).

3.6.3.3 Climate Change Effects

Potential impacts of climate change on acoustic environment are relatively minor. Since the sound attenuation rate depends on seawater acidity, it has been suggested that increasing ocean acidification resulting from rising anthropogenic CO_2 emissions will result in decreased sound absorption (Hester et al. 2008). Increases in underwater low-frequency noise have already been reported, attributable largely to an overall increase in human activities, such as shipping, that are unrelated to climate change (Andrews et al. 2002). In addition, reduced sea ice associated with climate change could provide a longer open water season for shipping and resource extraction, which could increase sound levels in the Beaufort and Chukchi Seas. Due to the combined effects of decreased absorption, the anticipated increase in overall human activities, and the longer open water season, ambient noise levels will increase considerably within the auditory range of 10–10,000 Hz, which are critical for environmental, biota, military, and economic interests (Hester et al. 2008). There will also be changes in frequency spectrum distributions.

3.7 MARINE, COASTAL, AND OTHER ADJACENT HABITATS

A habitat is defined as an area or environment where an organism or ecological community normally lives. Marine and coastal habitats occur as characteristic arrangements of geologic, hydrologic, oceanographic, and biologic features and processes that create environments favorable for the establishment, flourishing, and continued survival of the flora and fauna of marine and coastal areas. This section focuses on the geologic, biologic and oceanographic features that define marine and coastal habitats of particular concern. Habitats of particular concern are so designated because of their ecosystem importance, their association with high productivity and/or faunal populations, and/or their high scientific interest. These habitats will be evaluated within an ecoregional geographic framework shown in Figure 3.7-1 and discussed in Section 3.2.

3.7.1 Coastal and Estuarine Habitats

3.7.1.1 Gulf of Mexico

Habitats are divided into coastal and marine categories. Coastal habitats occur in estuarine areas along virtually the entire U.S. GOM coast. The EIS uses the EDAs from NOAA's Coastal Assessment Framework (http://coastalgeospatial.noaa.gov/) database to show the areas where the coastal habitats that are considered in the EIS are located (Figure 3.7-1). Marine habitats occur seaward of the coastal habitats that occur within estuarine watersheds. While a convenient boundary between coastal and marine habitats is the most seaward coastal feature, which typically would be barrier islands or beaches in the GOM, the actual boundary between predominantly coastal and predominantly marine habitats is a transition zone blurred by the influence of estuarine discharges onto the continental shelf. Figure 3.7-1 shows that the central coastal ecoregion estuarine influence extends to the edge of the continental shelf as a result of the discharge of the Mississippi River, while it is much more restricted on the continental shelf offshore Florida and Texas.

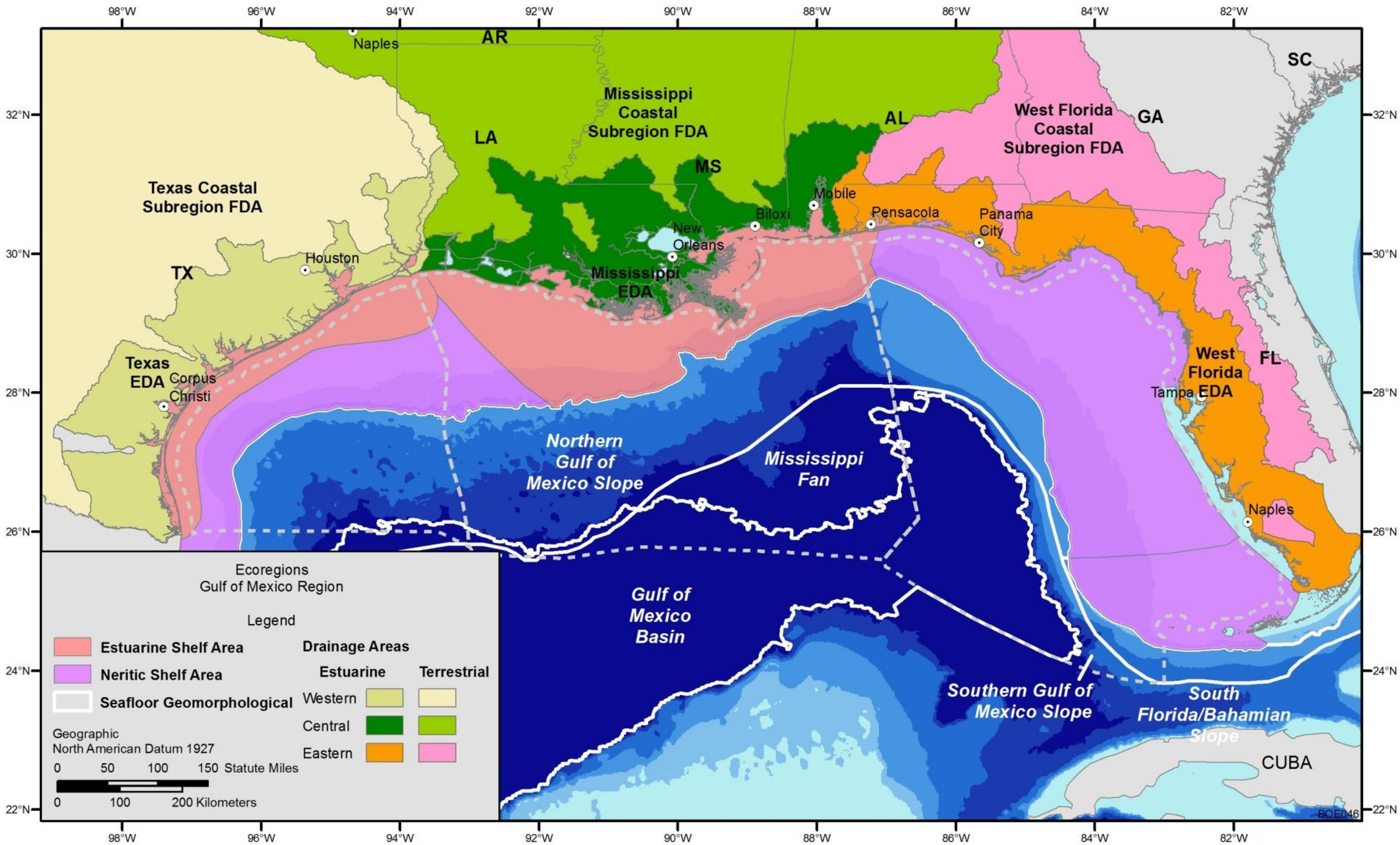

FIGURE 3.7-1 Ecoregions of the GOM Region

GOM coastal habitats are associated with a nearly continuous estuarine ecosystem that is made up of 31 major estuarine watersheds that extend across the coastal waters of the northern GOM. Coastal and nearshore habitats of concern within these areas include barrier islands and beaches, wetlands (marsh, bottomland swamp, mangrove, and scrub/shrub communities), and seagrasses. These habitats occur within estuarine watersheds in and around bays, lagoons, and river mouths where marine and fresh waters intermix. Coastal and nearshore habitats of the GOM can be subdivided into three GOM Estuarine Ecoregions (Figure 3.7.1-1), each with distinguishing characteristics, arrangements of habitat components, and freshwater inflows with associated nutrient and sediment loads: a western coastal ecoregion, extending from near the Mexico–Texas border to just east of the Louisiana border; the Central GOM Estuarine Region, extending to just east of the Florida border; and the Eastern GOM Estuarine Region, extending to the southern tip of Florida. These ecoregions are similar to the geographic/hydrologic regions of Yanez-Arancibia and Day (2004) and are consistent with estuarine influenced zones identified on the GOM continental shelf in the Marine Ecoregions of North America (CEC 2008).

Figure 3.7.1-1 emphasizes coastal habitats. It shows terrestrial, estuarine, and continental shelf estuarine areas and values for fluvial and marine processes/quantities. Fluvial drainage areas are shown because they depict the land area that drains into the estuarine portion of the watershed. The estuarine drainage areas show where coastal habitats potentially affected by OCS oil and gas activities occur. While OCS activities would not be expected to extend upstream into the terrestrial portion of the watershed, the terrestrial watershed characteristics have important influences on estuarine habitats. Terrestrial discharges introduce dissolved and suspended materials into estuarine and marine waters that can serve either as nutrients that enrich marine and coastal productivity or as pollutants that degrade habitat quality. The terrestrial discharges also carry suspended and bed load sediments from the land into estuarine areas where they are redistributed through the coastal zone to provide the substrate for many coastal habitats. Marine processes are also at work on the seaward side of estuarine areas through the action of waves, tides, and currents. These processes affect the redistribution of terrestrial sediments in the coastal zone, coastal erosion and deposition patterns, and mixing of fresh and salt water within the coastal zone and onto the continental shelf. To a large degree, the variations in the interactions among these terrestrial and marine processes and properties within the GOM explain the distinctions among the three coastal ecoregions that characterize the northern GOM.

Figure 3.7.1-1 indicates that marine processes affecting estuarine habitats, such as tidal range, wave height, and longshore sediment transport, are fairly uniform across the GOM coast. In contrast, there is substantial variation in terrestrial drainage properties among the coastal ecoregions. Fluvial discharge, for example, varies by a factor of over 25 across the three coastal ecoregions. The effect of the amount of fresh water discharged through the central GOM estuarine costal ecoregion is apparent on Figure 3.7.1-1, which shows the entire continental shelf area offshore of the Mississippi River delta as being estuarine influenced compared to smaller estuarine areas on the continental shelf offshore of the eastern and western coastal ecoregions.

The sizes and configurations of the fluvial drainage areas also affect governance issues that would apply to managing coastal environments and habitats and present and future programs for mitigating and restoring coastal habitats there. The central coastal fluvial drainage area is sub-continental in size and under the jurisdiction and regulatory authority of numerous state

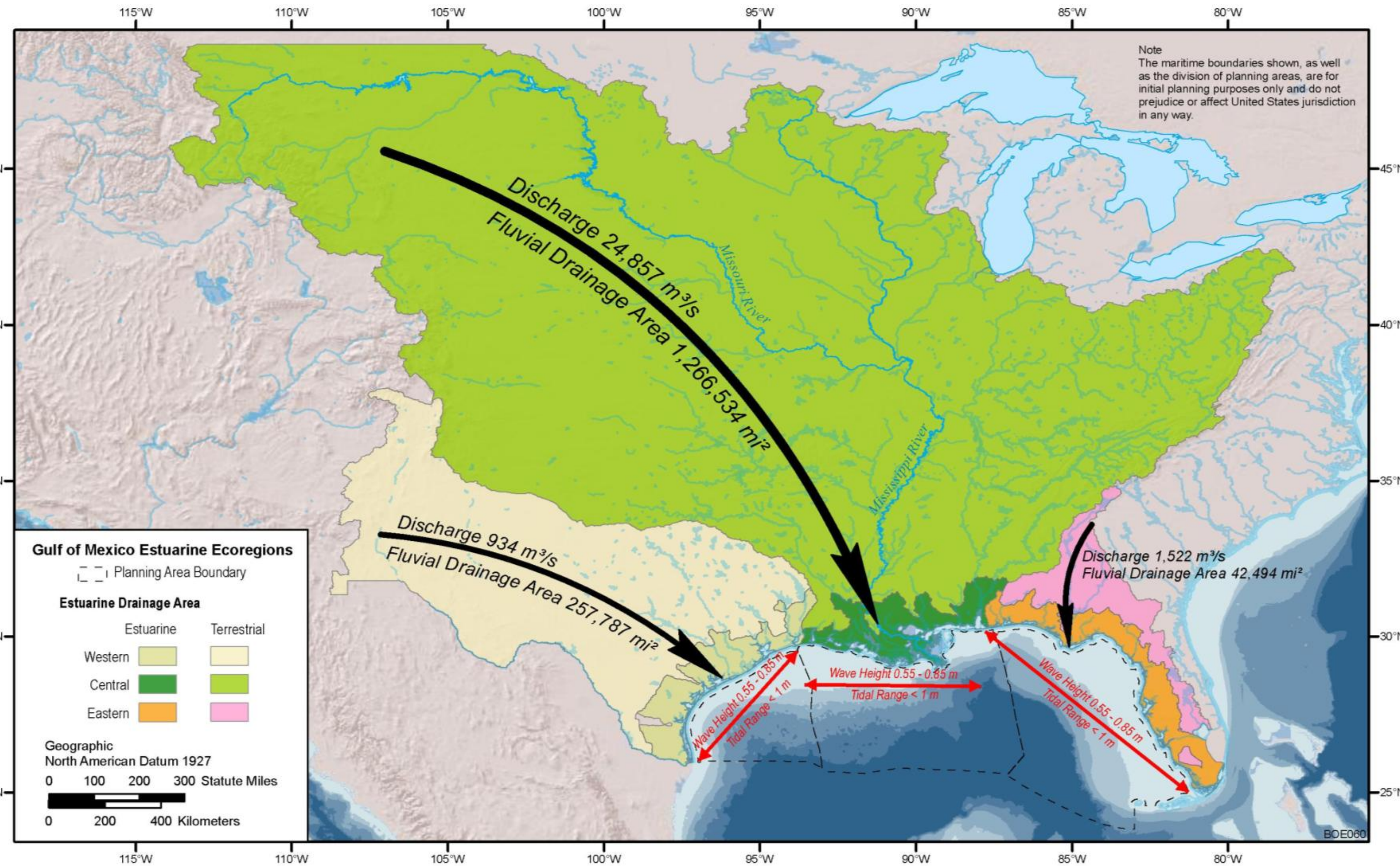

FIGURE 3.7.1-1 Estuarine and Fluvial Drainage Areas of the Gulf of Mexico Region

governments, federal agencies, and interagency programs. Furthermore, the hydrology of the Mississippi River system in the central GOM fluvial drainage area supports numerous navigational, agricultural, recreational, and industrial activities and enterprises that together create a complex set of governance and trade-off issues that would affect the management of coastal and marine habitats there. The western and eastern fluvial drainage areas, in contrast, are nearly contained within the boundaries of a single State, which would act to simplify governance issues affecting coastal habitat management there.

3.7.1.1.1 Barriers. Coastal barrier landforms consist of barrier islands, major bars, sand spits, and beaches that extend across the nearshore waters from the Texas–Mexico border to southern Florida. These elongated, narrow landforms are composed of sand and other unconsolidated, predominantly coarse sediments that have been transported to their present locations by rivers, waves, currents, storm surges, and winds.

Coastal landforms are transitory in nature and are constantly being modified by the same forces that led to their original deposition. The GOM coast shoreline is constantly changing as a result of the action of wind-driven waves and longshore currents that cause sediment transport. The coastline has a narrow tidal range, and energy forces tend to be storm dominated, with episodic high wave energy. These landforms are continually modified by waves, currents, storm surges, and winds. Coastal currents in the GOM transport sediments in a counter-clockwise direction from east to west, and contribute to sediment accretion as well as erosion of coastal landforms. Over extended periods of time, landforms may move landward (transgressive), seaward (regressive), or laterally along the coast. Sediments are also transported to coastal areas from rivers that discharge to the GOM. Barrier islands and sand spits protect wetlands and other estuarine habitats located behind them from the direct impacts of the open ocean, and slow the dispersal of freshwater into the GOM, thus contributing to the total area and diversity of estuarine habitat.

On barrier landforms, the nonvegetated foreshore slopes up from the low-tide line to the beach berm-crest. The backshore is found between the beach berm-crest and the dunes, and it may be sparsely vegetated. The berm-crest and backshore may occasionally be absent because of storm activity. The dune zone of a barrier landform consists of one or more low dune ridges that may be stabilized by vegetation such as grasses and scrubby woody vegetation. During storms, waves can overwash lower barrier landforms, and vegetation communities on these are often sparse and in early successional stages. On higher, more stabilized landforms, vegetation behind the dunes consists of scrubby woody vegetation, marshes, and maritime forests. Fresh- and saltwater ponds may occur on landward flats or between dunes. On the landward side of islands and spits, low flats grade into intertidal wetlands or mudflats.

Barrier islands are prevalent along the Texas coast from the Bolivar Peninsula southward to the Mexican border. Barrier islands and sand spits present in this region of the Texas coast were formed from sediments supplied by major deltaic headlands. The barrier islands in this region are arranged symmetrically around old, eroding delta headlands, and tend to be narrow and sparsely vegetated, exhibiting a low profile with numerous washover channels. The barrier islands and beaches are moving generally to the southwest. Net coastal erosion has been occurring in some areas. Inland beaches of sand and shells are found along the shores of bays, lagoons, and tidal streams.

The Chenier Plain is transitional between the Central estuarine ecoregion, which is heavily influenced by the Mississippi River delta building processes, and the Western estuarine ecoregion, where the river influence greatly diminishes. Most barrier shorelines of the Mississippi River Delta complex in Louisiana occur along the outward remains of a series of old abandoned river deltas and are transgressive. Only a minor portion of the sediments of the Mississippi River, now channelized, enter longshore currents and contribute to barrier landforms. Most dune areas of the delta consist of low single-line dune ridges that are sparsely to heavily vegetated, depending on the length of time between major storms.

Short time intervals between storms can cause reductions in the size and resiliency of barrier islands and shorelines. Although barrier islands and shorelines have some capacity to regenerate over time, the process is very slow and often incomplete. The past decade has seen an increase in tropical storm activity for the project area. Figure 3.7.1-2 shows hurricane landfalls from 1994 to 2009. Hurricane Katrina in 2005 caused severe erosion and land loss for the coastal barrier islands of the Deltaic Plain. Hurricane Katrina was the fifth hurricane to impact the Chandeleur Island chain in 8 yr. The Chandeleur Islands were reduced by Hurricane Katrina from 14.6 km^2 (5.64 mi^2) to 6.5 km^2 (2.5 mi^2), and then to 5.2 km^2 (2.0 mi^2) by Hurricane Rita (Di Silvestro 2006).

The Mississippi River Delta in Louisiana has the most rapidly retreating beaches in North America. Most of the barrier beaches of southeast Louisiana are composed of medium to coarse sand. Mudflats occur in lower intertidal areas. Gentle slopes of subtidal substrates in much of the area reduce wave energies and erosion. The Statewide average shoreline retreat for 1956–1978 was 8.29 m/yr (27.2 ft/yr) (van Beek and Meyer-Arendt 1982). More recent analyses reveal that Louisiana shorelines are retreating at an average rate of 4.2 m/yr (13.8 ft/yr) and range from a gain of 3.4 m/yr (11.2 ft/yr) to a loss of 26.3 m/yr (86.2 ft/yr) (USGS 1988). In comparison, the average shoreline retreat rates for the GOM, Atlantic seaboard, and Pacific seaboard were reported at 1.8, 0.8, and 0.0 m/yr (5.9, 2.6, and 0.0 ft/yr), respectively. The highest reported rates of Louisiana's coastal retreat have occurred along the coastal plain of the Mississippi River. Regressive shorelines occur, however, at the mouth of the Atchafalaya River, where sediment discharges from that river are forming new deltas.

Wide beaches and a large dune system are located on the Alabama coast. The Mississippi Sound barrier islands, along the coast of Mississippi and Alabama, have formed as a result of westward sand migration resulting in shoal and sand bar growth (Otvos 1980). The islands are separated from each other by fairly wide, deep channels, and are offset from the coast by as much as 16 km (10 mi). They are generally regressive and stable in size, and slowly migrating westward in response to the westward moving longshore current. These islands have high beach ridges and prominent sand dunes, and sand shoals typically occur adjacent to the islands. The dunes and margins of ponds on the islands are well vegetated, with mature southern maritime forests of pine and palmetto behind some dunes areas. Although some of these islands may experience washover during significant storms, washover channels are not common.

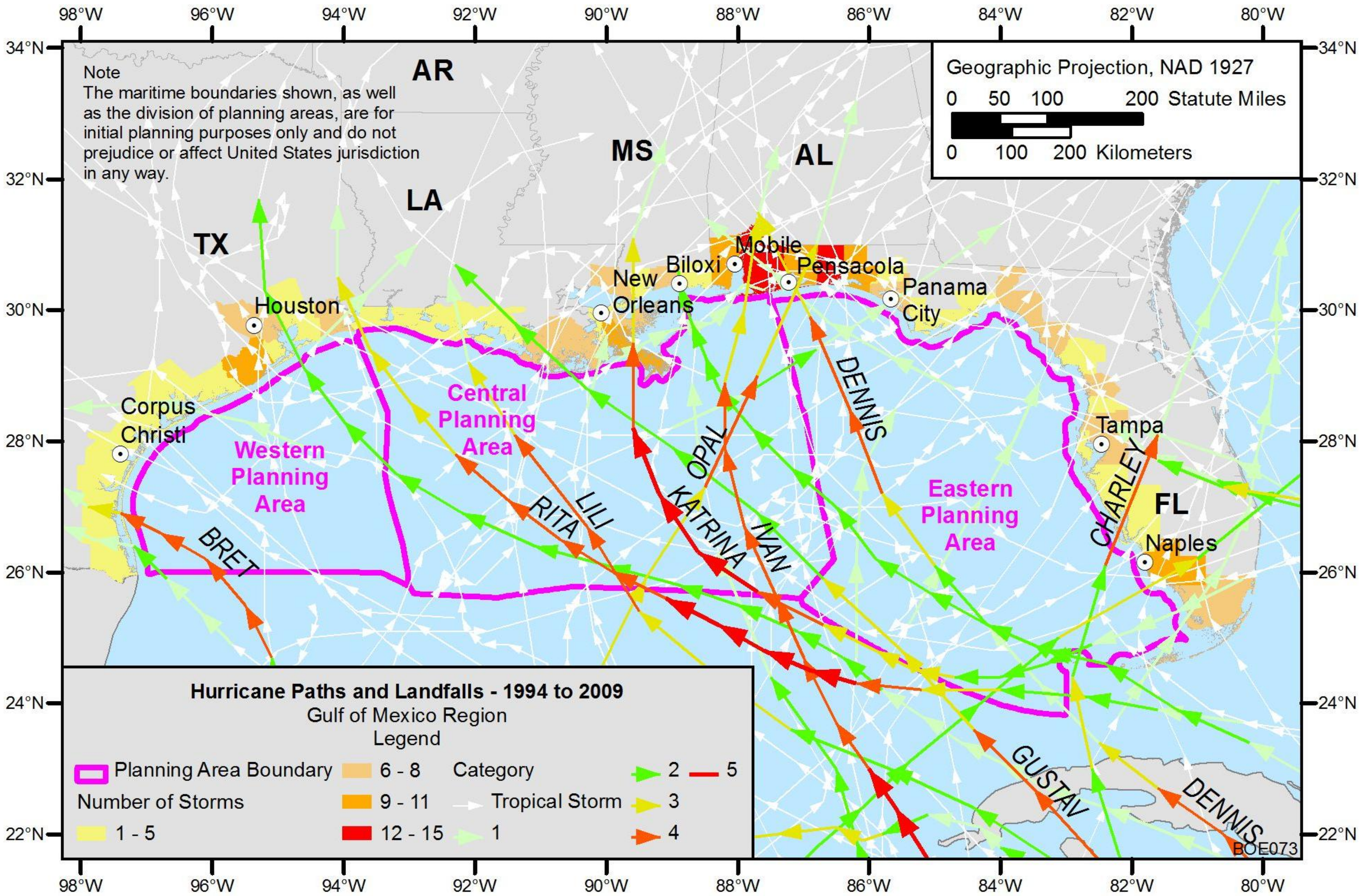

FIGURE 3.7.1-2 Hurricane Paths and Landfalls 1994–2009

Exceptions include a number of barrier islands of Mobile Bay's ebb-tidal delta, portions of which are low-profile transgressive islands frequently overwashed by storms. They continually change shape under storm and tidal pressures. Their sands generally move northwesterly into the longshore drift, nourishing beaches down drift. These sediments may also move landward during flood tides (Hummell 1990).

Barrier islands and sand beaches occur along the southwest Florida coastline, north of the Everglades, except in the Big Bend area. The Big Bend area, one of the lowest energy coastlines in the world, is devoid of typical barrier islands and beaches. Because of the low energy and minimal erosive forces, forested wetlands occur down to the water's edge. The barrier islands and mainland beaches of the Florida Panhandle typically are stable, with broad, high-profile beaches backed by high dunes. The Florida Keys, at the southern tip of Florida, are limestone islands, an unusual landform type that does not occur elsewhere in the GOM, and provide unique habitats in the region (MMS 1996).

3.7.1.1.2 Wetlands. Wetland habitats along the coast of the GOM consist of fresh, brackish, and salt marshes; mudflats; forested wetlands of bottomland hardwoods, cypress tupelo swamps, and mangrove swamps. Wetland habitats may occupy only narrow bands along the shore, or they may cover vast expanses of the coastline. Marshes and mangrove swamps are primarily intertidal habitats. Forested wetlands are generally found inshore, above the tidal influence. Coastal wetland areas of the GOM States are given in Table 3.7.1-1 and wetland density is shown in Figure 3.7.1-3.

Coastal wetlands are characterized by high organic productivity, including the production and export of detritus, and efficient nutrient recycling. They provide habitat for numerous species of plants, invertebrates, fish, reptiles, birds, and mammals. Freshwater marshes generally support a greater diversity of plant and animal species than do brackish and salt marshes.

TABLE 3.7.1-1 Gulf of Mexico Coastal Wetland Inventory

State	Marsh[a]	Estuarine Scrub-Shrub[a]	Forested Scrub-Shrub[a]	Total[a]	% Total
Texas	183,900	1,100	3,000	188,000	14
Louisiana	723,500	4,100	1,900	729,500	55
Mississippi	23,800	400	–	24,200	2
Alabama	10,400	1,100	800	12,300	1
Florida	108,100	255,100	13,100	363,900	28
Total	1,041,700	261,800	18,800	1,319,900	–

[a] Measured in ha.

Source: EPA 1992.

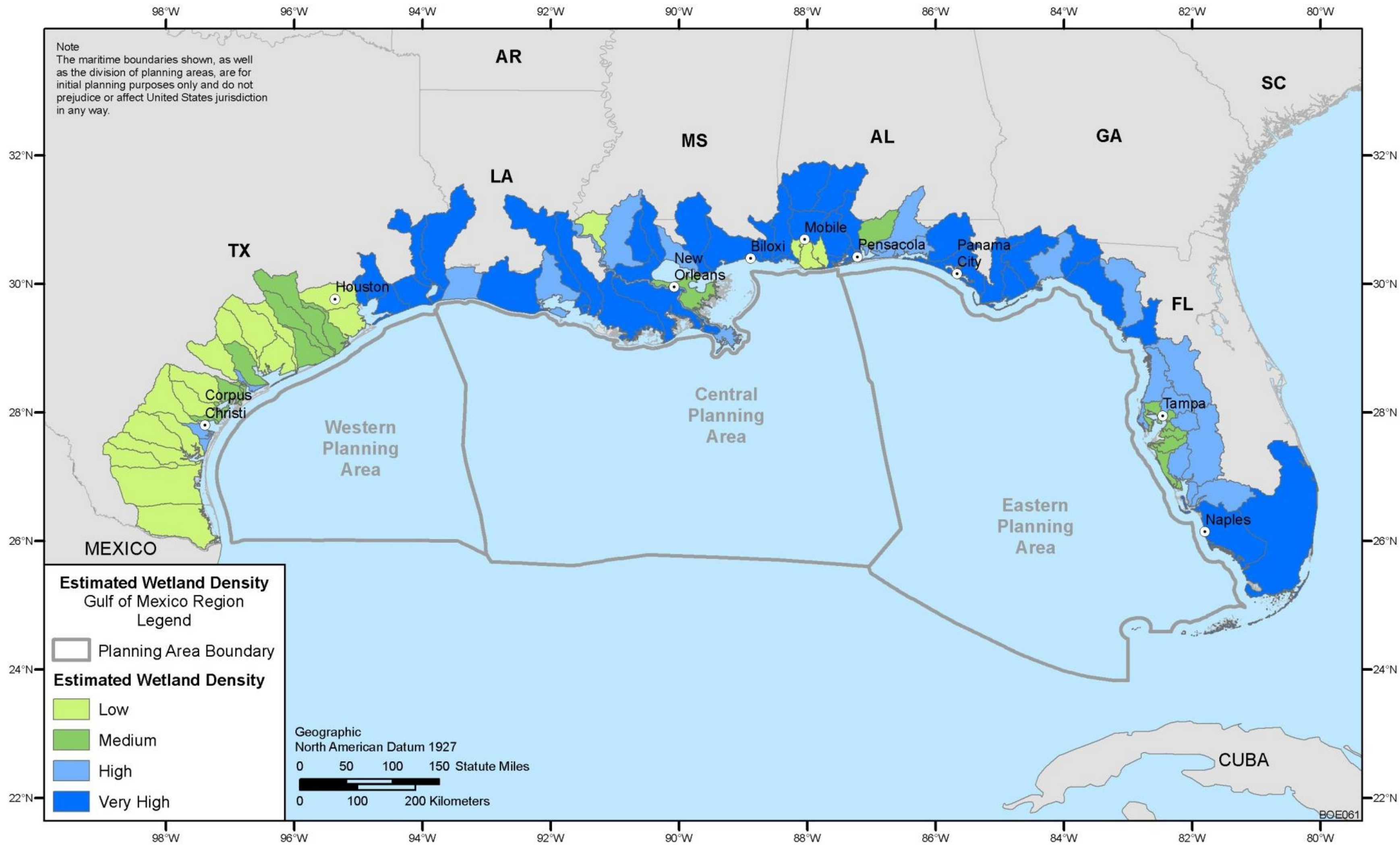

FIGURE 3.7.1-3 Estimated Wetland Density of the Gulf of Mexico Region (Stedman and Dahl 2008)

The coast of the Chenier Plain, which includes western Louisiana and eastern Texas from the Bolivar Peninsula just north of Galveston Bay, is composed of sand beaches and extensive intertidal mudflats. The mudflats are the result of mud and fine particles being transported from the Mississippi and the Atchafalaya Rivers. A subtidal mud bottom extends a great distance seaward in shallow water, reducing wave energy and resulting in minimal longshore sediment transport (USDOI and USGS 1988), and helping to protect coastal wetland communities. The shoreline is in a state of transgression (moving landward). Thin accumulations of sand, shell, and caliche nodules form beaches that are migrating landward over tidal marshes. These beaches have poorly developed dunes and numerous washover channels. Barrier beaches in the Chenier Plain area are narrow, low, thin sand deposits present along the seaward edge of the coastal marsh, and have poorly developed dunes and numerous washover channels. In some western areas of the Chenier Plain, the beach and subtidal substrates are composed of shelly sand (Fisher et al. 1973). Subtidal substrates in the eastern portions are mud and muddy sand. Most of the shoreline of the Chenier Plain is sediment starved and transgressive.

Along the Texas coast, from the Mexican border to the Bolivar Peninsula, estuarine marshes occur in discontinuous bands arund bays and lagoons, on the inner sides of barrier islands, and in the deltas and tidally influenced reaches of rivers. Salt marshes, composed primarily of smooth cordgrass (*Spartina alterniflora*), are evident nearest the mouths of bays and lagoons in areas of higher salinities. Salt-tolerant species such as saltwort (*Batis maritima*) and glasswort (*Salicornia* spp.) are among the dominant species. Brackish water marshes, some of which are infrequently flooded, occur farther landward. Freshwater marshes occur along the major rivers and tributaries, lakes, and catchments (White et al. 1986). Broken bands of black mangroves (*Avicennia germinans*) also occur in this area (Brown et al. 1977; White et al. 1986). Mud and sand flats occur around shallow bay margins and near shoals, increasing toward the south as marshes decrease. Freshwater swamps and bottomland hardwoods are uncommon, and do not occur in the southern third of this coastal area.

Localized sedimentation conditions have favored deposition in the area of the Chenier Plain, which is a series of sand and shell ridges separated by progradational mudflats, marshes, and open water lakes. Few tidal passes are located along the Chenier Plain, and the tidal movement of saline water is reduced. Salt marshes are not widely distributed on the Chenier Plain. They are generally directly exposed to GOM waters and are frequently inundated. Brackish marshes are dominant in estuarine areas and are the most extensive and productive in the Louisiana portion of this coastal area. Marsh-hay cordgrass (*Spartina patens*) is generally the dominant species.

Freshwater wetlands are extensive on the Chenier Plain. While tidal influence is minimal, these wetlands may be inundated by strong storms. Some inland freshwater marshes, bottomland swamps, and hardwood forests were inundated by hurricane Rita with up to 1.5 m (4 ft) of saltwater. Detritus tends to collect in freshwater marshes and may form thick accumulations, sometimes forming floating marshes in very low energy areas. Forested wetlands of cypress-tupelo swamps, black willow stands, and bottomland hardwoods occur only in the floodplains of major streams.

Wetlands in the Mississippi Deltaic Plain are associated with a series of overlapping riverine deltas. These wetlands developed in shallow areas that received flow and sediments from the Mississippi River. The effects of sea-level rise and high, natural subsidence of these organically rich sediments are continually impacting these wetlands (van Beek and Meyer-Arendt 1982). Extensive salt and brackish marshes occur throughout the southern half of the plain and east of the Mississippi River. Farther landward, extensive intermediate and freshwater marshes are found. In freshwater areas, cypress-tupelo swamps occur along the natural levees and in areas that are impounded by dredged materials, levees, or roads. Bottomland hardwoods occur on natural levees and in drained levee areas. Extensive freshwater marshes, swamps, and hardwood forest also occur in Atchafalaya Bay in association with the delta sediments. Sparse stands of black mangrove are scattered in some high-salinity areas of the Mississippi Deltaic Plain.

Most marshes around Mississippi Sound and associated bays occur as discontinuous wetlands associated with estuarine environments. The more extensive coastal wetland areas in Mississippi are associated with the deltas of the Pearl River and Pascagoula River. The marshes in Mississippi are more stable than those of either Alabama or Louisiana, reflecting a more stable substrate and continued active sedimentation in the marsh areas. In Alabama, most of the wetlands are located in Mobile Bay and along the northern side of Mississippi Sound. Forested wetlands are the predominant wetland type along the coast of Alabama; large areas of estuarine marsh and smaller areas of freshwater marsh also occur (Wallace 1996). Major causes of marsh loss in Alabama have included industrial development, navigational dredging, natural succession, and erosion-subsidence (Roach et al. 1987).

From 1956 to 2006, the land loss rate for coastal Louisiana was 69.7 km^2/yr (26.9 mi^2/yr), for a total net loss of 3,494 km^2 (1,349 mi^2) (Barras et al. 2008). The net land loss rate has declined, however, from previous years: a loss of 562 km^2 (217 mi^2) from 2001–2006, at 16.4 km^2/yr (6.3 mi^2/yr) from 2001 to 2004, and 256.4 km^2/yr (99.0 mi^2/yr) from 2004 to 2006. Although the net land loss rate is expected to continue to decline from 2000 to 2050, averaging 26.7 km^2/yr (10.3 mi^2/yr), Louisiana can be expected to lose about 1,329–1,813 km^2 (513–700 mi^2) of coastal wetlands over that time period, in spite of predicted gains from natural processes and current restoration projects (Johnston 2003; USGS 2003; LCWCRTF 2003; COE 2004). Historic and projected future land losses for coastal Louisiana (developed before hurricanes Katrina and Rita) are shown in Figure 3.7.1-4.

Losses of coastal wetlands have been occurring along the GOM coast for decades, resulting in the conversion of wetland habitats to open water. Coastal land loss is a particular problem in Louisiana. Many factors contribute to the coastal land loss problem there, including the effects of large storm events, subsidence, sea-level rise, saltwater intrusion, drainage and development, canal construction, herbivory, sediment deprivation, reduced flooding, and induced subsidence and fault reactivation. Upstream alterations of the Mississippi River drainage system are factors of particular importance because the construction of dams on upstream tributaries has resulted in approximately a 50% reduction in sediment load transported to the GOM (Turner and Cahoon 1988), and flood control levees constructed along the Mississippi River have prevented seasonal overbank flooding and sediment deposition in coastal marshes. Projects undertaken through the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA, or Breaux

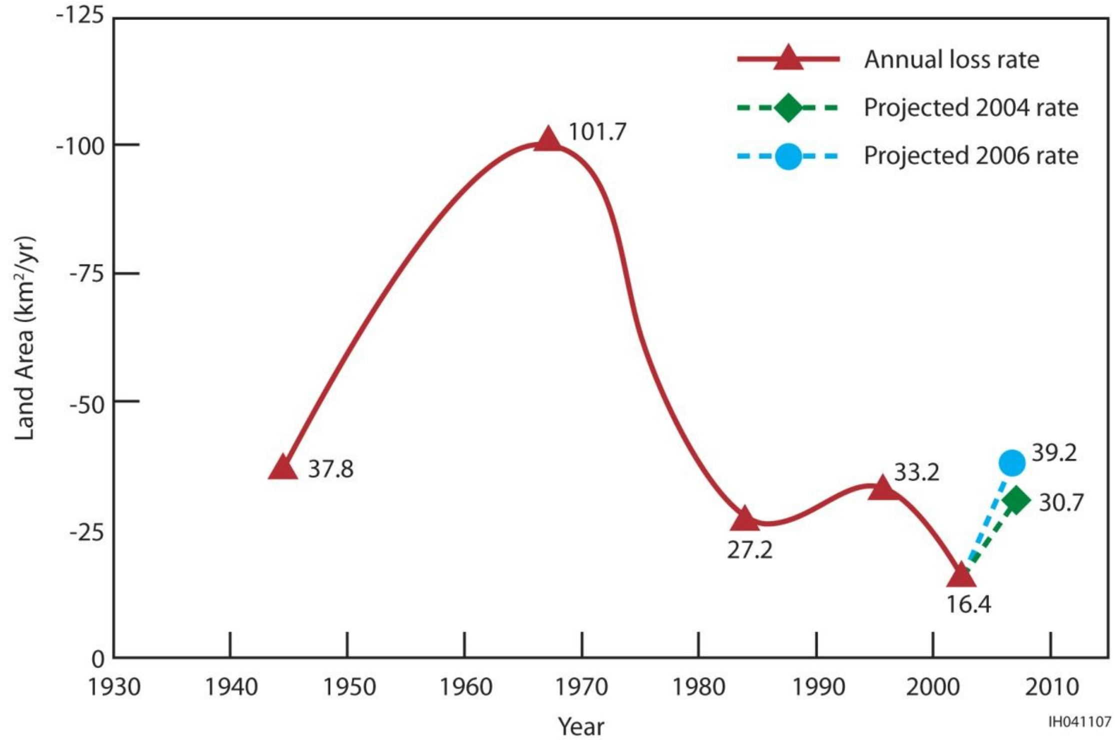

FIGURE 3.7.1-4 Annual Rates of Land Area Change in Coastal Louisiana (Barras et al. 2008)

Act) program (LCWCRTF 2003), Coast 2050 Plan (LCWCRTF 1998), and Louisiana Coastal Area Plan (USACE 2004c) are designed to contribute to ecosystem-scale restoration and sustainability.

Land losses along the Louisiana coast result from numerous factors, some of which are relatively recent in origin, while others have been ongoing for many years. Coastal wetlands are lost due to the effects of large storm events, and erosion of barrier islands reduces wetland protection (LCWCRTF 2001). In addition, hydrologic alterations have resulted in changes in salinity and inundation, causing a dieback of marsh vegetation and a subsequent loss of substrate (LCWCRTF 2001). The sediment load of the Mississippi River has been reduced by about 50% since the 1950s as a result of upstream tributary dam construction and reduced soil erosion in the watershed. Furthermore, levees constructed along the Mississippi River have, for many years, prevented seasonal overbank flooding and the sediment deposition in coastal marshes. The Louisiana coastal marshes require an adequate addition of sediment annually to continue building vertically in pace with ongoing subsidence and sea level change (LCWCRTF 1998, 2003; COE 2004). As a result, coastal marshes are being converted to open water.

Subsidence is a natural process resulting from the compaction of highly organic sediment deposits underlying the coastal marshes, and has been occurring for centuries. The rate of subsidence is 0.15–1.31 m (0.49–4.30 ft) per century in the delta area and 0.08–0.61 m (0.26–2.00 ft) per century on the western Louisiana Coast (COE 2004). The rise in sea level is attributed to the melting of ice sheets and glaciers, and increased ocean temperatures, induced by global climate change. Sea levels have risen 0.12 cm/yr (0.05 in./yr) over the past century, and may rise as much as 20 cm (7.9 in.) by 2050 (LCWCRTF 1998, 2001; COE 2004). Relative sea-level rise is a combination of the rise in sea level and local subsidence, and the average rate is currently estimated to be 1.03–1.19 m (3.38–3.90 ft) per century along the Louisiana Coast (COE 2004). The rate of relative sea-level rise on the deltaic plain is occurring at a higher rate than in most coastal areas, and the rapid rise in relative sea level exacerbates the effects of reduced sedimentation in the wetlands.

Numerous canals have been constructed within the coastal marshes for navigation and shoreline access and, because of widening over time, contribute to the breakup of marsh (LCWCRTF 2003). Spoil banks along the canals cover wetland areas and prevent the effective draining of adjacent areas, resulting in higher water levels or more prolonged tidal inundation. Canals also create a means for salt water intrusion into brackish and freshwater wetlands and increased tidal processes, resulting in shifts in species composition, habitat deterioration, erosion, and wetland loss (LCWCRTF 1998, 2003).

Marsh loss in Louisiana has also resulted from sudden marsh dieback, or brown marsh. Large areas of coastal marsh vegetation have died, particularly in 2000 and 2009. Brown marsh results from a combination of factors related to extensive drought conditions, primarily reduced soil moisture combined with physical and chemical changes in the soil (Lindstedt and Swenson 2006). Most areas affected in 2000 have recovered.

Induced subsidence and fault reactivation attributed to oil and gas extraction below the coastal marshes have also been identified as causes of coastal wetland loss in some locations in Louisiana (USGS 2001b; Morton et al. 2002, 2003). Large-volume extraction of hydrocarbon fluids and formation water has likely caused compaction of the overlying rock strata and downward displacement along nearby faults, resulting in land surface subsidence and conversion of marsh to open water, particularly during the years of high petroleum production.

In coastal Louisiana, it is difficult to establish possible linkages from deep onshore and nearshore hydrocarbon production to subsidence and wetland loss because wetland loss is ubiquitous and caused by numerous processes and conditions, both natural and anthropogenic (Morton et al. 2002). Thus, it is increasingly complex and difficult to establish the extent to which onshore subsidence and land loss is caused by hydrocarbon fluids and formation water extraction in offshore Federal waters.

A number of coastal habitat protection and restoration projects have been initiated along the GOM coast to address the issue of erosion and land losses. Many of these projects have focused on rebuilding barrier islands and coastal beaches for shoreline maintenance, as well as protection of coastal salt marshes. Modern techniques for navigation channel dredging and maintenance use the dredged sediments to nourish adjacent coastal landforms, minimizing potential erosion impacts. The MMS, now BOEM, in cooperation with State and local agencies, has been involved in developing habitat restoration projects using OCS sand resources.

3.7.1.1.3 Seagrasses. Seagrass beds grow in shallow, relatively clear and protected waters with predominantly sand bottoms. Their distribution depends on an interrelationship among a number of environmental factors that include temperature, water depth, turbidity, salinity, turbulence, and substrate suitability. Extensive areas of seagrass beds occur in exposed, shallow subtidal coastal waters of the northern GOM and in protected, natural embayments. Seagrasses are uncommon where freshwater inflow is high and salinities average less than 20 parts per thousand (ppt), as well as the upper portions of most estuaries. An estimated 3,000,000 ha (7,413,000 acres) of submerged seagrass beds exist in exposed, shallow coastal waters of the northern GOM. An additional 166,000 ha (410,200 ac) are found in protected, natural embayments. The area off Florida contains approximately 98.5% of all coastal seagrasses in the northern GOM. Texas and Louisiana contain approximately 0.5% of coastal seagrasses. Mississippi and Alabama have the remaining 1% of seagrass beds. Seagrass beds provide habitat for a highly diverse group of marine species.

Hurricane impacts, such as the influx of salt water in low salinity estuaries, can produce changes in seagrass community quality and composition. The distribution of seagrass beds in coastal waters of the Western and Central GOM has diminished during recent decades. Primary factors believed to be responsible include dredging, dredged material disposal, trawling, water quality degradation, hurricanes, a combination of flood protection levees that have directed freshwater away from wetlands, saltwater intrusion that moved growing conditions closer inland, and infrequent freshwater diversions from the Mississippi River into coastal areas during the flood stage.

Primarily because of low salinity and high turbidity, robust seagrass beds are found only within a few scattered, protected locations in the Western and Central GOM, although seagrass meadows occur in nearly all bay systems along the Texas coast. Seagrasses in the Western GOM are widely scattered beds in shallow, high-salinity coastal lagoons and bays. Lower-salinity, submerged beds of aquatic vegetation are found inland and discontinuously in coastal lakes, rivers, and the most inland portions of some coastal bays. The distribution of seagrass beds in coastal waters of the Western and Central GOM has diminished during recent decades.

The turbid waters and soft, highly organic sediments of Louisiana's estuaries and offshore areas limit widespread distribution of higher salinity seagrass beds. Consequently, only a few areas in offshore Louisiana support seagrass beds. In Mississippi and Alabama, seagrasses occur within the Mississippi Sound. Widgeon grass (*Ruppia maritima*), an opportunistic species, is tolerant of low salinities and occurs in some estuaries.

3.7.1.1.4 Climate Change Effects. Coastal habitats would be affected by global climate change. Factors associated with global climate change include changes in temperature, rainfall, alteration in stream flow and river discharge, wetland loss, salinity, sea level rise, changes in hurricane frequency and strength, sediment yield, mass movement frequencies and coastal erosion, and subsidence (Yanez-Arancibia and Day 2004). Effects of sea level rise include damage from inundation, floods, and storms; erosion; saltwater intrusion; rising water tables/impeded drainage; and wetland loss and change (Nicholls et al. 2007). Effects of increased storm intensity include increases in extreme water levels and wave heights, and increases in episodic erosion, storm damage, risk of flooding, and defence failure (Nicholls et al. 2007). Patterns of erosion and accretion can also be altered along coastlines (Nicholls et al. 2007). The small tidal range of the GOM coast increases the vulnerability of coastal habitats to the effects of climate change. A study of coastal vulnerability along the entire U.S. GOM coast found that 42% of the shoreline mapped was classified as being at very high risk of coastal change due to factors associated with future sea-level rise (Thieler and Hammar-Klose 2000). A revised coastal vulnerability index (CVI) study of the coast from Galveston, Texas, to Panama City, Florida, indicated that 61% of that mapped coastline was classified as being at very high vulnerability, with coastal Louisiana being the most vulnerable area of this coastline (Pendleton et al. 2010) (see Figure 3.7.1-5, which shows the CVIs of Pendleton et al. [2010] from Galveston to Panama City, and CVIs of Thieler and Hammar-Klose [2000] for the remainder of the coast).

Saltwater intrusion/increased salinity and sea level rise can result in mortality of salt-intolerant species, resulting in reductions in habitat area and changes in species composition of coastal habitats. Effects observed include declines in coastal bald cypress (*Taxodium disticum*) forests in Louisiana and migration of mangroves into adjacent wetland communities in Florida (Nicholls et al. 2007). In some areas, existing plant communities may be displaced farther inland (Nicholls et al. 2007). Enhanced coastal erosion, coastal flooding, and loss of coastal wetlands, particularly in Louisiana and Florida, are projected impacts of sea level rise and increased frequency of storm surges, both of which are associated with climate change (IPCC 2002).

Land losses would likely increase due to the effects of climate change. The acceleration of sea level rise and increases in storm intensity as a result of climate change would exacerbate the current level of coastal land loss in the Mississippi deltaic plain, an already expected additional loss of 1,300 km^2 (501.9 mi^2) if current global, regional, and local processes continue (Nicholls et al. 2007). Recent rates of sea level rise have been approximately 3 mm/yr (0.12 in./yr), but this rate may increase to 4 mm/yr (0.16 in./yr) by 2100 (Blum and Roberts 2009). Combined with potential rates of subsidence in the area of the Mississippi Delta Plain, relative sea level rise may range from 0.5 to 1.4 m (1.6 to 4.6 ft) by 2100 (Blum and Roberts 2009). In the absence of sediment input, resulting submergence in the delta region could range from 10,000 to 13,500 km^2/yr (3,861 to 5,212 mi^2/yr) by 2100 (Blum and Roberts 2009).

3.7.1.1.5 Effects of Deepwater Horizon Event. Oil released into coastal waters as a result of the DWH event, April–July, 2010, affected more than 1,046 km (650 mi) of the GOM coastal habitat, from the Mississippi River delta to the Florida panhandle, with the Louisiana, Mississippi, Alabama, and Florida coasts all affected (OSAT-2 2011; National Commission 2011). The greatest impacts were in Louisiana. More than 209 km (130 mi) of coastal habitat were moderately to heavily oiled, only 32 km (20 mi) of which occurred outside of Louisiana (National Commission 2011). Little or no oil affected Texas coastal habitats. Heavy to moderate oiling occurred along a substantial number of Louisiana beaches, with the heaviest oiling on the Mississippi Delta, in Barataria Bay, and on the Chandeleur Islands (OSAT-2 2011). The majority of Mississippi barrier islands had light oiling to trace oil, although heavy to moderate oiling occurred in some areas. Some heavy to moderate oiling also occurred on beaches in Alabama and Florida, with the heaviest stretch of oiling extending from

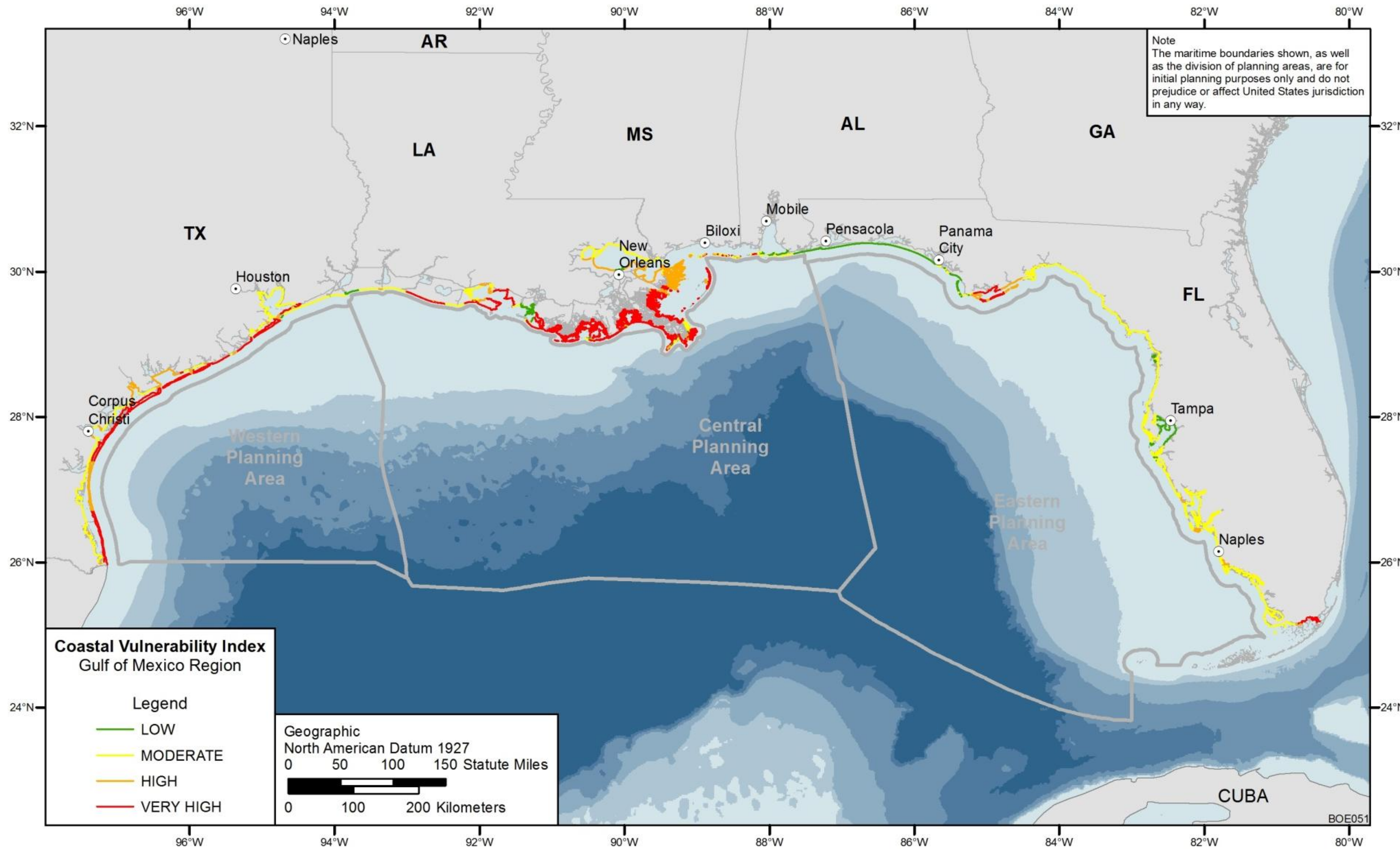

FIGURE 3.7.1-5 Coastal Vulnerability Index of the Gulf of Mexico Region (Pendleton et al. 2010; Thieler and Hammar-Klose 2000)

Dauphin Island, Alabama, to near Gulf Breeze, Florida (OSAT-2 2011). Light to trace oiling occurred from Gulf Breeze to Panama City, Florida. Deposition of oil occurred in the supratidal zone (above the high tide mark), deposited and buried during storm events; in the intertidal zone; and in the subtidal zone, remaining there as submerged oil mats (OSAT-2 2011). On Grand Isle, Louisiana, and Bon Secour, Alabama, oil was found up to 105 cm (41 in.) below the surface (OSAT-2 2011). Although much of the oil remaining after cleanup is highly weathered, several constituents have the potential to cause toxicological effects (OSAT-2 2011). Oil was also deposited along the coast in marshes such as those of the Mississippi River Delta and Chandeleur Sound, mudflats, and mangroves, oil contacted seagrass beds such as those behind the Chandeleur Island chain, and submerged aquatic vegetation communities such as those in Plaquemines and St. Bernard Parishes, Louisiana. These habitats also were also affected by prevention and cleanup efforts (NOAA 2010). Loss of marsh habitat along its edge as a result of oiling was observed. A full understanding of the effects of the spill is expected to take years but is not needed at the programmatic stage to make a reasoned choice among alternatives (see Section 1.3.1.1, Incomplete and Unavailable Information).

3.7.1.2 Cook Inlet

Coastal and nearshore habitats of concern within the Cook Inlet Planning Area include beaches, marshes, tidal flats, scarps, riverine mouths/deltas, and marine algae. Coastal habitats of Cook Inlet are given in Table 3.7.1-2. These habitats occur within estuarine watersheds in and around bays, lagoons, and river mouths where marine and fresh waters intermix. Coastal and nearshore habitats of Cook Inlet can be subdivided into two ecoregions (Figure 3.2.2-2), each with distinguishing characteristics, arrangements of habitat components, and freshwater inflows with associated nutrient and sediment loads: the Cook Inlet, extending from the northeastern Alaska Peninsula to the southern tip of the Kenai Peninsula, and the Gulf of Alaska, extending south along Kodiak Island and the Alaska Peninsula. These are based on the Level III Marine Ecoregions of the Commission for Environmental Cooperation (CEC 2008). Four terrestrial ecoregions are located along the coast of the Cook Inlet Planning Area: the Cook Inlet, the Alaska Range (along the southwestern coastline), Coastal Western Hemlock-Sitka Spruce Forests (on the southeastern coastline and northern Kodiak Island), and the Alaska Peninsula Mountains (along the Alaska Peninsula and southern Kodiak Island) (USEPA 2011e).

In Cook Inlet, the amount of sea ice varies annually. In general, sea ice forms in October to November, increases from October to February from the West Foreland to Cape Douglas, and melts in March to April. Sea-ice formation is controlled in upper Cook Inlet primarily by air temperature and in lower Cook Inlet by the temperature and inflow rate of the Alaska Coastal Current (Poole and Hufford 1982).

Coastal forest occurs along much of Alaska’s south central coast and on the coastal islands, and is predominantly evergreen forest composed of Sitka spruce and western hemlock (BLM 2002). Deciduous forest occurs primarily along floodplains, streams, and in disturbed areas. Many areas around Cook Inlet also support white spruce and black spruce forest, as well as wet tundra, referred to as “muskegs,” with sedges, mosses, and scattered shrubs (ADNR 1999). Also occurring along or near the shoreline are forested wetlands, wetlands with

TABLE 3.7.1-2 Coastal Habitats of the Cook Inlet Planning Area

Habitat: ESI Rank	Habitat Area and Shoreline Length
Salt- and brackish-water marshes: 10A	11,338 mi^2; 672 mi
Sheltered tidal flats: 9A	104,977 mi^2; 356 mi
Sheltered scarps in mud or clay: 8A	279 mi
Exposed tidal flats: 7	280,010 mi^2; 426 mi
Gravel beaches: 6A	167 mi
Mixed sand and gravel beaches: 5	317 mi^2; 792 mi
Coarse-grained sand beaches: 4	36 mi
Fine- to medium-grained sand beaches: 3A	7 mi
Exposed wave-cut platforms in bedrock, mud, or clay: 2A	10,252 mi^2; 449 mi
Exposed, solid man-made structures: 1B	1 mi
Exposed rocky shores: 1A	25 mi^2; 284 mi

emergent vegetation, and shrub wetlands that are not tidally influenced but that have saturated soils or are flooded seasonally or continuously (BLM 2002).

Extensive freshwater marshes and salt marshes composed of sedge and grass wet meadow communities occur on river deltas along the coast. Coastal habitat in the Gulf of Alaska includes several large estuaries and wetlands (MMS 2002c).

In some areas of the south Alaskan coastline, numerous peninsulas and islands with irregular shorelines form bays, lagoons, and steep prominences (BLM 2002). Much of the shoreline consists of steep slopes with a narrow zone of tidal influence.

Coastal habitats throughout the Gulf of Alaska, including Cook Inlet, include intertidal and shallow subtidal communities (O'Clair and Zimmerman 1986). Intertidal wetlands include unvegetated rocky and soft sediment (sand or mud) shores, as well as coastal salt marshes with emergent vegetation and wetlands with submerged or floating vegetation (BLM 2002). These wetlands are all periodically inundated or exposed by tides. Large areas of soft-sediment shores are common in Cook Inlet (McCammon et al. 2002). Salt marshes and other wetlands occur throughout the coastal margins of the Cook Inlet (ADNR 1999).

Submerged or floating vegetation community types in estuaries include eelgrass communities and marine algae communities (BLM 2002). Eelgrass communities are common in protected bays, inlets, and lagoons with soft sediments (Viereck et al. 1992; McCammon et al. 2002). Marine algae communities often occur along exposed rocky shores on much of the coast (Viereck et al. 1992). Large kelps form dense communities in shallow subtidal areas along much of the Gulf of Alaska coast (McCammon et al. 2002). Marine algae communities dominate the low intertidal areas, to about 3 m (10 ft) in depth, and do not occur below about 5 m (16 ft) in depth (MMS 2003a).

Coastal salt marshes occur on soft sediments along low-energy shorelines. Coastal marshes may contain a number of vegetation community types that are tidally influenced, ranging from irregularly exposed to irregularly inundated (BLM 2002). The higher areas of coastal marshes may support sedge-scrub wet meadow communities (Viereck et al. 1992). These communities are not generally inundated by tides, but may be flooded during storm surges. Upper areas of coastal marshes may also support a hairgrass community (ADNR 1999).

The lower, outer areas of coastal salt marshes typically consist of sedge and grass communities (Viereck et al. 1992). The inland portion of these marshes often includes the taller and denser communities of salt-tolerant sedges. The seaward margin often adjoins a sparse community of salt-tolerant alkali grass, often associated with salt-tolerant forbs (Viereck et al. 1992). Halophytic herb wet meadow communities occur in early successional stages on seaward portions of beaches and coastal marshes where inundation occurs at least a few times per month (Viereck et al. 1992).

Brackish ponds occasionally occur within coastal marshes of deltas, tidal flats, and bays (BLM 2002; Viereck et al. 1992). These communities occur in shallow water and are periodically inundated by tides.

Coastal habitats along Cook Inlet are vulnerable to the effects of climate change. Sea level rise is expected to increase, inundating low-lying coastal habitats (Nicholls et al. 2007). Climate change is also expected to result in an increase in the incidence of pests and diseases, which could result in increased forest tree mortality (Anisimov et al. 2007).

Dynamic tidal currents in the inlet are related to the vulnerability of shoreline communities and their sensitivity to disturbance. The overall environmental sensitivity of Cook Inlet shorelines has been ranked independently by NOAA, the Alaska Regional Response Team, and recently by the *Exxon Valdez* Oil Spill Trustees/Cook Inlet Regional Citizens Advisory Council (Harper et al. 2004). In general, the vulnerability of shoreline habitats is rated as low if the shoreline substrate is impermeable (rock) and exposed to high wave energy or tidal currents, and is rated as high for vegetated wetlands and semipermeable substrates (mud) that are sheltered from wave energy and strong tidal currents. Sensitive shoreline habitats identified in lower Cook Inlet include marshes, sheltered tidal flats, sheltered rocky shores, and exposed tidal flats (NOAA 1994) (see Table 3.7.1-2). A study of the recovery rate of organisms on sheltered rocky shores in Cook Inlet concluded that 5–10 yr would be needed for full recolonization of rocky shorelines (Highsmith et al. 2001). Ongoing *Exxon Valdez* oil spill studies have shown that traces of spilled oil have persisted in Prince William Sound shoreline sediments and intertidal organisms for more than a decade (Short 2004; MMS 2003a).

3.7.1.3 Alaska – Arctic

Arctic coastal and nearshore habitats of concern include barrier islands and beaches, low tundra, marshes, tidal flats, scarps, peat shorelines, and marine algae. These habitats occur within estuarine watersheds along the coastline and in and around bays, lagoons, and river mouths where marine and fresh waters intermix. Coastal and nearshore habitats of the Arctic region can be subdivided into two ecoregions (Figure 3.2.2-3), each with distinguishing characteristics, arrangements of habitat components, and freshwater inflows with associated nutrient and sediment loads: the Chukchian Neritic Ecoregion, extending from near Point Hope to near Cape Lisburne, and the Beaufortian Neritic Ecoregion, extending from near Cape Lisburne to the border of Canada. These are based on the Level III Marine Ecoregions of the Commission for Environmental Cooperation (CEC 2008). Most of the coastline along the Chukchi Sea Planning Area, from near Cape Lisburne to near Point Barrow, lies within the Beaufortian Neritic Ecoregion. Two terrestrial ecoregions are located along the arctic coast: the Arctic Foothills, from Kotzebue to near Cape Beaufort, and the Arctic Coastal Plain, from near Cape Beaufort to near the border of Canada (USEPA 2011e).

The fluvial discharge and freshwater flow into the Beaufortian ecoregion is much larger than the flow into Chukchian ecoregion. Fluvial discharge into the Chukchian ecoregion is relatively limited, with the Kukpuk River being the only major river system present, although there are numerous named and unnamed streams discharging into the Chukchi Sea. Numerous large rivers, such as the Kukpowruk River, Utukok River, and Kuk River along the Chukchi Sea, and the Colville River, Kuparuk River, Sagavanirktok River, and Canning River along the Beaufort Sea, discharge into the Beaufortian ecoregion.

Stream flows generally begin in late May or early June as a rapid flood event, with more than half of the annual discharge of a stream sometimes occurring over a period of several days to a few weeks (MMS 2008). Fluvial discharges introduce dissolved and suspended materials into estuarine and marine waters that can serve either as nutrients that enrich marine and coastal productivity or as pollutants that can degrade habitat quality. Human society sometimes discharges into the environment constituents that also occur naturally in the ecosystem. These anthropogenic discharges, however, are different than the biogenic sources because they occur in greater concentrations and often suddenly; the chemical bondings are different than what is found in the natural system; the discharges occur outside the area where they would naturally occur; or they occur out of phase of the natural cycle of the same biogenic contributions to the system. Examples of anthropogenic constituents include sediment, metals, and hydrocarbons (see Section 3.4.3 for a further discussion of water quality). The fluvial discharges also carry suspended and bed load sediments that when deposited at the river mouths and redistributed through the coastal zone provide the substrate and foundation for many coastal habitats.

Arctic coastal habitats are greatly influenced by a short growing season and extremely cold winters. The onshore sediments are frozen during most of the year and are underlain by permafrost (permanently frozen soil). Growth and even biodegradation in coastal habitats are limited to only a few months per year (Prince et al. 2002).

Although differences exist in fluvial discharge, the coastal and estuarine habitats of both ecoregions are greatly affected by the dynamics of sea ice. The arctic coastline is highly disturbed due to the movement of sea ice that frequently is pushed onshore, scouring and scraping the coastline. Sea ice dominates the coastal habitats during most of the year. Landfast ice, which is attached to the shore and freezes to the seafloor (grounded ice) in shallow water up to 2 m (7 ft) in depth, is relatively immobile (MMS 2010); however, landfast ice along the Chukchi Sea coast is not as stable as along the Beaufort Sea coast (MMS 2008b). Onshore pileups of ice often extend up to 20 m (66 ft) inland from the shoreline, while rideups of unbroken ice sheets over the ground surface occasionally extend more than 50 m (164 ft) and rarely beyond 100 m (328 ft) (MMS 2008b). Landfast ice begins forming in late October to late December along the Chukchi Sea, with breakup in late May to mid-June (MMS 2010); in the Beaufort Sea, landfast ice begins forming in September to October, with breakup beginning in early June to early July (MMS 2008b). The areal extent of sea ice in the Arctic has substantially decreased over the past several decades (MMS 2010). Decreases in ice cover can increase wave action and shoreline erosion. The duration of landfast ice has also decreased, with ice breaking up earlier in the spring (MMS 2008b).

Coastal habitats of the Arctic ecoregions are given in Table 3.7.1-3, with general characteristics in Table 3.7.1-4. The coastline of the Beaufort Sea includes eroding bluffs, sandy beaches, lower tundra areas with some saltwater intrusions, sand dunes, sandy spits, and estuarine areas where streams enter the Beaufort Sea (MMS 2002b, 2003b). The Chukchi Sea coastline consists of nearly continuous sea cliffs cut into permafrost (MMS 2010). While the cliffs are abutted by narrow beaches along most of the coastline, in some areas, barrier islands enclose shallow lagoons. Barrier islands occur along the Beaufort and Chukchi Sea coastlines and also support tundra communities. These islands are generally narrow (less than 250 m [820 ft] wide) and low-lying (less than 2 m [7 ft] in elevation) and are washed over in large storms (MMS 2003b). Deltas of the Colville, Sagavanirktok, Kadleroshilik, and Shaviovik Rivers support a complex mosaic of wet arctic saltmarsh, dry coastal barrens, salt-killed tundra, typical moist and wet tundra, and dry, partially vegetated gravel bars.

TABLE 3.7.1-3 Length of Coastal Habitats (mi) of the Alaskan Arctic Ecoregions

Habitat: ESI Rank	Chukchian Ecoregion[a]	Beaufortian Ecoregion
Salt- and brackish-water marshes: 10A	–	88
Inundated low-lying tundra: 10E	–	763
Sheltered tidal flats: 9A	–	24 mi^2[a]; 394
Sheltered, vegetated low banks: 9B	–	225
Peat shorelines: 8E	–	283
Sheltered scarps in mud or clay: 8A	–	1
Exposed tidal flats: 7	–	196
Riprap: 6B	<1	1
Gravel beaches: 6A	2	13
Mixed sand and gravel beaches: 5	76	488
Coarse-grained sand beaches: 4	–	72
Tundra cliffs: 3C	–	338
Fine- to medium-grained sand beaches: 3A	–	393
Exposed wave-cut platforms in bedrock, mud, or clay: 2A	–	–
Exposed, solid man-made structures: 1B	–	<1
Exposed rocky shores: 1A	18	19

[a] Square mileage represents total habitat area.

TABLE 3.7.1-4 Characteristics of Coastal Habitats of the Alaskan Arctic Ecoregions

Habitat	Chukchian Ecoregion	Beaufortian Ecoregion
Barrier beaches and islands	Narrow beaches along coastline, predominantly fronting steep cliffs cut in bedrock, up to 260 m (853 ft) high at Cape Lisburne (MMS 2007c). Barrier islands occur only at Point Hope at Marryat Inlet/Kukpuk River delta and nearby Aiautak Lagoon; nearly continuous, composed of sand and gravel.	Narrow beaches along coastline; lower cliffs, where present, cut in bedrock (south of Utukok River) or perennially frozen ice-rich sediments (MMS 2007c). Barrier islands, typically enclosing lagoons, frequent along Chukchi and Beaufort Sea coasts, some, such as at Kasegaluk Lagoon, <3 m (10 ft) relief, and <2 m (7 ft) in Beaufort. Coastal relief along these marine depositional areas is generally <5 m (16 ft). Much of coast eroded by ice, waves, and currents, but active wave erosional coast is rare along Chukchi Sea where cliffs are generally <1 m (3 ft) high.
Wetlands	Little wetland occurrence along coastline except along Point Hope.	Estuarine wetland systems occur in enclosed and protected bays along the Chukchi Sea shoreline. Large estuarine wetland complexes in Chukchi Sea lagoons and other well protected areas, such as Omalik Lagoon, Kasegaluk Lagoon, Icy Cape, Peard Bay, Wainwright Inlet; include sand/silt flats and brackish-water sedge marshes. Few, scattered narrow marshes along remainder of coastline
Marine algae	–	Few known beds along coast, on hard bottom substrates; includes many species of macroalgae, e.g., 15 at the Stefansson Sound Boulder Patch; community dominated by a few common species (Iken 2009). Present along Chukchi Sea in Kasegaluk Lagoon, Peard Bay, near Skull Cliffs, and 25 km (16 mi) southwest of Wainright, in 11–13 m (36–443 ft) water.

Source: MMS 2007c; Iken 2009.

Marine algae communities occur on hard bottom substrates in several areas along the Chukchi Sea coast, such as in Peard Bay, or southwest of Wainwright at a depth of 11–13 m (36–43 ft) (MMS 2010). The distribution and extent of these communities are likely limited by the presence of rock and other hard substrate (MMS 2010). Few known beds occur along the Beaufort Sea coast. These communities include many species of macroalgae (e.g., 15 species at the Stefansson Sound Boulder Patch); however, the community is dominated by a few common species (Iken 2009).

Several estuarine habitats within shallow bays, inlets, and lagoons occur along the Chukchi Sea coastline, including Kasegaluk Lagoon, Wainwright Inlet, Peard Bay, and Kugrua Bay (BLM and MMS 2003). These areas often have low-energy sand beaches and wetlands along their margins, and some support communities of marine algae, such as sea lettuce (*Ulva* spp.). Kasegaluk Lagoon is usually ice covered from mid-September through mid-July. During the summer, many animals concentrate around the passes between the ocean and the shallow lagoon.

Salt marshes occur along the arctic coastline and support emergent vegetation communities. These coastal marshes are intertidal wetlands exposed at low tides and inundated by high tides and storm surges. The arctic coastline experiences tides of small fluctuation, 6 to 10 cm (2.4 to 4 in.) along the Beaufort Sea (MMS 2003b); however, coastal water levels are driven primarily by wind stress and barometric pressure changes from the passage of storm centers and frontal passages (Gill et al. 2011). Storm surge and water level withdrawal on the coast can be considerable, about 1 m (3 ft) in amplitude (Gill et al. 2011). The Arctic coastline is subject to strong erosive forces (BLM 2002; MMS 2002c). Disturbance from sea ice action is common along the generally unstable and erosion-prone shoreline (MMS 2002c). Arctic coastal salt marshes are therefore smaller, often only a few meters in extent, and less common than on south Alaskan coasts (Macdonald 1977; Viereck et al. 1992). The most extensive salt marsh habitats along the coast occur in the deltas of the major rivers and a few protected bays.

The predominant community types of arctic coastal salt marshes are dense halophytic (salt-tolerant) sedge wet meadow communities and sparse halophytic grass wet meadow communities (Meyers 1985; Viereck et al. 1992; Funk et al. 2004). The former occur where tidal inundation ranges from several times per month to once a summer, while the latter occur at lower elevations under regular or daily inundation from tides.

Halophytic sedge wet meadow communities often form the main body of the coastal marsh. Soils are fine-textured silts and clays, often overlying sand or gravel. The shoreward marsh community forms a broad transition zone with freshwater wetlands (Viereck et al. 1992). The substrate is typically peat. The seaward margin is often adjacent to a halophytic grass wet meadow community.

The seaward portions of beaches and areas of coastal marshes where inundation occurs at least a few times per month support halophytic herb wet meadow communities (Viereck et al. 1992). These also occur in brackish ponds within coastal marshes of deltas, tidal flats, and bays (Viereck et al. 1992).

The most important coastal estuarine wetlands along the Beaufort Sea coast include Elson Lagoon, just east of Point Barrow; Fish Creek Delta; Colville River Delta; Simpson Lagoon; Canning River Delta; Jago Lagoon–Hulahula River Delta; and Demarcation Bay. Along the Chukchi Sea coast, the primary estuaries include Peard Bay, Kasegaluk Lagoon, and Point Hope (MMS 2002c).

Nearshore areas of the Beaufort and Chukchi Seas are estuarine subtidal deepwater habitat and are generally unvegetated (BLM 2002). However, dense marine algae communities occasionally grow in shallow nearshore subtidal areas (less than about 11 m [36 ft) in depth) and generally in protected areas (such as behind barrier islands and shoals) with hard substrates (MMS 2003b).

Estuaries and coastal lagoons are characterized by large fluctuations in salinity and temperature. Salinity can range from 180 parts per trillion (ppt) in winter to 1–32 ppt in summer (Houghton et al. 1984). At ice breakup in spring, the large influx of freshwater from ice melt and terrestrial runoff can create hyposaline conditions approaching freshwater. Temperature also fluctuates widely and rapidly at breakup, ranging from 0°C to 14°C (Craig et al. 1984).

Effects of climate change on Alaskan arctic habitats include decreases in sea ice cover, warming of permafrost, longer growing season, and changes in precipitation. Decreased sea ice has led to increased wave activity and accelerated coastal erosion and increases in shoreline erosion from storms, along with increased turbidity (MMS 2008b). Portions of the coast have experienced considerable erosive losses, up to 457 m (1,500 ft) over the past few decades (MMS 2008b). Coastal peat bluffs along the Chukchi Sea coast have experienced more rapid erosion. The erosion rate in areas of the Beaufort Sea coast has more than doubled between 1955 and 2005.

Increases in air temperature and precipitation have also occurred as a result of climate change, particularly in autumn and winter (MMS 2008b). Permafrost, occurring on much of the Arctic Coastal Plain, creates an impermeable soil layer, limiting the water storage capability of the subsurface and, when near the surface, generally maintaining saturated soils above the permanently frozen layer, thereby maintaining lakes and wetland habitats. Permafrost is warming across the Arctic, with rapid warming in Alaska over the last 50 yr (Anisimov et al. 2007). Significant permafrost degradation has been observed in some areas. Increased permafrost temperatures at 15–20 m (49–66 ft) depths over the past 20 yr have been recorded (MMS 2008b). Increases in mean annual ground surface temperatures have been observed since the 1960s and, in some areas, discontinuous permafrost has begun thawing downward at a rate of 0.1 m/yr (0.3 ft/yr) (MMS 2008b). Thawing of permafrost tends to result in collapse of the soil structure of thaw-unstable soils and slumping of the soil surface, which may subsequently result in flooding. Deepening of the active layer, the upper soil layer that thaws each summer, and associated hydrologic change is accompanied by large changes in the plant community. Evaporation/precipitation ratios have also increased in the Arctic, resulting in the desiccation of some lakes (MMS 2008b). Earlier spring melt in the Arctic and later freeze-up has resulted in a longer growing season, along with changes in plant communities, such as an increased abundance of shrubs (Anisimov et al. 2007).

Projections for future climate change indicate continued increases in temperature and precipitation in the Arctic. The depth of the permafrost active layer is expected to increase by 15 to 25% on average by 2050, and 50% or more in the northernmost areas (Anisimov et al. 2007). Areas of continuous permafrost are likely to show increasing patchiness (Anisimov et al. 2007). An initial increase in the number and total area of wetlands and shallow lakes due to permafrost thawing may be followed over time by the loss of these habitats as permafrost continues to thaw, surface water increasingly drains into groundwater systems, and shallow groundwater tables continue to drop, resulting in the drying of wetland habitats and drainage of lakes (MMS 2008b; Anisimov et al. 2007). A longer growing season and warmer water temperatures of lakes that currently freeze to the bottom would likely change the chemical, mineral, and nutrient status. Arctic species may be at a competitive disadvantage as subarctic species ranges expand northward and changes in plant communities are likely to continue. Arctic tundra in Alaska may be replaced by boreal forest by 2100 (Anisimov et al. 2007).

Decreases in sea ice cover are also expected to continue. The Arctic sea ice is undergoing changes in extent, thickness, distribution, age, and melt duration (NSIDC 2010, 2011; Kwok and Cunningham 2010, 2011). The analysis of long-term datasets indicates substantial reductions in both the extent (area of ocean covered by ice) and thickness of the Arctic sea-ice cover during the past 20–40 yr. Generally, it is thought that the Arctic will become ice-free in the summer, but at this time there is considerable uncertainty about when that will happen (Stroeve et al. 2011; Tietsche et al. 2011; Zhang et al. 2010; Overland and Wang 2010). See also Section 3.3 for further discussion of sea ice. The suspended sediments associated with increased coastal erosion will likely affect marine algae communities. In addition, sea level is projected to rise an average of 0.73 m (2.4 ft) in the Arctic between 2000 and 2100, flooding low-lying coastal habitats (MMS 2008b). Coastal wetlands and estuaries would be threatened by inundation from rising sea levels, intensification of storms, and higher storm surges. Increased wave activity, relative sea level rise, and thawing of permafrost that binds coastal sediments lead to retreat of coastal habitats (Nicholls et al. 2007). Temperature, salinity, and oxygen levels of coastal estuaries would be affected by changes in rates and timing of river runoff. Seasonal ice cover on rivers and lakes is breaking up earlier each year, with a longer open water season (MMS 2008b). Observed changes in tundra habitats are expected to continue. Snow cover over tundra is expected to melt earlier and large-scale changes in permafrost are predicted to be likely.

No federally listed or candidate plant species occur in the Arctic region. Seven species of rare vascular plants are known to occur on the ACP and Arctic Foothills (Lipkin 1997; MMS 2003b; BLM 2003). These species are found nowhere else in Alaska, and several are endemic to Alaska.

3.7.1.3.1 Chukchian Neritic. Habitats of the Chukchian ecoregion include narrow beaches along the coastline, predominantly fronting steep cliffs cut in bedrock, up to 260 m (853 ft) high at Cape Lisburne (MMS 2007c). Barrier islands occur only at Point Hope at the Marryat Inlet/Kukpuk River delta and nearby Aiautak Lagoon; the islands are nearly continuous, composed of sand and gravel. There is little or no wetland occurrence along the Chukchian ecoregion coastline other than the lagoon at Point Hope.

3.7.1.3.2 Beaufortian Neritic. Habitats of the Beaufortian ecoregion include narrow beaches along the coastline; lower cliffs, where present, are cut in bedrock (south of Utukok River) or perennially frozen ice-rich sediments (MMS 2007c). Barrier islands, typically enclosing lagoons, are frequent along Chukchi and Beaufort Sea coasts; some, such as at Kasegaluk Lagoon, have less than 3 m (10 ft) relief and less than 2 m (7 ft) in the Beaufort Sea. Beaufort islands are narrow, at less than 250 m (820 ft), and short (MMS 2008b). Coastal relief along these marine depositional areas is generally less than 5 m (16 ft). The Chukchi Sea coast is a high-energy shoreline when ice is absent. Erosion and flooding are associated with autumn and spring storms and ice movement (MMS 2008b). Much of the coast is eroded by ice, waves, and currents, but active wave erosional coast is rare along the Chukchi Sea, where cliffs are generally less than 1 m (3 ft) high (MMS 2007c).

Estuarine wetland systems occur in enclosed and protected bays along the Chukchi Sea shoreline. Large estuarine wetland complexes in Chukchi Sea lagoons and other well-protected areas, such as Omalik Lagoon, Kasegaluk Lagoon, Icy Cape, Peard Bay, and Wainwright Inlet, include sand/silt flats and brackish-water sedge marshes. A few scattered, narrow marshes occur along the remainder of the coastline. Beaufort Sea coastal waters are estuarine during a portion of the year, with freshwater inflows from numerous rivers and streams mixing with marine waters (MMS 2007c, 2008b). Maximum discharge is late May to early June, with melting of landfast ice in early June to July, initially near river deltas. The coastline includes bays and lagoons, as well as Stefansson Sound, enclosed by barrier islands.

3.7.1.3.3 Arctic Coastal Plain. The Arctic Coastal Plain (ACP) is relatively flat and borders the Beaufort Sea and the eastern portion of the Chukchi Sea, encompassing most of the Beaufortian ecoregion. The ACP includes a complex mosaic of vegetation types, the distribution and extent of which are strongly influenced by local soil characteristics, elevation, temperature, and moisture (BLM 2002). Freshwater wetlands, including a wide variety of vegetation types, cover nearly all of the coastal plain and foothills (ADNR 2008; BLM 2002; BLM and MMS 2003).

On the ACP, the presence of thick, continuous permafrost that is generally near the soil surface restricts soil drainage and results in saturated soils over most of the area (BLM 2002; BLM and MMS 2003). Wetland plant communities, characterized by sedges, grasses, dwarf shrubs, and mosses, are the predominant vegetation types of the ACP (BLM 2002; MMS 2002b, 2003b). Numerous small lakes and ponds are scattered across the landscape. Even small-scale variations in the land surface elevation alter patterns of species occurrence and influence the distribution of plant communities. These variations determine the occurrence of wet, moist, and dry tundra (BLM and MMS 2003). Flooded tundra and aquatic vegetation cover types also occur. Coastal plain soils generally consist of an organic mat over fine-textured mineral soil.

Over much of the near coastal area inland from Point Barrow, along the Beaufort Sea to the Canning River, wet graminoid moss communities, with moist communities on higher microsites, are the predominant plant communities (Raynolds et al. 2006). Wet sedge moss communities, with moist communities such as tussock-sedge and dwarf-shrub communities on higher microsites, extend over much of the ACP from near Point Lay on the Chukchi coast to the border of Canada. Non-tussock sedge, dwarf-shrub, moss tundra communities and Non-tussock sedge, dwarf-shrub, forb, moss tundra communities, both on mesic soils, occur at the margin of the ACP near the Arctic Foothills. Tussock-sedge, dwarf-shrub, moss tundra communities, occurring on sandy soils in complex with lakes and wet tundra, are the predominant community type over a large area south of Teshekpuk Lake, in the central portion of the ACP.

Ground patterns form polygons in much of the east-central portion of the ACP. Low polygons, enclosed by rims, are common and support wet sedge/moist sedge tundra in basins and dwarf shrub tundra on rims, with troughs between polygons (Noel and McKendrick 2000; MMS 2002b). Near the coastline, high centered polygons bordered by deep troughs support moist sedge and dwarf shrub tundra.

Over much of the ACP, thaw lakes (typically 1–7 m [3–23 ft] in depth) shaped and oriented by wind direction cover 20–50% of the surface area (Gallant et al. 1995). Ponds are generally smaller and shallower. Lake margins and smaller ponds frequently support the fresh grass marsh vegetation type, generally in surface water depths of 0.2–2 m (0.7–7 ft) (Viereck et al. 1992).

Thaw lakes generally follow a cyclic pattern of draining and reforming (BLM 2002). Wet tundra communities, later becoming wet sedge meadow communities, commonly become established in drained basins (BLM 2002). Surface water in these areas may be present much of the growing season and may be up to 15 cm (0.5 ft) deep (Viereck et al. 1992).

Barren areas along major streams are composed of 60% barren peat, mineral soil, or gravel. These areas may have patches with sparse cover of forbs and dwarf shrubs. The margins of ACP rivers typically include gravel bars, sandbars, and sand dunes (BLM 2002). Active sand dunes support dunegrass communities, while floodplains support low willow shrub and seral herb communities. Large, braided rivers on the ACP, such as the Sagavanirktok River, include extensive areas that are predominantly unvegetated or sparsely vegetated. Some plant communities near the Sagavanirktok and Kadleroshilik Rivers are maintained in early and mid-successional stages by the deposition of windblown silt from the river channel (MMS 2002b; BLM 2002).

3.7.1.3.4 Arctic Foothills. Inland from the Chukchian ecoregion and southwestern Beaufortian ecoregion coast, the Arctic Foothills extend across northern Alaska between the ACP and the Brooks Range, reaching to the Beaufort Sea near the border of Canada. Thick permafrost extends over the hills and plateaus of the Arctic Foothills, and most soils are poorly drained with thick organic layers (BLM 2002). Although the foothills have more distinct drainage patterns and fewer lakes than the ACP, much of the landscape in the foothills consists of wetlands.

A wide variety of plant community types occurs on the foothills (Raynolds et al. 2006). Near the Chukchian ecoregion coast, the wet sedge moss communities (with moist communities on higher microsites), non-tussock sedge, dwarf-shrub, forb, moss communities (mesic soils), and prostrate dwarf-shrub, forb, lichen (dry limestone slopes) are the predominant community types. Farther inland, and extending along much of the southwestern Beaufortian ecoregion, the tussock-sedge, dwarf-shrub, moss community type, on mesic soils, is a predominant community type of the Arctic Foothills. Also occurring near the coast are erect dwarf-shrub, lichen communities on mesic sites and prostrate dwarf-shrub, lichen communities on dry granitic slopes. The foothills approach the Beaufort Sea along the northeastern coast of Alaska. Here, tussock-sedge, dwarf-shrub, moss (mesic soils); erect dwarf-shrub (mesic soils); and prostrate dwarf-shrub, sedge community types (dry limestone slopes) occur at or near the coast.

3.7.2 Marine Benthic Habitats

3.7.2.1 Gulf of Mexico

Marine benthic (bottom) habitats are areas of the seafloor used by organisms at some or all stages in their life for critical functions such as feeding, reproduction, and shelter. In the GOM Planning Areas, marine benthic habitats on the continental shelf and slope/deep sea habitats include soft sediments, hard bottom areas, chemosynthetic communities, warm-water coral reefs, and deepwater corals (Table 3.7.2-1).

3.7.2.1.1 Soft Sediments. Sediments of the Northern GOM are primarily composed of sand, silt, and clay. Thus soft bottom habitat is not a unique habitat of concern like the hard bottom, deepwater coral, and deepwater community habitats discussed below. However, soft sediments do provide habitat to most marine organisms in the GOM and are the site of fundamental ecosystem processes, such as the breakdown of organic matter, nutrient transformation and recycling, and the metabolization of natural and anthropogenic releases of hydrocarbons (Hazen et al. 2010). As the predominant sediment substrate type, soft sediment habitat will be most affected by oil and gas development and production activities.

Continental Shelf Soft Bottom Habitat. The Northern GOM Continental Shelf Marine Ecoregion extends from the coastline out to the shelf break at water depths ranging about 118 to 150 m (387 to 492 ft) and encompasses the Mississippi and Texas Estuarine Ecoregions and the Western Gulf Neritic Ecoregion. The major marine benthic habitat consists of soft muddy bottom. An exception is the sandy sediments along beaches and barrier islands.

Much of the organic matter in the upper water column is eventually deposited on the seafloor in seasonal pulses, following springtime peaks in river discharge and spring phytoplankton blooms. Once reaching the seafloor, organic matter is consumed by bacteria, meiofauna, and macrofauna. Consequently, soft sediments are important sites for detrital processing and the remineralization of critical elements like sulfur, nitrogen, and phosphate. Sediment-associated nutrients and organic matter may also be resuspended into the water column, where they support new water column primary and secondary production. This coupling between benthic and pelagic habitats is particularly strong in shallow areas of the continental shelf.

TABLE 3.7.2-1 Benthic and Pelagic Marine Habitat Types Found in the Northern Gulf of Mexico Shelf, Slope, Mississippi Fan, and Basin Marine Ecoregions within the Western and Central Planning Areas

Marine Habitat Type	Marine Ecoregion
Benthic	
Soft sediments	All ecoregions
Hard bottom areas	Shelf (Mississippi Estuarine Area, Western Gulf Neritic), Slope, and Basin
Coral reefs	Shelf (Western Gulf Neritic)
Deep/coldwater corals	Primarily Slope
Chemosynthetic communities	Primarily Slope
Man-made structures	Shelf (Mississippi Estuarine Area, Western Gulf Neritic), Slope
Pelagic	
Water column	All ecoregions
Sargassum	All ecoregions

Biological interactions as well as physiochemical factors such as substrate, temperature, salinity, water depth, currents, oxygen, nutrient availability, and turbidity are critical in determining the distribution, composition, and abundance of continental shelf soft bottom communities. The major factor influencing the megafaunal distributions appears to be the differing substrates, with primarily carbonate sediments found east of DeSoto Canyon and along the west Florida shelf in the Eastern Planning Area and with more terrigenous muds found in the estuarine and neritic shelf sediments in the Eastern and Western Planning Areas (Defenbaugh 1976). Soft sediment infaunal communities on the GOM continental shelf are generally dominated, in both number of species and individuals, by surface-deposit-feeding polychaete worms, followed by crustaceans and mollusks (Continental Shelf Associates, Inc. 1992, 1996; Brooks 1991; Baustian and Rabalais 2009). Common species on the sediment surface include sea anemones, brittle stars, portunid crabs, and penaid shrimp. These animals are typically distributed on the basis of water depth and sediment composition or grain size, with seasonal components also being present in shallower water areas.

Northern Gulf of Mexico Slope/Basin Ecoregion. Soft sediments of the continental slope and deep sea have a unique faunal community adapted to the cold, high-pressure, and low-productivity environment. Recent surveys from south Texas to the Florida panhandle revealed that echinoderms, sea anemones, nematodes, copepods, amphipod, polychaetes, and bivalves were common constituents of soft sediment assemblages in the deep sea. There were distinct faunal communities from east to west of the Mississippi River and from the upper slope to the abyssal plain (Rowe and Kennicutt 2009; Wei et al. 2010). The highest macroinvertebrate densities were found near the Mississippi River, followed by areas to the east. A general decrease in the abundance of fish, meiofauna, and macrofauna was observed from the upper continental slope to the abyssal areas in the GOM (Rowe and Kennicutt 2009). The number of invertebrate species was higher on the shelf/slope than the outer shelf, and the number of benthic invertebrate species was highest on the mid to upper slope. Overall, biomass, species number, and species composition were influenced by water depth, the proximity of locations to canyons and methane seeps, and the organic matter content of sediment (Rowe and Kennicutt 2009). Other physical and chemical parameters — such as oxygen concentration, temperature, salinity, and chemical contaminants within the sediments — did not appear to be related to community structure (Rowe and Kennicutt 2009).

The abundance patterns just described, such as the high density of macrofauna near the Mississippi River, are in large part attributable to food availability. The offshore GOM has low nutrient concentrations and surface water productivity. In such areas, most organic matter is therefore tightly recycled in the water column and much less is exported to sediment or higher trophic levels (Hagstrom et al. 1988; Buesseler 1998; Pomeroy et al. 2007; Hung et al. 2010). Organic matter that does fall below the photic zone breaks down as it sinks and reaches the seafloor in a highly degraded state. The continental slope/deep sea benthos is thus typically food starved; consequently, the size, biomass, and abundance of benthic consumers decline with depth as one goes from the continental shelf to the deep sea. Although much of the deep sea is relatively unproductive, deep sea cold seep communities are exceptions and will be discussed later in this section.

3.7.2.1.2 Warm Water Coral Reefs. Coral reefs are formed by reef-building coral species. Coral are suspension feeders, and their prey predominantly consist of planktonic organisms carried in the water column. Photosynthetic corals also harbor dinoflagellate algae that benefit the coral's physiology through products resulting from photosynthesis. Where they are present, coral reefs in the GOM serve ecological functions as important sites of primary productivity and as habitat for dense and diverse reef-associated communities.

Coral reefs are primarily concentrated on the west Florida shelf. Although not in the Western or Central Planning Areas, these reefs could be affected by accidental oil spills. Coral reefs are not found in the Central Planning Area and are relatively uncommon in the Western Planning Area, although individual corals are common in hard-bottom seafloor habitats in both areas. The East and West Flower Garden Banks in the FGBNMS, located in the Western Gulf Neritic Marine Ecoregion, are considered the only coral reefs present in the Western Planning Area (Figure 3.7.2-1). The East and West Banks are prominent topographic features covering approximately 50 and 74 km^2 (12,355 and 18,286 ac), respectively, and rising to a depth of 17 m (63 ft) below the water surface from surrounding water depths below 100 m (328 ft) (Hickerson et al. 2008). The banks formed over salt domes, which forced the overlying seabed upward, resulting in exposed carbonate that provided substrate for the colonization and growth of reef organisms. The crests of these features are carbonate rock formed by reef-building corals, coralline algae, and other lime-secreting creatures. The dominant community on these banks at water depths above 36 m (118 ft) is composed of reef-building corals (approximately 20 species), with an average cover of more than 50% (Bright et al. 1984; Dokken et al. 1999; Precht et al. 2008). In addition, more than 80 species of algae, approximately 250 species of macroinvertebrates, and more than 120 species of fishes are associated with these features (Dokken et al. 1999).

On the basis of data from 1978 to 2006, there do not appear to be any long-term trends in the percentage of coral cover at the FGBNMS (Hickerson et al. 2008; Robbart et al. 2009), and

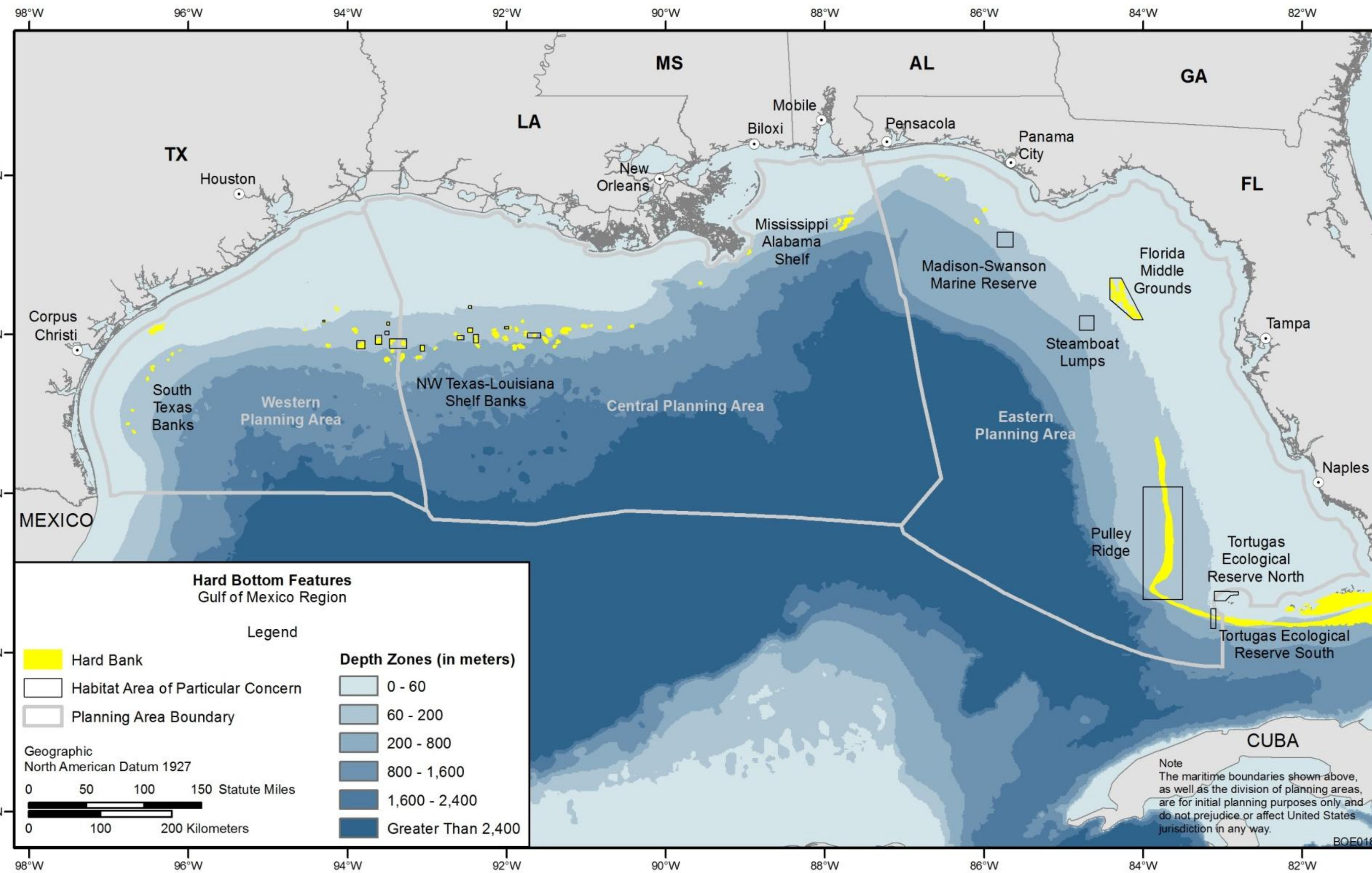

FIGURE 3.7.2-1 Location of Hard Bottom Features in the Western, Central, and Eastern Planning Areas

despite causing some physical damage to reef structure, recent hurricanes have not caused significant lasting damage to the FGBNMS (Robbart et al. 2009). Within a 6.4-km (4-mi) radius of the FGBNMS, there are currently 14 oil production platforms, and there is one gas production platform within the East Sanctuary boundary. However, there is no evidence that oil and gas production activities have adversely affected the FGBNMS (Gittings 1998). Ongoing stressors on the FGBNMS include mechanical disturbance from anchors and discarded fishing gear, coastal runoff, and disease (Hickerson et al. 2008).

3.7.2.1.3 Deepwater Corals. Research from 2003 to the present has resulted in extensive data on the distribution of deepwater (or coldwater) corals and the compositions of their associated communities (CSA International, Inc. 2007). Deepwater corals are found on rock outcroppings in the Northern GOM Slope Ecoregion in waters typically deeper than 300 m (984 ft) (Figure 3.7.2-2). The primary deepwater species in the GOM is *Lophelia pertusa*. This highly branching species can develop from small bushes to thickets of hemispherical colonies. *Lophelia* aggregations typically develop on lithified outcroppings formed in the past by now-inactive hydrocarbon seeps. Although often located near cold hydrocarbon seeps, *Lophelia* corals and associated biota do not appear to use seep hydrocarbons as a food source; instead, they depend on plankton and organic matter falling from the upper water column (CSA International, Inc. 2007). *Lophelia* produce larvae whose dispersal ability is limited when compared with that of species that produce planktotrophic larvae. Consequently, gene flow appears to occur primarily within individual *Lophelia* thickets; nevertheless, enough long-distance dispersal occurs to maintain regional genetic distinctiveness (USGS 2008).

Lophelia beds provide complex benthic habitat that attracts deepwater fish and invertebrates in greater density than that found in the surrounding soft-bottom habitat. Surveys of *Lophelia* communities off the coast of Louisiana conducted in 2004 and 2005 indicated that polychaetes, brittle stars, sponges, and hydroids were the most common species (CSA International, Inc. 2007). Predatory polychaetes and shrimp and crabs were also common. Overall, suspension feeders and predators were the dominant trophic guilds represented, but large scavengers were also present (CSA International, Inc. 2007). A study of the Viosca Knoll *Lophelia* communities found that fish communities differ according to depth, with communities found at 325 m (1,066 ft) being distinctly different than the deepwater fish species collected at 500 m (1,640 ft) (USGS 2008).

3.7.2.1.4 Hard Bottom. The term hard bottom (also referred to as live bottom) generally refers to exposed rock, but it can also refer to other substrata, such as coral and clay, or even artificial structures. Hard bottoms often support highly productive algal and animal communities. The sessile (nonmotile) biota typically growing on hard-bottom areas may include macroalgae, seagrasses, sponges, barnacles, hydroids, corals, cnidarians, bryozoans, and tunicates, which, in turn, provide shelter, food, and spawning sites for mobile fish and invertebrates. Within the Eastern and Western Gulf Neritic and the Mississippi Gulf Estuarine Ecoregions, major topographic features occur on the continental shelf and shelf edge across the west Florida shelf and in more restricted locations off Alabama, Mississippi, Louisiana, and Texas. The estimated areal extent of natural hard bottom in the GOM on the continental shelf is

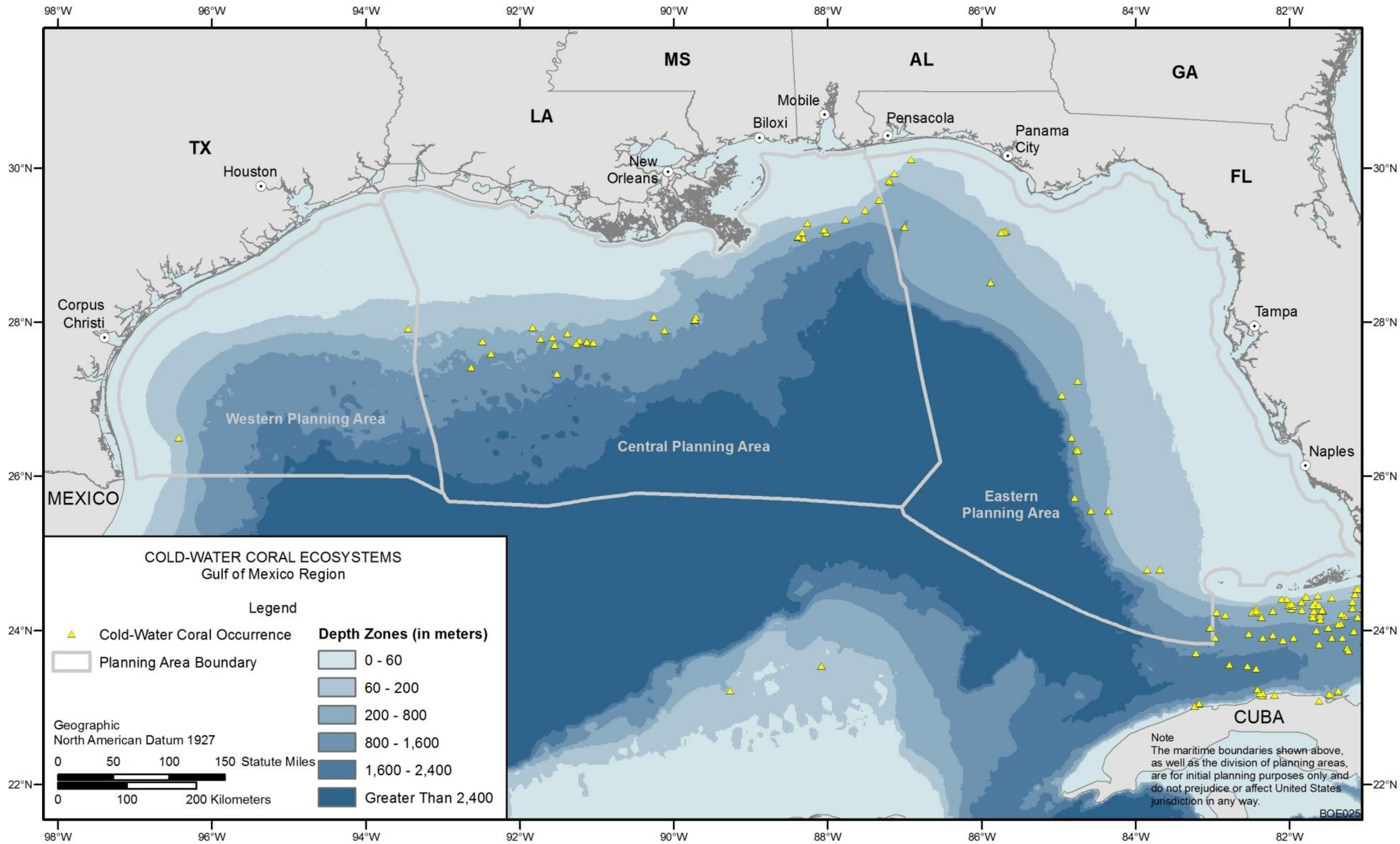

FIGURE 3.7.2-2 Location of Coldwater Coral System Features in the Western, Central, and Eastern Planning Areas

4,772,600 ha (11,793,300 ac), with only 6% of this occurring in the Central and Western Planning Areas (GMFMC 1998). Authigenic carbonate exposed in deepwater areas below 300 m could total more than 200,000 ha (494,208 ac) as determined from 3D seismic remote sensing data (less than 1% of the total bottom area of the deep GOM).

Mississippi-Alabama Shelf. Within the Mississippi Estuarine Area, in inner-shelf and mid-shelf regions off Mobile Bay and the Alabama/Florida State line, there are small low-relief outcrops of rock, shell hash, and sandstone on areas with sand or shell bottom (Figure 3.7.2-1). This hard-bottom habitat, found in water depths of 18 to 40 m (59 to 131 ft), ranges from low-relief exposed rock in shallow depressions to rock outcrops with up to 5 m (16.4 ft) of vertical relief (Thomson et al. 1999). The dominant biota varies with location, but it can include barnacles, coralline algae, hydroids, sponges, octocorals, solitary hard corals, bryozoans, and ascidians (Schroeder et al. 1989; Thompson et al. 1999). These inner shelf outcrops also served as spawning grounds for a variety of fish, including the spot (*Leiostomus xanthurus*) and the Atlantic croaker (*Micropogonias undulates*).

Along the shelf edge between the Mississippi River and DeSoto Canyon, there are discontinuous carbonate reef structures called Pinnacle Trend regions; they fall primarily in two parallel bands along depth contours. BOEM (as MMS)-sponsored studies (Brooks 1991; Continental Shelf Associates, Inc. 1992; Continental Shelf Associates, Inc., and Texas A&M University, Geochemical and Environmental Research Group 1999) have provided further information about these features, which consist of thousands of carbonate mounds ranging in size from less than a few meters to nearly a kilometer in diameter. The larger "pinnacle" features are found at depths of 74–82 m (243–269 ft) and 105–120 m (344–394 ft), and their vertical relief ranges from 2 to 20 m (6 to 66 ft), with the average being 9 m (30 ft). Linear ridges paralleling the isobaths were also mapped in the shallower depth zone. These ridges are typically about 20 to 250 m (66 to 820 ft) in width, are more than 1 km (0.6 mi) long, and have a relief of up to 8 m (26 ft). Shallow (generally less than 1 m, or 3 ft, deep) depressions, usually less than 15 m (49 ft) in diameter, were also found (Sager et al. 1992).

The pinnacle features provide a significant amount of hard substrate for colonization by suspension-feeding invertebrates, and they support relatively rich biological communities. Barnacles, worms, coralline algae, sponges, corals, and bryozoans are present at the tops of the shallowest features in water depths of less than about 70 m (230 ft) (GMFMC 2004). The diversity and abundance of the associated species appear to be related to the size and complexity of the features, with the low-relief rock outcrops (less than 1 m [3 ft] high) typically having low faunal densities, and the higher-relief features having the more diverse faunal communities. Although it is likely that little active reef building is occurring now, the Pinnacle Trend may serve as an important colonization site for hard-bottom species and allow cross-shelf gene flow between reef species in the western and eastern GOM (GMFMC 2004). In addition, pinnacles off Mobile Bay serve as aggregation sites and spawning grounds for fish and invertebrates during multiple life stages.

Louisiana-Texas Shelf Banks and South Texas Banks. Within the Mississippi Estuarine and Western Gulf Neritic Ecoregions, there are several low- to high-relief banks and ridges along the mid to outer Louisiana-Texas shelf in 22 to 200 m (72 to 656 ft) of water. Bank relief ranges from less than 1 to 150 m (3 to 492 ft) and can be as large as several hundred square meters in area. The major topographic features of the central and western GOM are shown in Figure 3.7.2-1. These features are elevated above the surrounding seafloor and are characterized as either mid-shelf bedrock banks or outer-shelf bedrock banks with carbonate caps (Rezak et al. 1983; Hickerson et al. 2008). Although these topographic features are small, the hard-bottom faunal assemblages associated with them often have high diversity, species richness, and biomass; they also provide habitat for important commercial and recreational fish species.

Benthic zones were described for the topographic features by Rezak et al. (1983). The zones were classified on the basis of their amount of reef-building activity and primary production (Rezak et al. 1983, 1985). The mid-shelf and shelf-edge banks along the Texas-Louisiana border contain a variety of zones, ranging from clear water high-productivity to low-productivity zones (Rezak et al. 1983). Several banks along the Louisiana-Texas mid shelf and shelf edge were near the storm track of Hurricane Rita in 2005. However, the long-term effects on these banks appear to have been minor (Robbart et al. 2009). Rezak et al. (1983) classifies the south Texas banks as low relief with turbidity-tolerant communities and little to no reef-building activity.

It appears that differences in the fish and invertebrate communities depend on the bank's structure, depth, and location. However, all areas have high fish and invertebrate densities and diversities, dominated by reef-associated species (Dennis and Bright 1988). Epibenthic biota that are colonizing the hard substrate include bryozoans, hard corals, octocorals, fire corals, sponges, sea whips, gastropods, hydroids, sea urchins, and spiny lobster (GMFMC 2004). Reef-associated fishes typical of the GOM congregate around these features, and many are of commercial and recreational importance (Section 3.8.4.1).

West Florida Shelf. Most of the hard-bottom habitat in the Northern GOM Shelf Marine Ecoregion is located on the west coast of Florida. Although not in the Western or Central Planning Areas, these areas could be affected by accidental oil spills and are therefore briefly described. The live-bottom communities on the west Florida shelf are tropical to temperate in nature, with the number of tropical species decreasing to the north. The communities are predominantly algal/sponge/coral assemblages, with the shallow-water octocorals and the hard corals significantly decreasing in abundance at depths deeper than about 40 m (161 ft). Most of the hard bottom on the west Florida shelf is low relief (less than 1 m [3 ft]), but it also includes ridges and pinnacles rising up to 30 m (98 ft) from the seafloor (Woodward-Clyde Consultants and Continental Shelf Associates, Inc. 1983; Continental Shelf Associates, Inc. 1987). Despite the relatively small amount of actual exposed rock outcrops across this shelf, dense sessile epifaunal assemblages are common. The primary topographic features on the west Florida shelf are the Florida Middle Ground (Figure 3.7.2-1), located about 160 km (99 mi) northwest of Tampa Bay, and Madison Swanson water, located south of Panama City at a depth of 60 to 100 m (197 to 328 ft). Steamboat Lumps, a low-relief area that measures 269 km^2 (104 mi^2) and is located west of Tarpon Springs, is another known spawning ground for reef fish. (Additional maps are available at http://oceanexplorer.noaa.gov/explorations/islands01/log/jun20/jun20.html).

Artificial hard-bottom sites, including sunken vessels, oil and gas platforms, and debris, represent only 1.3% of all hard-bottom sites in the GOM (GMFMC 1998); nevertheless, these structures support locally abundant fish populations in shelf waters of all GOM coast States (GMFMC 1998). Artificial reefs are placed in the GOM continental shelf to improve fishery production and recreational fishing opportunities.

Oil platforms also serve as artificial reef habitats. There are 3,315 active oil platforms now present in GOM Federal waters (Boudreaux 2011). After oil platforms are decommissioned, they can be converted to artificial reefs by being toppled or partially removed. Oil platforms represent a novel habitat when compared with the surrounding soft sediments, and they provide attachment sites for sessile reef invertebrates such as corals, bryozoans, and sponges. In this way, they allow the range of fish and invertebrate species to expand. In addition, by serving as "islands" of hard substrate, the platforms can also promote gene flow between the eastern and western portion of the GOM (Sammarco et al. 2004).

Although the algae growing on oil platforms provide food for some platform biota, plankton is the primary food source supporting the platform community. The attached platform community in turn provides food for many but not all structure-oriented fish and invertebrates living on or near the platform. Single offshore platforms of average size have been found to provide habitat for an average of 10,000 to 30,000 fish within 50 m (164 ft) of the structure (Stanley and Wilson 2000). The high densities of fish near the platform decline to background levels within 10 to 50 m (33 to 164 ft) of the platform. Jacks, amberjack, red snapper, gray snapper, and triggerfish dominate the oil platform fish assemblage (Stanley and Wilson 2000).

Although platforms undoubtedly have higher amounts of organismal biomass than do the surrounding soft sediments, their role in enhancing fish production is controversial. Initially it was argued that reef fish are habitat-limited because of the scarcity of hard bottom on the Gulf continental shelf. Consequently, it was thought that artificial reefs provide needed habitat (Brickhill et al. 2005). Others argued that reef fish are not habitat-limited, and artificial reefs such as oil platforms simply attract fish away from natural hard bottom. Thus, platforms may simply attract fish rather than increasing fish production and, at the same time, make them easier to harvest by commercial and recreational fisheries (Brickhill et al. 2005). The benefit or detriment of artificial reefs as habitat depends on how fisheries are managed on the reef and the individual life histories and habitat requirements of the species present.

3.7.2.1.5 Chemosynthetic (Seep) Communities. In deepwater areas where oil and natural gas compounds seep up through the sediments, chemosynthetic bacteria inhabit specialized cells in clam, mussel, and worm hosts; they form symbiotic relationships in which methane and/or hydrogen sulfide are used to produce basic organic compounds. In the Northern GOM Slope Marine Ecoregion, chemosynthetic communities are associated with hydrocarbon seeps in water depths ranging from less than 300 m (984 ft) to more than 2,700 m (8,858 ft; Brooks et al. 2008). Figure 3.7.2-3 shows known chemosynthetic community locations. In addition, maps of acoustic seafloor anomalies in the GOM have been developed over the last 13 yr that can be used to predict the location of deepwater corals (Section 3.7.2.1.3-1) and chemosynthetic communities (Figure 3.7.2-3). The anomalies are present in the form of positive

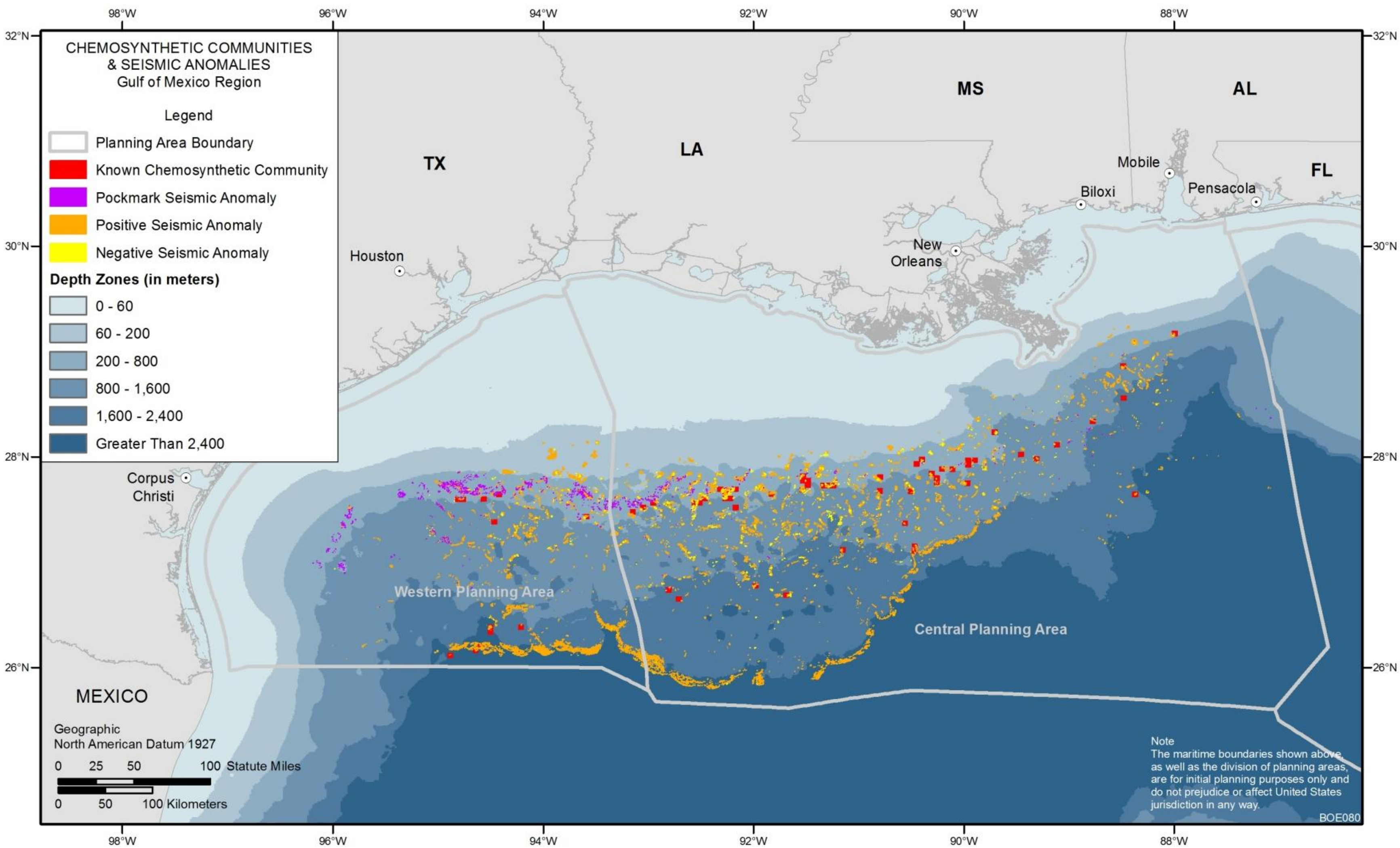

FIGURE 3.7.2-3 Location of Chemosynthetic Communities in the Western and Central Planning Areas

anomalies, negative anomalies, and pockmark features. The positive anomalies are indicative of hard-bottom authigenic carbonate deposits or solid hydrate formations with which deepwater coral or chemosynthetic communities are often associated. Positive anomalies do not guarantee the presence of deepwater communities because there may be a lack of exposed hard substrate for corals and the hydrocarbon seep could be inactive and not capable of supporting chemosynthetic communities. The negative anomalies are areas of rapid gas expulsion where it is generally not possible for significant communities to develop, although suitable hard substrate may be nearby. Pockmarks may be caused by large, short-term gas expulsion events and may or may not have associated hard substrate. BOEM has successfully used the presence of positive anomalies to predict the location of exposed hard-bottom, chemosynthetic, and/or deepwater coral communities, which has allowed these sensitive features to be avoided by oil and gas activities. Sassen et al. (1993b) showed that at locations for which data were available, most significant oil fields in the deepwater GOM had associated chemosynthetic communities. Since there is extensive natural oil and gas seepage in the GOM, an extensive amount of habitat is thought to be available for these types of communities, although the amounts are small in individual areal extent. In addition, chemosynthetic communities not associated with oil and gas seepage have been found at the base of the Florida Escarpment in water at a depth of about 3,200 m (10,499 ft) (Paull et al. 1984; Hecker 1985).

Evidence indicates that fauna associated with chemosynthetic communities can be extremely slow-growing. For example, tubeworms are estimated to grow less than 1 cm (0.4 in.) per year and to live longer than 200 yr (Fisher et al. 1997; MacDonald 2000). The seep mussels also exhibit slow growth rates, with adults surviving up to 40 yr (Nix et al. 1995; MacDonald 2000). Chemosynthetic communities on the upper continental slope (<1,000 m [3,281 ft]) and the mid to lower continental slope (>1,000 m [3,281 ft]) have been studied. Although general groups of epifauna, such as galatheid crabs, decapod shrimp, mussels, and tubeworms, were present at upper and lower slope sites, differences were strong at the species level (Brooks et al. 2008). There were differences in the invertebrate communities associated with mussel and tubeworm habitats although a single species of shrimp (*Alvinocaris muricola*) was typically numerically dominant at both habitat types. Depth, relative abundance of different mussel species in a bed, and the tubeworm size were important determinants of community composition (Cordes et al. 2010).

3.7.2.1.6 Climate Change Effects on GOM Marine Benthic Habitats. Climate change has the potential to profoundly affect marine benthic habitats and communities. One seafloor habitat likely to be affected is coral reefs. For example, as a stress response to warming water temperatures, coral reefs could suffer from an increased frequency of bleaching (Hoegh-Guldberg et al. 2007). Globally, bleaching appears to have increased in frequency and severity since the last quarter of the 20th century (Janetos et al. 2008), but on the basis of data from 1978 to 2006, there do not appear to be any long-term trends in the percentage of coral cover at the FGBNMS (Hickerson et al. 2008; Robbart et al. 2009). Recent surveys indicate that the FGBNMS appears to be healthy, with coral cover ranging from 50 to 70% on both banks and a low incidence of bleaching and other coral disease (Precht et al. 2008; Robbart et al. 2009). Much of this may be due to the distance of the coral reefs from land and the depth at which the reefs are located. However, the IPCC estimates that water temperatures could increase by 1.8 to

4.0°C by 2050 (IPCC 2007b), and with the rise in temperature, coral bleaching at the FGBNMS could increase.

In addition to coral bleaching, there are other challenges to coral reefs related to climate change. For example, there has been a rise in the occurrence of excessive algal growth on reefs and an increase in bacterial, fungal, and viral agents (Boesch et al. 2000; Twilley et al. 2001). There is also the potential for greater frequency of mechanical damage to corals from greater severity of tropical storms and hurricanes (Janetos et al. 2008).

In addition, the increase in atmospheric CO_2 has resulted in the formation of carbonic acid, at the expense of carbonates (aragonite and calcite), in seawater. The resulting decreases in the oceanic pH and carbonate concentration are expected to reduce the reef formation rate, weaken the existing reef structure, and alter the composition of coral communities (Janetos et al. 2008). The projected decrease in pH varies depending on the model and model assumptions used; nevertheless, by 2050, the ocean's carbonate saturation might drop below levels necessary for coral reef accretion, and the pH of surface oceans might drop by as much as 0.5 pH by the end of this century (Royal Society 2005; Hoegh-Guldberg et al. 2007). Recent work also suggests ecosystem respiration is higher in the GOM because eutrophication has increased dissolved CO_2 and reduced oceanic pH by 0.11 to 0.16 (Cai et al. 2010). The trend is expected to continue, potentially leading to carbonate undersaturation (Cai et al. 2010).

As climate change has the potential to affect warm water corals, it could also affect coldwater *Lophelia* habitats. The saturation depth of aragonite (the primary carbonate form used by hard corals) appears to be a primary determinant of deep water coral distribution, with reefs forming in areas of high aragonite solubility (Orr et al. 2005). The depth at which the water is saturated with aragonite is projected to become shallower over the coming century, and most coldwater corals may be in undersaturated waters by 2100 (Orr et al. 2005). Consequently, the spatial extent, density, and growth of deepwater corals may decrease, diminishing their associated ecosystem functions (Orr et al. 2005).

In nearshore and mid-shelf benthic habitats, climate change may cause the temporal variability of key physical parameters — particularly dissolved oxygen, salinity, and temperature — to change or increase, which could significantly alter the existing structure of the benthic community (Rabalais et al. 2010). For example, freshwater discharge into the GOM has been increasing and is expected to continue to increase as a result of the increased rainfall in the Mississippi River Basin (Dai et al. 2009). Such changes could result in severe long-term or short-term fluctuations in temperature and salinity that could reduce or eliminate sensitive species. Such changes are most likely to occur in the Mississippi Estuarine Ecoregion, where freshwater inputs are highest. Habitats most likely to be affected include inner-shelf and mid-shelf hard-bottom and soft-sediment habitats, although the benthos of deepwater areas affected by the Mississippi River, such as Mississippi and DeSoto Canyons, may also be affected. In addition, greater rainfall may increase inputs of nutrients into the GOM, potentially resulting in more intense phytoplankton blooms that could promote benthic hypoxia (Rabalais et al. 2010). The increased freshwater inputs and surface water temperature may also promote water column stratification, which is also conducive to the development and expansion of the existing GOM

Dead Zone. Hypoxic or anoxic conditions can reduce or eliminate the suitability of benthic habitat for marine organisms.

3.7.2.1.7 Effects of DWH Event on Marine Benthic Habitats. Few observations or analyses have been conducted on the effects of the DWH event on soft sediment habitats. Some researchers have reported seeing dead and dying benthic animals as well as what appear to be thick deposits of oil or flocculants of oil and organic matter on the seafloor (BOEMRE 2010b). More data are needed before characterizing the implications of the DWH event on soft sediment habitat. It is likely that the sediment hydrocarbon concentrations decreased significantly with distance from the well. In heavily oiled areas, the recovery time is unknown, but sediments in deeper waters may take longer to recover because of colder temperatures. Overall, natural processes should break down the oil, and it is likely that no permanent changes in soft sediment habitat affected by the DWH event would occur.

There is some evidence that the DWH event affected more sensitive benthic habitats. In November 2010, a survey of deepwater corals along the predicted trajectory of the DWH event in 1,400 m (4,593 ft) of water revealed a 15 × 40-m (49 × 131-ft) area of dead and dying deepwater corals covered in brown flocculent. The mortality was attributed to oil from the DWH event located approximately 11 km (7 mi) to the northeast (http://www.boemre.gov/ooc/press/2010/press1104a.htm). Investigations are ongoing. It is not known how many deepwater coral communities were affected or whether the affected corals will recover. The DWH event occurred more than 320 km (200 mi) from the FGBNMS, and there were no reports of oil from the spill reaching the FGBNMS (http://flowergarden.noaa.gov/education/oilspill.html). The FGBNMS is monitored as part of a regular program, and any changes related to the spill should be detected.

3.7.2.2 Alaska – Cook Inlet

The Cook Inlet Planning Area is located within the Alaska Fjordland Shelf Ecoregion (Wilkinson et al. 2009). The physical characteristics of the benthic habitats of Kachemak Bay, Shelikof Strait, and lower Cook Inlet are critical in determining habitat function. Several distinct benthic habitats have been identified based on tidal inundation and substrate, which can consist of rock, sand, silt, and/or shell debris. Plant and animal communities in rocky habitats have strong patterns of zonation with marked variation in species composition, community structure, and productivity. In the rocky intertidal habitat, benthic assemblages are concentrated below the seaweed zone, probably due to battering by waves and kelp (MMS 1996b). The Shelikof Strait is relatively ice free even in winter (MMS 2003a). However, seasonal ice is an important influence on habitat function in Cook Inlet. The western side of Cook Inlet experiences seasonal ice scour and has biological and physical characteristics that are more similar to arctic habitats compared to the eastern side, which does not experience ice scour (MMS 1996b, 2003a). The Cook Inlet lease sale 149 EIS (MMS 1996b) and 191 and 199 lease sale EIS (MMS 2003b) contain a comprehensive description of the habitats and biota found in Cook Inlet. See Section 3.8.4.2 and Section 3.8.5.2 for a further description of fish and benthic invertebrate communities in Cook Inlet.

The Gulf of Alaska is located outside of the Cook Inlet Planning Area and therefore would not be directly disturbed by oil and gas infrastructure. However, it could be affected by an oil spill associated with OCS activities in Cook Inlet and therefore will be briefly described. In the Gulf of Alaska, sediment deposition and sediment grain size are important determinants of benthic communities. In areas of the Gulf of Alaska where sediments are fine and sedimentation rates are high (particularly in the north-central region), nearshore infauna consists mostly of mobile deposit-feeding organisms. Greater numbers of sessile and suspension feeding infauna occur west of Prince William Sound as sediment changes to sand/gravel. A relatively low biomass of deposit feeders occurs in the eastern Gulf of Alaska, an environment characterized by strong tidal currents and sediment of low organic content (Semenov 1965).

Strong benthic-pelagic coupling is present in the Gulf of Alaska. Studies of Prince William Sound indicate sediment habitat receive the greatest springtime inputs of phytoplankton in years when phytoplankton blooms are of short duration and high biomass (Eslinger et al. 2001). Soft sediment habitat also contributes to water column productivity when sediments are resuspended by wind and wave action.

Climate Change Effects on Cook Inlet Marine Benthic Habitats. Continuing trends in climate change are expected to result in chemical, physical, and hydrologic changes in Cook Inlet. For example, increased river discharge is expected to alter the salinity, temperature, and turbidity regimes in nearshore benthic habitat (Arctic Council 2005), potentially resulting in changes in the composition, abundance, and diversity of sessile benthic communities. See Section 3.8.4.2 and Section 3.8.5.2 for a discussion of climate change and benthic fish and invertebrates. In addition to changes in hydrology, the expected reduction in landfast ice extent and duration resulting from rising temperatures may reduce the scouring of intertidal and shallow subtidal habitats on the western side of Cook Inlet. Warmer temperatures may also increase phytoplankton productivity, potentially resulting in greater food inputs to benthic habitats and subsequent increases in the productivity of benthic biota.

3.7.2.3 Alaska – Arctic

The Beaufort and Chukchi Planning Areas include the Beaufort/Chukchian Shelf Marine Ecoregion and the Arctic Slope and Arctic Plains Marine Ecoregions. In both planning areas, oil and gas exploration and production activities will generally occur in water depths of less than 200 m (656 ft).

Most of the seafloor of the Beaufort/Chukchian Shelf Marine Ecoregion consists of a soft-bottom, featureless plain composed of silt, clay, and sand. Deposits of flocculated particles from plankton blooms, epontic organisms, and ice algae from ice retreat all contribute to the bottom sediments in these regions. Disturbance from sea ice scour is a dominant process affecting the seafloor of the Beaufort and Chukchi shelves. Deep keels of icebergs moving across the shelf scour sediments, causing chronic disturbance to benthic communities. Strudel (drainage of large volumes of freshwater through the ice at holes and cracks) scouring of the seafloor also occurs near the mouths of rivers during spring flood periods. Few species inhabit the seafloor in waters shallower than 2 m (6.6 ft) deep because of the bottom fast ice, which prohibits overwintering of most organisms. This nearshore benthic area is recolonized each summer, mainly by mobile, opportunistic, epifaunal crustaceans (amphipods, mysids, cumaceans, and isopods, which are fed on primarily by waterfowl and fishes). In slightly deeper water, the gouging of the seafloor by ice keels creates a habitat for opportunistic infauna (e.g., small clams and other invertebrates), which are fed on by seabirds, fishes, and walrus (Bluhm and Gradinger 2008). Surveys on the Chukchi Shelf revealed that tunicates, echinoderms, jellies, crabs, polychaetes, and sponges make up most of the benthic biomass (NPFMC 2009). Common fish on soft sediments included arctic cod (*Arctogadus glacialis*), Pacific herring (*Clupea pallasii*), sculpins, and pollock (*Theragra chalcogramma*) (NPFMC 2009). See Sections 3.8.4.3 and 3.8.5.3 for descriptions of fish and invertebrate communities.

Food sources supporting soft-sediment habitat are highly seasonal and primarily derive from terrestrial sources and from water column primary and secondary production originating locally or advected from the Bering Sea. Data from the Northern Bering Sea and the Chukchi Sea suggests there is a strong coupling between phytoplankton biomass and benthic invertebrate biomass (also known as benthic-pelagic coupling), suggesting that communities on seafloor habitats rely strongly on organic matter originating from the water column. These benthic communities in turn support higher trophic levels such as benthic feeding birds and marine mammals (Dunton et al. 2005; Grebmeier et al. 2006). Thus, the fact that the biomass of benthic invertebrates in Chukchi Shelf sediments is higher than that in Beaufort Shelf sediments is thought to result from the higher phytoplankton and organic matter available on the former (Dunton et al. 2005). In contrast, benthic communities on the Beaufort Shelf do not appear to be related to phytoplankton biomass but rather to the availability of terrestrial organic matter from coastal erosion or riverine inputs (Dunton et al. 2006). Organic matter released from sea ice habitat is another food source that may be critical to benthic species in certain locations and seasons. For example, early life stages of benthic invertebrates are commonly found in the water column associated with sea ice (Gradinger and Bluhm 2005). In addition, much of the phytoplankton from ice-edge blooms associated with the spring sea ice melt is exported to the seafloor because of the low zooplankton density in the water column in the early spring (Bluhm and Gradinger 2008).

Hard-bottom seafloor habitat is also present, primarily in the form of cobble and boulders distributed sporadically along the inner Beaufort and Chukchi shelves and in the Barrow Canyon (MMS 2002a). Three such locations are in Stefansson Sound and western Camden Bay in the Beaufort Sea and in Peard Bay in the Chukchi Sea (MMS 2003b, Section III.B.1.b; BLM and MMS 2003b, Section III.A.2.c(3)). In addition, Peard Bay and the Stefansson Sound Boulder Patch have kelp communities, with the latter having the largest brown kelp (*Laminaria solidungula*) community in the Alaskan Arctic (Phillips et al. 1984; Dunton et al. 2004; Figure 3.7.2-4). The resident species are found at higher diversity, abundance, and biomass in boulder patches than in surrounding areas and are composed of a unique community of algae, bryozoans, hydroids, polychaetes, bivalves, crustaceans, and the soft coral associated with them (Iken 2009). Sediment inputs from rivers and ice scouring are primary controls on biological productivity in boulder habitat. Results of a recent study conducted under the BOEM Arctic Nearshore Impact Monitoring in the Development Area (ANIMIDA) Program demonstrated that suspended sediment can reduce the light available for kelp production during open-water periods

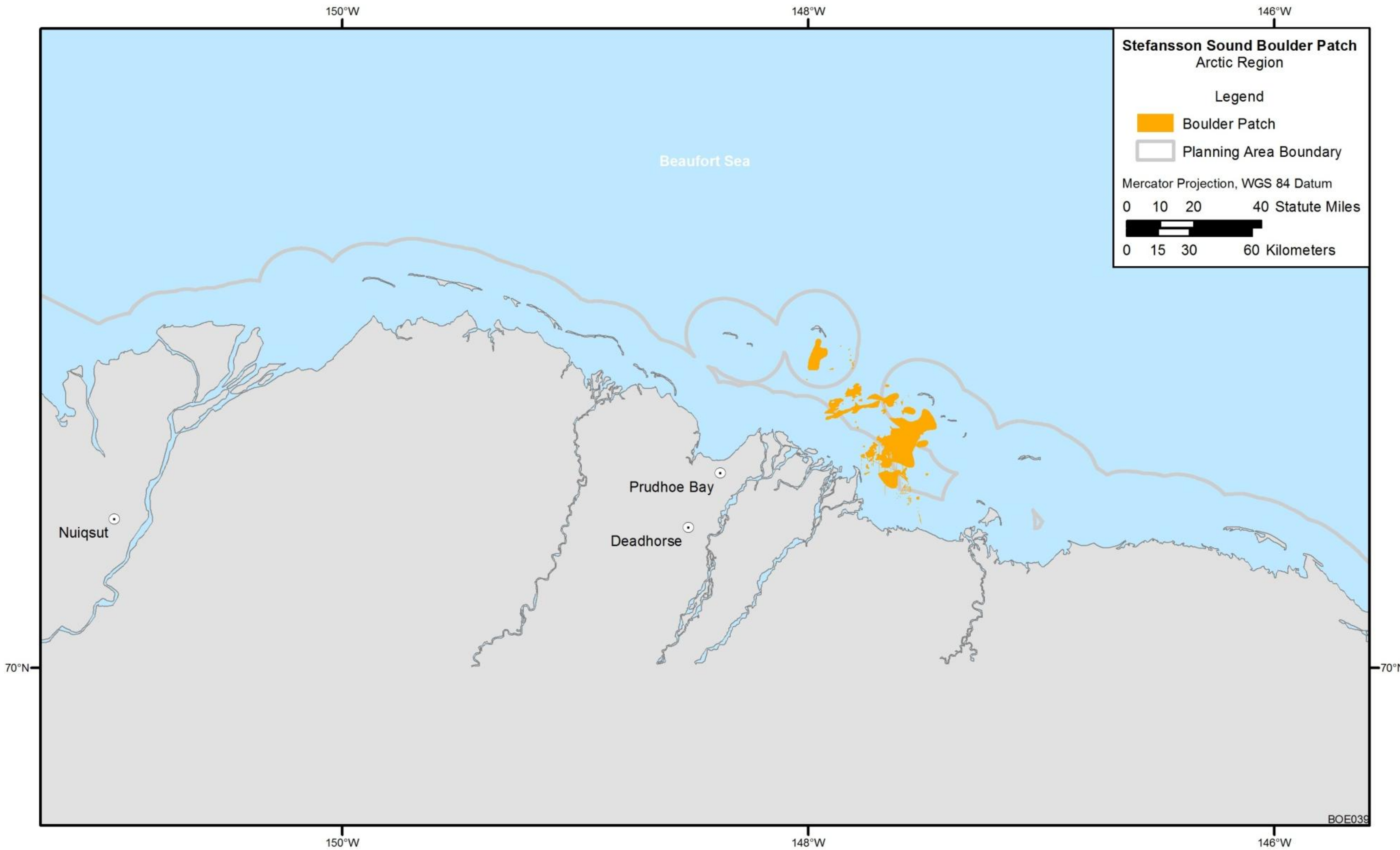

FIGURE 3.7.2-4 Location of the Stefansson Sound Boulder Patch in the Beaufort Sea Planning Area

of summer (Dunton et al. 2004) and that kelp productivity is significantly reduced in years where sediment loading is high (Aumack et al. 2007). The reduced photosynthesis can result from sediment coating kelp blades or reducing light penetration into the water column. Multiple studies have also demonstrated that boulder habitats are subject to frequent disturbance from the freezing and thawing of ice. If significantly scoured or overturned, communities associated with boulders are slow (2 or more years) to begin recovery, with full recovery taking a decade or more (Konar 2007 and references therein).

Although no drilling is proposed on the Beaufort or Chukchi slope, in recent investigations, "pock marks" were discovered on the Chukchi slope (MacDonald et al. 2005). These crater-like features are about 1 km (3,281 ft) in diameter and 40 m (131 ft) deep and are located between the 500-m and 1,000-m (1,640-ft and 3,280-ft) isobath. The abundance and diversity of invertebrates were higher in the pock marks than in the surrounding sediments. Brittle stars, various types of anemones, shrimps, eel pouts, stalked crinoids, benthic ctenophore, gooseneck barnacles, mysids, and holothurians were the most abundant epifauna. Polychaetes, foraminiferans, nemertineans, cnidarians, peanut worms, and clams were the most abundant infauna (MacDonald et al. 2005).

Climate Change Effects on Arctic Marine Benthic Habitats. Continuing trends in climate change are expected to result in chemical, physical, and hydrologic changes in the Alaska Fjordland Shelf and Beaufort/Chukchian Shelf Ecoregion. For example, increased river discharge is expected to alter the salinity, temperature, and turbidity regimes in nearshore benthic habitat (Arctic Council 2005; Hopcroft et al. 2008), potentially resulting in changes in the composition, abundance, and diversity of sessile benthic communities.

The predicted decrease in the extent and duration of sea ice also has implications for benthic habitat. The retreat of the summer sea-ice cover from the coastline during the last few decades (Arctic Council 2005) has created an unusually wide expanse of open water, which has led to the formation of large storm waves that cause shoreline erosion and consequent changes to the intertidal and shallow subtidal benthic habitats. A reduction in the extent of sea-ice cover may also reduce the intensity of benthic scouring. A decrease in the sea-ice cover will adversely affect sea-ice-dependent benthic biota and reduce the seasonally important pulse of sea-ice organic matter to the seafloor. Recent data also suggests that benthic-pelagic coupling could be weakened if the existing temperature increases and reductions in sea ice continue in the Arctic. A reduction in organic matter inputs to the benthos could reduce benthic productivity and shift the system from a benthic-dominated food web to a more pelagic-oriented system dominated by pelagic fishes (Grebmeier et al. 2006). Benthic feeding birds and marine mammals could suffer from the reduced benthic productivity (Grebmeier et al. 2006). Such changes are less likely to affect the Beaufort Sea than the Chukchi Sea, where there is tight benthic-pelagic coupling (Hopcroft et al. 2008). The loss of sea-ice organic-matter deposition may be made up for by higher open water phytoplankton productivity, some of which will settle to the seafloor.

Climate change also has several potential implications for hard-bottom habitat. The reduction in sea-ice cover may reduce the spatial and temporal extent of scouring, and it may also increase wave action, which could result in more frequent disturbance of slow-recovering Boulder Patch habitats. The increase in total suspended solids due to coastal erosion and the greater riverine sediment loading could increase turbidity in the water column and consequently decrease the penetration of photosynthetically active radiation available for kelp production (Hopcroft et al. 2008).

3.7.3 Marine Pelagic Habitats

Marine pelagic habitats exist in the water column rather than the seafloor, and include the water surface. The following sections focus on the water column as habitat for biota. See Section 3.4 for a discussion of water quality in the GOM, Cook Inlet Planning Area, and the Beaufort and Chukchi Sea Planning Areas.

3.7.3.1 Gulf of Mexico

3.7.3.1.1 Water Column. Pelagic habitats in the GOM include unique habitats such as drifting surface *Sargassum* and areas where dynamic ocean circulation processes result in high biological productivity. The Mississippi and Texas Estuarine Areas have high inputs of riverine nutrients, which promote phytoplankton productivity in the surface water; this, in turn, supports a high biomass of vertebrate and invertebrate consumers. Primary production is typically limited by nutrients whose concentrations are greatly reduced in the absence of riverine inputs. Therefore, primary production decreases to the west and east with distance from the Mississippi River, and it decreases from the Mississippi and Texas Estuarine Areas seaward to the neritic ecoregions, where the phytoplankton are dominated by small picophytoplankton, dinoflagellates, and cyanobacteria (Hulbert and Corwin 1972; Wawrik and Paul 2004). Oceanic waters beyond the continental shelf edge are similarly unproductive. Although most oceanic waters are relatively unproductive, there are areas of temporarily high productivity. For example, upwelling zones occur along the edge of the GOM shelf, where deepwater moves up the continental slope, bringing nutrients into the photic zone. The combination of high irradiance and high nutrient levels allows seasonally high primary and secondary production in upwelling zones. The DeSoto and Mississippi Canyons are important upwelling zones in the Central Planning Areas, and the south Texas shelf is an upwelling zone in the Western Planning Area (GMFMC 2004; Walker et al. 2005; Zavala-Hidalgo et al. 2006).

Most pelagic primary consumers are temporary or permanent zooplankton. Temporary zooplankton are larval stages of fish and invertebrates that mature in the marine environment or are transported into estuaries where they will reach their juvenile stage. Permanent zooplankton remain in a planktonic state for their entire life cycle. Zooplankton serve as critical food sources. They also play a key role in recycling nutrients within the water column and in transferring water column primary production to sediment consumers in the form of fecal pellets and carcasses.

Pelagic waters can be classified into zones on the basis of their depth (Bond 1996). Epipelagic habit is defined as the upper 200 m (656 ft) of the water column. Because of the high clarity of the water, light penetrates deeply enough to support limited primary production in water as deep as 200 m (656 ft). Below this euphotic zone, light levels and consequently primary production are limited or nonexistent. Below the epipelagic zone, the water column may be layered into the mesopelagic zone (200 to 1,000 m [656 to 3,281 ft]) and bathypelagic (>1,000 m [>3,281 ft]) zone. To overcome the low availability of food at depth, many mesopelagic fishes and megaplankton spend their days in depths of 200 to 1,000 m (656 to 3,281 ft) but migrate vertically at night into food-rich near-surface waters. Mesopelagic fish and zooplankton are important ecologically because they transfer significant amounts of energy between mesopelagic and epipelagic zones over each daily cycle. For example, the lanternfishes, which are abundant mid-water species in the GOM, are important prey for meso- and epipelagic predators like tuna (Hopkins et al. 1997).

The bathypelagic zone is an aphotic, food-poor habitat. Consequently, predators and scavengers dominate this zone. The base of the food web is relatively degraded particulate falling from the photic zone. This material can aggregate into larger particles called marine snow. Many organisms occupying the bathypelagic zone have evolved adaptations to the harsh physical and chemical conditions; these include a lowered metabolic rate and soft bodies with high water content to reduce the need for food and hypercephelization and large jaws to swallow a greater size range of prey (Miller 2004). Deeper-dwelling (bathypelagic) fishes are composed of strange, little-known species, such as snipe eels (family Nemichthyidae), slickheads (family Alepocephalidae), bigscales (family Melamphaidae), and whalefishes (family Cetomimidae) (McEachran and Fechhelm 1998). Most species are capable of producing and emitting light (bioluminescence) to aid communication in an environment devoid of sunlight.

The ecological effects of the DWH event are still being investigated. However, data collected from recent research cruises indicate that some tentative conclusions can be made about the effect of the spill on marine pelagic habitats. The spill released both oil and methane gas into the water column. Some of it rose to the surface above the well, and some of it was entrained in bottom currents, forming a subsurface plume. Surveys in late June 2010 indicated that there was a subsurface methane plume in 800 to 1,200 m (2,625 to 3,937 ft) of water that extended from the DWH. However, by September 2010, the plume had not been found, despite extensive areal sampling coverage (Kessler et al. 2011). Also in June 2010, an oil plume trending southwest from the well was found at a depth of 1,100 m (3,609 ft); it extended 35 km (22 mi) from the wellhead. The plume was as thick as 200 m (656 ft) and up to 2 km (6,562 ft) in width (Camilli et al. 2010). Dispersants were also found in the subsurface oil plume; their concentrations decreased significantly with time and distance from the well as a result of their dilution with seawater (Kujawinski et al. 2011). However, dispersant was still detectable at low, nontoxic levels up to 300 km (186 mi) away from the wellhead 64 days after the dispersant release ended, suggesting slow natural breakdown (Kujawinski et al. 2011). The DWH event also changed pelagic microbial communities. The amount of menthanotropic and oil-eating bacteria increased greatly after the DWH event (Camilli et al. 2010; Kessler et al. 2011). However, the increase in microbial biomass did not result in significant oxygen depletion, even in deep water. The hydrocarbons appeared to be assimilated by bacteria and transferred up through the zooplankton food web (Graham et al. 2010). These studies suggest the GOM has a tremendous natural capacity to assimilate accidental oil spills.

3.7.3.1.2 Pelagic *Sargassum* Habitat. Floating *Sargassum* mats are present in neritic and oceanic waters (Figure 3.7.3-1). *Sargassum* in the GOM consists of three species of brown algae: *Sargassum natans* (80%) *S. fluitans* (10%), and detached sessile *S. filapendula* (10%) (GMFMC 2004). Satellite maps indicate that *Sargassum* originates in the northwest GOM in the spring and is transported through the Florida Straits into the Atlantic Ocean via the Loop Current and Gulf Stream (Gower and King 2008). Its abundance is highest in the summer and decreases in the fall and winter (Figure 3.7.3-1). *Sargassum* is distributed over the entire GOM in shelf, basin, and slope waters.

As many as 54 fish species are closely associated with floating *Sargassum* at some point in their life cycle, but only two species spend their entire lives there: the *Sargassum* fish (*Histrio histrio*) and the *Sargassum* pipefish (*Syngnathus pelagicus*) (MMS 1999). Hydroids, anthozoans, flatworms, bryozoans, polychaetes, gastropods, nudibranchs, bivalves, cephalopods, pycnogonids, isopods, amphipods, copepods, decapod crustaceans, insects, and tunicates can all be found in the *Sargassum*-associated invertebrate community (GMFMC 2004). Most fish associated with *Sargassum* are temporary residents, such as juvenile stages of species that reside in shelf or coastal waters as adults (MMS 1999). *Sargassum* mats are also recognized as preferred habitat for hatchling sea turtles (Carr and Meylan 1980). These species subsist on the shrimp and crabs that dominate the invertebrate biomass within the *Sargassum* mat. Several large fish species of recreational or commercial importance — including dolphin fish, yellowfin tuna, blackfin tuna, skipjack tuna, Atlantic bonito, little tunny, and wahoo — feed on the small fishes and invertebrates attracted to *Sargassum* (Morgan et al. 1985; MMS 1999).

3.7.3.1.3 Climate Change Effects on GOM Marine Pelagic Habitats. See Water Quality, in Section 3.4.1, for a discussion of the potential effects of climate change on water quality in the GOM.

Climate change may affect water column productivity and ecosystem processes (Table 3.7.3-1). Surface water phytoplankton productivity in nearshore and mid-shelf areas is likely to increase during the spring because of the greater discharge of nutrient-rich river water into the GOM (Rabalais et al. 2010). The composition of the phytoplankton community may also change to reflect the new nutrient, salinity, and temperature regime, although the nature of the changes is unknown. Some have predicted that silica limitation in the face of greater nutrient inputs may reduce the relative abundance of diatoms in favor of nuisance phytoplankton such as dinoflagellates (Turner 2001). If this were to occur, the traditional diatom-zooplankton food web could potentially shift to a microbial-based food web, resulting in a reduction in energy transfer to higher trophic levels. Along with increased primary production in the springtime, the greater freshwater inputs and surface water temperature may promote water column stratification; together, these could promote the development and expansion of the existing GOM Dead Zone (area of hypoxic or anoxic water that develops seasonally in the GOM). In the summer, the productivity of surface water phytoplankton may decrease because higher water temperatures may promote greater thermal stratification and reduce the transfer of nutrients to the upper water column. However, the expected increase in the frequency and severity of tropical storms may promote water column turnover and reduce the duration of hypoxic conditions (Rabalais et al. 2010).

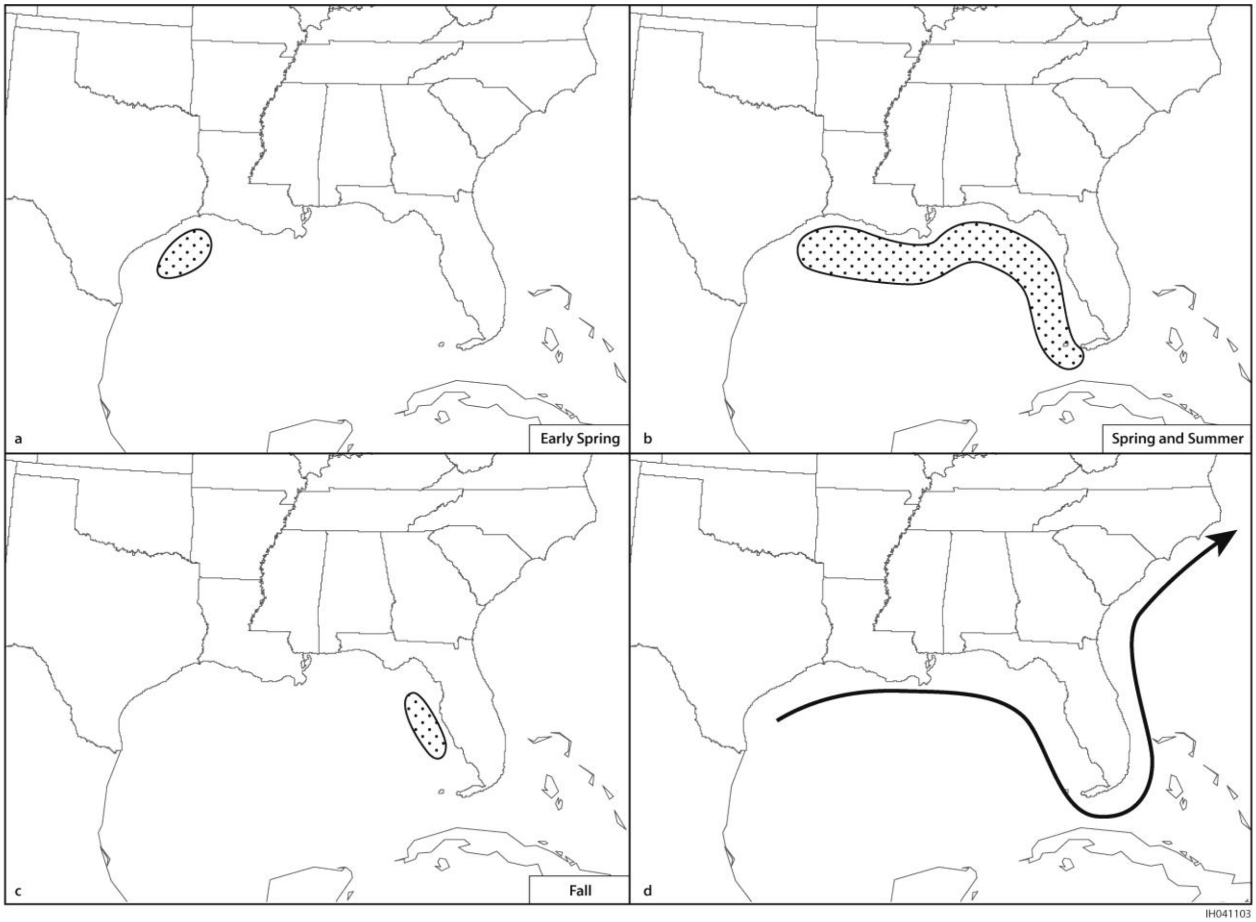

FIGURE 3.7.3-1 Areas of High Abundance of *Sargassum* in the GOM in (a) Early Spring, (b) Spring and Summer, and (c) Fall. General Trajectory of *Sargassum* Movement Is Shown in (d). Map based on satellite data collected by Gower and King (2008)

The impact of increased atmospheric CO_2 on pelagic productivity is complicated and difficult to predict. Increased CO_2 could increase primary productivity by increasing the carbon available for photosynthesis. However, greater CO_2 has also resulted in the formation of carbonic acid at the expense of carbonates in seawater. Aside from affecting pelagic invertebrates (Section 3.8.5.1), ocean acidification could also negatively affect calcifying phytoplankton species such as the coccolithophores (Royal Society 2005), which are often a dominant primary producer found in low-nutrient waters over the outer continental shelf and slope. However, other research suggests coccolithophore productivity will increase with greater CO_2 concentrations (Royal Society 2005).

3.7.3.2 Alaska – Cook Inlet

See Section 3.4.2 for a discussion of water quality in Cook Inlet. Cook Inlet pelagic waters are influenced by riverine and marine inputs, resulting in salinity gradients and horizontal mixing near the inlet. In general, extensive areas of pack ice do not form in Cook Inlet because

TABLE 3.7.3-1 Summary of Potential Changes in the Marine and Pelagic Habitats of the Northern GOM Marine Ecoregion That Could Result from Climate Change

Climate Change Impact Factor	Soft Sediment	Coral	Hard Bottom	Deepwater Coral	Chemosynthetic Communities	Pelagic Habitat
Sea level rise		Decrease in light availability				
Temperature increase	Changes in biogeochemical processes; changes in food inputs to the seafloor	Increase in coral bleaching	Changes in food inputs to the seafloor	Changes in food inputs to the seafloor		Greater water column stratification; changes in water column productivity
Ocean acidification		Decrease in growth and distribution	Decrease in coral growth	Decrease in growth and distribution	Decrease in growth of chemosynthetic mussels and clams	Changes in phytoplankton composition
Increased storm frequency	Increase in benthic disturbance	Physical damage to corals	Physical damage and scouring			Greater mixing of water column
Increased river discharge	Physiological stress on sessile organisms; changes in biogeochemical processes	Increased nutrients and turbidity may reduce light penetration	Physiological stress on sessile organisms	Could affect habitat in GOM canyons	Could affect habitat in GOM canyons	Greater water column stratification and variation in water chemistry; changes in water column productivity

of the large tidal range and strong tidal currents. However, seasonal ice is observed during the winter (MMS 2003a). The Shelikof Strait is relatively ice free even in winter (MMS 2003a). Pelagic habitat in Cook Inlet is highly productive, with phytoplankton biomass peaking in the spring. The spring phytoplankton bloom begins as the water column stratifies and light levels increase. However, productivity remains high in summer because of the resuspension of nutrient-rich bottom sediments due to tidal flux and strong winds. There is spatial variation in productivity as well, with the west side of Cook Inlet having lower primary and secondary production due to greater sediment loading. Diatoms and microflagellates, many of them advected from the Gulf of Alaska, dominate the phytoplankton assemblage.

In Shelikof Strait, studies indicate that the densities of zooplankton and pollack eggs are higher than in the adjacent continental shelf, and interannual variation in both appears to be controlled primarily by physical factors such as currents, salinity, and temperature, which in turn influence biologically important variables such as phytoplankton production (Kendall et al. 1996; Napp et al. 1996; Incze et al. 1997; Speckman et al. 2005; Bacheler et al. 2009). Zooplankton are dominated by copepods of estuarine, continental shelf, and marine origin (Incze et al. 1997; Speckman et al. 2005).

The fate of phytoplankton depends on the timing of the spring phytoplankton bloom. Zooplankton biomass in Cook Inlet tracks seasonal peaks in phytoplankton. Zooplankton can consume a high proportion of phytoplankton biomass in years with a prolonged lower density bloom (Eslinger et al. 2001). However, in years with a short high-density bloom, zooplankton consumption cannot keep up with phytoplankton production and much of the phytoplankton is exported to the seafloor.

Climate Change Effects on Cook Inlet Planning Area Pelagic Habitat. See Section 3.4.2 for a discussion of climate change and water resources in Cook Inlet. The effects of climate change on pelagic habitat in Cook Inlet are difficult to predict with certainty because of the complexity of the system. However, current and predicted trends suggest climate change will significantly alter the chemical, physical, and hydrologic properties of pelagic habitat, which will in turn alter biological communities. For example, the predicted increase in river discharge could change the salinity, temperature, and turbidity regimes in nearshore areas and alter the composition of existing phytoplankton communities. The rise in ocean temperature may also increase yearly phytoplankton productivity and alter the timing and duration of phytoplankton blooms.

Ocean acidification from increasing CO_2 inputs into the ocean is also predicted to continue in Alaskan waters and may reduce the availability of calcite and aragonite to calcifying marine organisms. In the Gulf of Alaska, carbonate undersaturated water from the outer shelf and slope periodically moves inshore, potentially reducing the abundance of calcifying invertebrate prey for commercially important species such as salmon and pollock (Fabry et al. 2009).

3.7.3.3 Alaska – Arctic

Water depths in the Beaufort and Chukchi Sea Planning Areas range up to 3,800 m (12,467 ft). Section 3.4.3 has a detailed description of the physical and chemical characteristics of the water column. In both planning areas, oil and gas exploration and production activities would generally occur in the inner shelf in water depths up to 200 m (656 ft).

The Beaufort Sea and Chukchi Sea are characterized by distinct hydrographic and productivity regimes. Both systems undergo extended seasonal periods of frigid and harsh environmental conditions, reduced light, seasonal darkness, prolonged low temperatures, and ice cover. The lack of sunlight and extensive ice cover in arctic latitudes during winter months greatly reduces primary and secondary productivity (Craig 1989).

Pelagic habitat in the Beaufort/Chukchi Marine Ecoregion consists of ice-free open water and high-productivity areas of open water surrounded by sea ice (polynyas). Productivity in the water column is primarily controlled by temperature, nutrients, light, and the amount of sea ice in a given year. Phytoplankton productivity is highest in the summer when temperatures are highest (Hopcroft et al. 2008) and when nutrient and solar irradiance are most conducive to productivity. Phytoplankton productivity gradually decreases from the southwestern Chukchi Sea to the east to the Beaufort Sea (especially east of Point Barrow) and from inshore to offshore areas, although there are isolated mid-shelf upwelling regions where productivity is higher than it is in the surrounding water. The east-to-west trend is thought to be caused by the import of nutrients, phytoplankton, and organic matter-rich water into the Chukchi Sea from the adjacent Bering Sea (Dunton et al. 2005) as well as the cold nutrient-poor water flowing into the Beaufort Sea from the Atlantic. Sea ice is also a primary influence on primary productivity, and nutrients from upwelling off the Barrow and Herald Canyons can also be delivered to the continental shelf (Pickart et al. 2009). Phytoplankton productivity is highest in warmer years with less sea ice because of the higher areal extent of surface water solar irradiance and the longer growing season (Wang et al. 2005).

There are multiple fates for water column productivity, and they depend highly on the timing of phytoplankton and zooplankton activity. In the early spring when waters are still cold, zooplankton (primarily protozoans and copepods) are not as active, and much of the productivity may be exported to the seafloor, where it is a critical subsidy for the benthic food web. In late spring and summer, however, during periods of active zooplankton growth, much of the productivity may be consumed in the water column (Hopcroft et al. 2008). In general, the Chukchi exhibits strong benthic-pelagic coupling, with high flux of phytoplankton and organic matter from open water areas (including polynyas) to the sediment. The production may also be advected to deep waters of the Canada Basin (Cooper et al. 2002; Bates et al. 2005).

Pelagic habitats of the Arctic contain classes of organisms similar to those found in subarctic and temperate waters, such as protozoan microzooplankton, copepods, euphausiids, shrimp, larvaceans, cnidarians, ctenophores, pteropods, and squid. The pelagic fish assemblage is dominated by arctic cod, whitefish (*Coregonus*), capelin (*Mallotus villosus*), and herring. All of these resources are important forage for marine mammals and birds. See Sections 3.8.4.3 and 3.8.5.3 for a discussion of arctic fish and invertebrates.

3.7.3.3.1 Sea Ice. Sea ice is an important habitat in the northern Beaufort and Chukchi Seas; it exists for variable periods in the colder months of the year near the coastline and perennially closer to the shelf edge and basin. Sea ice is more extensive and lasts longer in the Beaufort Sea than the Chukchi Sea. Algae growing on the underside of sea ice can be the primary source of productivity in northern areas of the shelf with permanent ice cover, and sea ice algal productivity and biomass can exceed the productivity of the water column during the spring (Gradinger 2009). One primary control over the growth of sea ice algae is the availability of light under the ice, which is a function of snow cover, ice thickness, and sediment loading; all of which are negatively related to productivity. In addition to the diatoms that dominate the algal assemblage, sea-ice communities contain a diverse mixture of bacteria, protozoans, and a rich meiofaunal and macroinvertebrate community dominated by amphipods, copepods, and nematodes. These organisms are, in turn, fed upon by higher trophic-level consumers, such as arctic cod, seals, and birds. In addition, sea ice provides shelter and resting habitat for marine mammals and birds. Sea ice also supports the early life stages of fish (especially arctic cod) and benthic invertebrates by providing temporary habitat (particularly nearshore sea ice) or by exporting seasonal pulses of organic matter to the seafloor (Gradinger and Bluhm 2005; Bluhm and Gradinger 2008). In addition, by trapping and transporting nutrients, sea ice can increase the spatial extent of nutrient availability to phytoplankton. Sea ice is responsible for strong ice-edge phytoplantkon blooms, which occur as melting sea ice releases organic matter and fresh water, creating a stratified upper water column high in nutrients (Hopcroft et al. 2008).

3.7.3.3.2 Climate Change. See Section 3.4.3 for a discussion of climate change and water resources in the Beaufort and Chukchi Seas. The effects of climate change on pelagic habitat in the Beaufort/Chukchi shelf are difficult to predict with certainty because of the complexity of the system. However, current trends suggest climate change will significantly alter the chemical, physical, and hydrologic properties of pelagic habitat, which will, in turn, affect biological communities. For example, increased river discharge is expected to alter the salinity, temperature, and turbidity regimes in nearshore areas (Hopcroft et al. 2008), which could change the distribution, abundance, and composition of existing phytoplankton and zooplankton communities (Section 3.8.5.3). Several rivers flow into the Beaufort shelf and this region may be more heavily affected than the western Chukchi shelf. The effects of increased river discharge on phytoplankton are difficult to predict because, although rivers deliver nutrients to coastal regions, the increase in sediment load could also reduce the availability of light.

Climate change in the Arctic is affecting the arctic sea ice cover, which has retreated unusually far from the coastline during the last few decades (Arctic Council 2005). Climate change is expected to decrease the spatial extent and temporal duration of sea ice as well as make the ice thinner. Recent studies suggest the amount of ice formed in the winter is not sufficient to replace the amount of ice lost in the summer; consequently there has been a decrease in the ratio of thicker, multi-year ice to thinner, first-year sea ice (Kwok et al. 2009). Although thinner ice and less snow cover may promote the primary productivity beneath sea ice, increased river discharge (i.e., Mackenzie River) may trap more sediment within ice and reduce the availability of light (Gradinger and Bluhm 2005). In addition, a reduction in landfast ice will increase the sloughing of sediments from shoreline during storms, adding to the sediment loads and changing water chemistry in nearshore areas. In the winter, before the spring phytoplankton bloom, sea ice algae are the primary food source supporting pelagic biota (Lee et al. 2008). The loss of sea ice may therefore reduce seasonal food availability to sea ice dependent species. Overall biological productivity in the open water is expected to increase with increasing temperature and ice retreat (Arctic Council 2005; Hopcroft et al. 2008). With the increase in phytoplankton productivity, the biomass of zooplankton may also increase; the result could be a shift to a pelagic-based rather than a benthic-based food web as the flux of organic matter to the sediment is reduced due to increased phytoplankton grazing in the water column (Hopcroft et al. 2008). Similarly, recent data suggests that the strong benthic-pelagic coupling in the Chukchi Sea could be weakened if the existing temperature increases and reductions in sea-ice continue (Grebmeier et al. 2006). This could reduce benthic productivity and shift the system from a benthic-dominated food web to a more pelagic-oriented system dominated by pelagic fishes (Grebmeier et al. 2006).

Ocean acidification from increasing CO_2 inputs into the ocean is also predicted to continue in arctic waters, which may reduce the availability of calcite and aragonite to calcifying marine organisms. Surface waters in the Arctic are currently supersaturated with aragonite (another form of carbonate), but it is predicted that they will be undersaturated by the century's end or earlier (reviewed in Fabry et al. 2009). Aside from affecting pelagic invertebrates, ocean acidification could also adversely affect calcifying phytoplankton species, such as the coccolithophores, which are often a dominant primary producer in low-nutrient waters over the outer continental shelf and slope. However, other research suggests that despite the potential adverse effects of reduced pH oncoccolithophore plate formation, their productivity could increase due to greater CO_2 concentrations which are used in photosynthesis. Clearly more research is needed as very few species have been tested, and many of these studies are laboratory based and may not be relevant to the far more complex oceanic environment (see Royal Society [2005] and Doney et al. [2009] for recent reviews).

3.7.4 Essential Fish Habitat

The National Marine Fisheries Service (NMFS) manages commercial and recreational fisheries within Federal waters under the Magnuson-Stevens Fishery Conservation and Management Act (FCMA) (16 USC 1801-1883). The 1996 amendments to this Act require regional fishery management councils (FMCs), with assistance from NMFS, to delineate essential fish habitat (EFH) in Fishery Management Plans (FMPs) or FMP amendments for all federally managed fisheries. EFH is defined as the water and substrate necessary for fish spawning, breeding, feeding, and growth to maturity (50 CFR Part 600). FMPs for fishery resources are submitted to the NMFS for approval and implementation. The FCMA mandates that any FMP shall: (1) describe and identify EFH for the fishery, (2) minimize to the extent practicable adverse effects on such habitat caused by fishing, and (3) identify other actions to encourage the conservation and enhancement of such habitat. The FCMA also requires Federal agencies to consult on activities that may adversely affect EFHs designated in the FMPs. Oil and gas development activities may have direct and indirect effects on an EFH that could be site-specific or habitat-wide.

In addition to designating EFH, the NMFS requires FMCs to identify habitat areas of particular concern (HAPCs) within FMPs (Figure 3.7.2.1.2-1). These HAPCs are discrete subsets of EFHs that the Councils may designate based on: (1) the importance of the ecological function provided by the habitat; (2) the extent to which the habitat is sensitive to human-induced environmental degradation; (3) whether, and to what extent, development activities are, or will be, stressing the habitat type; or (4) the rarity of the habitat type (GMFMC 2004). While the HAPC designation does not confer additional protection for or restrictions on an area, it can help prioritize conservation efforts.

3.7.4.1 Gulf of Mexico

Various State and Federal agencies are involved in the management of fish resources in the GOM. The GOM Fishery Management Council (GMFMC), which typically prepares FMPs for the GOM, has identified marine and estuarine EFHs within its management area for a variety of fish and invertebrates. These species are listed in Tables 3.7.4-1 and 3.7.4-2 (NMFS 2010a). See Section 3.8.4.1 for a general discussion of fish in the GOM, as well as the potential changes to fish communities resulting from climate change.

Estuarine and coastal EFH includes the following habitats: submerged aquatic vegetation, emergent intertidal wetlands (marshes and mangroves), soft-bottom (mud, sand, or clay), live hard-bottom, oyster reefs, and estuarine water column. See Section 3.7.1.1 for a description of these coastal habitats. Coral reefs, marine water column, marine sediment, live-/hard-bottom, the continental slope, chemosynthetic cold seeps, *Sargassum*, and man-made structures are representative offshore and marine EFH. See Section 3.7.2.1 and Section 3.7.3.1 for descriptions of marine benthic and pelagic habitats in the GOM as well as the potential changes to these habitats resulting from climate change.

Within the Central and Western GOM Planning Areas, several individual reefs and banks located offshore of the Louisiana–Texas border have been designated HAPCs by the GMFMC (NMFS 2010a; Table 3.7.4-3; Figure 3.7.2-1). The HAPCs in the Eastern Planning Area that could be affected by oil spills from the Central or Western Planning Areas include the Florida Middle Grounds, the Madison-Swanson Marine Reserve, Pulley Ridge, and Tortugas North and South Ecological Reserve. Most of these HAPCs are important with respect to corals and coral reefs, and provide habitats for reef species such as snappers, groupers, and spiny lobster.

Effects of DWH Event on EFH and Managed Species. The DWH event has the potential to affect coastal and offshore EFH and managed species. Oil released as a result of the DWH event affected more than 1,046 km (650 mi) of the GOM coastal EFH, from the Mississippi River delta to the Florida panhandle (OSAT-2 2011; National Commission 2011). More than 209 km (130 mi) of coastal habitat were moderately to heavily oiled, primarily in Louisiana (National Commission 2011). EFH affected by oiling included beaches, coastal marshes, mudflats, mangroves, seagrass beds, and submerged aquatic vegetation (Section 3.7.1.1.5). These habitats also were also affected by prevention and cleanup efforts (NOAA 2010). Although much of the oil remaining after cleanup is highly weathered, several constituents have the potential to cause toxicological effects (OSAT-2 2011). Loss of marsh

TABLE 3.7.4-1 Species for Which Essential Fish Habitat Has Been Designated in the GOM Region by the GOM Fisheries Management Council

Reef Fish Fishery

Snappers – Family Lutjanidae
Blackfin snapper (*Lutjanus buccanella*)
Cubera snapper (*Lutjanus cyanopterus*)
Dog snapper (*Lutjanus jocu*)
Gray snapper (*Lutjanus griseus*)
Lane snapper (*Lutjanus synagris*)
Mahogany snapper (*Lutjanus mahogoni*)
Mutton snapper (*Lutjanus analis*)
Schoolmaster (*Lutjanus apodus*)
Queen snapper (*Etelis oculatus*)
Red snapper (*Lutjanus campechanus*)
Silk snapper (*Lutjanus vivanus*)
Vermillion snapper (*Rhomboplites aurorubens*)
Yellowtail snapper (*Ocyurus chrysurus*)
Wenchman (*Pristipomoides aquilonaris*)

Groupers – Family Serranidae
Black grouper (*Mycteroperca bonaci*)
Gag (*Mycteroperca microlepis*)
Misty grouper (*Epinephelus mystacinus*)
Nassau grouper (*Epinephelus striatus*)
Red grouper (*Epinephelus morio*)
Red hind (*Epinephelus guttatus*)
Rock hind (*Epinephelus adscensionis*)
Scamp (*Mycteroperca phenax*)
Speckled hind (*Epinephelus drummondhayi*)
Snowy grouper (*Epinephelus niveatus*)
Yellowedge grouper (*Epinephelus favolimbatus*)
Yellowfin grouper (*Mycteroperca enenosa*)
Yellowmouth grouper (*Mycteroperca interstitialis*)

Jacks – Family Carangidae
Greater amberjack (*Seriola dumerili*)
Lesser amberjack (*Seriola fasciata*)
Almaco jack (*Seriola rivoliana*)
Banded rudderfish (*Seriola zonata*)

Triggerfishes – Family Balistidae
Gray triggerfish (*Balistes capriscus*)

Reef Fish Fishery (Cont.)

Tilefishes – Family Malacanthidae
Goldface tilefish (*Caulolatilus crysops*)
Blackline tilefish (*Caulolatilus cyanops*)
Blueline tilefish (*Caulolatilus microps*)
Anchor tilefish (*Caulolatilus intermedius*)
Tilefish (*Lopholatilus chamaeleonticeps*)

Wrasses – Family Labridae
Hogfish (*Lachnolaimus maximus*)

Sand Perches – Family Serranidae
Dwarf sand perch (*Diplectrum bivittatum*)
Sand perch (*Diplectrum formosum*)

Red Drum Fishery
Red drum (*Sciaenops ocellatus*)

Coastal Migratory Pelagic Fishes
Bluefish (*Pomatomus saltatrix*)
Cero (*Scomberomorus regalis*)
Cobia (*Rachycentron canadum*)
Dolphin (*Coryphaena hippurus*)
King mackerel (*Scomberomorus cavalla*)
Little tunny (*Euthynnus alletteratus*)
Spanish mackerel (*Scomberomorus maculatus*)

Corals
Class Hydrozoa (stinging and hydrocorals)
Class Anthozoa (sea fans, whips, precious coral, sea pen, stony corals)

Invertebrate Fishery
Brown shrimp (*Penaeus aztecus*)
Pink shrimp (*Penaeus duorarum*)
Royal red shrimp (*Hymenopenaeus robustus*)
Spiny lobsters (*Panulirus* spp.)
Slipper lobsters (*Scyllarides* spp.)
Stone crab (*Menippe* spp.)
White shrimp (*Penaeus setiferus*)

Source: NMFS 2010a.

TABLE 3.7.4-2 Highly Migratory Species Designated in the GOM Region under Federally Implemented Fishery Management Plans

Coastal Sharks
- Atlantic angel shark (*Squatina dumerili*)
- Atlantic sharpnose (*Rhizoprionodon terraenovae*)
- Basking shark (*Cetorhinus maximus*)
- Bigeye sand tiger (*Odontaspis noronhai*)
- Blacknose shark (*Carcharhinus acronotus*)
- Bignose shark (*Carcharhinus altimus*)
- Blacktip shark (*Carcharhinus limbatus*)
- Bonnethead (*Sphyrna tiburo*)
- Bull shark (*Carcharhinus leucas*)
- Caribbean sharpnose shark (*Rhizoprionodon porosus*)
- Caribbean reef shark (*Carcharhinus perezi*)
- Dusky shark (*Carcharhinus obscurus*)
- Finetooth shark (*Carcharhinus isodon*)
- Galapagos shark (*Carcharhinus galapagensis*)
- Great hammerhead (*Sphyrna mokarran*)
- Lemon shark (*Negaprion brevirostris*)
- Narrowtooth shark (*Carcharhinus Brachyurus*)
- Night shark (*Carcharhinus signatus*)
- Nurse shark (*Ginglymostoma cirratum*)
- Sandbar shark (*Carcharhinus plumbeus*)
- Scalloped hammerhead (*Sphyrna lewini*)
- Silky shark (*Carcharhinus falciformis*)
- Smooth hammerhead (*Sphyrna zygaena*)
- Spinner shark (*Carcharhinus brevipinna*)
- Tiger shark (*Galeocerdo cuvieri*)
- White shark (*Carcharodon carcharias*)
- Sand tiger shark (*Carcharias taurus*)
- Whale shark (*Rhinocodon typus*)

Pelagic Sharks
- Bigeye sixgill shark (*Hexanchus vitulus*)
- Bigeye thresher shark (*Alopias superciliosus*)
- Blue shark (*Prionace glauca*)
- Common thresher shark (*Alopias vulpinus*)
- Longfin mako shark (*Isurus paucus*)
- Porbeagle shark (*Lamna nasus*)
- Sevengill shark (*Heptranchias perlo*)
- Sixgill shark (*Heptranchias griseus*)
- Shortfin mako shark (*Isurus oxyrinchus*)
- Oceanic whitetip shark (*Carcharhinus longimanu*)

Tuna
- Albacore (*Thunnus alalunga*)
- Atlantic bigeye (*Thunnus obesus*)
- Atlantic bluefin (*Thunnus thynnus*)
- Atlantic yellowfin (*Thunnus albacares*)
- Skipjack (*Katsuwonus pelamis*)

Swordfish
- Swordfish (*Xiphias gladius*)

Billfish
- Blue marlin (*Makaira nigricans*)
- Sailfish (*Istiophorus platypterus*)
- White marlin (*Tetrapturus albidus*)
- Longbill spearfish (*Tetrapturus pfluegeri*)

Source: NMFS 2010a.

habitat along its edge as a result of oiling was observed. A full understanding of the effects of the spill is expected to take a considerable period of time, likely years.

The DWH event affected offshore marine EFH as well. There is little information on the effects of the DWH event on offshore seafloor EFH. Some researchers have reported seeing what appear to be thick deposits of oil or flocculants of oil and organic matter on the seafloor (BOEMRE 2010b). In heavily oiled areas, the recovery time is unknown, but sediments in deeper waters may take longer to recover because of colder temperatures. Overall, natural processes should break down the oil, and it is likely that no permanent changes in seafloor EFH affected by the DWH event would occur. There is some evidence that the DWH event affected habitat-forming deepwater corals (http://www.boemre.gov/ooc/press/2010/press1104a.htm; Section 3.7.2.1.7). It is not known how many deepwater coral communities were affected or whether the affected corals will recover. The DWH event occurred several hundred kilometers

TABLE 3.7.4-3 The HAPCs Designated within the Central, Western, and Eastern GOM Planning Areas

Central and Western Planning Areas	
East Flower Garden Banks	Geyer Bank
West Flower Garden Banks	McGrail Bank
Stetson Bank	Jakkula Bank
29 Fathom Bank	Bouma Bank
MacNeil Bank	Sonnier Bank
Rezak Sidner Bank	Alderdice Bank
Rankin Bright Bank	
Eastern Planning Area	
Florida Middle Grounds	Madison-Swanson Marine Reserve
Tortugas North and South Ecological Reserves	Pulley Ridge

Source: NMFS 2010a.

from hard-bottom topographic features considered HAPC. There were no reports of oil from the spill reaching the FGBNMS (http://flowergarden.noaa.gov/education/oilspill.html). The FGBNMS is monitored as part of a regular program, and any changes related to the spill should be detected.

The DWH event released oil and methane gas into marine water column EFH, forming both a surface slick and a subsurface plume containing oil mixed with dispersants (Section 3.7.3.1.1; Camilli et al. 2010; Kessler et al. 2011; Kujawinski et al. 2011). The methane plume appeared to be relatively short-lived (Kessler et al. 2011), but dispersant was still detectable at low, nontoxic levels up to 300 km (186 mi) away from the wellhead 64 days after the dispersant release ended (Kujawinski et al. 2011).

There are few studies of the impacts of the DWH event on fish communities in the GOM. The spill has the potential to cause population level impacts on fish species, particularly species that have already depressed populations or early life stages that rely heavily on marine and coastal habitats affected by the spill. The few initial studies suggest that, despite occurring during the spawning period for many GOM fishes, the DWH event did not have an immediate negative impact on fish populations (including juvenile age classes, although there remains the potential for long-term population impacts from sublethal and chronic exposure (Fodrie and Heck 2011). Landings of shrimp also do not suggest any reduction in shrimp populations (http://gomos.msstate.edu/gomosshrimplandingimpactGOM.html). However, managed species such as tuna and billfish that have important spawning habitat in the GOM and are currently in decline have not been investigated. Several years may be required to fully assess the impacts of the DWH event on fish populations, given the time lag between the spill and the eventual recruitment of immature year classes that may have been affected by the spill.

3.7.4.2 Alaska – Cook Inlet

See Section 3.8.4.2 for a general description of fish communities, their life history, and their ecological role in the Cook Inlet Planning Area as well as the potential changes to fish communities resulting from climate change. This section discusses managed species and EFH within Cook Inlet. Cook Inlet falls within the Gulf of Alaska (GOA) Fisheries Management Area of the North Pacific Fisheries Management Council (NPFMC). As required under the FCMA, EFH is described for federally managed species in each FMP. The FMPs and the EFHs that occur in waters of Cook Inlet are described below. Regulatory measures to mitigate the effects of fishing on EFH include permanent and temporary closures for certain times or areas; restrictions on vessel sizes and trip limits; restrictions or limitations on gear types; restrictions on the spacing of nets; restrictions on the catch size and number; fishing practices that minimize bottom contact; limitations on boat sizes and speeds; bycatch limits; and license limitations (NPFMC 2002). Supporting EFH documents can be found in NMFS (2005) and at http://www.fakr.noaa.gov/npfmc/fmp/fmp.htm. Additional information concerning the biology, ecology, and behavior of fish species of Cook Inlet can be found in Section 3.8.4.2. The NMFS Alaska Fisheries Science Center also regularly publishes Stock Assessment and Fishery Evaluation Reports that describe stocks and other germane population information for valued fish resources (see http://www.afsc.noaa.gov).

FMPs applicable to Cook Inlet include the GOA Groundfish FMP, the Scallop FMP, and the Salmon FMP. The GOA Groundfish FMP (NPFMC 2010) applies to the U.S. EEZ waters south and east of the Aleutian Islands at longitude 170° W and Dixon Entrance at longitude 132°40' W and includes the western, central, and eastern regulatory areas. The Groundfish FMP covers all stocks of finfish except salmon (*Oncorhynchus* spp.), steelhead (*Oncorhynchus mykiss*), Pacific halibut (*Hippoglossus stenolepis*), Pacific herring, and tuna (*Scombridae*). Tuna are not found in Alaskan waters except during El Nino years. Species groups managed under the GOA Groundfish FMP are listed in Table 3.7.4-4. EFH has not been designated for all life stages of managed species. For example, there is insufficient information to specify EFH for early juvenile stages of all managed species. In addition, no EFH has been designated for any life stage of the following species: sharks, octopus, and forage fish. For species and life stages for which EFH has been designated, EFHs includes, taken together, the entire sediment and water column from lower Cook Inlet to the Gulf of Alaska Shelf (NPFMC 2010). The most diverse species group, the rockfish, is represented by 30 species (NMFS 2005). These fish use one or more aquatic habitats during different stages of their life cycles; the habitats include estuarine; bays; kelp forests; reefs; and nearshore, coastal, continental shelf, oceanic, and bathypelagic waters and/or substrates. Information on species-specific EFHs can be found in NPFMC (2010). The Alaska Seamount Habitat Protection Areas and Gulf of Alaska Coral Protection Areas are designated as HAPCs. No HAPC is designated within Cook Inlet. See individual sections on water quality, coastal habitat, and marine benthic and pelagic habitats in the Cook Inlet Planning Area for a description of these habitat types as well as potential changes to these habitats resulting from climate change.

The scallop FMP covers all Federal waters off the GOA. The fishery occurs in the GOA from the panhandle out to the Aleutian Islands and the Bering Sea. Portions of upper and lower Cook Inlet are closed to scallop fishing to reduce crab bycatch and protect crab habitat from

TABLE 3.7.4-4 Managed Species Designated under the Gulf of Alaska Groundfish Fisheries Management Plan and Life Stages for which EFH Has Been Designated

Management Group	Life Stage[a]	Management Group	Life Stage
Walleye pollock (*Theragra chalcogramma*)	E, L, LJ, A	Sculpins (various species)	LJ, A
Pacific cod (*Gadus macrocephalus*)	E, L, LJ, A	Atka mackerel (*Pleurogrammus monopterygius*)	L, A
Sole (*Pleuronectidae* spp., including dover, yellowfin, Alaska paice, rex, and flathead)	E, L, LJ, A	Squid	LJ, A
Rock sole (*Lepidopsetta polyxystra*)	L, LJ, A	Skates	A
Arrowtooth flounder (*Atheresthes stomias*)	L, LJ, A	Sharks	I
Sablefish (*Anoplopoma fimbria*)	E, L, LJ, A	Octopus	I
Pacific Ocean perch (*Sebastes alutus*)	L, LJ, A	Forage fish (eulachon, capelin, sand lance, myctophids and bathylagids, sand fish, euphausiids, and pholids and stichaeids).	I
Rockfish (*Sebastes* spp., including shortraker, rougheye, northern, dusky, yelloweye, and thornyhead)	Varies by species		

[a] E = egg; L = larvae; LJ = late juvenile; A = adults; I = insufficient information.

dredging damage (NPFMC 2004). Closed areas are specified in regulations. Under existing State regulations, most areas closed to scallop dredging are also closed to bottom trawling. Scallops are found from intertidal waters to a depth of 300 m (984 ft). Their abundance tends to be greatest between 45 and 130 m (148 and 426 ft) on beds of mud, clay, sand, and gravel (Hennick 1973). Traditional knowledge and sampling data indicate that scallop distributions may contract and expand as the result of a variety of factors, including, but not limited to, temperature changes, current patterns, changes in population size, and changes in predator and prey distribution (NMFS 1998). EFH has been defined only for the late juvenile and adult life stages of weathervane scallops (*Patinopecten caurinus*; NPFMC 2004). The EFH for weathervane scallops was identified on the basis of historical information on their range and includes the lower Cook Inlet (NPFMC 2004). Weathervane scallops occur in discrete beds in areas 60 to 140 m (197 to 459 ft) deep over predominantly clayey silt and sandy bottoms, but they are also found in areas with gravelly sand and silty sand. No HAPC has been designated within Cook Inlet for scallops.

Salmon fisheries are managed by the State of Alaska rather than the NPFMC. Even though the Council and NMFS are removed from routine management of salmon fisheries in the EEZ, the FMP asserts general NMFS and Council participation in and oversight of salmon management in the EEZ, and it asserts their express and specific authority in the State in the southeast commercial troll fishery and the EEZ sport fishery. At present, Council staff is comprehensively reviewing the Salmon FMP and may repeal or modify the current plan.

The Salmon FMP applies to the EEZ off the coast of Alaska and the salmon fisheries that occur there (NMFS 2005). Most fishing occurs in coastal waters or inlets, bays, and rivers where salmon are migrating, but fishing also occurs in offshore waters. The EFH has also been defined for the six salmon life stages: eggs and larvae, juveniles in freshwater, juveniles in estuaries, juveniles before their first winter in the marine environment, immature and maturing adults in the marine environment, and adults in fresh water. EFH for Pacific salmon includes waters and substrate necessary for spawning, breeding, feeding, or growth to maturity. The locations of many bodies of fresh water that are used by salmon (including several within Cook Inlet and associated tributaries and lakes) are described in documents organized and maintained by the Alaska Department of Fish and Game (ADF&G) in the *Catalogue of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes* (http://www.adfg.alaska.gov/sf/SARR/AWC). Additional information on the biology, ecology, and EFH of Pacific salmon can be found at http://www.fakr.noaa.gov/habitat/efh/review/appx5.pdf.

Some fisheries that occur in Cook Inlet and the GOA are managed by authorities other than the NPFMC. Pacific halibut is managed by the International Halibut Comimission, and there are a variety of State-managed fisheries for groundfishes, shellfish, salmon, and Pacific herring. The ADF&G regularly publishes stock assessment information on State-managed fishes.

3.7.4.3 Alaska – Arctic

See Section 3.8.4.3 for a general description of fish communities, their life histories, and their ecological role in the Beaufort and Chukchi Sea Planning Areas as well as potential changes in Arctic fish communities resulting from climate change. This section discusses managed species and EFH within the Beaufort and Chukchi Sea Planning Areas. There are two fishery management plans that apply to the Chukchi and Beaufort Planning Areas: the FMP for the Arctic Management Area (Arctic FMP; NPFMC 2009) and the FMP for the salmon fisheries in the EEZ off the coast of Alaska (NPFMC and NMFS 1990). The Arctic FMP applies to all marine waters in the U.S. EEZ of the Chukchi and Beaufort Seas from 5.6 km (3.5 mi) (3 NM) offshore the coast of Alaska or its baseline to 370 km (230 mi) (200 NM) offshore, north of the Bering Strait (from Cape Prince of Wales to Cape Dezhneva), westward to the 1990 U.S./Russia maritime boundary line, and eastward to the U.S./Canada maritime boundary (NPFMC 2009). Complete FMPs can be found at http://www.fakr.noaa.gov/npfmc/fmp/fmp.htm.

The Arctic FMP governs all stocks of marine living resources, except for Pacific salmon and Pacific halibut, which are managed under the salmon FMP and the International Pacific Halibut Commission, respectively (NPFMC and NMFS 1990). The Arctic Management Area is closed to commercial fishing until such time in the future that sufficient information is available with which to initiate a planning process for commercial fishery development (NPFMC 2009). Although species managed under separate FMPs, such as salmon, groundfish, halibut, crabs, and scallops, are present in arctic waters, their commercial harvest is not permitted in the Beaufort and Chukchi Sea Planning Areas (NPFMC 2009).

Under the Arctic FMP, EFH has been designated for three species (NPFMC 2009):

- *Arctic cod (Arctogadus glacialis*). Insufficient information is available to determine EFH for eggs, larvae, and early juveniles. For late juvenile and adults, EFH includes pelagic and epipelagic arctic waters from 0 to 200 m (0 to 656 ft) and upper slope waters from 200 to 500 m (656 to 1,640 ft).

- *Saffron cod (Eleginus gracilis*). Insufficient information is available to determine EFH for eggs, larvae, and early juveniles. For late juveniles and adults, EFH includes coastal pelagic and epipelagic arctic waters from 0 to 50 m (0 to 164 ft) and wherever there are sand and gravel substrates.

- *Snow crab (Chionoecetes opilio*). Insufficient information is available to determine EFH for larvae and early juvenile life stages. EFH for eggs, late juveniles, and adult snow crabs consists of bottom habitats along the inner shelf from 0 to 50 m (0 to 164 ft) and middle shelf from 50 to 100 m (164 to 328 ft) in Arctic waters south of Cape Lisburne, wherever there are substrates consisting mainly of mud.

See individual sections on water quality, coastal habitat, and marine benthic and pelagic habitats in the Beaufort and Chukchi Seas for a description these habitat types as well as potential changes to these habitats resulting from climate change.

The salmon FMP designates EFH for the juvenile or adult marine life stages of chinook (*Oncorhynchus tshawytscha*), coho (*O. kisutch*), pink (*O. gorbuscha*), sockeye (*O. nerka*), and chum (*O. keta*) salmon as being all marine waters of the Chukchi Sea and Arctic Ocean from the mean higher tide line to the 370-km (200-NM) limit of the U.S. EEZ (NMFS 2005). There are no salmon HAPCs designated within the Beaufort Sea or Chukchi Sea Planning Area. No commercial fishing for salmon is allowed in the U.S. EEZ off Alaska except in designated areas, none of which are in the Beaufort or Chukchi Sea Planning Areas. Thus no commercial salmon fishery is present. In addition, all five managed salmon species decrease in abundance north of the Bering Strait (Craig and Haldorson 1986) and from west to east along the coast of the Beaufort and Chukchi Seas. Pink salmon and chum salmon are most common in arctic waters (Augerot 2005; Stephenson 2005; Moss et al. 2009; Kondzela et al. 2009). Salmon are most abundant west of Point Barrow and appear to be rare in the Beaufort Sea and extremely rare in the eastern Beaufort Sea, although chum salmon are natal to the Mackenzie River and consistently found there in low numbers (Irvine et al. 2009). Chum and pink salmon may be natal to other rivers on the North Slope; that possibility has not been confirmed (Irvine et al. 2009).

3.8 MARINE AND COASTAL FAUNA

3.8.1 Mammals

All marine mammals are protected in U.S. waters under the Marine Mammal Protection Act of 1972 (MMPA; 16 USC 1631 *et seq*.). The MMPA organizes marine mammals into separate stocks for management purposes. By definition, a stock is a group of animals in common spatial arrangement that interbreed (NMFS 2011a). Some species receive additional protection under the Endangered Species Act (ESA; 16 USC 1531 *et seq*.). In the northern GOM and the Alaska OCS regions, the NMFS is the Federal agency responsible for conservation and management of whales, seals, dolphins, and porpoises. While the USFWS manages manatees in the GOM and in Alaska waters, the USFWS manages sea otters, walruses, and polar bears. The MMPA also created the U.S. Marine Mammal Commission to provide an oversight role for the Federal agencies implementing the MMPA. Marine mammals are among the most important subsistence resources for coastal Alaskan Natives, and a large body of traditional and local knowledge exists about marine mammals (see Section 3.5.5). In recognition of both these factors, many marine mammal stocks are co-managed by the Federal Government (USFWS or NMFS) and Alaskan Native subsistence users under the authority of the MMPA. The take of other mammals (upland or terrestrial) is primarily regulated by the respective State.

3.8.1.1 Gulf of Mexico

3.8.1.1.1 Marine Mammals. The U.S. GOM marine mammal community is diverse and distributed throughout the northern GOM waters (Table 3.8.1-1). Twenty-one species of cetaceans regularly occur in the GOM (Jefferson et al. 1992; Davis et al. 2000) and are identified in the NMFS GOM Stock Assessment Reports (Waring et al. 2010) in addition to one species of Sirenian. The GOM's marine mammals are represented by members of the taxonomic order Cetacea, which is divided into the suborders Mysticeti (i.e., baleen whales) and Odontoceti (i.e., toothed whales), as well as the order Sirenia, which includes the manatee and dugong. Most GOM cetacean species have worldwide distributions; however, two exceptions are Atlantic spotted dolphins (*Stenella frontalis*) and clymene dolphins (*Stenella clymene*). Common in the GOM, these two species are found only in the Atlantic Ocean and its associated waters.

There are species that have been reported from GOM waters, either by sighting or stranding, that are not considered further in this document. These species include the blue whale (*Balaenoptera musculus*), the North Atlantic right whale (*Eubalaena glacialis*), and the Sowerby's beaked whale (*Mesolplodon bidens*), all considered extralimital in the GOM; along with the humpback whale (*Megaptera novaeangiliae*), the fin whale (*Balaenoptera physalus*), the sei whale (*Balaenoptera borealis*), and the minke whale (*Balaenoptera acutorostrata*), all considered rare occasional migrants in the GOM (Würsig et al. 2000; Mullin and Fulling 2004). Because these species are uncommon in the GOM (and by extension the WPA), they are not included in the most recent NMFS Stock Assessment Reports for the GOM (Waring et al. 2010).

TABLE 3.8.1-1 Marine Mammals in the GOM[a]

		General Occurrence[b]			Typical Habitat		
Family/Species	Status[c]	Western GOM[d]	Central GOM[e]	Eastern GOM[f]	Coastal	Shelf	Slope/ Deep
Order Cetacea							
Suborder Mysticeti (Baleen whales)							
Family Balaenidae							
North Atlantic right whale (*Eubalaena glacialis*)	E/D	EX	EX	EX	–	X	X
Family Balaenopteridae							
Bryde's whale (*Balaenoptera edeni*)		O	O	O	–	X	X
Fin whale (*Balaenoptera physalus*)	E/D	EX	EX	EX	–	X	X
Humpback whale (*Megaptera novaeangliae*)	E/D	EX	EX	EX	–	X	X
Minke whale (*Balaenoptera acutorostrata*)		EX	EX	EX	–	X	X
Sei whale (*Balaenoptera edeni*)	E/D	EX	EX	EX	–	X	X
Blue whale (*Balaenoptera musculus*)	E/D	EX	EX	EX	–	X	X
Suborder Odontoceti (Toothed whales and dolphins)							
Delphinidae							
Atlantic spotted dolphin (*Stenella frontalis*)		C	C	C	–	X	X
Bottlenose dolphin (*Tursiops truncatus*)		C	C	C	X	X	X
Clymene's dolphin (*Stenella clymene*)		C	C	C	–	–	X
False killer whale (*Pseudorca crassidens*)		O	O	O	–	–	X
Fraser's dolphin (*Lagenodelphis hosei*)		O	O	O	–	–	X
Killer whale (*Orcinus orca*)		O	O	O	–	–	X
Melon-headed whale (*Peponocephala electra*)		UC	UC	O	–	–	X
Pantropical spotted dolphin (*Stenella attenuata*)		C	C	C	–	–	X

TABLE 3.8.1-1 (Cont.)

		General Occurrence[b]			Typical Habitat		
Family/Species	Status[c]	Western GOM[d]	Central GOM[e]	Eastern GOM[f]	Coastal	Shelf	Slope/ Deep
Delphinidae (Cont.)							
Pygmy killer whale (*Feresa attentuata*)		O	O	O	–	–	X
Risso's dolphin (*Grampus griseus*)		UC	UC	UC	–	–	X
Rough-toothed dolphin (*Steno bredanensis*)		UC	UC	UC	–	–	X
Short-finned pilot whale (*Globicephala macrorhynchus*)		UC	UC	O	–	–	X
Spinner dolphin (*Stenella longirostris*)		O	O	O	–	–	X
Striped dolphin (*Stenella coeruleoalba*)		UC	UC	UC	–	–	X
Kogiidae							
Dwarf sperm whale (*Kogia sima*)		O	O	O	–	–	X
Pygmy sperm whale (*Kogia breviceps*)		O	O	O	–	–	X
Physeteridae							
Sperm whale (*Physeter macrocephalus*)	E/D	C	C	C	–	–	X
Ziphidae							
Blainville's beaked whale (*Mesoplodon densirostris*)		O	O	O	–	–	X
Cuvier's beaked whale (*Ziphius cavirostris*)		O	O	O	–	–	X
Gervais' beaked whale (*Mesoplodon europaeus*)		O	O	O	–	–	X
Sowerby's beaked whale (*Mesoplodon bidens*)		EX	EX	EX	–	–	X
Sirenidae							
West Indian manatee, Florida subspecies (*Trichechus manatus latrostris*)	E	O	O	UC	X	–	–

Footnotes on next page.

TABLE 3.8.1-1 (Cont.)

[a] C = Common — regularly observed throughout the year; EX = Extralimital — known only on the basis of a few records that probably resulted from unusual wanderings of animals into the region; O = Occasional — relatively few observations throughout the year, but some species may be more frequently observed in some locations or during certain times (e.g., during migration); and UC = Uncommon — infrequently observed throughout the year, but some species may be more common in some locations or during certain times of the year (e.g., during migration or when on summer calving grounds or wintering grounds). – = Absent — not recorded from the area; X = Present.

[b] The indicated occurrence does not reflect the distribution and occurrence of individual stocks of marine mammals within localized geographic areas, but rather the broad distribution of the species within the larger categories of OCS waters.

[c] E = Endangered under the Endangered Species Act; D = Depleted under the Marine Mammal Protection Act.

[d] Western GOM includes OCS waters from the Texas-Mexico border to the Texas-Louisiana border.

[e] Central GOM includes OCS waters from the Texas-Louisiana border to the Alabama-Florida border.

[f] Eastern GOM includes OCS waters of the west coast of Florida.

Source: Waring et al. (2010).

Threatened or Endangered Marine Mammals. Five baleen whales including the North Atlantic right whale (*Eubalaena glacialis*), blue whale (*Balaenoptera musculus*), fin whale (*Balaenoptera physalus*), sei whale (*Balaenoptera borealis*), and humpback whale (*Megaptera novaeangliae*); one toothed whale, the sperm whale (*Physeter macrocephalus*); and one sirenian, the West Indian manatee (*Trichechus manatus*) occur in the northern GOM; and are all listed as federally endangered under the ESA. The sperm whale is common in oceanic waters of the northern GOM and may be a resident species, while the baleen whales are rare or extralimital in the northern GOM (Würsig et al. 2000). The West Indian manatee typically inhabits only coastal marine, brackish, and freshwater areas.

Cetaceans: Mysticetes. The occurrences of the North Atlantic right whale in the northern GOM represent distributional anomalies, normal wanderings of occasional animals, or a more extensive historic range beyond the sole known calving and wintering ground in the waters of the southeastern United States (Waring et al. 2010), and are therefore considered extralimital. The North Atlantic right whale inhabits primarily temperate and subpolar waters (Jefferson et al. 2006). It ranges from wintering and calving grounds in coastal waters of the southeastern United States to summer feeding, nursery, and mating grounds in New England waters and northward to the Bay of Fundy, the Scotian Shelf, and the Gulf of St. Lawrence (Waring et al. 2010). In the North Atlantic, it primarily inhabits the area between 20° and 60°N (NMFS 2011a). The North Atlantic right whale forages on or near the surface on copepods and other zooplankton (e.g., krill) (Jefferson et al. 2006). Six major congregation areas identified for the western North Atlantic right whale are the coastal waters of the southeastern United States, Great South Channel, Georges Bank/Gulf of Maine, Cape Cod and Massachusetts Bays, Bay of Fundy, and Scotian Shelf (Waring et al. 2010). The minimum stock size in western North Atlantic, estimated in 2005, is 361 individuals (Waring et al. 2010). The few confirmed records of the North Atlantic right whale in the northern GOM have been in the Northern GOM Slope and the GOM Basin Level II Ecoregions (see Figure 3.2.2-1).[9]

The blue whale is the largest marine mammal. Blue whales are extralimital in the northern GOM (Würsig et al. 2000) with the only records consisting of two strandings, one each on the Louisiana and Texas coasts, with the identifications for both strandings being questionable (Davis and Schmidly 1997). It occurs in all major oceans of the world (Jefferson et al. 2006; Waring et al. 2010). Those that migrate move to feeding grounds in polar waters during spring and summer, after wintering in subtropical and tropical waters (Yochem and Leatherwood 1985). Most blue whale sightings in the North Atlantic are from the Gulf of St. Lawrence, where they may be present throughout most of the year (NMFS 2011a). Blue whales tend to occur in the open ocean; however, in some areas they come close to shore to feed and possibly breed (Jefferson et al. 2006). Blue whales tend to occur alone or in pairs, but aggregations of 12 or more may develop in prime feeding grounds (Jefferson et al. 2006). They feed almost exclusively on krill (euphausids) (Pauly et al. 1995; Jefferson et al. 2006; NMFS 2011a). The minimum blue whale population estimate for the western North Atlantic, based on counts made in the Gulf of St. Lawrence, is 440 (Waring et al. 2010).

The fin whale is an oceanic species that occurs worldwide. There are few reliable reports of fin whales in the northern GOM, indicating that fin whales are not abundant there (Jefferson and Schiro 1997) and they are therefore considered extralimital. Most fin whale sightings occur where deep water approaches the coast (Jefferson et al. 2006), and it mostly occurs in temperate to polar waters and less commonly in tropical waters (NMFS 2011a). Fin whales tend to be more common north of 30°N (NMFS 2010b). In the North Atlantic, fin whales occur in groups of two to seven (NMFS 2011a). The fin whale makes seasonal migrations between tropical and subtropical waters (where it mates and calves in winter) and the north-temperate polar feeding grounds that it occupies during the summer months (Jefferson et al. 2006). New England waters are a major feeding ground for fin whales (Waring et al. 2010), where they feed on concentrations of zooplankton (e.g., krill), fishes, and cephalopods (Pauly et al. 1995; Jefferson et al. 2006). The best estimate for the western North Atlantic fin whale stock is 3,985 with a minimum estimate of 3,269 (Waring et al. 2010).

The sei whale is rare in the northern GOM (Würsig et al. 2000), based on records of a single stranding in the Florida Panhandle and three strandings in eastern Louisiana (Jefferson and Schiro 1997) and they are therefore considered extalimital. It is an oceanic species that occurs in tropical to polar waters, being more common in the mid-latitude temperate zones. It seldom occurs close to shore (Jefferson et al. 2006). Groups of two to five individuals are commonly observed, but loose aggregations of 30 to 50 occasionally occur (Jefferson et al. 2006; NMFS 2011a). The sei whale feeds on concentrations of zooplankton (e.g., krill and copepods), fishes, and cephalopods (Pauly et al. 1995). The best estimate for the Nova Scotia sei whale stock is 386 with a minimum estimate of 208 (Waring et al. 2010).

Humpback whales are rare in the northern GOM (Würsig et al. 2000), based on a few confirmed sightings and one stranding event, and are therefore considered extralimital. The

9 Descriptions of the marine ecoregions in the northern GOM are provided in Section 3.2.3.

humpback whale occurs in all oceans, feeding in higher latitudes during spring, summer, and autumn, and migrating to a winter range over shallow tropical and subtropical banks, where they calve and presumably breed (Jefferson et al. 2006). They normally occur in coastal and shelf waters but frequently travel across deep water during migration (Clapham and Mead 1999). Humpback whales usually occur alone or in groups of two or three, although larger aggregations occur in breeding and feeding areas (Jefferson et al. 2006). Humpback whales feed on concentrations of zooplankton (e.g., krill) and fishes (Pauly et al. 1995; Jefferson et al. 2006). The best estimate of the Gulf of Maine humpback whale stock is 11,570 individuals (NMFS 2011a).

Cetaceans: Odontocetes. The sperm whale occurs worldwide in deep waters from the tropics to the pack-ice edges, although generally only large males venture to the extreme northern and southern portions of the species' range (Jefferson et al. 2006). It is the only great whale considered common in the northern GOM (Mullin et al. 1991; Davis and Fargion 1996; Jefferson and Schiro 1997). Consistent sightings and satellite tracking results indicate that sperm whales occupy the northern GOM throughout the year (Mullin et al. 1991; Davis and Fargion 1996; Jefferson and Schiro 1997; Davis et al. 2000; Jochens et al. 2008), where it is widely distributed in the Northern GOM Slope, Mississippi Fan, and GOM Basin Level II Ecoregions (see Figure 3.2.2-1) (Read et al. 2011; Waring et al. 2010; Wilkinson et al. 2009). Sperm whales tend to inhabit areas with water depths of 600 m (1,970 ft) or more and are uncommon at depths shallower than 300 m (984 ft) (NMFS 2011a). However, they do come close to shore where submarine canyons or other geophysical features bring deep water near the coast (Jefferson et al. 2006). Aggregations of sperm whales commonly occur in waters over the shelf edge in the vicinity of the Mississippi River Delta in waters that are 500 to 2,000 m (1,641 to 6,562 ft) in depth (Mullin et al. 1991; Davis and Fargion 1996; Davis et al. 2000). Sperm whales often concentrate along the continental slope in or near cyclones and zones of confluence between cyclones and anticyclones (Davis et al. 2000). They commonly occur in medium to large groups of up to fifty individuals (Jefferson et al. 2006). Dive depths observed in the GOM range from 544 to 644 m (1,784 to 2,113 ft) and average 45.5 minutes in length (Watwood et al. 2006). Sperm whales prey on cephalopods, fishes, and benthic invertebrates (Pauly et al. 1995; Jefferson et al. 2006). For management purposes, sperm whales in the GOM are considered a separate stock from those in the Atlantic Ocean (Jochens et al. 2008). The best estimate of the abundance of sperm whales in the northern GOM is 1,665 individuals with a minimum population estimate of 1,409 (Waring et al. 2010).

Sirenians. The West Indian manatee occurs in tropical and subtropical coastal marine, brackish, and fresh waters of the southeastern United States, GOM, Caribbean Sea, and Atlantic coast of northeastern South America (Jefferson et al. 2006). There are two subspecies of the West Indian manatee: the Florida manatee (*T. m. latirostris*), which ranges from the northern GOM to Virginia, and the Antillean manatee (*T. m. manatus*), which ranges from northern Mexico to eastern Brazil, including the islands of the Caribbean Sea (Jefferson et al. 2006). The Florida manatee inhabits marine, estuarine, and freshwater habitats (coastal tidal rivers and streams, mangrove swamps, salt marshes, freshwater springs, and vegetated bottoms). In the northern GOM, most Florida manatee sightings are from the Western Florida Estuarine Area and Eastern Gulf Neritic Level III Ecoregions (see Figure 3.2.2-1) (Read et al. 2011; Waring et al. 2010; Wilkinson et al. 2009). The Florida manatee makes use of specific areas for foraging (especially shallow grass beds with ready access to deep water), drinking (springs and freshwater runoff sites), resting (secluded canals, creeks, embayments, and lagoons), and for travel corridors (open waterways and channels) (USFWS 2007a). While Florida manatees can occur at depths greater than 4 m (12 ft), most occur in relatively shallow water (Haubold et al. 2006). The West Indian manatee mostly occurs alone or in groups of up to six individuals. However, larger groups may occur, especially in winter at sources of warm water (e.g., power plant outfalls) (Jefferson et al. 2006). The Florida manatee feeds on submerged, floating, and emergent vegetation, and requires freshwater for drinking (USFWS 2009a). In some cases (e.g., at docks), they actively consume invertebrates (Courbis and Worthy 2003).

The Florida manatee is intolerant of cold waters, seeking warm-water sites when temperatures drop below 20°C (68°F). It is unable to tolerate prolonged exposures to temperatures colder than 16°C (61°F) (Haubold et al. 2006). To avoid cold water, the Florida manatee seeks refuge in natural warmwater sites (e.g., springs, deep water areas, and areas thermally influenced by the Gulf Stream) and industrial plant thermal discharges (Laist and Reynolds 2005). Nearly two thirds of Florida manatees winter in industrial plant discharges, most of which are power plants (USFWS 2007a). In winter, the GOM subpopulations move southward to warmer waters. The winter range is restricted to waters at the southern tip of Florida and to waters near localized warm-water sources, such as power plant outfalls and natural springs in west-central Florida. Crystal River in Citrus County is typically the northern limit of the manatee’s winter range on the GOM coast. In the spring, they leave warm-water sites and often travel large distances along the GOM and Atlantic coastlines. During warmer months, manatees are common along the GOM coast of Florida from Everglades National Park northward to the Suwannee River in northwestern Florida and less common farther westward, infrequently occurring as far west as Texas (Powell and Rathbun 1984; Rathbun et al. 1990; Davis and Schmidly 1997).

Florida manatees have been divided into four distinct regional management units: the Atlantic Coast Unit that occupies the east coast of Florida, including the Florida Keys and the lower St. Johns River north of Palatka, Florida; the Southwest Unit that occurs from Pasco County, Florida, south to Whitewater Bay in Monroe County, Florida; the Upper St. Johns River Unit that occurs in the river south of Palatka, Florida; and the Northwest Unit that occupies the Florida Panhandle south to Hernando County, Florida (USFWS 2009). Manatees from the Northwest Unit are more likely to be seen in the northern GOM, and can be found as far west as Texas; however, most sightings are in the eastern GOM. Based on a survey of warm water refuges made in 2009, the best available count of the Florida manatee is 3,802 individuals (Waring et al. 2010). This includes manatees that occur within the GOM and along the Atlantic coast.

Non-ESA-Listed Marine Mammals. Twenty-two species of cetaceans, not listed under the ESA, occur in the GOM. The mysticetes (baleen whales) account for two of these species while the other 20 species are odontocetes (toothed whales and dolphins).

Cetaceans: Mysticetes. The Bryde’s whale (*Balaenoptera edeni*) occurs in tropical and subtropical waters throughout the world, both offshore and near the coast (Jefferson et al. 2006). Individuals tend to occur alone or in pairs, but may aggregate in groups of 10 to 20 on feeding grounds. The Bryde's whale feeds on fishes, shrimp, pelagic red crabs, and large zooplankton such as krill and copepods (Pauly et al. 1995; Jefferson et al. 2006; NMFS 2011a). Dives last 5 to 15 minutes and can reach a depth of 300 m (1,000 ft) (NMFS 2011a). In the northern GOM, most sightings of Bryde's whales have been made in the DeSoto Canyon region and off western Florida, although some sightings have been made in the west-central portion of the northeastern GOM (i.e., in the Northern GOM Slope Level II Ecoregion south of the Florida Panhandle; see Figure 3.2.2-1) (Waring et al. 2010; Read et al. 2011; Wilkinson et al. 2009). The best estimate of Bryde's whale abundance for the northern GOM is 15 individuals with the minimum population estimate of 5 individuals (Waring et al. 2010).

The minke whale *(Balaenoptera acutorostrata*) occurs worldwide. It prefers temperate to boreal waters, but also occurs in subtropical to tropical waters (NMFS 2011a). Most records from the GOM have come from the Florida Keys, although strandings in western and northern Florida, Louisiana, and Texas have been reported (Jefferson and Schiro 1997) and they are therefore considered extralimital. The minke whale occurs more often in coastal and inshore areas compared to offshore areas (Jefferson et al. 2006). Similar to other baleen whales, minke whales generally occupy the continental shelf rather than the continental shelf edges (Waring et al. 2010). It usually occurs alone or in groups of only two to three whales, although loose aggregations of up to 400 can occur in feeding areas in higher latitudes (NMFS 2011a). The minke whale preys on a variety of large zooplankton (e.g., krill and copepods) and small schooling fishes (Pauly et al. 1995; Jefferson et al. 2006). Minke whales are rare in the GOM with the only confirmed records coming from stranding information (Würsig et al. 2000), and are therefore considered extralimital. The best estimate for the Canadian East Coast population, which includes the minke whales that occur off the eastern coast of the United States to the GOM, is 8,987 individuals. The minimum population estimate is 6,909 (Waring et al. 2010).

Cetaceans: Odontocetes (Family Kogiidae). The pygmy sperm whale (*Kogia breviceps*) has a worldwide distribution in deep waters from temperate to tropical waters. It is especially common over and near the continental slope (Jefferson et al. 2006). The pygmy sperm whale usually occurs alone or in groups up to seven individuals (NMFS 2011a). In some areas, including the GOM, it is among the most frequently stranded small whale species (Jefferson et al. 2006; Waring et al. 2010). Pygmy sperm whales can dive at least 300 m (1,000 ft) (NMFS 2011a). They feed mainly on squid, but will also eat crab, shrimp, and fishes (Pauly et al. 1995; Jefferson et al. 2006). In the GOM, they occur primarily along the continental shelf edge and in deeper waters off the continental shelf (Mullin et al. 1991).

The dwarf sperm whale *(Kogia sima*) has a worldwide distribution in temperate to tropical waters, mostly over the continental shelf and slope (Jefferson et al. 2006; Culik 2010). In the northern GOM, most sightings occur in oceanic waters (Waring et al. 2010). The dwarf sperm whale mostly occurs in groups of less than five individuals, although groups of up to 10 do occur (Jefferson et al. 2006). It is capable of diving to a depth of at least 300 m (1,000 ft) (NMFS 2011a). The dwarf sperm whale feeds on squid, fishes, and crustaceans (Pauly et al. 1995; Jefferson et al. 2006).

At sea, it is difficult to differentiate the pygmy sperm whale from the dwarf sperm whale. Most sightings of these two species have been in the Northern GOM Slope and GOM Basin

Level II Ecoregions (see Figure 3.2.2-1) (Read et al. 2011; Waring et al. 2010; Wilkinson et al. 2009). The best estimate of abundance for dwarf and pygmy sperm whales combined in the northern GOM is 453 individuals with a minimum population estimate of 340 (Waring et al. 2010).

Cetaceans: Odontocetes (Family Ziphiidae). Due to the difficulty of at-sea identification of beaked whales, most observations in the GOM are identified as Cuvier's beaked whales (*Ziphius cavirorostris*), *Mesoplodon* spp, or unidentified *Ziphiidae* (Waring et al. 2010). In the northern GOM, beaked whales are broadly distributed in waters greater than 1,000 m (3,280 ft) in depth over lower slope and abyssal landscapes (Davis et al. 1998, 2000) in the Northern GOM Slope, Mississippi Fan, and GOM Level II Ecoregions (see Figure 3.2.2-1) (Read et al. 2011; Waring et al. 2010; Wilkinson et al. 2009).

The Blainville's beaked whale (*Mesoplodon densirostris*) occurs in warm-temperate to tropical waters worldwide, mostly in offshore deep waters (Jefferson et al. 2006). It is often associated with steep underwater geologic structures such as banks, submarine canyons, seamounts, and continental slopes (NMFS 2011a). The Blainville's beaked whale most commonly occurs singly or in pairs, but groups of up to 7 to 12 individuals are reported (Jefferson et al. 2006; NMFS 2011a). Commonly, dives occur to depths of 500 to 1,000 m (1,600 to 3,300 ft) and last 20 to 45 minutes (NMFS 2011a). Blainville's beaked whales feed on squid and some fishes (Pauly et al. 1995; Jefferson et al. 2006). There have been four documented strandings and two sightings of the Blainville's beaked whale in the northern GOM (Waring et al. 2010).

The Gervais' beaked whale (*Mesoplodon europaeus*) is widely, but sparsely, distributed in temperate to tropical oceanic waters worldwide (Waring et al. 2010). It usually occurs alone or in small social groups (NMFS 2011a). The species feeds on squid, mysid shrimp, and fish (Pauly et al. 1995; Jefferson et al. 2006; NMFS 2011a). Stranding records suggest that the Gervais' beaked whale is probably one of the most common *Mesoplodon* species in the northern GOM (Jefferson and Schiro 1997).

The best abundance estimate for the Gervais' and Blainville's beaked whales combined in the northern GOM is 57 individuals with a minimum population estimate of 24 (Waring et al. 2010).

The Cuvier's beaked whale (*Ziphius cavirorostris*) occurs worldwide in offshore deep waters, except for polar waters (Jefferson et al. 2006; Waring et al. 2010). It prefers waters of the continental slope and edge and steep underwater geologic features such as banks, seamounts, and submarine canyons where depths are greater than 1,000 m (3,000 ft) (NMFS 2011a). The Cuvier's beaked whale mostly occurs alone or in small groups up to 12 individuals, although groups up to 25 whales have been reported (NMFS 2011a). It can dive to depths of at least 1,000 m (3,000 ft) that last 20 to 40 minutes (NMFS 2011a). Its diet consists of squid, fishes, and crustaceans (Pauly et al. 1995; Jefferson et al. 2006). The Cuvier's beaked whale is probably one of the most common beaked whale species in the northern GOM (Jefferson and Schiro 1997; Davis et al. 1998, 2000). The best estimate of abundance for Cuvier's beaked whale in the northern GOM is 65 individuals with a minimum population estimate of 39 (Waring et al. 2010).

The Sowerby's beaked whale (*Mesoplodon bidens*) generally occurs in cold temperate to subarctic waters of the North Atlantic. It usually occurs alone or in small groups of 3 to 10 individuals. Dives, lasting 10 to 15 minutes, can reach depths of 1,500 m (4,920 ft) (NMFS 2011a). It feeds on squid and small fishes (Pauly et al. 1995; Jefferson et al. 2006). There are no abundance estimates for the Sowerby's beaked whale in the GOM. The Sowerby's beaked whale does not regularly inhabit the GOM (MacLeod et al. 2006). The one stranding report from the GOM represents an extralimital occurrence (Jefferson and Schiro 1997; Waring et al. 2010).

Cetaceans: Odontocetes (Family Delphinidae). The Atlantic spotted dolphin (*Stenella frontalis*) is endemic to the Atlantic Ocean in tropical to temperate waters from about 50°N to 25°S (Culik 2010). It mostly occurs in coastal or continental shelf waters that are 20 to 250 m (65 to 820 ft) deep, but also inhabits continental slope waters up to 2,000 m (6,562 ft) deep (Culik 2010; Jefferson et al. 2006; NMFS 2011a). The Atlantic spotted dolphin may seasonally enter shallow water in pursuit of migratory prey (Perrin 2002). In the northern GOM, the Atlantic spotted dolphin is usually observed from the continental shelf waters 10 to 200 m (33 to 656 ft) deep to slope waters less than 500 m (<1,640 ft) deep throughout the Northern GOM Shelf and the more shoreward portions of the Northern GOM Slope Level II Ecoregions (see Figure 3.2.2-1) (Read et al. 2011; Waring et al. 2010; Wilkinson et al. 2009). The Atlantic spotted dolphin generally occurs in groups smaller than 50 individuals, with coastal groups usually consisting of 5 to 15 individuals (Jefferson et al. 2006); however, groups as large as 200 do occur (NMFS 2011a). They sometimes associate with other cetaceans such as bottlenose dolphins (*Tursiops truncatus*) (NMFS 2011a). Atlantic spotted dolphins usually dive about 10 m (30 ft) but can reach depths up to 60 m (200 ft) (NMFS 2011a). They feed on fishes and cephalopods (Pauly et al. 1995; Jefferson et al. 2006). Current population size for the Atlantic spotted dolphin in the northern GOM is unknown because survey data is more than 8 yr old. Estimated abundance, based on outer continental shelf observations made from fall 2000 and 2001 surveys, is 37,611 individuals (Waring et al. 2010).

The bottlenose dolphin inhabits tropical and temperate waters worldwide primarily between 45°N to 45°S (NMFS 2011a). For management purposes, in the northern GOM, bottlenose dolphins are divided into six stock groups: (1) western coastal stock (Mississippi River Delta to the Texas-Mexico border); (2) northern coastal stock (Mississippi River Delta to 84°W); (3) eastern coastal stock (84°W to Key West); (4) continental shelf stock; (5) oceanic stock; and (6) 32 bay, sound, and estuarine stocks (Waring et al. 2010). The seaward boundary for the three bottlenose dolphin coastal stocks is the 20-m (66-ft) isobath, which ranges 4 to 90 km (2.5 to 56 mi) from shore (Waring et al. 2010). The northern GOM continental shelf stock occurs in waters from 20 to 200 m (66 to 656 ft) deep, while the oceanic stock inhabits waters greater than 200 m (656 ft) deep (Waring et al. 2010). The continental shelf stock; coastal stocks; and bay, sound, and estuarine stocks occur throughout the Northern GOM Shelf Level II Ecoregion, while the oceanic stock occurs primarily within the Northern GOM Slope Level II Ecoregion (see Figure 3.2.2-1) (Read et al. 2011; Waring et al. 2010; Wilkinson et al. 2009).

Bottlenose dolphins usually occur in groups of less than 20 individuals, but offshore herds of several hundred individuals occur. It commonly associates with other cetaceans (Jefferson et al. 2006). Bottlenose dolphins are opportunistic feeders, taking a wide variety of fishes, cephalopods, and shrimp (Pauly et al. 1995; Jefferson et al. 2006). Coastal bottlenose dolphins consume benthic invertebrates and fish, while offshore individuals feed on pelagic fish and squid (NMFS 2011a).

The population sizes for the continental shelf stock; the western coastal stock; and most of the bay, sound, and estuarine stocks have been not been estimated in over 8 yr. Therefore, their current population estimates are unknown (Waring et al. 2010). The best current estimate of abundance for the eastern coastal stock is 7,702 with a minimum population estimate of 6,551 bottlenose dolphins, while the best current estimate of abundance for the northern coastal stock is 2,437 with a minimum population estimate of 2,004. The best current estimate of abundance for the oceanic stock is 3,708 individuals with a minimum population estimate of 2,641 dolphins (Waring et al. 2010).

The Clymene dolphin *(Stenella clymen*e) is endemic to tropical and sub-tropical waters of the Atlantic Ocean including the Caribbean Sea and GOM. It is a deepwater oceanic species not often observed near shore (Jefferson et al. 2006), generally occurring in waters 250 to 5,000 m (820 to 16,400 ft) deep (NMFS 2011a). There is an atypical report of a Clymene dolphin off southern Texas waters with a bottom depth of 44 m (144 ft) (Fertl et al. 2003). In the northern GOM, most Clymene dolphin sightings are in the Northern GOM Slope, Mississippi Fan, and GOM Basin Level II Ecoregions (see Figure 3.2.2-1) (Read et al. 2011; Waring et al. 2010; Wilkinson et al. 2009). Herds, often segregated by age and sex, are normally less than 200 individuals and are often less than 50 individuals. Clymene dolphins occur with other dolphin species (Jefferson et al. 2006; Jefferson and Curry 2003). They occur in the GOM throughout the year (Jefferson et al. 1995; Jefferson and Curry 2003). The Clymene dolphin is an active bowrider and will approach ships from many miles away (Jefferson and Curry 2003). It feeds on fishes and cephalopods (Pauly et al. 1995; Jefferson et al. 2006). The best estimate for the abundance of the Clymene dolphin in the northern GOM is 6,575 individuals with a minimum population estimate of 4,901 (Waring et al. 2010).

The false killer whale (*Pseudorca crassidens*) occurs worldwide in tropical and temperate oceanic waters (generally between 50°N and 50°S) that are deeper than 1,000 m (3,300 ft) (Culik 2010; Jefferson et al. 2006; NMFS 2011a). However, inshore movements occasionally occur that are associated with either food resources or shoreward flooding of warm oceanic currents (Stacey et al. 1994). In the GOM, most sightings occur in the Northern GOM Slope, Mississippi Fan, and GOM Basin Level II Ecoregions (see Figure 3.2.2-1) (Read et al. 2011; Waring et al. 2010; Wilkinson et al. 2009). The false killer whale normally occurs in groups of 10 to 60, but groups of up to 300 or more do occur (Culik 2010). The false killer whale is one of the most common cetacean species involved in mass strandings; one observed mass stranding near Mar del Plata, Argentina, included 835 individuals (Baird 2009). It associates with at least 10 other species of cetaceans, especially the bottlenose dolphin (Stacey et al. 1994). False killer whales primarily eat fish and cephalopods, but they will attack small cetaceans (Pauly et al. 1995; Jefferson et al. 2006). To increase their potential to find prey, a group may travel in a broad band several kilometers wide (NMFS 2011a). The best estimate for the abundance of the false killer whale in the northern GOM is 777 individuals with a minimum population estimate of 501 (Waring et al. 2010).

The Fraser's dolphin (*Lagenodelphis hosei*) has a worldwide distribution in tropical to warm temperate waters between 30°N and 30°S (NMFS 2011a). It normally occurs in oceanic waters deeper than 1,000 m (3,300 ft) but will occur near shore where deep water approaches the coast (Jefferson et al. 2006; NMFS 2011a). Fraser's dolphins are often associated with areas of upwelling (NMFS 2011a). In the GOM, they occur in deeper waters off the continental shelf (Waring et al. 2010), mostly in the Northern GOM Slope and at the boundary between the Northern GOM Slope and the GOM Basin Level II Ecoregions (see Figure 3.2.2-1) (Read et al. 2011; Waring et al. 2010; Wilkinson et al. 2009). Some Fraser's dolphins inhabit the northern GOM throughout the year (Waring et al. 2010). The Fraser's dolphin usually occurs in herds of 10 to 100 individuals, but occasionally occurs in herds consisting of hundreds to thousands of individuals (Jefferson et al. 2006; NMFS 2011a). It often occurs with other cetaceans, particularly the melon-headed whale (*Peponocephala electra*) (Jefferson et al. 2006). Fraser's dolphins can dive to nearly 600 m (2,000 ft) (NMFS 2011a), where they feed on fishes, cephalopods, and crustaceans (Pauly et al. 1995; Jefferson et al. 2006). Based on observations made from 1996 to 2001, 726 Fraser's dolphins occurred in the northern GOM.

The killer whale (*Orcinus orca*) has a worldwide distribution from tropical to polar waters. They are more common in nearshore cold temperate to subpolar waters (Jefferson et al. 2006). In the GOM, killer whales occur primarily in the deeper oceanic waters off the continental shelf at depths ranging from 256 to 2,652 m (840 to 8,700 ft) (Davis and Fargion 1996; Waring et al. 2010). Sightings in the northern GOM occur from the Northern GOM, Mississippi Fan, and GOM Basin Level II Ecoregions (see Figure 3.2.2-1) (Read et al. 2011; Waring et al. 2010; Wilkinson et al. 2009). Killer whale pods contain 1 to 55 individuals with resident pods tending to be larger than transient pods (Jefferson et al. 2006). Killer whales are top-level predators that feed on marine mammals, marine birds, sea turtles, fishes, and cephalopods (Pauly et al. 1995; Jefferson et al. 2006). The best estimate of the abundance of killer whales in the northern GOM is 49 individuals with a minimum population estimate of 28 (Waring et al. 2010).

The melon-headed whale has a worldwide distribution in subtropical to tropical oceanic waters (Jefferson et al. 2006). In the GOM, sightings of melon-headed whales are mostly in the Northern GOM Slope Level II Ecoregion, with some sightings in the GOM Basin Level II Ecoregion (see Figure 3.2.2-1) (Mullin et al. 1994; Read et al. 2011; Waring et al. 2010; Wilkinson et al. 2009). The melon-headed whale occurs in most areas of its range throughout the year (Jefferson and Barros 1997). Worldwide, it usually occurs in pods of 100 to 500 individuals with a known maximum of 2,000 individuals (Jefferson et al. 2006). Average herd size in the GOM is 130 to 310 individuals (Jefferson and Barros 1997). The melon-headed whale has strong social bonds, evidenced by mass strandings including up to several hundred individuals observed for mass strandings in Brazil and Australia (Jefferson and Barros 1997). Strandings of individual melon-headed whales have occurred in the GOM (Waring et al. 2010). In the GOM, melon-headed whales often occur with other species such as Fraser's dolphin or the rough-toothed dolphin (*Steno bredanensis*) (Jefferson and Barros 1997; Jefferson et al. 2006). Melon-headed whales will occasionally ride the bow waves of passing ships (Jefferson and

Barros 1997). They feed on cephalopods, fishes, and some crustaceans (Pauly et al. 1995; Jefferson et al. 2006; NMFS 2011a). The best estimate of the abundance of the melon-headed whale in the northern GOM is 2,283 individuals with a minimum population estimate of 1,293 (Waring et al. 2010).

The pantropical spotted dolphin (*Stenella attenuata*) occurs in tropical to warm temperate oceanic waters worldwide roughly from 40°N to 40°S (Culik 2010). In the GOM, sightings of the pantropical spotted dolphin occur in the Northern GOM Slope, Mississippi Fan, and the GOM Basin Level II Ecoregions (see Figure 3.2.2-1) (Read et al. 2011; Waring et al. 2010; Wilkinson et al. 2009). During the day, they typically occur in waters between 90 and 300 m (300 and 1,000 ft) deep and will dive into deeper waters at night in search of prey (NMFS 2011a). The pantropical spotted dolphin is the most common cetacean in the oceanic northern GOM (Mullin et al. 1991). School sizes may range from several to thousands of individuals (Perrin 2001). It often schools with other dolphins such as spinner dolphins (*Stenella longirostri*s) (NMFS 2011a). The pantropical spotted dolphin primarily feeds on epipelagic fishes and cephalopods (Pauly et al. 1995; Jefferson et al. 2006). The best estimate of the abundance of the pantropical spotted dolphin in the northern GOM is 34,067 individuals with a minimum population estimate of 29,311 (Waring et al. 2010).

The pygmy killer whale (*Feresa attenuata*) occurs worldwide in deeper tropical and subtropical waters, generally between 40°N and 35°S (Jefferson et al. 2006; Culik 2010). Generally, the pygmy killer whale occurs in groups of 50 individuals or less, although some herds of several hundred occur (Jefferson et al. 2006). Its diet includes cephalopods and fishes, though reports of feeding on other dolphins are reported (Pauly et al. 1995; Jefferson et al. 2006). In the northern GOM, the pygmy killer whale occurs primarily in deeper oceanic waters off the continental shelf (Waring et al. 2010). It inhabits the Northern GOM Slope, Mississippi Fan, and GOM Basin Level II Ecoregions (see Figure 3.2.2-1) (Read et al. 2011; Waring et al. 2010; Wilkinson et al. 2009). The best estimate of the abundance of the pygmy killer whale in the northern GOM is 323 individuals and the minimum population estimate is 203 (Waring et al. 2010).

The Risso's dolphin (*Grampus griseus*) occurs worldwide in tropical to temperate waters, generally between 60°N and 60°S, where it inhabits deep oceanic waters (e.g., depths greater than 1,000 m [3,300 ft]) seaward of the continental shelf and slopes) (Culik 2010; Jefferson et al. 2006; NMFS 2011a). In the northern GOM, they are widely distributed throughout the Northern GOM Slope, Mississippi Fan, and GOM Basin Level II Ecoregions (see Figure 3.2.2-1) (Read et al. 2011; Waring et al. 2010; Wilkinson et al. 2009). Their core area of occurrence is between the 350- and 975-m (1,150- and 3,200-ft) isobaths with seafloor slopes greater than 22 m/km (116 ft/mi) (Baumgartner 1997). Groups of 4,000 can occur, but herds tend to average 10 to 30 in number (Jefferson et al. 2006; NMFS 2011a). Risso's dolphins associate with other cetaceans and hybridization with bottlenose dolphins is recorded (Jefferson et al. 2006). It can dive to at least 300 m (1,000 ft) and remain underwater for up to 30 minutes (NMFS 2011a). The Risso's dolphin feeds primarily on squid and secondarily on fishes and crustaceans (Pauly et al. 1995; Jefferson et al. 2006). The best estimate of the abundance of the Risso's dolphin in the northern GOM is 1,589 individuals with a minimum population estimate of 1,271 (Waring et al. 2010).

The rough-toothed dolphin occurs in tropical to warm-temperate oceanic and continental shelf waters worldwide (Jefferson et al. 2006; Waring et al. 2010). In the northern GOM, sightings are scattered throughout most Level II ecoregions, with most sightings in the Northern GOM Slope (see Figure 3.2.2-1) (Mullin and Fulling 2004; Read et al. 2011; Waring et al. 2010; Wilkinson et al. 2009). It most commonly occurs in groups of 10 to 20, but herds of more than 100 do occur (Jefferson et al. 2006; NMFS 2011a). The rough-toothed dolphin often associates with other dolphins including the short-finned pilot whale (*Globicephala macrorhynchus*), bottlenose dolphin, pantropical spotted dolphin, and spinner dolphin (NMFS 2011a). It feeds on benthic invertebrates, cephalopods, and fishes (Pauly et al. 1995; Jefferson et al. 2006). The abundance of the rough-toothed dolphin in the northern GOM, based on a combined abundance estimate for the oceanic and OCS portions of the GOM based on surveys conducted between 2000 and 2004, was 2,653 (Waring et al. 2010).

The short-finned pilot whale occurs worldwide in tropical to temperate waters, generally in deep offshore areas (Jefferson et al. 2006). In the GOM, most sightings occur in the Northern GOM Slope with a few sightings in the Mississippi Fan and GOM Basin Level II Ecoregions (see Figure 3.2.2-1) (Waring et al. 2010; Wilkinson et al. 2009). Pods often consist of 25 to 50 animals; however, a pod can consist of up to several hundred individuals (Jefferson et al. 2006; NMFS 2011a). While swimming or looking for food, a pod may spread out over 1 km (0.6 mi) (NMFS 2011a). The short-finned pilot whale feeds at depths of 305 m (1,000 ft) or more (NMFS 2011a) predominately on squid, with fishes being consumed occasionally (Pauly et al. 1995; Jefferson et al. 2006). It is among the cetacean species that most frequently mass-strand (Jefferson et al. 2006). The best estimate of the abundance of the short-finned pilot whale in the northern GOM is 716 individuals with a minimum population estimate of 542 (Waring et al. 2010).

The spinner dolphin occurs worldwide in tropical, subtropical, and some warm-temperate waters normally in deep oceanic waters between 40°N and 40°S (Culik 2010; NMFS 2011a). In the northern GOM, most sightings are within the Northern GOM Slope Level II Ecoregion (see Figure 3.2.2-1) (Read et al. 2011; Waring et al. 2010; Wilkinson et al. 2009). Herd size ranges from under 50 to several thousand (Jefferson et al. 2006), and the spinner dolphin often schools with other dolphins, such as the pantropical spotted dolphin (Perrin 1998). It feeds on mesopelagic fishes, squid, and shrimp (Culik 2010; Pauly et al. 1995; Jefferson et al. 2006). The best estimate of the abundance of the spinner dolphin in the northern GOM is 1,989 individuals with a minimum population estimate of 1,356 (Waring et al. 2010).

The striped dolphin (*Stenella coeruleoalba*) occurs in tropical to temperate waters. In the northern GOM, sightings occur in oceanic waters (Waring et al. 2010). Its presence is often associated with areas of upwelling and convergence zones (NMFS 2011a). The striped dolphin only occurs close to shore in areas where deep water approaches the coast (Jefferson et al. 2006). In the northern GOM, sightings are mostly in the Northern GOM Slope, Mississippi Fan, and GOM Basin Level II Ecoregions (see Figure 3.2.2-1) (Read et al. 2011; Waring et al. 2010; Wilkinson et al. 2009). Mass strandings of the striped dolphin are rare because of its offshore distribution (Archer and Perrin 1999). Individual strandings in the GOM are reported (Waring et al. 2010). School size throughout its range generally ranges from about 25 to

100 individuals, although schools of hundreds to thousands of individuals do occur (NMFS 2011a). The striped dolphin can dive to depths of 700 m (2,300 ft) or more (NMFS 2011a). They feed primarily on small, mid-water squid and fishes, especially lanternfish (Pauly et al. 1995; Jefferson et al. 2006). The best estimate of the abundance of the striped dolphin in the northern GOM is 3,325 individuals with a minimum population estimate of 2,266 (Waring et al. 2010).

Factors Influencing Cetacean Distribution and Abundance. Various mesoscale oceanographic circulation patterns strongly influence the distribution and abundance of cetaceans within the northern GOM. These patterns are primarily driven by river discharge (primarily the Mississippi/Atchafalaya Rivers), wind stress, and the Loop Current and its derived circulation phenomena. Circulation on the continental shelf is largely wind-driven, with localized effects from freshwater (i.e., river) discharge, while mesoscale circulation beyond the shelf is largely driven by the Loop Current in the eastern GOM. Approximately once or twice a year, the Loop Current sheds anticyclonic eddies (also called warm-core rings). Anticyclones are long-lived, dynamic features that generally migrate westward and transport large quantities of high-salinity, nutrient-poor water across the near-surface waters of the northern GOM. These anticyclones, in turn, spawn cyclonic eddies (also called cold-core rings) during interaction with one another and upon contact with topographic features of the continental slope and shelf edge. These cyclones contain and maintain high concentrations of nutrients and stimulate localized production (Davis et al. 2000).

In the north-central GOM, the relatively narrow continental shelf south of the Mississippi River Delta may be an additional factor affecting cetacean distribution (Davis et al. 2000). Outflow from the Mississippi River mouth transports large volumes of low salinity, nutrient-rich water southward across the continental shelf and over the slope. River outflow also may be entrained within the confluence of a cyclone-anticyclone eddy pair and be transported beyond the continental slope. In either case, this nutrient-rich input of water leads to a localized deepwater environment with enhanced productivity, and may explain the persistent presence of aggregations of sperm whales within 50 km (31 mi) of the Mississippi River Delta in the vicinity of the Mississippi Canyon. Other marine predators, such as the bottlenose dolphin, also focus their foraging efforts on these abundant prey locations to improve overall efficiency and reduce energy costs (Bailey and Thompson 2010).

Climate Change. Marine mammal populations throughout the GOM may be affected by climate change and to a lesser extent by hurricane events. As previously discussed (Section 4.8.1.1), there is growing evidence that climate change is occurring, and potential effects in the GOM may include a change (i.e., rise) in sea level or a change in water temperatures. Such changes could affect the distribution, availability, and quality of marine mammal habitats and the abundance of marine mammal forage or prey resources. The construction of sea walls or other structures to protect coastal habitats against rising sea levels could potentially impact coastal marine species and possibly interfere with the movement of species such as the West Indian manatee (Learmonth et al. 2006). It is not possible at this time to identify the likelihood, direction, or magnitude of climate change on the marine mammals of the GOM. However, the current state of climate change and its impacts on marine mammals would need to be considered in any subsequent environmental reviews for lease sales or other OCS-related activities.

Unusual Mortality Event for Cetaceans in the Gulf of Mexico. On December 13, 2010, NMFS declared an unusual mortality event (UME) for cetaceans (whales and dolphins) in the GOM. A UME is defined under the MMPA as a "stranding that is unexpected, involves a significant die-off of any marine mammal population, and demands immediate response." Evidence of the UME was first noted by NMFS as early as February 2010. A total of 550 cetaceans (4% stranded alive and 96% stranded dead) have stranded since the start of the UME through September 18, 2011, with a vast majority of these strandings involving premature, stillborn, or neonatal bottlenose dolphins between Franklin County, Florida, and the Louisiana/Texas border (NMFS 2011f). Table 3.8.1-2 provides information on the cetacean strandings during pre-response, initial-response, and post-response phases for the DWH event. The 550 animals include 6 dolphins killed during a fish-related scientific study and 1 dolphin killed incidental to a dredging operation (NMFS 2011f).

It is unclear at this time whether the increase in strandings is related partially, wholly, or not at all to the DWH event (NMFS 2011f). The NMFS has also documented an additional 15 UMEs since 1991 that have been previously declared in the GOM; 11 of these involved cetaceans and the other 4 UMEs involved manatees (NMFS 2011g). However, the current data in the table above also shows a marked increase in strandings during the DWH event response and afterward. NMFS (2011f) considers the investigation into the cause of the UME and the potential role of the DWH event to be "ongoing and no definitive cause has yet been identified for the increase in cetacean strandings in the northern Gulf in 2010 and 2011." It is therefore unclear whether increases in stranded cetaceans during and after the DWH event response period

TABLE 3.8.1-2 Unusual Mortality Event Cetacean Data for the Northern Gulf of Mexico

Cetaceans Stranded	Phase of Deepwater Horizon Oil-Spill Response	Dates
113 cetaceans stranded	Prior to the response phase for the oil spill	February 1, 2010–April 29, 2010
115 cetaceans stranded or were reported dead offshore	During the initial response phase to the oil spill	April 30, 2010–November 2, 2010
322 cetaceans stranded[a]	After the initial response phase ended	November 3, 2010–September 18, 2011[b]

[a] This number includes 6 dolphins that were killed incidental to fish-related scientific data collection and 1 dolphin killed incidental to trawl relocation for a dredging project.

[b] The initial response phase ended for all four states on November 3, 2010, but then re-opened for eastern and central Louisiana on December 3, 2010.

Source: NMFS 2011f.

are or are not related to impacts from the DWH event; this will likely remain unclear until NMFS completes its UME and NRDA evaluation processes.All marine mammals collected either alive or dead were found east of the Louisiana/Texas border through Franklin County, Florida. The highest concentration of strandings has occurred off eastern Louisiana, Mississippi, and Alabama, with a significantly lesser number off western Louisiana and western Florida (NMFS 2011h) (see *Map of Cetacean (Dolphin and Whale) Strandings in the Northern Gulf of Mexico* at http://www.nmfs.noaa. gov/pr/health/mmume/cetacean_gulfofmexico2010.htm, last accessed September 22, 2011).

Deepwater Horizon Event. The DWH event in Mississippi Canyon Block 252 and the resulting oil spill and related spill-response activities (including use of dispersants) have affected marine mammals that have come into contact with oil and remediation efforts. Within the designated DWH spill area, 171 marine mammals (89% of which were deceased) were reported. This includes 155 bottlenose dolphins, 2 *Kogia* spp., 2 melon-headed whales, 6 spinner dolphins, 2 sperm whales, and 4 unknown species (NMFS 2011h). There have not been any manatees reported within the areas affected by the DWH event. All marine mammals collected either alive or dead were found east of the Louisiana/Texas border through Apalachicola, Florida. The highest concentration of strandings occurred off eastern Louisiana, Mississippi, and Alabama with a significantly lesser number off western Louisiana and western Florida (see *Map of Cetacean (Dolphin and Whale) Strandings in the Northern Gulf of Mexico* at http://www.nmfs.noaa.gov/pr/health/mmume/cetacean_gulfofmexico2010.htm). Due to known low detection rates of carcasses, it is possible that the number of deaths of marine mammals is underestimated (Williams et al. 2011). It is also important to note that evaluations have not yet confirmed the cause of death, and it is possible that many, some, or no carcasses were related to the DWH oil spill (NMFS 2011f).

3.8.1.1.2 Terrestrial Mammals. This section focuses on federally endangered terrestrial mammals likely to be present in coastal habitats of the northern GOM, although numerous other terrestrial mammals may be present in coastal habitats at any given time. Four federally endangered GOM coast "beach mice" subspecies occupy restricted habitats within mature coastal dune habitats of northwestern Florida and Alabama: (1) the Alabama beach mouse (*Peromyscus polionotus ammobates*), (2) Choctawhatchee beach mouse (*Peromyscus polionotus allophrys*), (3) Perdido Key beach mouse (*Peromyscus polionotus trissyllepsis*), and (4) St. Andrew beach mouse (*Peromyscus polionotus peninsularis*). They are recognized subspecies of the old-field mouse (*Peromyscus polionotus*) (Bowen 1968; USFWS 1987). Additionally, the federally endangered Florida salt marsh vole (*Microtus pennsylvanicus dukecampbelli*), a subspecies of the meadow vole (*Microtus pennsylvanicus*), occurs in limited salt marsh areas in the Big Bend area of Florida (NatureServe 2010a). Figure 3.8.1-1 shows the GOM coast distributions of the four beach mouse subspecies and the Florida salt marsh vole.

Beach mouse habitat is restricted to mature coastal barrier sand dunes. The primary and secondary (frontal) dunes are generally characterized by thick growths of sea oats (*Uniola paniculata*) and other species such as blue stem (*Schizachyrium scoparium*), beach grass (*Panicum amarum*), and beach goldenrod (*Chrysoma pauciflosculosa*) (USFWS 2006a). The

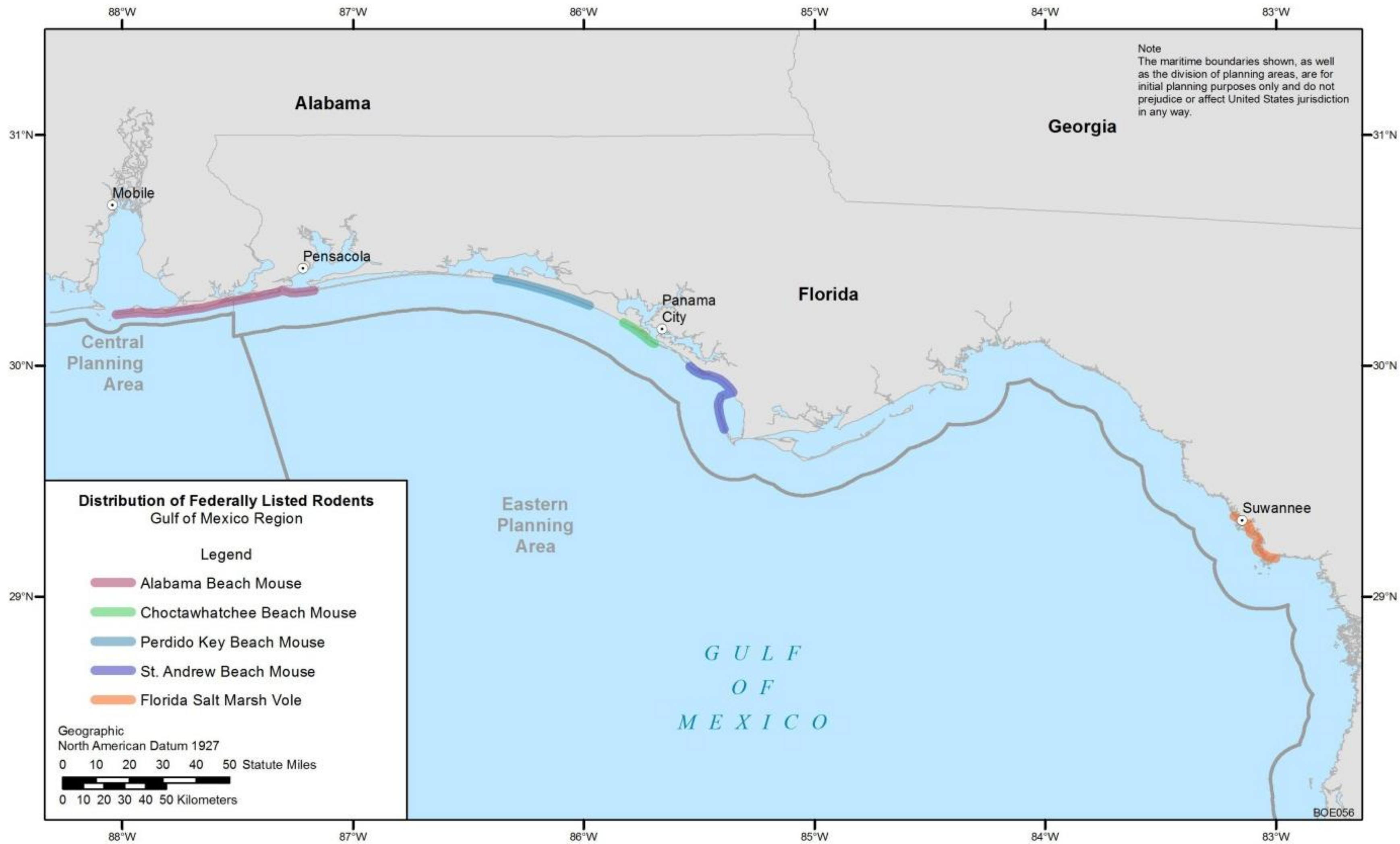

FIGURE 3.8.1-1 Coastal Distribution of the Endangered Beach Mouse Subspecies and the Florida Salt Marsh Vole in the GOM

scrub dunes provide refugia for beach mice during and after tropical storm events (USFWS 2007b). The scrub dunes tend to be dominated by large patches of scrub live oak (*Quercus geminata*) with gopher apple (*Licania michauxii*) and green briar (*Smilax* spp.) ground cover (USFWS 2006a). The inland extent of the scrub dune habitat ends where the maritime forest begins (USFWS 2006a). Beach mice dig burrows mainly on the lee side of the primary dunes and in other secondary and interior dunes where the vegetation provides suitable cover. The beach mice may also use ghost crab (*Ocypoda quadratus*) burrows. The dynamic hurricane-dune regeneration cycle maintains the dune habitat structure preferred by beach mice (Bird et al. 2009).

Beach mice typically feed nocturnally in the dunes and remain in burrows during the day. Their diets vary seasonally but consist mainly of seeds, fruits, and insects (Bird et al. 2009). Most foraging occurs in the sand dunes. Beach mice inhabit a single home range during their lifetime that averages about 5,000 m^2 (53,820 ft^2). Individual home ranges normally overlap. An individual may have 20 or more burrows within its home range (Bird et al. 2009). Beach mice use the highly vegetated areas of swales when moving between the primary and secondary dunes (Bird et al. 2009). The densities of beach mice are cyclic and can have large fluctuations on a seasonal and annual basis resulting from changes in reproductive rates, food availability, habitat quality and quantity, catastrophic events, disease, and predation (USFWS 2007b). Beach mice breed year-round with up to 13 generations per year. Peak breeding occurs in fall and winter, declines in spring, and occurs at low levels in summer. Average life span is about 9 months (USFWS 2007b).

The endangered status of beach mouse subspecies results from the loss and degradation of coastal dune habitats due to coastal development and natural processes. The combination of habitat loss and fragmentation resulting from beachfront development, the subsequent isolation of remaining habitat fragments and beach mouse populations, and destruction of these remaining habitats by hurricanes has increased the threat of extinction of the beach mouse subspecies (USFWS 1987; Oli et al. 2001).

The following provides additional information on the four beach mouse subspecies and the Florida salt marsh vole.

The Alabama beach mouse occurs in Alabama within disjunctive private coastline holdings and a coastal strand habitat in the Bon Secour National Wildlife Refuge (Baldwin County). It appears to be the dominant small mammal in the dune and scrub habitats on the Fort Morgan Peninsula. Surveys and habitat analyses (Lynn 2000; Sneckenberger 2001; Swilling et al. 1998) provide overwhelming evidence that beach mice also forage and burrow in areas beyond the frontal dunes, including the escarpment and interior scrub. The Alabama beach mouse originally occurred along 53.9 km (33.5 mi) of coastline in Baldwin County, Alabama. As of May 2008, the Alabama beach mouse occurred within 991 ha (2,450 ac) of primary, secondary, and tertiary dunes and interior scrub habitat along an estimated 21 km (13 mi) of Alabama coastline (USFWS 2009b) (Figure 3.8.1-1). The revised critical habitat for the Alabama beach mouse encompasses about 490 ha (1,211 ac) of coastal dune and scrub habitat in Baldwin County, Alabama (USFWS 2007b). The critical habitat includes five units: (1) Fort Morgan — 180 ha (446 ac); (2) Little Point Clear — 108 ha (268 ac); (3) Gulf Highland —

111 ha (275 ac); (4) Pine Beach — 12 ha (30 ac); and (5) Gulf State Park — 78 ha (192 ac). The USFWS (2007b) describes and provides maps for these critical habitat units.

The Choctawhatchee beach mouse was once present along the coastal dunes between Choctawhatchee Bay and St. Andrew Bay, Florida (Figure 3.8.1-1). Since Hurricane Ivan, trapping sessions have indicated healthy populations at Topsail Hill Preserve State Park. The viability of populations elsewhere appear to be in decline and/or are at very low densities (USFWS 2007b). Habitat for the Choctawhatchee beach mouse is primary, secondary, and occasionally tertiary sand dunes with a moderate cover of grasses and forbs (FNAI 2001). About 1,010 ha (2,500 ac) of Choctawhatchee beach mouse habitat exists (USFWS 2007b). The revised critical habitat for the Choctawhatchee beach mouse encompasses about 973 ha (2,404 ac) of coastal dune and scrub habitat in Okaloosa, Walton, and Bay Counties, Florida (USFWS 2006a). The critical habitat includes five units: (1) Henderson Beach — 39 ha (96 ac); (2) Topsail Hill — 125 ha (309 ac); (3) Grayton Beach — 73 ha (179 ac); (4) Deer Lake — 20 ha (49 ac); and (5) West Crooked Island/Shell Island — 716 ha (1,771 ac). The USFWS (2006a) provides maps for and describes these critical habitat units.

Historically, the Perdido Key beach mouse occurred in coastal dune habitat between Perdido Bay, Alabama, and Pensacola Bay, Florida (Bowen 1968). The effects of Hurricane Frederic (in 1979) combined with increased habitat fragmentation due to human development led to the extirpation of all but one population of Perdido Key beach mouse. The remaining population at Gulf State Park (at the westernmost end of Perdido Key) contained 30 individuals. Some of the individuals from this site were used to reestablish the subspecies at Gulf Islands National Seashore (GINS) during 1986–1988 (Holler et al. 1989). In 2000, five pairs were relocated from the GINS-Perdido Key area to Perdido Key State Park. In February of 2001, this relocation was supplemented with an additional 16 pairs that were released on both north and south sides of Highway 292 in suitable habitat. After 2 yr of quarterly survey trapping, indications were that the relocations to Perdido Key State Park successfully established a population at that location (USFWS 2004). Individuals were also trapped on private lands between GINS and Perdido Key State Park in 2004, increasing documentation of current occurrences of the Perdido Key beach mouse. Currently, the Perdido Key beach mouse exists on lands in areas along 13.5 km (8.4 mi) of coastline from Perdido Key at GINS to Perdido Key State Park (Figure 3.8.1-1). The revised critical habitat for the Perdido Key beach mouse encompasses about 525 ha (1,300 ac) of coastal dune and scrub habitat in Baldwin and Escambia Counties, Florida (USFWS 2006a). The critical habitat includes five units: (1) Gulf State Park — 96 ha (238 ac); (2) West Perdido Key — 59 ha (147 ac); (3) Perdido Key State Park — 111 ha (275 ac); (4) Gulf Beach — 66 ha (162 ac); and (5) Gulf Islands National Seashore — 258 ha (638 ac). The USFWS (2006a) describes and provides maps for these critical habitat units.

The St. Andrew beach mouse is the easternmost of the four GOM coastal subspecies (Figure 3.8.1-1) and currently consists of two disjunct populations: East Crooked Island in Bay County, Florida, and St. Joseph Peninsula in Gulf County, Florida (USFWS 2010a). The current population at East Crooked Island is a result of translocations of beach mice from St. Joseph State Park to Crooked Island (1997–1998). The St. Andrew beach mouse also occurs on private lands to the west of Mexico Beach, Florida (USFWS 2009c). Population estimates reported in

2008 were 3,000 mice at East Crooked Island and 1,775 mice in the front dunes at St. Joseph State Park (USFWS 2009c). Optimal habitat is an undisturbed, intact, and functioning system of unconsolidated marine substrate, beach sand, primary natural sand dunes, and secondary and scrub dunes (USFWS 2009c). Of the estimated 83.3 km (51.8 mi) of current suitable habitat within the historic range of the St. Andrew beach mouse, the beach mouse occupies 44.5 km (27.7 mi) (USFWS 2010a). The critical habitat for the St. Andrew beach mouse encompasses about 1,008 ha (2,490 ac) of coastal dune and scrub habitat in Bay and Gulf Counties, Florida (USFWS 2006a). The critical habitat includes three units: (1) East Crooked Island — 335 ha (826 ac); (2) Palm Point — 65 ha (162 ac); and (3) St. Joseph Peninsula — 608 ha (1,502 ac). The USFWS (2006a) describes and provides maps for these critical habitat units.

Originally the only known occurrence of the Florida salt marsh vole was Waccasassa Bay in Levy County, Florida, where it existed in low numbers. In 2004, several individuals were discovered on the Lower Suwannee National Wildlife Refuge located in southeastern Dixie/northwestern Levy Counties, Florida (Raabe and Gauron 2005). The two locations are only about 8 km (5 mi) apart (USFWS 2008a), resulting in the currently known approximate range shown in Figure 3.8.1-1. The Florida salt marsh vole appears to be most common in areas vegetated by saltgrass (*Distichlis spicata*). Its salt marsh habitat is vulnerable to flooding by hurricanes and extremely high tides (NatureServe 2010a). It probably survives high tides and storm flooding by swimming and climbing vegetation. Due to the very restricted range of the Florida salt marsh vole, catastrophic events could result in its extinction (NatureServe 2010a). Due to its rarity, life history and reproductive behavior of the subspecies are not well studied. However, some aspects are assumed to be similar to the meadow vole — feeding on a variety of plant matter, high reproductive rates with breeding throughout the year, and a lifespan of about 6 months (USFWS 1997). Critical habitat is not designated for the Florida salt marsh vole, primarily because publishing critical habitat maps could increase the chance of illegal collecting or attracting trespass on the lands where it occurs (USFWS 1991a).

Climate Change. GOM coastal habitats will be affected by climate change. Factors associated with climate change that can effect beach mice and the Florida salt marsh vole include alteration in stream flow and river discharges, wetland loss, sea level rise, changes in storm frequency and strength, sediment yield, mass movement frequencies and coastal erosion, and subsidence. The small tidal range of the GOM coast increases the vulnerability of coastal habitats to the effects of climate change. Rising sea levels and changes in the frequency, intensity, timing, and distribution of tropical storms and hurricanes are expected to have substantial impacts on coastal wetland and shoreline patterns and processes (Michener et al. 1997; Scavia et al. 2002). Increases in sea level rise and storm frequency and severity may increase inundation and erosion of beach mice and Florida salt marsh vole habitats. The construction of sea walls or other protective measures to protect coastal habitats from increasing sea levels could potentially impact alternative sites suitable for these species.

3.8.1.2 Alaska – Cook Inlet

3.8.1.2.1 Marine Mammals. The following information describes the life history attributes, distributions, and seasonal movements of 17 marine mammal species that occur in Cook Inlet (Cook Inlet Level III Coastal Ecoregion) or nearby waters of the Gulf of Alaska (Gulf of Alaska Level III Coastal Ecoregion) that could be affected by activities related to lease sales in Cook Inlet (Table 3.8.1-3).[10] (The Level III Ecoregions are described in Section 3.2.4 and are shown in Figure 3.2.2-2.) Nine of these species are threatened or endangered under the ESA.

Threatened and Endangered Marine Mammals.

Cetaceans: Mysticetes. The endangered blue whale (*Balaenoptera musculus*) occurs in Alaska in a narrow area just south of the Aleutian Islands between 160°W and 175°W (Berzin and Rovnin 1966; Rice 1974) and rarely occurs in the far southwestern Bering Sea (Rice 1998). It also occurs north of 50°N extending from southeastern Kodiak Island across the Gulf of Alaska and from southeast Alaska to Vancouver Island (Berzin and Rovnin 1966). Individuals from the eastern North Pacific and western North Pacific blue whale stocks can occur in the Gulf of Alaska during spring and summer after wintering in subtropical and tropical waters (Carretta et al. 2011). The eastern North Pacific blue whale stock occurs in the eastern North Pacific, ranging from the northern Gulf of Alaska to the eastern tropical Pacific. Most winter in the highly productive waters of Baja California, Gulf of California, and on the Costa Rica Dome (Carretta et al. 2011). Blue whales from the central North Pacific stock feed in summer southwest of Kamchatka, south of the Aleutian Islands, and in the Gulf of Alaska. This stock winters in lower latitudes in the western Pacific and less frequently in central Pacific including offshore waters north of Hawaii (Carretta et al. 2011). While the blue whale occurs in south central Alaska, it is not expected to occur within Cook Inlet. Blue whales tend to occur alone or in pairs, but aggregations of 12 or more may develop in prime feeding grounds (Jefferson et al. 2006). Blue whales feed year-round (Carretta et al. 2011). They feed almost exclusively on krill (euphausids) (Pauly et al. 1995; Jefferson et al. 2006; NMFS 2011a). Mating and calving occur in the late fall and winter (Zimmerman and Rehberg 2008). The best estimate of the abundance of the eastern North Pacific blue whale stock is 2,497 with a minimum abundance of 2,046; no abundance estimates are available for the central North Pacific blue whale stock (Carretta et al. 2011).

The endangered fin whale (*Balaenoptera physalus*) ranges worldwide from subtropical to arctic waters, and most sightings occur where deep water approaches the coast (Jefferson et al. 2006). Most fin whales migrate seasonally from relatively low-latitude wintering habitats where breeding and calving occur to high-latitude summer feeding areas (Perry et al. 1999). Northward migration begins in spring with migrating whales entering the Gulf of Alaska from early April through June (MMS 1996b). Their summer distribution extends from central California into the Bering and Chukchi Seas, while their winter range is restricted to the waters off the coast of California. Some fin whales feed in the Gulf of Alaska, including near

[10] A solitary Pacific walrus inhabited the Cook Inlet from the 1980s until its death in 2001 (Little 2001); however, as the occurrence of the Pacific walrus in the Cook Inlet is atypical, the species is not addressed in this section.

TABLE 3.8.1-3 Cook Inlet Marine Mammals

Species	Status[a]
ORDER CETACEA	
Suborder Mysticeti (baleen whales)	
Eubalaena japonica (North Pacific right whale)	E/D
Balaenoptera acutorostrata (minke whale)	–
Balaenoptera borealis (sei whale)	E/D
Balaenoptera musculus (blue whale)	E/D
Balaenoptera physalus (fin whale)	E/D
Eschrichtius robustus (gray whale)	DL/D
Megaptera novaeangliae (humpback whale)	E/D
Suborder Odontoceti (toothed whales and dolphins)	
Physeter macrocephalus (sperm whale)	E/D
Delphinapterus leucas (beluga whale)	E/D
Orcinus orca (killer whale)	D
Lagenorhychus obliquidens (Pacific white-sided dolphin)	–
Ziphius cavirostris (Cuvier's beaked whale)	–
Phocoenoides dalli (Dall's porpoise)	–
Phocoena phocoena (harbor porpoise)	–
ORDER CARNIVORA	
Suborder Pinnipedia (seals, sea lions, and walrus)	
Eumetopias jubatus (Steller sea lion)	E/D, T/D[b]
Phoca vitulina richardsi (harbor seal)	–
Suborder Fissipedia (sea otters and polar bears)	
Enhydra lutris (sea otter)	T

[a] Status: E = endangered under the ESA; T = threatened under the ESA; C = candidate for listing under the ESA; DL = delisted under the ESA; D = depleted under the MMPA (for the killer whale, it only applies to the AT1 group of eastern North Pacific transient killer whales); – = not listed.

[b] The western U.S. stock of Steller sea lion encompasses the range of the Western District Population Segment of the Steller sea lion, which is listed as endangered under the ESA, and the eastern U.S. stock encompasses the range of the Eastern District Population Segment, which is listed as threatened under the ESA.

the entrance to Cook Inlet (NMFS 2003). During the months of July and August, fin whales concentrate in the Bering Sea-eastern Aleutian Island area. In September to October, most fin whales are in the Bering Sea, Gulf of Alaska, and along the U.S. coast as far south as Baja, California (Mizroch et al. 1984; Brueggman et al. 1984). The fin whale feeds on concentrations of zooplankton (e.g., krill), fishes, and cephalopods (Pauly et al. 1995; Jefferson et al. 2006). A provisional estimate for the fin whale population west of the Kenai Peninsula is 5,700 animals (Allen and Angliss 2011).

The endangered humpback whale (*Megaptera novaeanglia*) occurs worldwide in all ocean basins, feeding in higher latitudes during spring, summer, and autumn, and migrating to a winter range over shallow tropical and subtropical banks, where they calve and presumably breed (Jefferson et al. 2006). Members of the Western North Pacific and Central North Pacific stocks occur in Alaskan waters. They migrate from winter breeding grounds near Japan, Hawaii, or Mexico to summer feeding grounds from Washington to as far north as the Chukchi Sea (Zimmerman and Karpovich 2008). The observation of some individuals in the Beaufort Sea east of Barrow suggests a northward expansion of their feeding grounds (Zimmerman and Karpovich 2008; Hashagen et al. 2009). In the Gulf of Alaska, areas with concentrations of humpback whales include the Portlock and Albatross Banks and west to the eastern Aleutian Islands, Prince William Sound, and the inland waters of southeastern Alaska (Berzin and Rovnin 1966). Current data demonstrate that the Bering Sea remains an important feeding area. Humpback whales usually occur alone or in groups of two or three, although larger aggregations occur in breeding and feeding areas (Jefferson et al. 2006). Humpback whales feed on concentrations of zooplankton (e.g., krill) and fishes using a variety of techniques that concentrate prey for easier feeding (Winn and Reichley 1985; Pauly et al. 1995; Jefferson et al. 2006). Feeding rarely occurs while migrating or during winter while in tropical waters (Zimmerman and Karpovich 2008). The best population estimate for the Western North Pacific stock is 938 whales with a minimum population estimate of 732 individuals; the best population estimate for the Central North Pacific stock is 7,469 whales with a minimum population estimate of 5,833 individuals (Allen and Angliss 2011). It is currently unknown whether the humpbacks observed in the southeastern Chukchi Sea and in the Beaufort Sea are part of the Western or Central stock.

The endangered North Pacific right whale (*Eubalaena japonica*) historically ranged across the entire North Pacific north of 35°N and occasionally as far south as 20°N before commercial whaling reduced their numbers. Today, distribution and migratory patterns of the North Pacific stock are largely unknown. The whales in the North Pacific population summer in their high-latitude calanoid copepod and euphausid crustacean feeding grounds, and migrate to more temperate, possibly offshore, waters during the winter (Braham and Rice 1984; Scarff 1986; Allen and Angliss 2011). North Atlantic and Southern Hemisphere right whales calve in coastal waters during the winter, but locations of calving grounds in the eastern North Pacific are not known (Scarff 1986). Right whales remain in the southeastern Bering Sea from May through December (Allen and Angliss 2011).

There is evidence of North Pacific right whale occurrence in the Gulf of Alaska and Bering Sea (Mellinger et al. 2004). Recent sightings have been concentrated in the western outer Bristol Bay area, midway on a line between Unimak Island and Kuskokwim Bay, and this area may be an important feeding area for the few remaining North Pacific right whales (Shelden et al. 2005). More recent sightings of North Pacific right whales in the eastern Bering Sea during the summer are the first reliable observations in decades (Goddard and Rugh 1998; Moore et al. 2000b; Tynan et al. 2001; Wade et al. 2011). These sightings include the first few calves documented in the eastern North Pacific in over a century (Goddard and Rugh 1998; LeDuc et al. 2001; Brownell et al. 2001; Wade et al. 2011). These sightings suggest that the abundance in the eastern North Pacific is possibly in the tens of animals. North Pacific right whales remain the most highly endangered marine mammal in the world. Little is known regarding the migratory behavior, life history characteristics, and habitat requirements of this species. The basic life history parameters and census data (including population abundance, growth rate, age structure, breeding ages, gender ratios, and distribution) remain undetermined. Given that the population is extremely small and little current information is available, recovery is not anticipated in the foreseeable future (e.g., several decades or longer).

Based on available evidence, the NMFS revised the species' critical habitat on July 6, 2006 (71 FR 38277) to include one area in the Gulf of Alaska and one in the Bering Sea. For more information on North Pacific right whales, see http://www.fakr.noaa.gov/protectedresources/whales/nright/default.htm. NMFS (2006) reported the largest number of eastern North Pacific right whales identified in the Bering Sea to be 23 individuals. The minimum estimate of abundance is 17 individuals (Allen and Angliss 2011).

The endangered sei whale (*Balaenoptera borealis*) is an oceanic species that occurs in tropical to polar waters, being more common in the mid-latitude temperate zones. It seldom occurs close to shore (Jefferson et al. 2006). They inhabit deepwater areas of the open ocean, most commonly over the continental slope (Carretta et al. 2011; Reeves et al. 1998). Sei whales migrate to lower latitudes for breeding and calving in the winter and to higher latitudes in summer for feeding (Kawamura 1980), including the Gulf of Alaska and along the Aleutian Islands and the southern Bering Sea (Reeves et al. 1998). The highest number of sightings south of the Aleutian Islands is off of the eastern Kamchatka Peninsula to the Commander Islands (Nasu 1963). Sei whales begin their southward migration in August or September. Groups of 2 to 5 individuals are commonly observed, but loose aggregations of 30 to 50 occasionally do occur (Jefferson et al. 2006; NMFS 2011a). Sei whales feed on concentrations of zooplankton (e.g., krill and copepods), fishes, and cephalopods (Pauly et al. 1995). Sei whales observed in Alaska are members of either the Eastern North Pacific stock and/or the Hawaiian stock. The abundance of the Eastern North Pacific stock is estimated at 126 individuals with a minimum estimate of 83 whales; while abundance estimates for the Hawaiian stock are 77 with a minimum abundance of 37 (Caretta et al. 2011).

Cetaceans: Odontocetes. The NMFS recognizes five stocks of beluga whales (*Delphinapterus leucas*) in U.S. waters: (1) Cook Inlet, (2) Bristol Bay, (3) eastern Bering Sea, (4) eastern Chukchi Sea, and (5) Beaufort Sea (Allen and Angliss 2011). There are no physical barriers among these stocks, but genetic data indicates that the stocks do not interbreed (Citta and Lowry 2008). The Cook Inlet stock was listed as an endangered distinct population segment (DPS) under the ESA in 2008 (NMFS 2008a). The beluga whales that inhabit Yakutat Bay (fewer than 20 individuals) are included as part of the Cook Inlet stock but are not considered part of the Cook Inlet DPS (Allen and Angliss 2011).

The beluga whale occurs throughout seasonally ice-covered arctic and subarctic waters of the Northern Hemisphere (Stewart and Stewart 1989) and is closely associated with open leads and polynyas in ice-covered regions (Hazard 1988). Depending on season and region, beluga whales may occur in both offshore and coastal waters. Ice cover, tidal conditions, access to prey, temperature, and human interaction affect seasonal distribution (Allen and Angliss 2011). During the winter, beluga whales generally occur in offshore waters associated with ice packs, and in the spring, many migrate to warmer coastal estuaries, bays, and rivers for molting and calving (Sergeant and Brodie 1969). Breeding occurs in March or April, with calves born the following May through July, usually when herds are at or near summer concentration areas (Citta and Lowry 2008). Beluga whales shed their skin (molt) yearly in July in shallow water, often where there is coarse gravel to rub against (Citta and Lowry 2008).

The Cook Inlet stock occurs near river mouths in the northern Cook Inlet during the spring and summer months and in mid-Inlet waters in the winter; evidence indicates that the stock remains in Cook Inlet throughout the year (Allen and Angliss 2011; NMFS 2008a). Based on surveys conducted in the Gulf of Alaska between 1936 and 2000, a few belugas occur in the Gulf of Alaska outside of Cook Inlet. Those belugas are considered part of the Cook Inlet stock (Laidre et al. 2000).

The NMFS (2011b) designated 7,800 km^2 (3,013 mi^2) of critical habitat for the Cook Inlet DPS of beluga whales on April 11, 2011 (Figure 3.8.1-2). Critical Habitat Area 1 and Critical Habitat Area 2 are respectively equivalent to the Type 1 and 2 habitats identified in the conservation plan for the Cook Inlet beluga whale (NMFS 2008a). Critical Habitat Area 1, encompassing1,909 km^2 (738 mi^2), occurs in the upper portion of Cook Inlet that contains a number of shallow tidal flats, river mouths, and estuarine areas that are important for foraging, calving, molting, and escaping predators. This area, considered the most valuable habitat type for Cook Inlet belugas, contains the highest concentrations of belugas from spring through fall (NMFS 2008a, 2011b). Critical Habitat Area 2, encompassing 5,891 km^2 (2,275 mi^2), is used less during spring and fall, but is known to be used in fall and winter. Dispersed fall and winter feeding and transit areas occur in this critical habitat area, which includes near and offshore areas of the mid- and upper Inlet and nearshore areas of the lower Inlet (Figure 3.8.1-2). The deeper dives made by Cook Inlet beluga whales in this area of critical habitat suggest that the area is an important fall and winter feeding area that may be important to the winter survival and recovery of Cook Inlet beluga whales (NMFS 2008a, 2011b).

Two fish species especially fed upon by Cook Inlet beluga whales are king (Chinook) salmon and Pacific eulachon. Other items prominent in their diet are Pacific salmon, cod, walleye pollock, yellowfin sole, and other fishes and invertebrates (NMFS 2011b). In spring, the belugas feed on eulachon, gadids (cod and pollock), anadromous steelhead trout, and freshwater fishes. During summer, belugas prey on the Pacific salmon species that spawn in the rivers throughout Cook Inlet. In the fall, they feed on the various fish species that occur in nearshore bays and estuaries. Stomach samples for Cook Inlet belugas during winter are not available, but the belugas probably prey on deeper water prey such as flatfish, sculpin, and pollock (NMFS 2008a).

During 1978 to 1979, 95% of the Cook Inlet beluga whale range occupied 7,226 km^2 (2,790 mi^2) of Cook Inlet (Rugh et al. 2010). The Cook Inlet beluga whale stock was estimated at 1,300 animals in 1979 (NMFS 2008a). By 1994, the stock numbered 653 whales and declined to 347 whales by 1998. Subsistence hunting and interactions with fishing gear appear to be the major factors leading to abundance declines (Laidre et al. 2000). The Cook Inlet stock has continued to decline by 1.45% per year from 1999 to 2008 (Allen and Angliss 2011). Between 1998 and 2008, 95% of the beluga whale range in Cook Inlet was 2,806 km^2 (1,083 mi^2). Most areas occupied are in the upper portions of Cook Inlet (Rugh et al. 2010). The current best

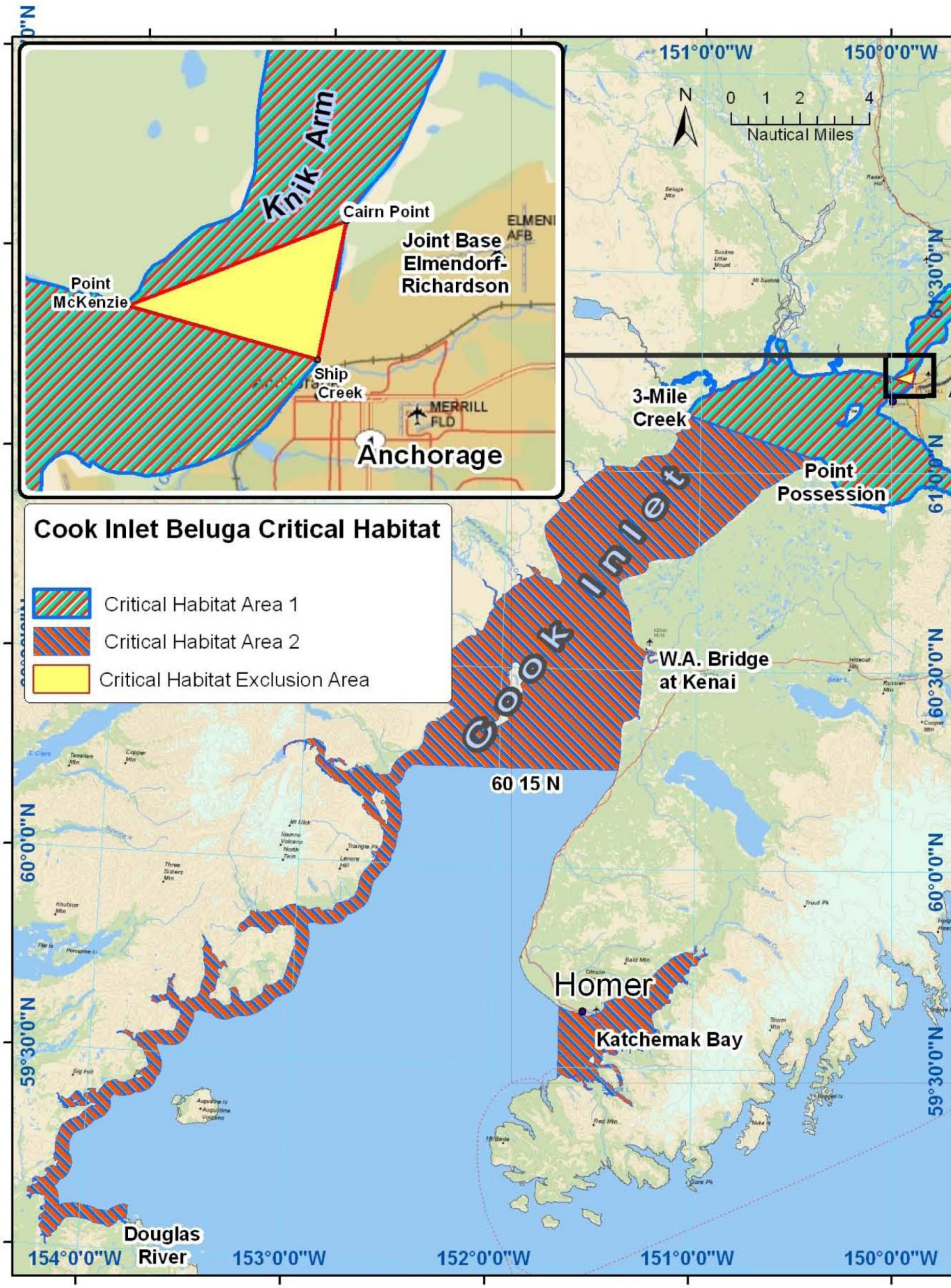

FIGURE 3.8.1-2 Critical Habitat for the Cook Inlet Beluga Whale DPS

population estimate for the Cook Inlet stock is 355 with a minimum estimate of 326 (Allen and Angliss 2011). A healthy population level for the Cook Inlet beluga whale stock should be at least 780 individuals (NMFS 2008a).

The endangered sperm whale (*Physeter macrocephalus*) occurs worldwide in deep waters from the tropics to the pack-ice edges, although generally only large males venture to the extreme northern and southern portions of the species' range (Jefferson et al. 2006). Sperm whales tend to inhabit areas with water depths of 600 m (1,970 ft) or more and are uncommon at depths shallower than 300 m (984 ft) (NMFS 2011a). However, they do come close to shore where submarine canyons or other geophysical features bring deep water near the coast (Jefferson et al. 2006). In Alaska, their northernmost boundary extends from Cape Navarin (62°N) to the Pribilof Islands, with whales more commonly found in the Gulf of Alaska and along the Aleutian Islands (Omura 1955; Allen and Angliss 2011). The shallow continental shelf may prevent their movement into the northeastern Bering Sea and Arctic Ocean (Rice 1989). Females and young sperm whales usually remain in tropical and temperate waters year-round, while males move north to feed in the Gulf of Alaska, Bering Sea, and waters around the Aleutian Islands (Gosho et al. 1984; Allen and Angliss 2011). Seasonal movement of sperm whales in the North Pacific is not well-defined, but they typically occur south of 40°N during the winter (Gosho et al. 1984). Males move north in the spring and summer to feed in the Gulf of Alaska, Bering Sea, and waters around the Aleutian Islands (Berzin and Rovnin 1966). Fall migrations begin in September and most whales have left Alaskan waters by December (MMS 1996b), returning to temperate and tropical portions of their range, typically south of 40°N, in the fall (Gosho et al. 1984; Allen and Angliss 2011). Breeding occurs during the spring and early summer (April through August). Sperm whales are present year-round in the Gulf of Alaska, but are apparently more abundant in summer than in winter (Mellinger et al. 2004). Sperm whales commonly occur in medium to large groups of up to 50 individuals (Jefferson et al. 2006). Sperm whales prey on cephalopods, fishes, and benthic invertebrates (Pauly et al. 1995; Jefferson et al. 2006). The number of sperm whales occurring in Alaska waters is unknown. More than 100,000 sperm whales were estimated to occur in the western North Pacific in the late 1990s (Allen and Angliss 2011).

Pinnipeds. The Steller sea lion (*Eumetopias jubatus*) in Alaska is comprised of an eastern U.S. stock, which includes animals east of Cape Suckling, Alaska (144°W), and a western U.S. stock, including animals at and west of Cape Suckling (Loughlin 1997). The eastern stock encompasses the range of the Eastern Distinct Population Segment of the Steller sea lion that is listed as threatened under the ESA, while the western stock encompasses the range of the Western Distinct Population Segment that is listed as endangered under the ESA (NOAA 2011a). The centers of abundance and distribution of the Steller sea lion are located in the Gulf of Alaska and the Aleutian Islands. Individuals from only the western stock inhabit areas of south central Alaska could be affected by oil and gas activities in the Cook Inlet Planning Area. The Steller sea lion is not known to migrate, but individuals disperse widely outside of the breeding season (late May to early July). At sea, Steller sea lions commonly occur near the 200-m (660-ft) depth contour, but individuals occur from nearshore to well beyond the continental shelf (Kajimura and Loughlin 1988). Some individuals may enter rivers in pursuit of prey (NMFS 2008b). Steller sea lions eat a variety of fishes and cephalopods and occasionally birds and seals (Zimmerman and Rehberg 2008). Older juveniles can dive to depths of 500 m

(1,500 ft) and can stay underwater for more than 16 minutes (Zimmerman and Rehberg 2008). However, dive depths of juveniles generally do not exceed 20 m (66 ft), while adults will dive to depths greater than 250 m (820 ft) (NMFS 1993).

Thirty-eight Steller sea lion rookeries and hundreds of haulouts occur within the range of the western stock of the Steller sea lion (Allen and Angliss 2011; NMFS 2008b). The locations of the rookeries and haulouts change little from year to year (NMFS 1993). Breeding and pupping occur on rookeries; rookeries normally occur on relatively remote islands, rocks, reefs, and beaches, where access by terrestrial predators is limited. Rookeries are normally occupied from late May through early July (NMFS 1993). Haulouts are areas used for rest and refuge by all sea lions during the non-breeding season and by non-breeding adults and subadults during the breeding season. Some rookeries are used as haulouts after the breeding season is over. In addition to rocks, reefs, and beaches normally used as haulouts, sea lions may also use sea ice and manmade structures such as breakwaters, navigational aids, and floating docks (NMFS 1993). Sea lion critical habitat includes a 32 nautical km (20 nautical mi) buffer around all major haulouts and rookeries, as well as associated terrestrial, air, and aquatic zones. Special foraging areas in Alaska have also been designated critical habitat for Steller sea lions including the Shelikof Strait area of the Gulf of Alaska, the Bogoslof area in the Bering Sea shelf, and the Seguam Pass area in the central Aleutian Islands (NMFS 1993). Figure 3.8.1-3 shows the Steller sea lion critical habitat in the area of Cook Inlet Planning Area. The minimum population estimate for the Steller sea lion western stock is 42,366 (Allen and Angliss 2011). The abundance of the western stock is stable or slightly decreasing (NMFS 2008b).

Fissipeds. The sea otter (*Enhydra lutris*) inhabits shallow water areas along the shores of the North Pacific. Three stocks of the sea otter occur in Alaskan waters: (1) Southwest Alaska, extending from the Kodiak Archipelago southwest through the Alaska Peninsula to the Aleutian Islands; (2) south central Alaska, between Cape Yukataga and the east coast of Cook Inlet and including the eastern side of Cook Inlet; and (3) Southeast Alaska, extending from the U.S./Canadian border to Cape Yukataga (Gorbics and Bodkin 2001). Individuals from both the south central and southwest Alaska stocks occur in south central Alaska where they could be affected by oil and gas activities in the Cook Inlet Planning Area. The Southwest Alaska stock has declined dramatically over the past several decades, probably due to predation by killer whales (Schneider and Ballachey 2008), causing the USFWS to list that stock as a threatened DPS under the ESA (USFWS 2006b).

Five units totaling 15,164 km^2 (5,855 mi^2) are designated as critical habitat for the Southwest Alaska DPS (USFWS 2009d). Unit 5 (Kodiak, Kamishak, Alaska Peninsula), containing 6,755 km^2 (2,607 mi^2) of critical habitat (USFWS 2009d), is the most likely of the sea otter critical habitat units to be affected by activities related to lease sales in Cook Inlet. This unit ranges from Castle Cape in the west to Tuxedni Bay in the east, and includes the Kodiak Archipelago (USFWS 2009d). The unit includes the nearshore marine environment ranging from the mean high tide to the 20-m (66-ft) depth contour as well as waters occurring within 100 m (330 ft) of the mean high tide line (USFWS 2009d). The lower western half of Cook Inlet to Redoubt Point is included in Unit 5 of the critical habitat (USFWS 2009d).

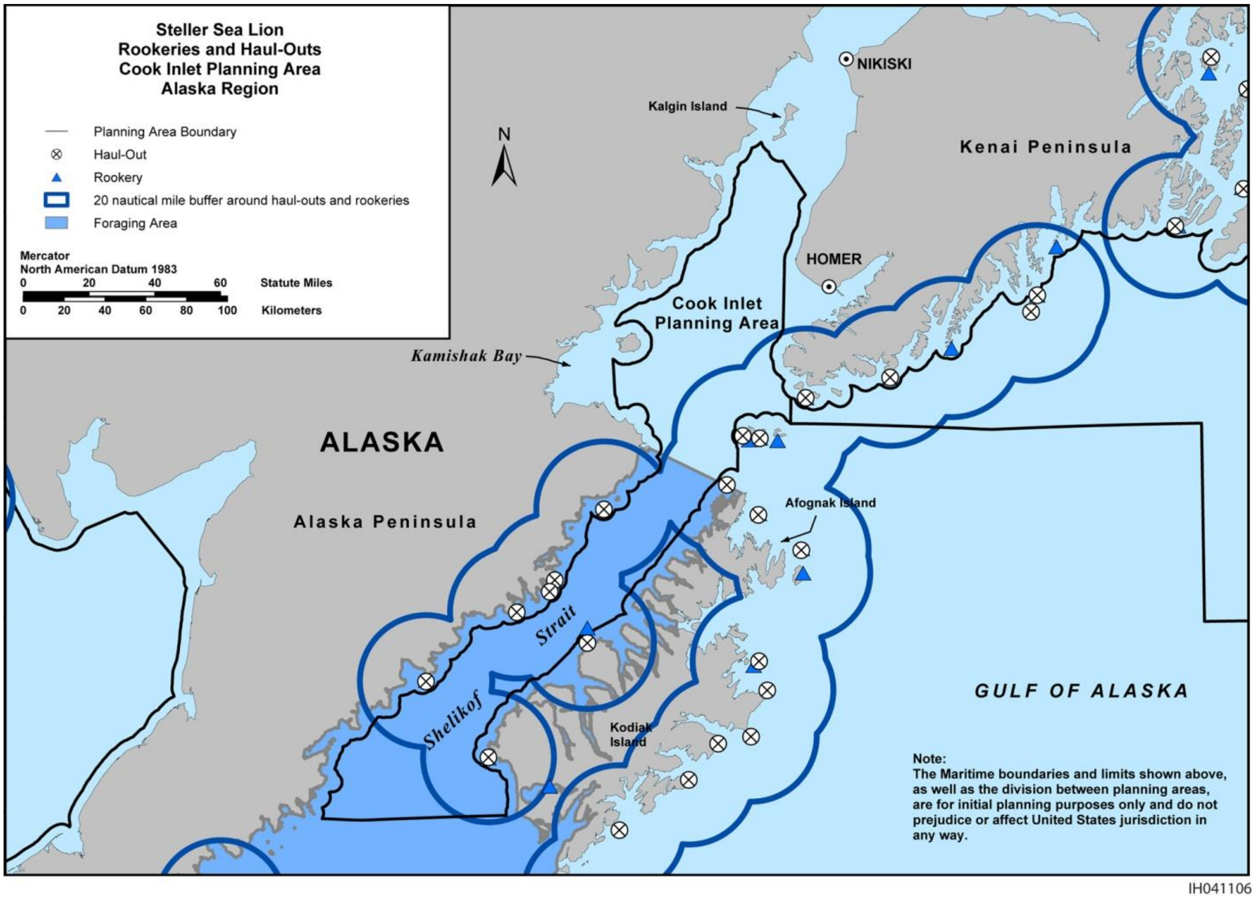

FIGURE 3.8.1-3 Steller Sea Lion Critical Habitat in the Area of the Cook Inlet Planning Area (note: the figure is in the process of being prepared/modified)

The sea otter inhabits coastal waters less than 90 m (295 ft) deep, with the highest densities usually found within the 40-m (130-ft) isobath where young animals and females with pups forage. Preferred habitat includes rocky reefs, offshore rocks, and kelp beds. Sea otters in Alaska are not migratory and, while capable of movements over 100 km (60 mi), generally do not disperse over long distances (Allen and Angliss 2011). They will sometimes rest in groups of fewer than 10 to more than 1,000 individuals. Sea otters seldom come onshore, and when they do, they are seldom more than a few meters from water (Schneider and Ballachey 2008).

Sea otters prey on a great variety of mostly benthic food sources including sea urchins, clams, mussels, snails, abalone, crabs, scallops, chitons, limpets, octopus, and fin fish (Estes et al. 1981; Garshelis et al. 1986; Riedman and Estes 1990; Green and Brueggeman 1991; Kvitek et al. 1993). They dive to depths of 1.5 to 76 m (5 to 250 ft). A dive usually lasts 1 to 1.5 minutes, but can last 5 minutes or more (Schneider and Ballachey 2008). The recovery and expansion of the sea otter populations in Prince William Sound and in Southeast Alaska, coupled with the otter's preference for crab and clam species that are of commercial interest (such as Dungeness crab and butter clam) (Garshelis et al. 1986; Kvitek et al. 1993), has resulted in competition and conflict with commercial-fishing interests (Garshelis and Garshelis 1984; Pitcher 1989).

Among marine mammals, sea otters probably have one of the higher reproductive rates and a potential for fairly rapid population recovery (such as 17–20% per year [Riedman et al. 1994]) after substantial losses due to natural or manmade causes (such as overharvest or an oil spill). Female sea otters can reach sexual maturity at 2 yr of age (30%), with all females mature at 5 yr of age (Bodkin et al. 1993). With a gestation period of about 6 months and a pup dependency of 6 months, most sexually mature female sea otters (85–90%) are able to pup in a given year (Jameson and Johnson 1993). Post-weaning survival can range from 18 to 86%, and survival of sea otters more than 2 yr of age can approach or exceed 90%. Females can live up to 22 yr and males up to 15 yr (USFWS 2010).

The current estimate for the Southwest Alaska stock is 47,676 sea otters, with a minimum population estimate of 38,703, while the current estimate for the Southcentral Alaska stock is 15,090 sea otters, with a minimum population estimate of 13,955. Of these, 2,673 sea otters occur in Cook Inlet/Kenai Fiords (Allen and Angliss 2011). The south central Alaska stock population trend is stable, while the Southwest Alaska stock is declining (Allen and Angliss 2011). The cause of the population decline is not known for sure, but weight of evidence indicates that increased predation by killer whales as the most likely cause. The most important threats to recovery of the population are predation and oil spills; other threats to recovery include subsistence harvest, illegal take, and infectious disease (USFWS 2010).

Non-ESA-Listed Marine Mammals.

Cetaceans: Mysticetes. The Eastern North Pacific population of the gray whale (*Eschrichtius robustus*) was delisted from the ESA in 1994 (USFWS 1994). The Eastern North Pacific stock (which encompasses this population) winters primarily along the west coast of Baja California where calving occurs from January to mid-February (Rice et al. 1981). The northward migration, which occurs in nearshore waters, begins in mid-February and continues through May (Rice et al. 1981). Gray whales arrive for their feeding season in the Gulf of Alaska in late March and April (at which time some individuals may occur close to Cook Inlet), the northern Bering Sea (Cherikov Basin located west and north of the Norton Basin) in May or June, and the Chukchi and Beaufort Seas in July or August (Rice and Wolman 1971; Consiglieri et al. 1982). They migrate out of the Chukchi and Beaufort Seas at freezeup and out of the Bering Sea during November to December (Rugh and Braham 1979). Breeding occurs during their southward migration to the Gulf of California and Baja. In recent years, gray whales have begun to delay their southbound migration, are expanding their feeding range along the migration route and northward to arctic waters, and some even remain in polar waters over winter (Moore 2008).

Gray whales usually live in small groups of about three whales, although groups up to 18 whales occur (Frost and Karpovich 2008). Gray whales feed primarily on benthic amphipods in the northern Bering, Chukchi, and western Beaufort Seas. Shallow coastal areas and offshore shoals in the Chukchi and western Beaufort Seas also provide rich feeding habitat (Rugh et al. 1999). Gray whales seldom feed while migrating or during winters in tropical waters (Frost and Karpovich 2008). In summer, gray whales select coastal/shoal waters and open waters, while in autumn they select coastal and shoal/trough habitats in light ice and open water (Moore et al. 2000a). They generally occur closer to shore than other large whale species (Shell Offshore, Inc. 2005). The abundance estimate for the Eastern North Pacific gray whale stock is 19,126 with a minimum estimate of 18,017 individuals. The population of this stock has been increasing over the past several decades (Allen and Angliss 2011).

The minke whale (*Balaenoptera acutorostrata*) occurs from the Bering and Chukchi Seas south to near the equator with apparent concentrations of whales near Kodiak Island (Allen and Angliss 2011; Rice and Wolman 1982). In spring, most minke whales are found over the continental shelf and prefer shallow coastal waters. In Alaska, minke whales are most abundant in the Gulf of Alaska during summer for feeding but become scarce in the fall, with most whales leaving by October (Consiglieri et al. 1982). Only a few whales have been reported in the northeastern Gulf of Alaska (offshore the Icy Bay area) and in southeastern Alaska (Sitka area) during winter. Breeding occurs year-round in the Pacific. The minke whale usually occurs alone or in groups of only two to three whales, although loose aggregations of up to 400 can occur in feeding areas at higher latitudes (NMFS 2011a). The minke whale preys on a variety of large zooplankton (e.g., krill and copepods) and small schooling fishes (Pauly et al. 1995; Jefferson et al. 2006). No estimates are available for the number of minke whales in the entire North Pacific. The provisional estimate for the number of minke whales in central-eastern and southeastern Bering Sea is 810 and 1,003, respectively (Allen and Angliss 2011). There are no data on the trends of minke whale abundance in Alaska (Allen and Angliss 2011).

Cetaceans: Odontocetes. The Cuvier’s beaked whale (*Ziphius cavirostris*) is the most widespread of the beaked whales, occurring in all oceans and most seas except in the high polar waters (Moore 1963). Its distribution in the northeastern Pacific ranges from Baja California to the northern Gulf of Alaska, Aleutian Islands, and Commander Islands (Rice 1986, 1988). Although the Cuvier’s beaked whale occurs in south central Alaska, individuals do not apparently enter Cook Inlet (Allen and Angliss 2011). The Cuvier’s beaked whale prefers waters of the continental slope and edge and steep underwater geologic features such as banks, seamounts, and submarine canyons where depths are greater than 1,000 m (3,000 ft) (NMFS 2011a). Within its range, the Cuvier’s beaked whale mostly occurs alone or in small groups up to 12 individuals, although groups up to 25 have been reported (NMFS 2011a). It dives to depths of at least 1,000 m (3,000 ft) that last 20 to 40 minutes (NMFS 2011a). Its diet consists of squid, fishes, and crustaceans (Pauly et al. 1995; Jefferson et al. 2006). Cuvier’s beaked whale strandings indicate that it is the most widespread beaked whale and not as rare as originally thought (Moore 1963; Heyning 1989; Culik 2010; Allen and Angliss 2011). Information on population abundance or trends for the Alaska stock of the Cuvier’s beaked whale is not available (Allen and Angliss 2011).

The Dall’s porpoise (*Phocoenoides dalli*) is present year-round throughout its entire range in the northeast Pacific, from Baja California, Mexico, to the Bering Sea in Alaska. However, within its range, the Dall’s purpose does not occur in the upper Cook Inlet or in the shallow eastern flats of the Bering Sea (Allen and Angliss 2011). Dall’s porpoise generally occurs over the continental shelf adjacent to the slope and over oceanic waters greater than 2,500 m (8,200 ft) deep (Allen and Angliss 2011). It also occurs closer to shore in narrow channels and fjords that have clear, relatively deep water (Culik 2010). The Dall’s porpoise usually travels in groups of 2 to 20 animals, but occasionally occurs in loosely associated groups of hundreds to thousands of animals (NMFS 2011a). They also occasionally occur with other marine mammals, especially the Pacific white-sided dolphin (*Lagenorhychus olbiquidens*) (Jefferson 1988). Dall's porpoises routinely feed at depths of 500 m (1,640 ft) or more, primarily on squid and small schooling fishes (Culik 2010; Jefferson 1988). Based on survey data over 8 yr old,[11] the best estimate of the abundance of the Alaska stock is 83,400 individuals with a minimum population estimate of 76,874 (Allen and Angliss 2011).

The harbor porpoise (*Phocoena phocoena*), in the Eastern North Pacific Ocean, ranges from Point Barrow, along the Alaska coast, and down the west coast of North America to Point Conception, California (Gaskin 1984). They generally occur in harbors, bays, and river mouths but may also be concentrated in and along turbid river water plumes such as the Copper River and Icy Bay areas. In the Gulf of Alaska and southeast Alaska, the harbor porpoise frequents waters less than 100 m (330 ft) in depth, with high densities of animals occurring in Glacier Bay, Yakutat Bay, Copper River Delta, and Sitkalidak Strait (Dahlheim et al. 2000). Activities associated with lease sales in Cook Inlet could potentially affect harbor porpoise individuals in the Gulf of Alaska stock. This stock includes individuals occurring from Cape Suckling to Unimak Pass (Allen and Angliss 2011). Harbor porpoises usually occur in groups smaller than 8 individuals, although they will aggregate into groups of 50 to several hundred during feeding or migration (Culik 2010). Harbor porpoises consume a wide variety of fishes and cephalopods, apparently preferring non-spiny schooling fish such as herring, mackerel, and pollock (Leatherwood and Reeves 1987). Based on survey data over 11 yr old, the population estimate for the Gulf of Alaska harbor porpoise stock is 31,046 with a minimum estimate of 25,987 (Allen and Angliss 2011).

The killer whale (*Orcinus orca*) occurs along the entire Alaskan coast within the Beaufort Sea, Chukchi Sea, Bering Sea, Aleutian Islands, Gulf of Alaska, Prince William Sound, Kenai Fjords, and southeastern Alaska. NMFS recognizes several stocks of killer whales in Alaskan waters: (1) the Eastern North Pacific Northern Resident stock, occurring from British Columbia through part of southeastern Alaska; (2) the Eastern North Pacific Alaska Resident stock, occurring from southeastern Alaska to the Aleutian Islands and the Bering Sea; (3) the Eastern North Pacific Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock, occurring mainly from Prince William Sound through the Aleutian Islands and the Bering Sea; (4) the AT1 Transient stock, occurring in Alaska from Prince William Sound through the Kenai Fjords; (5) the West Coast Transient stock, occurring from California through southeastern Alaska; and (6) the Eastern North Pacific Offshore stock, occurring from California through Alaska (Allen and Angliss 2011). Oil and gas activities in the Cook Inlet Planning Area could potentially

[11] The NMFS has a policy to use data less than 8 years old for the purposes of calculating the potential biological removal, which is defined by the MMPA as the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population. The potential biological removal level is the product of the following factors:

- The minimum population estimate of the stock;
- One-half the maximum theoretical or estimated net productivity rate of the stock at a small population size; and
- A recovery factor of between 0.1 and 1.0.

affect killer whales from the Eastern North Pacific Alaska Resident stock and the Eastern North Pacific Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock. Killer whales are relatively common in lower Cook Inlet but are somewhat infrequent in the upper Cook Inlet (Shelden et al. 2003).

Killer whales are top-level predators that feed on marine mammals, marine birds, sea turtles, fishes, and cephalopods (Pauly et al. 1995; Jefferson et al. 2006). The resident stocks mainly feed on salmonids, whereas the transient stocks tend to feed on marine mammals (NMFS 2011a). In spring, killer whales occur throughout the Gulf of Alaska in shallow waters less than 200 m (660 ft) deep (Braham and Dahlheim 1982). In summer, they concentrate in Prince William Sound, the Kodiak Island area, and the nearshore waters of southeastern Alaska. The inshore migration of prey partly accounts for movement of killer whales to nearshore waters, especially in summer and fall (Balcomb et al. 1980; Heimlich-Boran 1988). In fall and winter, killer whales are numerous around Kodiak Island and adjacent shelf waters but not elsewhere in the Gulf of Alaska (Consiglieri et al. 1982). The peak breeding period of killer whales is May through July (Consiglieri et al. 1982).

Killer whale group or pod size varies from 1 to 100 (Braham and Dahlheim 1982). Most pods in Alaska have fewer than 40 individuals (Zimmerman and Small 2008). Transient killer whale pods move over broader ranges of territory than do resident pods and prefer to feed on other marine mammals, such as seals, porpoises, and baleen whales (Heimlich-Boran 1988; Barr and Barr 1972; Hancock 1965). The minimum size of the Eastern North Pacific Alaska Resident stock is 2,084 individuals, while the minimum size of the Gulf of Alaska, Aleutian Island, and Bering Sea Transient stock is 552 individuals (Allen and Angliss 2011).

The Pacific white-sided dolphin occurs in the Eastern North Pacific from the southern Gulf of California, north to the Gulf of Alaska and west to Amchitka in the Aleutian Islands. They rarely occur in the southern Bering Sea (Allen and Angliss 2011). This dolphin species generally occurs offshore over the continental slope in waters from 200 to 2,000 m (660 to 6,600 ft) deep (Stacey and Baird 1991; Consiglieri et al. 1982). Individuals do enter the inshore passes of Alaska (Stacey and Baird 1991; Consiglieri et al. 1982; Ferrero and Walker 1996). In the Gulf of Alaska, occurrences of the Pacific white-sided dolphins vary seasonally, in that they are rarely present in winter, become increasingly abundant in spring, and are most abundant in the summer when fish abundance is highest (Consiglieri et al. 1982). They commonly occur in groups of several hundred individuals, and groups of more than 1,000 individuals have been sighted (Leatherwood and Reeves 1987). Pacific white-sided dolphins feed on squid and fish (Pauly et al. 1995). There are no reliable population estimates for the North Pacific stock of the Pacific white-sided dolphin because abundance estimates are over 8 yr old. The estimated minimum population abundance in the early 1990s was 26,880 individuals (Allen and Angliss 2011).

Carnivores: Pinnipeds. The harbor seal (*Phoca vitulinea richardsi*) is distributed along the southeast Alaska coastline west through the Gulf of Alaska and Aleutian Islands, and into the Bering Sea north to Cape Newenham and the Pribilof Islands (Allen and Angliss 2011). Among the three stocks of harbor seals that occur in Alaska, the Gulf of Alaska stock could be affected by oil and gas activities in the Cook Inlet Planning Area. The Gulf of Alaska stock occurs from

Cape Suckling to Unimak Pass, including animals that occur throughout the Aleutian Islands (Allen and Angliss 2011). Harbor seals are nonmigratory with local movements associated with tides, weather, season, food availability, and reproduction (Scheffer and Slipp 1944; Fisher 1952; Bigg 1969, 1981). Harbor seals occupy a wide variety of habitats in fresh and saltwater and along protected and exposed coastlines. They prefer to haul out on gently sloping or tidally exposed habitats including reefs, offshore rocks and islets, mud and sandbars, sand and gravel beaches, and floating and shorefast ice (Calambokidis et al. 1987; Bigg 1981; Allen and Angliss 2011). In Cook Inlet, harbor seals haul out near available prey and in areas that avoid high anthropogenic disturbance. They also select sites of rock substrate and those near deep water (Montgomery et al. 2007). Typically, an individual in a given area uses one or two haulout sites. Breeding occurs generally in late spring through fall. Females aggregate on glacial fjords to give birth between May and mid-July (Kinkhart et al. 2008). Important pupping areas occur within Icy and Yakutat Bays and Kodiak Island (Loughlin et al. 1994). Most dives are less than 20 m (65 ft) deep and last less than 4 minutes, although dives can occur to depths of 500 m (1,640 ft) and last up to 20 minutes (Kinkhart et al. 2008). In Cook Inlet, harbor seal abundance increases with proximity to bathymetric depths of 20 m (66 ft) (Montgomery et al. 2007). Harbor seals are opportunistic feeders. Their diet varies with season and location; they primarily feed on fish, cephalopods, molluscs, and crustaceans (Pitcher and Calkins 1979; Pauly et al. 1995). Feeding occurs in marine, estuarine, and occasionally fresh waters (Allen and Angliss 2011). The current estimate of the Gulf of Alaska stock is 45,975 with a minimum population estimate of 44,453 (Allen and Angliss 2011).

Climate Change. A major concern regarding marine mammals in Arctic and subarctic regions is the potential for climate change and associated changes in the extent of sea ice. Climate change will primarily affect marine mammals from loss of habitat, changes in prey availability, and potentially increased expansion of other species that are likely to cause competitive pressure on some species, as well as putting them at greater risk of predation, disease, and parasitic infections (Alter et al. 2010; Kovacs et al. 2011). Alteration of sea ice and increasing human presence and activities will cause extensive redistribution of mobile species, disappearance of non-mobile species throughout portions of their range, and possible species extinctions (Ragen et al. 2008). The Cook Inlet beluga whale is the marine mammal species most likely to be effected by climate change. However, it is not possible at this time to identify the likelihood, direction, or magnitude of climate change on the marine mammals of Cook Inlet. The current state of climate change and its impacts on marine mammals would need to be considered in any subsequent environmental reviews for lease sales or other OCS-related activities.

3.8.1.2.2 Terrestrial Mammals. Approximately 40 species of terrestrial mammals occur in south central Alaska, including the American bison (*Bison bison*), American black bear (*Ursus americanus*), brown bear (*Ursus arctos;* also commonly known as the grizzly bear), caribou (*Rangifer tarandus*), Dall sheep (*Ovis dalli*), moose (*Alces americanus*), mountain goat (*Oreamnos americanus*), Roosevelt elk (*Cervus canadensis roosevelti*), and Sitka black-tailed deer (*Odocoileus hemionus sitkensis*), American beaver (*Castor canadensis*), American marten (*Martes americana*), American mink (*Neovision vision*), Canadian lynx (*Lynx canadensis*), coyote (*Canislatrans*), ermine (*Mustela erminea*), gray wolf (*Canis lupus*), least weasel (*Mustela nivalis*), North American river otter (*Lontra canadensis*), red fox (*Vulpes vulpes*), and wolverine

(*Gulo gulo*) (ADFG 2011a; McDonough 2007; Peltier 2007; Van Daele and Crye 2007). The following information describes the life history attributes, distribution, and seasonal movement of select terrestrial big game and furbearer species expected to use coastal habitats in the Cook Inlet Planning Area or nearby coastal habitats in the Gulf of Alaska.

American Black Bear (*Ursus americanus*). In Alaska, American black bears occur throughout most forests and coastal areas. However, they do not occur on the Seward Peninsula, Yukon-Kuskokwim Delta, north of the Brooks Range, several islands in the Gulf of Alaska and from the Alaska Peninsula beyond the area of Lake Iliamma. However, they do inhabit most islands in Southeast Alaska except for Admiralty, Baranof, Chichagof, and Kruzof (ADFG 2011). American black bear populations vary among the game management units in Alaska, ranging from several hundred to several thousand. It is estimated that 3,000 to 4,000 American black bears inhabit the Kenai Peninsula, which is bordered on the west by Cook Inlet (Selinger 2008). The population estimate for Game Management Unit 16B (west side of Cook Inlet) is under 1,900 (Peltier 2008). American black bears hibernate during winter. Following den entrance, pregnant females give birth to one to three cubs. On the Kenai Peninsula, average dates of den entrance and emergence are October 18 and April 26, respectively, although severe spring weather can delay den emergence (Schwartz et al. 1987). Breeding occurs during the summer. Apart from that time, American black bears are usually solitary, except for sows with cubs. Cubs remain with their mother through the first winter. American black bears make heavy use of coastal habitats in the spring following den emergence (McIlroy 1970; Johnson 2008). During the summer, salmon from spawning runs are common food sources (Frame 1974), but bears will also eat vegetation, insects, berries, winter-killed animals, and newborn moose calves (Johnson 2008). Large amounts of berries are particularly important to American black bears during the summer; often bears will switch from salmon to berries during this time.

Brown Bear (*Ursus arctos*). Brown bears (also commonly referred to as grizzley bears) occur throughout most of Alaska except on the islands south of Frederick Sound in southeast Alaska, west of Unimak in the Aleutian Islands, and on the Bering Sea islands (Eide et al. 2008). Recent genetic studies do not support the differentiation of brown bear subspecies (NatureServe 2011). The brown bear mating season occurs from May to July. Pregnant females tend to enter their dens in the fall. Females give birth to one to four cubs in their dens between January and February and emerge from dens in June. Males enter their dens later than females and tend to emerge from them before females do. In the northern part of Alaska, brown bears may stay in their dens up to 8 months; in areas with relatively mild winters, they may stay active all winter (Eide et al. 2008). Cubs stay with their mothers for up to 3 yr, but fewer than half the cubs survive (Eide et al. 2008). Brown bear densities vary with the quality of the environment. For example, in areas of low productivity such as the North Slope, bear densities are as low as one bear per 777 km^2 (300 mi^2), while in areas of high productivity such as the Alaska Peninsula, Kodiak Island, and Admiralty Island, densities are as high as one bear per 39 to 65 km^2 (15 to 25 mi^2). Areas occupied by an individual bear overlap those used by other bears (Eide et al. 2008). In the early 1990s, the population for brown bears in Game Management Unit 16 (west side of Cook Inlet) was estimated at 586 and 1,156. Similar numbers were estimated in the early 2000s (Kavalok 2007).

Large males may weigh up to 680 kg (1,500 lb) in coastal areas but only 227 kg (500 lb) in interior areas (Eide et al. 2008). Brown bears are generally solitary, but may aggregate at feeding areas such as salmon spawning streams, sedge flats, open garbage dumps, or whale carcasses (Eide et al. 2008). Brown bears are omnivorous — their foods include grasses, sedges, berries, fish, ground squirrels, caribou, moose, domestic animals, garbage, and carrion (Eide et al. 2008). During spring, coastal bears rely heavily on beaches, meadows, and shorelines while foraging on newly emergent plants, carrion, and intertidal infauna such as clams. In summer and early fall, brown bears aggregate along coastal streams to feed on salmon and other spawning fish. The salmon runs are especially important to the Kodiak, Alaska Peninsula, and McNeil River brown bears and are available from late June to mid-December on Kodiak Island (Barnes 1990). Large amounts of berries are particularly important to brown bears during the summer; often bears will switch from salmon to berries during this time.

Moose (*Alces americanus*). Moose are associated with northern forests. They are most abundant in recently burned areas where dense stands of willow, aspen, and birch shrubs have propagated; timberline plateaus; and along major rivers of Southcentral and Interior Alaska (Crouse et al. 2008). Up to 200,000 moose occur in Alaska. Based on estimates made between 2000 and 2005, about 6,000 moose occur in the western Kenai Peninsula (which includes the eastern side of Cook Inlet), while about 2,000 moose occur in game management units that include the western portion of Cook Inlet (ADFG 2011). Moose make seasonal movements to calving, rutting, and wintering areas. Females generally breed at 28 months, with breeding occurring in the fall. Calves are born from mid-May to early June after a gestation period of about 120 days. Calves remain with their mothers until about 1 yr old (Crouse et al. 2008). Moose consume willow, birch, and aspen twigs in the fall and winter; twigs, sedges, horsetail, pond weeds, and grasses in spring; and pond plants, forbs, and leaves of birch, willow, and aspen in summer (Crouse et al. 2008). Predation by wolves and bears limits population growth of moose in many locations in Alaska. Hunting and severe winter weather are also controlling factors on moose populations (Crouse et al. 2008).

North American River Otter (*Lutra canadensis*). River otters frequently occur in nearshore coastal waters, beaches, and intertidal areas throughout the South Alaska, where they forage on small fish, clams, crustaceans, and other invertebrates. Sculpin and rockfish are predominant prey items of river otters occurring along the coast of southeastern Alaska (Larsen 1984). River otters in Alaska breed in May, with mating occurring in and out of the water (Solf and Golden 2008). One to six pups are born the following year any time from late January to June. River otters reach sexual maturity at 2 yr of age and live up to 20 yr (Solf and Golden 2008). Family units consisting of a female with her pups, with or without an adult male, travel only a few kilometers. Larger groups of neighboring family units (more than 10 individuals) form temporary associations. These groups travel over a wide area and apparently do not have exclusive territories (Solf and Golden 2008).

Sitka Black-Tailed Deer (*Odocoileus hemionus sitkensis*). Sitka black-tailed deer are native to wet coastal rainforests of southeast Alaska and north-coastal British Columbia. Transplants have led to the establishment of populations near Yakutat in Prince William Sound and on Kodiak and Afognak Islands (ADFG 2011b). Sitka black-tailed deer populations fluctuate depending on the severity of winters. They have a high reproductive potential, so they can generally rebound quickly from reduced populations (ADFG 2011b). From winter through early spring, they are mostly restricted to uneven-aged old-growth forest below 366 m (1,500 ft) in elevation. During extreme snow events, the deer may congregate in heavily timbered stands at lower elevation or even on beaches (ADFG 2011b). After the winter snow pack recedes, migratory deer move to high-elevation alpine and subalpine habitats, while resident deer remain at lower elevation forested areas. With the first heavy frost, deer occupying alpine and subalpine habitats descend to the upper forest (Merriam et al. 2008). Summer and winter home ranges average 454 ha (1,122 ac) and 107 ha (264 ac), respectively (Van Daele and Crye 2009). The distance between winter and summer home ranges is about 22 km (13 mi) for migratory deer and 0.8 km (0.5 mi) for resident deer (Merriam et al. 2008; Van Daele and Crye 2009). During summer, Sitka black-tailed deer feed on herbaceous vegetation and shrub leaves, while in winter they feed on evergreen forbs and woody browse (ADFG 2011b). The breeding season begins in late October and continues through November. Fawning occurs from late May to early June (ADFG 2011b). In 2008, about 60,000 Sitka black-tailed deer populated the Kodiak Archipelago with the population appearing to be decreasing (Van Daele and Crye 2009).

Climate Change. Cook Inlet coastal habitats are vulnerable to the effects of climate change. Sea level rise is expected to inundate low-lying coastal habitats (Nicholls et al. 2007). Changes in sea level and increases in storms and erosion could result in loss of low-lying habitats critical to productivity and welfare of some wildlife species (Clark et al. 2010). Moose have timing and synchrony or parturition area adaptations to long-term patterns in climate and may be more susceptible to climate change than other ungulates that are more adapted to climatic variability (Bowyer et al. 1998). Shorter winters caused by climate change may increase the threat from ticks and deer-borne parasites (Howard 2011). Because brown bears are opportunistic, omnivorous, and highly adaptable, climate change is not expected to threaten their populations due to ecological threats or constraints; however, it may lead to an increase in brown bear/human interactions, in part from later den entry and earlier den exit (Servheen and Cross 2010).

3.8.1.3 Alaska – Arctic

3.8.1.3.1 Marine Mammals. There are 15 species of marine mammals in the Arctic region (Beaufort and Chukchi Seas). Four of these species are listed as threatened or endangered under the ESA, one is a candidate species, and two are proposed for listing as threatened species (Table 3.8.1-4). The following information describes the life history attributes, distribution, and seasonal movement of these 14 marine mammal species within the Alaska OCS lease sale areas in the Arctic region (Beaufort and Chukchi Seas). These areas encompass and/or could impact marine mammals that occur in the Beaufort/Chukchian Shelf Level II Ecoregion and include the Chukchian Neritic and Beaufortian Neritic Level III Ecoregions. (The ecoregions are described in Section 3.2.5 and shown in Figure 3.2.2-3.)

TABLE 3.8.1-4 Arctic Marine Mammals

Species	Status[a]
ORDER CETACEA	
Suborder Mysticeti (baleen whales)	
Balaenoptera acutorostrata (minke whale)	–
Balaenoptera mysticetus (bowhead whale)	E/D
Balaenoptera physalus (fin whale)	E/D
Eschrichtius robustus (gray whale)	DL/D
Megaptera novaeangliae (humpback whale)	E/D
Suborder Odontoceti (toothed whales and dolphins)	
Delphinapterus leucas (beluga whale)	–
Monodon monoceros (narwhal)	
Orcinus orca (killer whale)	D
Phocoena phocoena (harbor porpoise)	–
ORDER CARNIVORA	
Suborder Pinnipedia (seals, sea lions, and walrus)	
Erignathus barbatus (bearded seal)	PT
Odobenus rosmarus divergens (Pacific walrus)	C
Phoca fasciata (ribbon seal)	–
Phoca hispida (ringed seal)	PT
Phoca largha (spotted seal)	–
Suborder Fissipedia (sea otters and polar bears)	
Ursus maritimus (polar bear)	T/D

[a] Status: E = endangered under the ESA; T = threatened under the ESA; C = candidate for listing under the ESA; DL = delisted under the ESA; D = depleted under the MMPA (for the killer whale, it only applies to the AT1 group of eastern North Pacific transient killer whales); PT = proposed threatened under the ESA; – = not listed.

Threatened and Endangered Marine Mammals.

Cetaceans: Mysticetes. The endangered bowhead whale (*Balaena mysticetus*) occurs in seasonally ice-covered waters of the Arctic and near Arctic, typically between 60°N and 75°N in the Western Arctic Basin (Allen and Angliss 2011). The critical habitat for the bowhead whale has not been identified because habitat issues were not a factor in the decline of the species (ADNR 2009). The Western Arctic stock is the only bowhead stock found in U.S. waters (Allen and Angliss 2011). As shown in Figure 3.8.1-4, bowhead whales migrate annually from winter breeding areas (November to March) in the northern Bering Sea, through the Chukchi Sea in the spring (March through June) where most calving occurs, and into the Canadian Beaufort Sea where they spend much of the summer (mid-May through September) (Allen and Angliss 2011). In the fall (September through November), the bowheads return along this general route, closer to shore across the Beaufort Sea, to the Bering Sea to overwinter in polynyas and along edges of the pack ice (Braham et al. 1980; Moore and Reeves 1993). Some bowhead whales, thought to

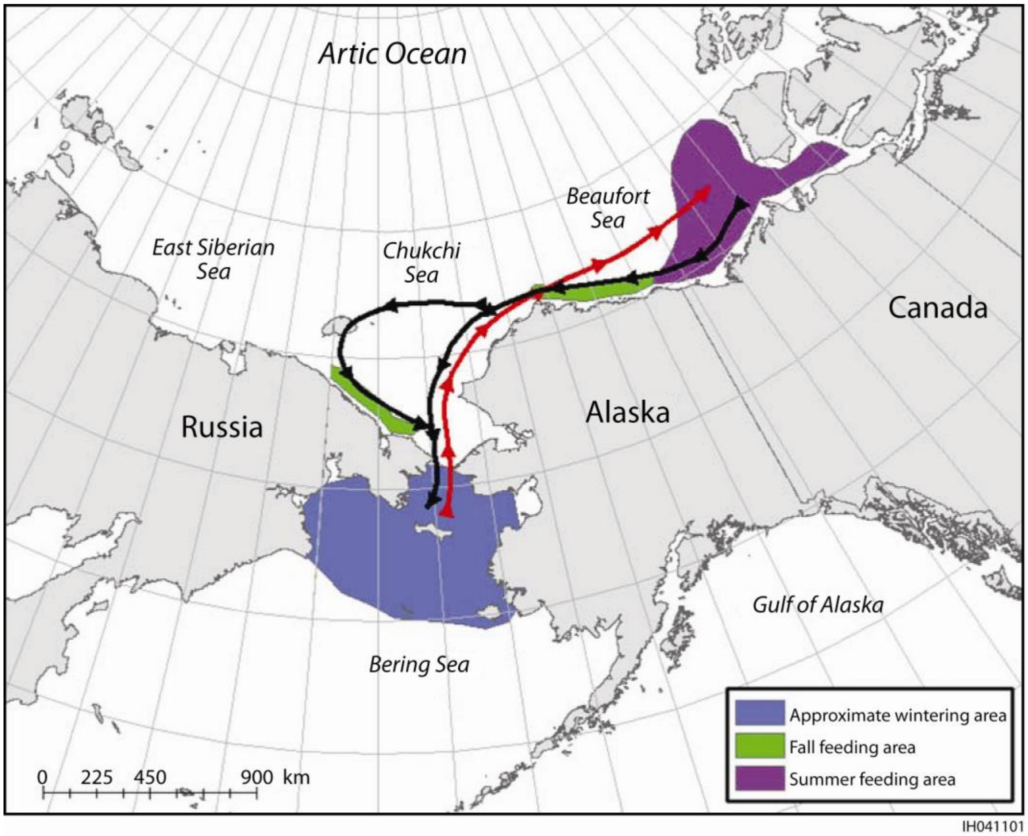

FIGURE 3.8.1-4 Generalized Migration Route, Feeding Areas, and Wintering Area for the Western Arctic Bowhead Whale Stock (Source: Moore and Laidre 2006)

be part of the expanding Western Arctic stock, remain in the Bering and Chukchi Seas during summer (Rugh et al. 2003).

Important winter areas in the Bering Sea include polynyas along the northern Gulf of Anadyr, south of St. Matthew Island, and near St. Lawrence Island. Bowheads congregate in these polynyas before migrating (Moore and Reeves 1993). Most mating occurs in late winter and spring in the Bering Sea, although some mating occurs as late as September and early October (Koski et al. 1993; Reese et al. 2001; Quakenbush 2008). Most calving occurs during the spring migration in and adjacent to the eastern Chukchi Sea and the Beaufort Sea spring lead ice systems (MMS 2008a). Females give birth to a single calf every 3 to 4 yr (MMS 2008a).

Bowhead whales usually travel alone, in small groups of up to six whales, or in mother-calf pairs (ADNR 2009). Also, bowhead whales usually feed as individuals, but groups occasionally feed together in an echelon formation (Quakenbush 2008). Bowheads feed throughout the water column, including bottom or near-bottom feeding as well as surface feeding. Food items of bowheads include euphausiids, mysids, copepods, and amphipods (Lowry and Frost 1984). Many or all of the bowhead whales from the Western Arctic stock feed in the Canadian Beaufort Sea in the summer and early fall, and in the Alaskan Beaufort Sea during their westward migration in late summer/early fall (Richardson and Thomson 2002). In mid to late fall, some bowheads feed in the southwestern Chukchi Sea. There have been no detailed bowhead whale feeding studies during winter in the Bering Sea. It is likely that some whales feed opportunistically during the spring migration (Carroll et al. 1987; Shelden and Rugh 1995).

The best estimate of the abundance of the Western Arctic bowhead whale stock is 10,545 with a minimum population estimate of 9,472 (Allen and Angliss 2011). Overall, the stock appears to be healthy and increasing in population (Allen and Angliss 2011).

The endangered fin whale ranges from subtropical to arctic waters and usually occurs in high-relief areas where productivity is probably high (Brueggeman et al. 1988). Their summer distribution extends from central California into the Chukchi Sea, while their winter range is restricted to the waters off the coast of California. In Alaskan waters, some fin whales feed in the Gulf of Alaska, while others migrate farther north to feed throughout the Bering and Chukchi Seas from June through October. There are few observations of fin whales in the eastern half of the Chukchi Sea and no documented occurrences of fin whales in the Beaufort Sea (MMS 2008b). From September through November, most fin whales migrate southward to California; however, a few animals may remain in the Navarin Basin (Brueggman et al. 1984). Northward migration begins in spring with migrating whales entering the Gulf of Alaska from early April–June (MMS 1996b).

Fin whales usually breed and calve in the warmer waters of their winter range off the coast of California. Breeding can occur year-round, but peaks between November and February (Ohsumi et al. 1958). The fin whale feeds on concentrations of zooplankton (e.g., krill), fishes, and cephalopods (Pauly et al. 1995; Jefferson et al. 2006). Reliable abundance estimates for the Northeast Pacific fin whale stock are not available. A provisional estimate for the fin whale population west of the Kenai Peninsula is 5,700 (Allen and Angliss 2011).

The endangered humpback whale occurs worldwide in all ocean basins, although it is less common in arctic waters. In winter, most humpback whales occur in the temperate and tropical waters. Humpback whales in the North Pacific are seasonal migrants to arctic waters where they feed on zooplankton and small schooling fishes in the cool coastal waters of the western United States, western Canada, and the Russian Far East (NMFS 1991). The historic feeding range of humpback whales in the North Pacific encompassed coastal and inland waters around the Pacific Rim from Point Conception, California, north to the Gulf of Alaska and the Bering Sea, and west along the Aleutian Islands to the Kamchatka Peninsula and into the Sea of Okhotck (Johnson and Wolman 1984; Allen and Angliss 2011). Current data demonstrate that the Bering Sea remains an important feeding area. During summer months, humpback whales will also enter the Chukchi Sea with rare observations in the western Beaufort Sea (Johnson and Wolman 1984; Hashagen et al. 2009; Allen and Angliss 2011).

NMFS recognizes three stocks of humpback whales occurring in U.S. waters, including the (1) California/Oregon/Washington and Mexico stock; (2) central North Pacific stock that migrates from Hawaii to northern British Columbia/Southeast Alaska and Prince William Sound west to Kodiak; and (3) western North Pacific stock that most likely migrates from Japan to waters west of the Kodiak Archipelago (the Bering Sea and Aleutian Islands) during the summer/fall (Berzin and Rovnin 1966; Allen and Angliss 2011). Winter/spring populations of humpback whales also occur near Mexico's offshore islands. The western North Pacific stock spends winter and spring in waters off Japan and migrates to the Bering Sea, Chukchi Sea, and Aleutian Islands in the summer and fall (Berzin and Rovnin 1966; Allen and Angliss 2011). During migrations, humpbacks are pelagic. The central North Pacific stock winters in Hawaiian Island waters and migrates to northern British Columbia/southeast Alaska and Prince William Sound west to Kodiak Island in the summer and fall (Baker et al. 1990; Perry et al. 1990; Allen and Angliss 2011). In the Gulf of Alaska, concentration areas of humpbacks include the Portlock and Albatross Banks and west to the eastern Aleutian Islands, Prince William Sound, and the inland waters of southeast Alaska (Berzin and Rovnin 1966).

Breeding and calving occur on the wintering grounds, and most births occur between January and March (Johnson and Wolman 1984). During the summer feeding period, the humpback whales generally occur nearshore. The central North Pacific stock of humpback whale feeding aggregations occur along the northern Pacific Rim. Humpback whale distribution in summer is continuous from British Columbia to the Russian Far East, with humpbacks present offshore in the Gulf of Alaska (Brueggeman et al. 1989; Allen and Angliss 2011). Their diet consists of euphausiids, amphipods, mysids, and small schooling forage fishes (Jefferson et al. 2006; Pauly et al. 1995).

The minimum population estimate for the Western North Pacific humpback whale stock is approximately 732 individuals and that for the central North Pacific stock is approximately 5,833 individuals (Allen and Angliss 2011).

Pinnipeds. The bearded seal (*Erignathus barbatus*, proposed threatened [NMFS 2010c]) occurs throughout the Arctic and usually inhabits waters less than 200 m (660 ft) in depth in areas of broken, moving sea ice (Cleator and Stirling 1990; Allen and Angliss 2011). Most of the bearded seals in Alaska occur over the continental shelf of the Bering, Chukchi, and Beaufort Seas between 85°N and 57°N (Cameron and Boveng 2009). Bearded seal densities are greatest during the summer and lowest during the winter. Many of the seals that winter in the Bering Sea migrate north in April and May to the summer ice edge of the Chukchi Sea (Burns 1967; Burns 1981). Others remain in the open waters of the Bering and Chukchi Seas (Burns 1981; Nelson 2008a). During spring, bearded seals prefer areas that contain 70 to 90% sea ice coverage and are most abundant 32 to 161 km (20 to 100 mi) from shore, except for the nearshore concentration to the south of Kivalina (Allen and Angliss 2011). Bearded seals generally prefer ice habitat that is in constant motion and produces natural openings and areas of open water, such as leads, fractures, and polynyas for breathing, hauling out on the ice, and access to water for foraging. They usually avoid areas of continuous, thick, shorefast ice and rarely occur in the vicinity of unbroken, heavy, drifting ice or large areas of multi-year ice (Cameron et al. 2010).

Pupping takes place on top of the ice less than 1 m (3 ft) from open water (Kovacs et al. 1996) from late March through May mainly in the Bering and Chukchi Seas, although some pupping occurs in the Beaufort Sea. Breeding occurs around one month later following the weaning of pups. Bearded seals tend to be solitary (Nelson 2008a), but sometimes form loose aggregations in areas such as polynya systems. Bearded seals primarily feed on benthic prey such as crustaceans, mollusks, fishes, and octopuses (NMFS 2011a). In the 1970s, the estimated number of bearded seals in the Bering and Chukchi Seas was 250,000 to 300,000 (Nelson 2008a). Allen and Angliss (2010a) stated that there are no current population estimates or trends for the Alaska stock of the bearded seal; however, NMFS (2010c) has given a population estimate of 155,000 individuals. Estimates provided in NMFS (2010c) are 3,150 bearded seals for the entire Beaufort Sea in June, and 27,000 bearded seals in the Chukchi Sea in the May–June timeframe.

The ringed seal (*Phoca hispida*, proposed threatened [NMFS 2010d]) is circumpolar in distribution and is associated with ice for much or all of the year. It occurs throughout the Beaufort, Chukchi, and Bering Seas as far south as Bristol Bay (Allen and Angliss 2011). The ringed seal is the most abundant seal in the Arctic (Citta 2008). Ringed seals live on and under extensive, largely unbroken, shorefast ice, and generally occur over water depths of 10 to 20 m (33 to 66 ft) (ADNR 2009). They are generally solitary when hauled out on ice (ADNR 2009). Ice cover strongly influences ringed seal movements, foraging, reproductive behavior, and vulnerability to predation (Kelly et al. 2010b). In the winter/spring period, when ringed seals occupy shorefast ice, their home ranges extend from <1 to 27.9 km^2 (<0.4 to 10.8 mi^2). Ringed seals inhabiting shorefast ice in the Beaufort Sea occupy ranges averaging <2 km^2 (<0.8 mi^2) during April through early June (Kelly et al. 2010a). In summer/fall, ringed seals may range up to 1,800 km (1,120 mi) from their winter/spring home ranges and return to the same home range sites during the ice-bound months in the following year. They continue to use sea ice as resting platforms during the summer/fall period (Kelly et al. 2010a). Some ringed seals occur during ice-free periods in the Bering and Chukchi Seas (Citta 2008). Primary pupping habitat is located on fast ice along the coasts of St. Lawrence Island, Norton Sound, and the Yukon River Delta. Ringed seals are monogamous to weakly polygamous (Kelly et al. 2010b). When sexually mature, males establish territories during the fall and maintain them during the pupping season. Pups are born in late March and April in subnivian lairs that seals excavate above breathing holes in the ice (Kelly et al. 2010b). During the breeding and pupping season, adults on shorefast ice (floating fast-ice zone) usually move less than individuals in other habitats; they depend on a relatively small number of holes and cracks in the ice for breathing and foraging. Ringed seals molt between mid-May to mid-July, at which time they spend long periods on the ice (NMFS 2010d). They are capable of diving to depths over 500 m (1,640 ft) and dives can last up to 39 minutes (Born et al. 2004). In the winter/spring, ringed seals feed under the ice while in summer/fall they feed either in open water or under the ice (Kelly et al. 2010a). Ringed seals prey on Arctic cod, saffron cod, shrimps, amphipods, and euphausiids (Kelly 1988b; Reeves et al. 1992). A reliable population estimate for the Alaska stock is not available, but is assumed to be over 249,000 (Allen and Angliss 2011). Kelly et al. (2010b) estimated a reasonable population of ringed seals to be about 1 million.

Fissipeds. The federally threatened polar bear (*Ursus maritimus*) lives only on the arctic ice cap in the Northern Hemisphere, mainly near coastal areas. The polar bear is considered a marine mammal because it principally inhabits the sea-ice surface rather than adjacent land masses (Amstrup 2003). In Alaska, polar bears primarily occur on the northern and northwestern coasts as far south as St. Matthew Island and the Pribilof Islands and extending north and eastward into the Chukchi and Beaufort Seas, from the Bering Strait to the Canadian border

(Ray 1971). There are two polar bear stocks recognized in Alaska: the Southern Beaufort Sea stock and the Chukchi/Bering Seas stock (Figure 3.8.1-5). The Southern Beaufort Sea population ranges from the Baillie Islands, Canada, and west to Point Hope, Alaska. Individuals of the Bering/Chukchi Seas stock range widely on pack ice from Point Barrow, Alaska, west to the Eastern Siberian Sea. The stock's southern boundary in the Bering Sea is determined by the annual extent of the pack ice (Allen and Angliss 2011). These two stocks overlap between Point Hope and Point Barrow, Alaska, centered near Point Lay (Allen and Angliss 2011).

The USFWS designated critical habitat for the polar bear on December 7, 2010 (USFWS 2010b). Three habitat areas designated as critical habitat include barrier islands, sea ice, and terrestrial denning habitat. USFWS (2010b) contains figures showing the location of the critical habitat areas. These critical habitat areas total about 484,734 km^2 (187,157 mi^2) of lands and water within the United States. The barrier island habitat includes coastal barrier islands and spits along the Alaska coast. These areas are used for denning, refuge from human disturbance, access to maternal dens and feeding habitat, and travel along the coast. A total of 10,576 km^2 (4,083 mi^2) of barrier island habitat is identified as critical habitat (USFWS 2010b). The sea ice critical habitat occurs over the continental shelf and includes water 300 m (984 ft) or less in depth. Sea ice habitat is essential for most polar bear activities as a platform for hunting and feeding, searching for mates and for breeding, moving to terrestrial maternity denning areas, resting, and making long-distance movements. A total of 464,924 km^2 (179,508 mi^2) of sea ice habitat has been designated as critical habitat (USFWS 2010b). Terrestrial denning critical habitat includes lands within 32 km (20 mi) of the northern coast of Alaska between the U.S./Canadian border and Kavik River and within 8 km (5 mi) between the Kavik River and Barrow. A total of 14,652 km^2 (5,657 mi^2) of terrestrial denning habitat has been designated as critical habitat (USFWS 2010b).

Seasonal movements of polar bears reflect changing ice conditions and breeding behavior. In spring, polar bears in the Beaufort Sea overwhelmingly prefer regions with ice concentrations greater than 90% and composed of ice floes 2 to 10 km (1.2 to 6.2 mi) in diameter (Durner et al. 2004). Mature males range offshore in early spring, but move closer to shore during the spring breeding season. With the breakup of the ice during spring and early summer, polar bears move northward where they select habitats with a high proportion of old ice. To reach this ice, polar bears may migrate as much as 1,000 km (620 mi) (Amstrup 2003). As ice reforms in the fall, the bears move southward, and by late fall are distributed seaward of the Chukchi and Beaufort Sea coasts. During winter, polar bears prefer the lead ice system at the shear zone between the shorefast ice and the active offshore ice. Annual activity areas for female polar bears in the Beaufort Sea range from 13,000 to 597,000 km^2 (5,020 to 230,500 mi^2) with an average of 149,000 km^2 (57,530 mi^2) (Amstrup et al. 2000).

Pregnant and lactating females with newborn cubs are the only polar bears that occupy winter dens for extended periods (Lentfer and Hensel 1980; Amstrup and Gardner 1994). The key denning habitat characteristics are topographic features that catch snow for den construction and maintenance (USFWS 2008b). The main terrestrial denning areas for the Southern Sea stock in Alaska occur on the barrier islands from Barrow to Kaktovik and along coastal areas up to 40 km (25 mi) inland (Allen and Angliss 2011). Most onshore dens are close to the seacoast, usually not more than 8–10 km (5–6 mi) inland. Information on polar bear use of terrestrial

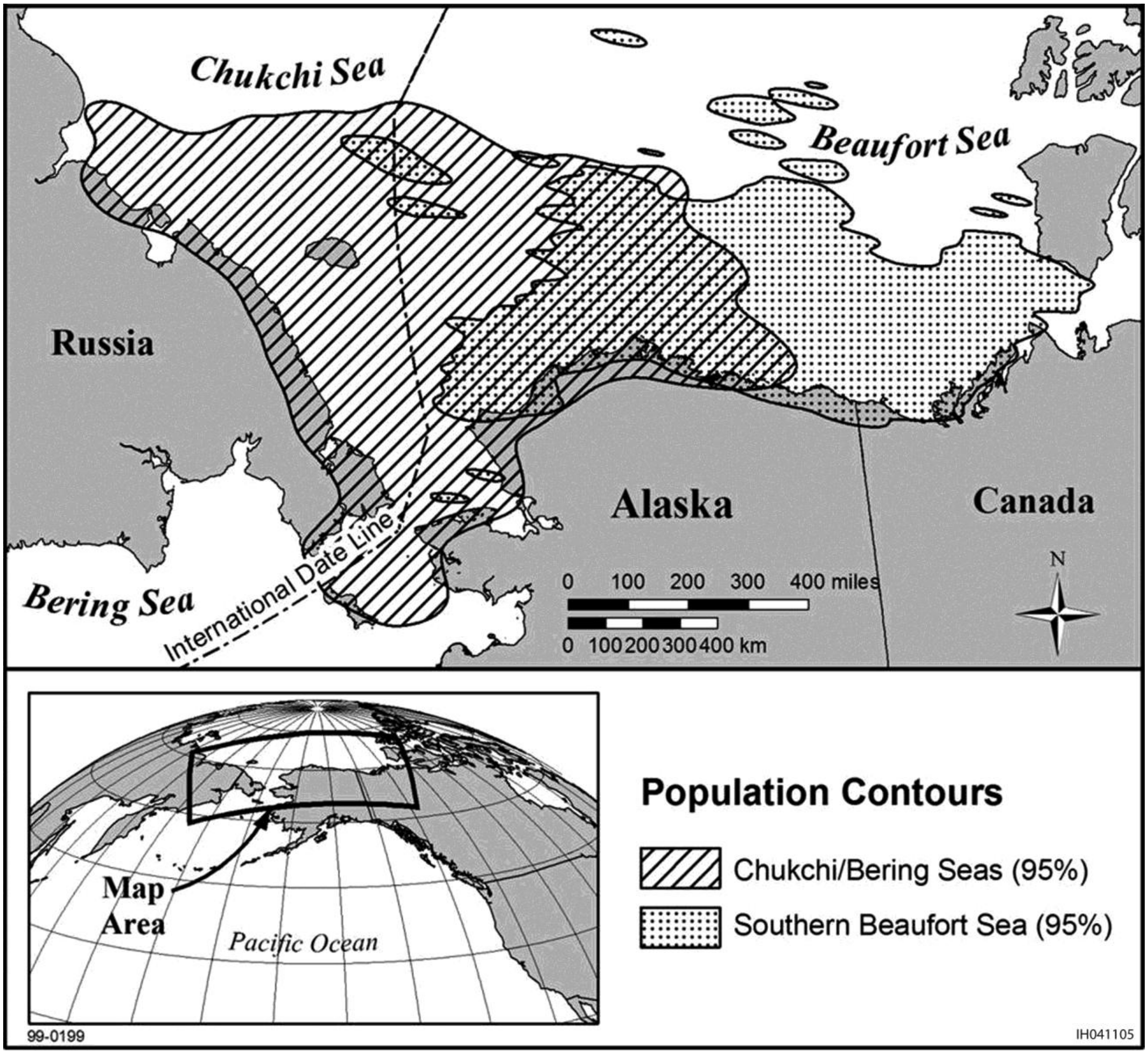

FIGURE 3.8.1-5 Distribution of Polar Bear Stocks in the Arctic Region (USFWS 2010c)

habitat for maternity denning in and near the Prudhoe Bay oil field indicates that dens were located or associated with pronounced landscape features, such as coastal and river banks, as well as lake shores and abandoned oil field gravel pads (Durner et al. 2003). In the Beaufort Sea and to a limited extent the Chukchi Sea, females may den on the drifting pack ice (Schliebe et al. 2005). Females enter dens by late November, with young being born in late December or early January (Harington 1968). Polar bears do not have denning site fidelity, but do return to the general substrate (i.e., land or ice) and geographic area (e.g., eastern or western Beaufort Sea) (ADNR 2009). Females and cubs emerge from dens in late March or early April. Coastal areas provide important denning habitat for polar bears. More polar bears are now denning near shore, rather than in far offshore regions. Data indicated that approximately 64% of all polar bear dens in Alaska from 1997 to 2004 occurred on land, compared to approximately

36% of dens from 1985 to 1994 (Fischbach et al. 2007). Recent information indicates that survival rates of cubs-of-the-year are now significantly lower than they were in previous studies, and there has also been a declining trend in cub-of-the-year size for the Southern Beaufort Sea stock. Although many cubs are currently being born into the Southern Beaufort Sea Stock region, more females are apparently losing their cubs shortly after den emergence, lowering recruitment of new bears into the population (Regehr et al. 2006).

Polar bears normally occur at low densities throughout their range. Most of the year, polar bears are solitary or occur in family groups of a mother and her cubs (Lentfer and Small 2008). Polar bears do aggregate along the Beaufort Sea coastline in the fall in areas where harvesting and butchering of marine mammals occurs. Specific aggregation areas include Point Barrow, Cross Island, and Kaktovik (USFWS 1999). Polar bear concentrations also occur during the winter in areas of open water, such as leads and polynyas, and areas where beach-cast marine mammal carcasses occur (USFWS 1999).

The predominant prey item of polar bears in Alaska is ringed seals, and to a lesser degree bearded seals (Stirling and McEwan 1975; Stirling and Archibald 1977; Stirling and Latour 1978) and spotted seals. To hunt seals in the Beaufort Sea, polar bears concentrate in shallow waters less than 300 m (1,000 ft) deep over the continental shelf and in areas with greater than 50% ice cover (Allen and Angliss 2011). In addition, bears may take walruses (Calvert and Stirling 1990), beluga whales (Freeman 1973; Heyland and Hay 1976; Lowry et al. 1987), caribou (Derocher et al. 2000; Brook and Richardson 2002), and other polar bears (Lunn and Stenhouse 1985; Taylor et al. 1985). Cannibalism of cubs and juvenile bears by adult bears is not uncommon (Dyck and Daley 2002; Derocher and Wiig 1999). Polar bears also scavenge whale, seal, and walrus carcasses (USFWS 2008b). When regular prey items are not available, polar bears may consume small mammals, birds, eggs, and vegetation, although these foods are not important dietary components (USFWS 1994). They also will consume human refuse (Amstrup 2003).

About 20,000 to 25,000 polar bears occur worldwide in 19 relatively discrete populations (USFWS 2008b). A reliable estimate for the Chukchi/Bering Seas stock does not exist, but the best information available provides a minimum population estimate of 2,000 individuals for the stock. There is also no reliable population trend for this stock (Allen and Angliss 2011). The best population estimate for the Southern Beaufort Sea stock is 1,526 individuals with a minimum population abundance of 1,397. This stock is experiencing a population decline (Allen and Angliss 2011).

Non-ESA-Listed Marine Mammals.

Cetaceans: Mysticetes. The eastern North pacific population of the gray whale (*Eschrichtius robustus*) was removed from ESA listing in 1994 (USFWS 1994). The gray whale (*Eschrichtius robustus*) occurs in the Gulf of Alaska in late March and April, moves into the Northern Bering Sea in May or June, and then enters the Chukchi and Beaufort Sea area in July or August (Rice and Wolman 1971; Consiglieri et al. 1982; Frost and Karpovich 2008). Gray whales migrate out of the Chukchi and Beaufort Seas at freezeup and migrate out of the Bering

Sea during November to December (Rugh and Braham 1979). Section 3.5.4.2.1 provides additional information on the gray whale, including population estimates.

The minke whale (*Balaenoptera acutorostrata*) occurs from the Bering and Chukchi Seas south to near the equator with apparent concentrations of whales near Kodiak Island (Leatherwood et al. 1982; Rice and Wolman 1982). Very little is known about minke whale use of the Chukchi Sea, and they would not be expected to occur in the Beaufort Sea. Sightings are infrequent during the summer months in the Chukchi Sea. There are no estimates for minke whales in the Chukchi Sea, but numbers are clearly very low because it is the northern extreme of the species range (Brueggeman 2009). Section 3.5.4.2.1 provides additional information on the minke whale.

Cetaceans: Odontocetes. The beluga whale (*Delphinapterus leucas*) is a subarctic and arctic species. Both the Beaufort Sea and Eastern Chukchi Sea stocks occur in the Arctic region. Beluga whales are associated with open leads and polynyas in ice-covered regions (Allen and Angliss 2011). Ice cover, tidal conditions, access to prey, temperature, and human interactions affect the seasonal distribution of beluga whales. They occur in ice-covered areas of the Bering Sea in winter and spring and in coastal waters of the Chukchi and Beaufort Seas in summer and fall. Some beluga whales migrate more than 2,700 km (1,500 mi) between the Bering Sea and the Mackenzie River estuary in Canada, sometimes moving more than 180 km (100 mi) per day. They will ascend large rivers and are apparently unaffected by salinity changes (Citta and Lowry 2008).

Small groups of 2 to 5 beluga whales are common, but they can occur in groups of up to 1,000 animals (Citta and Lowry 2008). Adult males will occur together in pods of 8 to10, while females occur in pods with juveniles and calves (Citta and Lowry 2008). Breeding occurs in March or April with calves being born between May and July after a gestation period of about 14.5 months. Calving occurs when herds are generally near or in their summer concentration areas (Lowry 1994). Fall migration occurs in September and October. While some belugas migrate along the coast (Johnson 1979), most migrate offshore along the pack-ice front (Moore et al. 2000b; Richard et al. 2001; Suydam et al. 2001).

Belugas shed their skin around July. To do this, they tend to concentrate in shallow water where there is coarse gravel to rub against (Citta and Lowry 2008). Feeding occurs over the continental shelf and in nearshore estuaries and river mouths. During summer, belugas feed primarily on various schooling and anadromous fishes and occasionally on cephalopods, shrimp, crabs, and clams. Winter foods are not known (Citta and Lowry 2008). Most feeding dives are to depths of 6 to 30 m (20 to 100 ft) and last up to 5 minutes; however, they can dive to over 860 m (2,800 ft) (Citta and Lowry 2008).

The best population estimate for the Beaufort Sea stock is 39,258 with a minimum estimate of 32,453 individuals; while the best population estimate for the Chukchi Sea stock is 3,710 individuals (which is also considered the minimum population size) (Allen and Angliss 2011). The population trend for the Beaufort Sea stock is unknown, and there is no evidence that the eastern Chukchi Sea stock is declining (Allen and Angliss 2011).

The narwhal (*Monodon monoceros*) typically occurs above the Arctic Circle. Narwhals are most common in Nunavut, Canada, west Greenland, and the European Arctic; but incidental sightings occur in the East Siberian, Bering, Chukchi, and Beaufort Seas (COSEWIC 2004; Jefferson et al. 1993). During summer, narwhals inhabit coastal areas with deep water and shelter from the wind. During the fall migration and, especially, while wintering in the pack ice, they prefer deep fjords and the continental slope at depths of 1,000 to 1,500 m (3,281 to 4,921 ft) (COSEWIC 2004). Narwhals often travel in small groups of under ten individuals, but do congregate in the hundreds during spring and fall migration. Peak mating occurs in mid-April with calving generally occurring in July and August following a gestation of up to 15.3 months (COSEWIC 2004). Prey items include fish and invertebrates including squid, shrimp, cod, and other demersal fish and crustaceans (COSEWIC 2004; Jefferson et al. 1993; Pauley et al. 1995). Population estimates for the Nunavut waters are up to 86,000 individuals (DFO 2008). There are no reliable population estimates or trends in population abundance for the narwhal in Alaska (Allen and Angliss 2011).

The harbor porpoise (*Phocoena phocoena*) ranges from Point Conception, California, to Point Barrow, Alaska (Gaskin 1984). Activities associated with lease sales in the Arctic region could affect harbor porpoises that belong to the Bering Sea stock. The Bering Sea stock includes harbor porpoises that occur throughout the Aleutian Islands and all waters north of Unimak Pass (Allen and Angliss 2011). Harbor porpoises frequent waters less than 100 m (325 ft) in depth (Dahlheim et al. 2000). Mating likely occurs from June or July to October, with peak calving occurring the following May and June (Consiglieri et al. 1982). Harbor porpoises consume a wide variety of fish and cephalopods, apparently preferring non-spiny schooling fish such as herring, mackerel, and pollock (Houck and Jefferson 1999; American Cetacean Society 2006). The best population estimate for the Bering Sea stock is 48,215 with a minimum population estimate of 40,039 based on survey data that is over 10 yr old (Allen and Angliss 2011).

The killer whale (*Orcinus orca*) occurs along the entire Alaska coast within the Chukchi Sea, Bering Sea, Aleutian Islands, Gulf of Alaska, Prince William Sound, Kenai Fjords, and southeast Alaska. Some killer whales may also stray into the western portion of the Beaufort Sea. Killer whales that occur in the northern Bering Sea, Chukchi Sea, and Beaufort Sea move south with the advancing pack ice (Culik 2010). Within these areas, three genetically distinct ecotypes, or forms, of killer whales exist: resident, transient, and offshore (Allen and Angliss 2011). The whales found in the Arctic region likely belong to the eastern North Pacific Transient Stock. Members of this stock occur from California to Alaska, with some also occurring within Canadian waters (Allen and Angliss 2011). Section 3.5.4.2.1 provides additional information on the killer whales in Alaska.

Pinnipeds. The Pacific walrus (*Odobenus rosmarus divergens*), a candidate for listing under the ESA (USFWS 2011a), ranges throughout the shallow continental shelf waters of the Bering and Chukchi Seas, where its distribution is closely linked with the seasonal distribution of the pack ice. It occasionally moves into the eastern Siberian Sea and western Beaufort Sea during summer (Fay 1982). The Pacific walrus is an extremely social and gregarious animal that spends approximately one third of its time hauled out onto land or ice, usually in close physical contact with one another. Group size can range from several individuals to several thousand individuals (USFWS 2011a). The Pacific walrus relies on sea ice as a substrate for resting, giving birth and nursing, isolation from predators, and passive transport to new feeding areas (USFWS 2009e). Spring migration usually begins in April, and most of the Pacific walruses move north through the Bering Strait by late June. During the summer months, most of the population moves into the Chukchi Sea; however, several thousand individuals, primarily adult males, use coastal haulouts in the Bering Sea (USFWS 2009e). Two large arctic areas are occupied by Pacific walruses during summer — from the Bering Strait west to Wrangell Island and along the northwest coast of Alaska from about Point Hope to north of Point Barrow. Within this area, summer/fall haulouts include Cape Lisburne, Corwin Bluff, Point Lay Barrier Islands, Icy Cape, Wainwright, Naokok, Asiniak Point, and Peard Bay (USFWS 2011b). Although a few Pacific walruses may move east throughout the Alaskan portion of the Beaufort Sea to Canadian waters during the open-water season, the majority of the population occurs west of 155°W, north and west of Barrow, with the highest seasonal abundance along the pack-ice front. With the southern advance of the pack ice in the Chukchi Sea during the fall (October to December), most of the Pacific walrus population migrates south of the Bering Strait, although solitary animals may occasionally overwinter in the Chukchi and Beaufort Seas. Breeding occurs in areas of broken ice from January through March, with calves born in late April or May of the following year (USFWS 2009e).

Most Pacific walrus feeding dives last 5 to 10 minutes, with a 1- to 2-minute surface interval between dives (USFWS 2009e). The diet primarily includes molluscs, snails, decapod crustaceans, amphipods, sea cucumbers, and segmented worms. Some walruses will occasionally eat seals (Fay 1985; USFWS 2009e).

Allen and Angliss (2010a) provided estimates of the Pacific walrus population over the past several centuries. A minimum population of 200,000 animals occurred in the 18th and 19th centuries. Commercial harvests reduced the population to an estimated 50,000 to 100,000 by the 1950s. Between 1975 and 1990, the population estimate ranged from 201,039 to 234,020 animals, and the 2006 estimated minimum population was 129,000 animals.

The ribbon seal (*Phoca fasciata*) inhabits the North Pacific Ocean and adjacent fringes of the Arctic Ocean. In Alaskan waters, ribbon seals occur in the open sea, on the pack ice, and only rarely on shorefast ice (Kelly 1988a), generally occurring in the open sea in summer and on the pack ice in winter (Nelson 2008b). The ribbon seal rarely occurs on land (Boveng et al. 2008). The ribbon seal ranges northward from Bristol Bay in the Bering Sea into the Chukchi and western Beaufort Seas (Allen and Angliss 2011). It inhabits the Bering Sea ice front from late March to early May. As the ice recedes in May to mid-July, ribbon seals move farther north in the Bering Sea, where they haul out on the receding ice edge (Allen and Angliss 2011). Kelly (1988a) suggests that many ribbon seals migrate into the Chukchi Sea for the summer. The ribbon seal is strongly associated with sea ice during its whelping, mating, and molting periods which occur from mid-March through June. During the remainder of the year, ribbon seals remain at sea feeding on fishes, cephalopods, and crustaceans (Nelson 2008a). Reliable population estimates and trends for the Alaska stock of the ribbon seal are not available, although there is a provisional estimate of 49,000 ribbon seals in the eastern and central Bering Sea. This estimate is consistent with historical estimates, which suggests no major changes in the ribbon seal stock over the past several decades (Allen and Angliss 2011).

Only the Bering Sea Distinct Population Segment of the spotted seal (*Phoca largha*) occurs in U.S. waters (NMFS 2011a). It occurs along the continental shelf of the Beaufort, Chukchi, and Bering Seas (Allen and Angliss 2011). It occurs year-round in the Bering Sea, while occurring in the Chukchi and Beaufort Seas in summer (Nelson 2008c). Terrestrial haul-out sites are generally located on isolated mud, sand, or gravel beaches or on rocks close to shore. Haul-out sites are apparently selected based on proximity to food (e.g., in Alaska, haul-out sites are located near herring and capelin spawning areas), lack of disturbance, and favorable tidal conditions (Boveng et al. 2009). Beaufort Sea coastal haul-out and concentration areas include the Colville River Delta, Peard Bay, Smith Bay, and Oarlock Island in Dease Inlet/Admiralty Bay, while along the Chukchi Sea coast they mostly haul out at Kasegaluk Lagoon but also at other locations to a lesser degree. Along the west coast of Alaska, spotted seals occur around the Pribilof Islands, Bristol Bay, and the eastern Aleutian Islands (Allen and Angliss 2011). Spotted seals frequently enter estuaries and sometimes ascend rivers, presumably to feed on anadromous fishes. Spotted seals migrate out of the Arctic region in the fall (September to mid-October) as the shorefast ice reforms and the pack ice advances southward. They spend the winter and spring periods offshore north of the 200-m (660-ft) isobath along the ice front throughout the Bering Sea where pupping, breeding, and molting occur (Lowry et al. 2000). Adult spotted seals forage at depths up to 300 m (984 ft), while pups can dive to 80 m (262 ft) (Boveng et al. 2009). Their diet includes a variety of fishes, crustaceans, and cephalopods (Nelson 2008b). A reliable population estimate for the Alaska stock is not available, but preliminary results provide a population estimate of over 59,000 individuals (Allen and Angliss 2011).

Climate Change. A number of reviews discuss the potential responses of arctic marine mammals to climate change (e.g., Tynan and DeMaster 1997; Learmonth et al. 2006; Laidre et al. 2008; Moore and Huntington 2008; Ragen et al. 2008; Simmonds and Eliott 2009; Kovacs et al. 2011). Climate change will primarily affect marine mammals from loss of habitat (particularly the extent and concentration of sea ice), changes in prey availability, and potentially increased expansion of other species that are likely to cause competitive pressure on some species, as well as putting them at greater risk of predation, disease, and parasitic infections (Alter et al. 2010; Kovacs et al. 2011). These changes may alter the seasonal distributions, geographic ranges, migration patterns, nutritional status, prey species, reproductive success, and ultimately the abundance and stock structure of some marine mammal species. The capacity of Arctic marine mammals to adapt to new or different food sources will have a key role in their ability to cope with climate change, with generalists probably having a better chance of coping than specialists (Kovacs et al. 2011).

Climate change impacts on marine mammals can be either direct (e.g., effects of reduced sea ice and rising sea levels on seal haul-out sites, or species tracking a specific range of water temperatures in which they can physically survive); or indirect (e.g., changes in prey availability and increased susceptibility to disease or contaminants) (Learmonth et al. 2006). Predicted indirect impacts on cetacean species are decreased reproductive capacity, asynchrony in space or time with prey species, increased prevalence and/or susceptibility to disease, and loss of habitat (Simmonds and Eliott 2009). Alteration of sea ice and the productive food web associated with it, as well as increasing human presence and activities, will cause extensive redistribution of mobile species, disappearance of non-mobile species throughout portions of their range, and possible species extinctions (Ragen et al. 2008). For instance, the loss of sea ice could have some potential beneficial effects on bowhead whales by increasing prey availability (Moore and Laidre 2006). However, loss of sea ice would include increase noise and disturbance related to increased shipping, increased interactions with commercial fisheries, including noise and disturbance, incidental intake, and gear entanglement; changes in prey species concentrations and distribution; and changes in subsistence-hunting practices.

Species that seasonally occupy Arctic and subarctic habitats may move further north, remain there longer, and compete with endemic arctic species (Moore and Huntington 2008). For example, humpback whales now occur as far north as the Beaufort Sea and fin whales occur farther north than usual within the Chukchi Sea. Higher calf counts in the spring are associated with years of delayed onset of freezeup in the Chukchi Sea. Killer whales appear to be extending their season of Arctic habitation and are expanding their range northward. Other species that may be shifting their summer distribution northward in the Arctic include the sei whale, blue whale, minke whale, and harbor porpoise (Kovacs et al. 2011). However, information is not sufficient to determine or predict whether short-term apparent changes in their distribution will persist and become longer term trends in the Arctic (MMS 2008).

Changes in sea ice will reduce habitat available for ice-associated marine mammals that give birth on sea ice, hide from predators, seek shelter from inclement weather on ice fields, or consume ice-associated fish and invertebrate prey or ice-associated marine mammals (Kovacs et al. 2011). Changes in the extent, concentration, and thickness of the sea ice in the Arctic may alter the distribution, geographic ranges, migration patterns, nutritional status, reproductive success, and ultimately the abundance of ice-associated pinnipeds that rely on the ice platform for pupping, rest, and molting (Tynan and DeMaster 1997). The early breakup of sea ice has resulted in increased mortality of seal pups within their birth lairs (Stirling and Lunn 2001). In the Alaskan Beaufort Sea, ringed seal-lair abandonment began earlier each year from 1999 (May 21) to 2003 (April 28) and was associated with early onset of spring melt over the sea-ice cover and the snow pack turning isothermal, at which time the thermal and structural integrity of the lairs was compromised (Kelly et al. 2003). Climate change may adversely affect populations of ringed seals as warmer temperatures and rain may collapse roofs of birth lairs, exposing pups to predators and to wet weather before they have enough blubber to insulate them (Kelly 2001; Ferguson et al. 2005; Citta 2008). Although longer periods of open water may increase prey accessibility, earlier spring break-up may force ringed seal pups into open water at an earlier age and expose them to increased risk of predation and thermal challenges (Ferguson et al. 2005). A loss of suitable sea ice due to climate change could isolate bearded seals from suitable benthic prey communities (Cameron and Boveng 2009).

Reductions in sea-ice coverage would adversely affect the availability of pinnipeds prey for polar bears (Ramsay 1995; Stirling et al. 1999; Stirling and Lunn 2001). This can force polar bears ashore earlier than normal and in poorer condition. Lack of access to seals for a long period of time can cause a decline in polar bear health, reproduction, survival, and population size. Generally, polar bears cannot meet their caloric needs from just terrestrial sources of food (USFWS 2008). Changing ice conditions due to climate change is expected to increase polar bear use of the coast during open-water seasons (June through November). Polar bears spending extended periods of time on land without an adequate food source may be nutritionally stressed animals and potentially more dangerous when encountering humans (USFWS 2009). Monnett and Gleason (2006) speculated that mortalities due to offshore swimming during late-ice (or mild ice) years may be an important and unaccounted source of natural mortality given energetic demands placed on individual polar bears engaged in long-distance swimming. Drowning-related deaths of polar bears may increase in the future if the observed trend of pack ice regression and/or longer open water period continues. Polar bear survival, breeding rates, and cub litter survival decline with an increasing number of days per year that waters across the continental shelf are ice free (Regehr et al. 2010).

Pacific walruses have been showing negative impacts of sea-ice reductions (e.g., reports of abandoned calves at sea, and mothers and calves spending more time on land, where stampede incidents have caused significant mortality). The Pacific walrus may also be shifting its diet toward eating more seals and fewer benthic invertebrates (Kovacs et al. 2011). Decreases in summer extent of sea ice may decrease the access of Pacific walrus to their food resources and increase their exposure to polar bear predation (Kelly 2001).

3.8.1.3.2 Terrestrial Mammals. Approximately 30 species of terrestrial mammals occur in Alaska's Arctic region (Sage 1996); these species include the brown bear (*Ursus arctos*), caribou (*Rangifer tarandus*), muskox (*Ovibos moschatus*), Arctic fox (*Alopex lagopus*), brown lemming (*Lemmus trimucronatus*), ermine (*Mustela ermine*), gray wolf (*Canis lupus*), least weasel (*Mustela rixosa*), North American river otter (*Lutra canadensis*), red fox (*Vulpes vulpes*), and wolverine (*Gulo gulo*) (ADFG 2011a; Carroll 2007; Szepanski 2007). Among these, the Arctic fox, brown bear, caribou, and muskox are the species most likely to be affected by proposed OCS oil and gas activities. The following information describes the life history attributes, distribution, and seasonal movement for these terrestrial mammal species in the Arctic region.

Arctic Fox (*Alopex lagopus*). In Alaska, the Arctic fox occurs in treeless coastal areas from the Aleutian Islands north to Point Barrow and east to the U.S./Canadian border (Stephenson 2008). Pups are born in dens that adults construct in sandy, well-drained soils of low mounds and river cutbanks (Stephenson 2008). In winter, dens provide shelter. In developed areas, Arctic foxes also use culverts and road embankments as denning sites (Audet et al. 2002). A den may cover more than 50 m^2 (540 ft^2) and contain up to 100 entrances. Den densities range from 1.0 den/2,500 km^2 (965 mi^2) to 1.0 den/12 km^2 (5 mi^2) (Audet et al. 2002). Arctic fox populations peak whenever lemmings and voles (their main prey) are abundant (Stephenson 2008). Other food sources include ringed seal pups and the carcasses of other marine mammals and caribou, which are important throughout the year (Chesemore 1967; Hammill and Smith 1991). Arctic foxes are the most common predator of arctic nesting birds and their eggs. They will cache eggs to consume during the winter. A single Arctic fox is capable of caching hundreds of eggs per nesting season (Audet et al. 2002). Marine mammals are an important part of the diet of Arctic foxes that occur along the coast of western Alaska (Anthony et al. 2000). In winter, Arctic foxes primarily feed on remains of polar bear kills (USFWS 2008b), and many Arctic foxes venture onto sea ice to search for seal remains (Stephenson 2008). The availability of winter food sources directly affects the Arctic foxes' abundance and productivity (Angerbjorn et al. 1991). During midwinter, Arctic foxes tend to be solitary except when congregating at carcasses of marine mammals or caribou (Stephenson 2008). Arctic foxes on the Prudhoe Bay oil field readily use developed sites for feeding, resting, and denning; their densities are greater in the oil fields than in surrounding undeveloped areas (Eberhardt et al. 1982; Burgess et al. 1993). Development on the Prudhoe Bay oil fields probably has led to increases in Arctic fox abundance and productivity (Burgess 2000).

Brown Bears (*Ursus arctos*). Population estimates for brown (grizzly) bears across the North Slope of Alaska are: 900 to 1,120 in Game Management Unit 26A (western North Slope) and 659 in Game Management Units 26B and 26C (eastern North Slope) (Shideler and Hecthel 2000; Carroll 2007). Brown bears are solitary animals except when breeding or concentrating near high-value food sources. On the North Slope, brown bear densities vary from about 0.1 to 2.3 bears/100 km^2 (0.3 to 5.9 bears/100 mi^2), with a mean density of 0.4 bear/100 km^2 (1 bear/100 mi^2). The number of brown bears using the Prudhoe Bay and Kuparuk oil fields adjacent to the Liberty Project in the Beaufort Sea has increased in recent years. An estimated 60 to 70 brown bears, or approximately 4 bears/1,000 km^2 (10 bears/1,000 m^2), inhabit the oil field area (Shideler and Hechtel 2000). Brown bears in the oil field area can have large home ranges, between 2,600 to 5,200 km^2 (1,000 to 2,000 mi^2), and travel up to 50 km (31 mi) per day (Shideler and Hechtel 1995). Home range size is influenced by the distribution of food and by the individual's age, sex, social status, condition, and foraging habits (Pasitschniak-Arts 1993). Home ranges overlap and there is no territorial defense (Pasitschniak-Arts 1993). Most brown bears den and hibernate during winter when food is scarce. On the North Slope, den sites are located in pingos, banks of rivers and lakes, sand dunes, and steep gullies in the uplands (Harding 1976; Shideler and Hechtel 1995). The grass meadows on the bluffs along the Colville River provide forage for brown bears during the spring. Common foods include berries, nuts, vegetation, roots, insects, fish, ground squirrels, birds and their eggs, carrion, and human garbage. In the Arctic region, brown bears will also prey on newborn muskoxen and particularly caribou and will occasionally prey on healthy adults of these species. Large males prey on newborn brown bear cubs and occasionally females (Pasitschniak-Arts 1993).

Caribou (*Rangifer tarandus*). Within the coastal habitats adjacent to the Arctic region occur two large caribou herds — the Western Arctic Herd (WAH) and the Porcupine Caribou Herd (PCH) — and two smaller herds — the Teshekpuk Lake Herd (TLH) and the Central Arctic Herd (CAH) (Figure 3.8.1-6). While the calving areas are separate for each herd, some intermingling occurs on winter and summer ranges (ADNR 2009; Lenart 2009a). Caribou herd size naturally fluctuates (e.g., cycles of years of growth followed by years of decline) due to a number of factors such as weather patterns, overpopulation, predation, disease, and hunting (Valkenburg and Arthur 2008).

The WAH herd, covering about 363,000 km^2 (140,000 mi^2) (Dau 2009), ranges over northwestern Alaska from the Chukchi Coast east to the Colville River and from the Beaufort Coast south to the Kobuk River. Herd size estimates included 490,000 animals in 2003, 377,000 in 2007, and 348,000 in 2009 (ADFG 2011d).

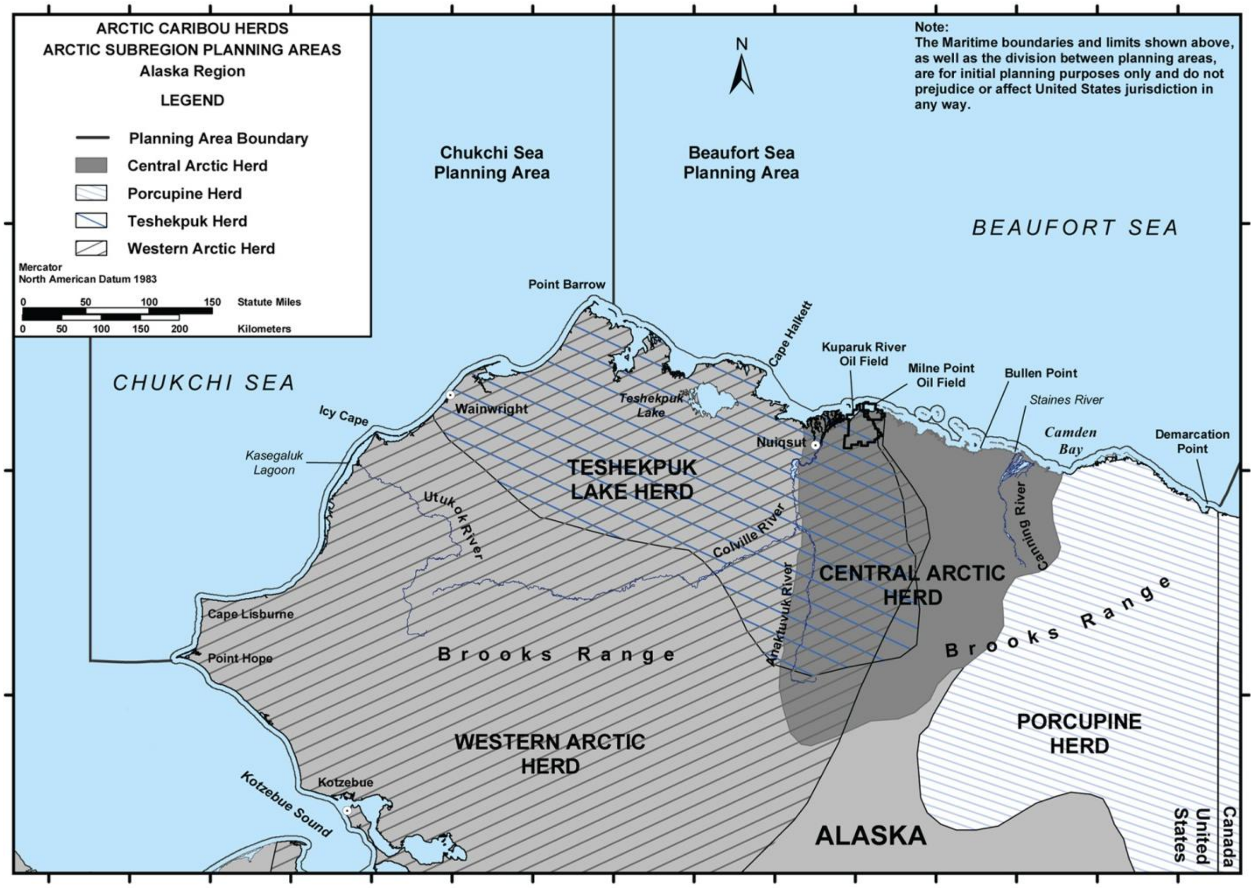

FIGURE 3.8.1-6 Distribution of Caribou Herds in the Arctic Region (Source: MMS 2007a)

The PCH, covering about 336,700 km^2 (130,000 mi^2) (Caikoski 2009), ranges south from the Beaufort Sea Coast, from the Canning River of Alaska in the west, eastward through the northern Yukon and portions of the Northwest Territories in Canada, and south to the Brooks Range. The herd peaked at 178,000 caribou in 1989, but had declined to 123,000 by 2001 (Caikoski 2009). A 2010 photocensus indicates the herd has grown to an estimated 169,000 caribou (ADFG 2011c).

The TLH primarily inhabits the central coastal plain north of the Brooks Range in spring and summer; its wintering areas encompass much of northwestern Alaska (Parrett 2009). The TLH occurs primarily within the National Petroleum Reserve-Alaska (NPR-A), with its summer range extending between Barrow and the Colville River. It uses the area around Teshekpuk Lake for calving, grazing, and insect relief (ADNR 2009). In some years, most of the TLH remains in the Teshekpuk Lake area all winter. In other years, part or all of the herd winters in the Brooks Range or within the range of the WAH and CAH. The TLH contained a record 64,106 caribou in 2008 (Parrett 2009).

The CAH ranges from the Itkillik River east to the Canning River and from the Beaufort Coast south into the Brooks Range. It occurs east and west of the Sagavanirktok River, and individuals show considerable movement between the eastern and western segments of the herd (Cronin et al. 1997, 2000). In 2008, the CAH totaled about 67,772 caribou (Lenart 2009).

Most caribou herds migrate seasonally between their calving area, summer range, and winter range to take advantage of seasonally available forage resources; however, as previously mentioned, in some years the TLH may remain in the Teshekpuk Lake area the entire year. If movements are greatly restricted, caribou are likely to overgraze their habitat, perhaps leading to a drastic, long-term population decline. The winter diet of caribou consists predominantly of lichens and mosses, shifting to vascular plants during the spring (Thompson and McCourt 1981). However, when TLH caribou winter near Teshekpuk Lake, where relatively few lichens are present, the herd may consume more sedges and vascular plants.

Spring migration of parturient female caribou from the overwintering areas to the calving grounds starts in April (Dau 2009). Often the most direct routes are used; however, certain drainages and routes are used during calving migrations because they tend to be corridors free of snow or with shallow snow (Lent 1980). Bulls and non-parturient females generally migrate at a very leisurely pace, with some remaining on winter ranges until June. Severe weather and deep snow can delay spring migration, with some calving occurring en route. Cows calving en route usually proceed to their traditional calving grounds (Hemming 1971).

The spring migration to traditional calving grounds consistently provides high nutritional forage to lactating females during calving and nursing periods, which is critical for the growth and survival of newborn calves. Calciphiles such as the sheathed cottonsedge (*Eriophorum vaginatum*) appear to be very important in the diet of lactating caribou cows during the calving season (Lent 1966; Thompson and McCourt 1981; Eastland et al. 1989), while shrubs (especially willows) are the predominant forage during the post-calving period (Thompson and McCourt 1981). The winter availability of sedges, which are dependent on temperature and snow cover, probably affects specific calving locations and calving success.

Cows reach calving grounds by mid- to late May, with calving occurring late May through early June (Dau 2007; ADNR 2009). The sequential spring migration, first by cows and later by bulls and the rest of the herd, is a strategy for optimizing the quality of forage as it becomes available with snowmelt on the arctic tundra (Whitten and Cameron 1980). The earlier migration of parturient cow caribou to the calving grounds also could reduce forage competition with the rest of the herd during the calving season.

Insect-relief areas become important during late summer when oestrid fly and mosquito harassment peaks (Lawhead 1997). Harassment by insects reduces foraging efficiency and increases physiological stress (Hagemoen and Reimers 2002). Caribou use various coastal and upland habitats for relief from insect pests, including areas such as sandbars, spits, river deltas, some barrier islands, mountain foothills, snow patches, and sand dunes. Stiff breezes in these settings prevent insects from concentrating and alighting on the caribou. Members of the TLH generally aggregate close to the coast for insect relief, but some small groups gather in other cool windy areas such as the Pik Dunes located about 30 km (19 mi) south of Teshekpuk Lake (Hemming 1971; Philo et al. 1993). Caribou aggregations move frequently from insect-relief areas along the arctic coast (CAH, WAH, and especially the TLH) and in the mountain foothills (some aggregations of the WAH) to and from green foraging areas. After calving along the coast, much of the PCH will move back into the Brooks Range foothills for insect relief.

During the post-calving period in July through August, caribou generally attain their highest degree of aggregation. They join into increasingly larger groups, foraging primarily on the emerging buds and leaves of willow shrubs and dwarf birch (Thompson and McCourt 1981). In the PCH and WAH, continuous masses of animals can number in the tens of thousands. Cow/calf groups are most sensitive to human disturbance during this period.

Fall migration begins from mid-August through late September and can last through late November. Migration is triggered by weather conditions such as the onset of cold weather or a snowstorm (ADNR 2009). Once on wintering grounds, caribou are relatively sedentary until spring migration initiates (Dau 2007). The primary winter range of the WAH is located south of the Brooks Range along the northern fringe of the boreal forest. During winters of heavy snowfall or severe ice crusting, caribou may overwinter within the mountains or on the Arctic Slope (Hemming 1971). Even during normal winters, some caribou of the WAH overwinter on the Arctic Coastal Plain. The TLH primarily resides year-round in the Teshekpuk Lake area; however, some animals travel great distances to the south, as far as the Seward Peninsula (Davis et al. 1982; Carroll 1992). The CAH overwinters primarily in the northern foothills of the Brooks Range (Roby 1980).

The movement and distribution of caribou over the winter ranges reflect their need to avoid predators and their response to wind (storm) and snow conditions (depth and snow density), which greatly influence the availability of winter forage (Henshaw 1968; Bergerud and Elliot 1986). The numbers of caribou using a particular portion of the winter range are highly variable from year to year (Davis et al. 1982; Whitten 1990). Range condition, distribution of preferred winter forage (particularly lichens), and predation pressure all affect winter distribution and movements (Roby 1980; Miller 1971).

Muskox (*Ovibos moschatus*). Indigenous populations of muskox were extirpated in the 1800s in northern Alaska (Smith et al. 2008). As a result of restoration efforts, numbers of muskoxen in Alaska had grown to about 3,800 individuals by the year 2000. This included 650 on Nunivak Island, 250 on Nelson Island, 550 in northcentral and northeastern Alaska, 450 in northwestern Alaska, 1,800 on the Seward Peninsula, and 100 on the Yukon-Kuskokwim Delta (Smith et al. 2008). Between the years 2000 and 2006, the numbers in north-central and northwestern Alaska declined by about 200 individuals. The most likely factors causing this decline are severe winters, predation by bears and wolves, and the limited availability of winter forage (Smith et al. 2008). Smith et al. (2008) concluded that muskoxen populations elsewhere in Alaska will continue to increase and expand their range. Lenart (2009b) stated that the likely combined population of muskoxen in Game Management Units 26A (eastern portion), 26B, and 26C, which comprise the Arctic Slope area, is less than 300 individuals. There is little or no overlap of habitat and feeding sites between muskoxen and caribou (Lent 1988).

Unlike caribou, muskoxen are sedentary, but will engage in limited movement in response to seasonal changes and variations in snow cover and vegetation. Being poor diggers, their winter habitat is generally restricted to areas with minimal snow accumulations or areas blown free of snow (Smith et al. 2008). They also use willow-shrub riparian habitats along the major river drainages on the Arctic Slope year-round. Calving takes place from mid-April through June (Lent 1988). Distributions of muskoxen during the calving season, summer, and winter are similar, with little movement during winter (Reynolds 1992). The breeding season occurs from August to October with calves born the following April to June (Smith et al. 2008). During the mating season, harems consist of 5 to 15 females and subadults with one dominant bull; mixed male and female winter herds may contain up to 75 animals. Some non-breeding bulls may form bull-only herds during spring (Smith et al. 2008). Muskoxen are herbivores and consume grasses, sedges, forbs, and woody plants (Smith et al. 2008).

Climate Change. An increase in temperature associated with climate change is not expected to directly affect most terrestrial mammals. Physiological tolerance to heat load would allow most species to survive, but changes in habitat through climate-vegetation linkages are expected to influence terrestrial mammal distributions (Johnston and Schmitz 1997). Climate change is predicted to increase the number and geographic range of large rain-on-snow events. When rain falls on snowpack, the rain either pools at the surface or trickles down to the soil below the snowpack, then freezes into a sheet of ice. Such events have been known to cause death due to starvation to muskoxen and caribou because they are unable to break through the ice to browse on plants under the snow (Putkonen and Roe 2003; Joyce 2009).

Other effects of climate change on caribou herds potentially include alteration in habitat use, migration patterns, foraging behavior, quality of forage, and demography (Lenart et al. 2002; Vors and Boyce 2009; Sharma et al. 2009). If climate change brings about a longer growing season, the amount of plant biomass available for caribou may increase and likely decrease calf abortion, improve birth mass of calves, and increase parturition rates (Couturier et al. 2009; Tews et al 2007); this would increase the survival and fecundity of migratory caribou and may also decrease the dependence of caribou on lichen (Sharma et al. 2009). However, adverse effects can occur if there is a mismatch between the timing of increased resource demands by caribou and resource availability. In West Greenland, this has caused an increase in offspring mortality and a decrease in offspring production (Post and Forchhammer 2008). It is also possible that climate change may lead to an overlap of herds in spring that could increase competition on the calving grounds or change their distribution (Post and Forchhammer 2008).

The absence or incomplete formation of ice on large streams and rivers can result in delays in crossing and possibly drowning of some migratory caribou (Sharma et al. 2009). Increased insect harassment appears to be a key climate change related factor that may adversely impact caribou (Weladji et al. 2002; Sharma et al. 2009). In addition, warming temperatures will benefit free-living bacteria and parasites whose survival and development is limited by lower temperatures. Climate warming may also favor the release of persistent environmental pollutants, some of which can affect wildlife immune systems and may favor the increased rates of some diseases (Bradley et al. 2005). Overall, climate change is predicted to negatively impact caribou body condition and demography (Couturier et al. 2009; Miller and Gunn 2003).

Potential changes in habitat across the North Slope due to development and climate change may influence the distribution and abundance of muskoxen in the future (Smith et al. 2008). Population declines in muskoxen are proposed to occur due to changes in forage availability, insect harassment, parasite load, infectious diseases, and habitat availability (Ytrehus et al. 2008). The absence or incomplete formation of ice on large streams and rivers can possibly result in drowning of muskoxen (Sharma et al. 2009).

Red foxes prey on and are superior hunters to Arctic foxes. Their expansion into the range of the Arctic fox, which has already begun, will continue as the tundra warms. In addition, Arctic fox prey (lemming and voles) are expected to have their population cycles disrupted and their numbers decrease as the climate changes (Hersteinsson and Macdonald 1992; Sillero-Zubiri and Angerbjorn 2009).

Because brown bears are opportunistic, omnivorous, and highly adaptable, climate change it is not expected to threaten their populations due to ecological threats or constraints; however, it may lead to an increase in brown bear/human interactions, in part from later den entry and earlier den exit (Servheen and Cross 2010).

Climate Change. An increase in temperature associated with climate change is not expected to directly affect most terrestrial mammals. Physiological tolerance to heat load would allow most species to survive, but changes in habitat through climate-vegetation linkages are expected to influence terrestrial mammal distributions (Johnston and Schmitz 1997). Climate change is predicted to increase the number and geographic range of large rain-on-snow events. When rain falls on snowpack, the rain either pools at the surface or trickles down to the soil below the snowpack, then freezes into a sheet of ice. Such events have been known to cause death due to starvation to muskoxen and caribou because they are unable to break through the ice to browse on plants under the snow (Putkonen and Roe 2003; Joyce 2009).

Other effects of climate change on caribou herds potentially include alteration in habitat use, migration patterns, foraging behavior, quality of forage, and demography (Lenart et al. 2002; Vors and Boyce 2009; Sharma et al. 2009). If climate change brings about a longer growing season, the amount of plant biomass available for caribou may increase and likely decrease calf abortion, improve birth mass of calves, and increase parturition rates (Couturier et al. 2009; Tews et al 2007); this would increase the survival and fecundity of migratory caribou and may also decrease the dependence of caribou on lichen (Sharma et al. 2009). However, adverse effects can occur if there is a mismatch between the timing of increased resource demands by caribou and resource availability. In West Greenland, this has caused an increase in offspring mortality and a decrease in offspring production (Post and Forchhammer 2008). It is also possible that climate change may lead to an overlap of herds in spring that could increase competition on the calving grounds or change their distribution (Post and Forchhammer 2008).

The absence or incomplete formation of ice on large streams and rivers can result in delays in crossing and possibly drowning of some migratory caribou (Sharma et al. 2009). Increased insect harassment appears to be a key climate change related factor that may adversely impact caribou (Weladji et al. 2002; Sharma et al. 2009). In addition, warming temperatures will benefit free-living bacteria and parasites whose survival and development is limited by lower temperatures. Climate warming may also favor the release of persistent environmental pollutants, some of which can affect wildlife immune systems and may favor the increased rates of some diseases (Bradley et al. 2005). Overall, climate change is predicted to negatively impact caribou body condition and demography (Couturier et al. 2009; Miller and Gunn 2003).

Potential changes in habitat across the North Slope due to development and climate change may influence the distribution and abundance of muskoxen in the future (Smith et al. 2008). Population declines in muskoxen are proposed to occur due to changes in forage availability, insect harassment, parasite load, infectious diseases, and habitat availability (Ytrehus et al. 2008). The absence or incomplete formation of ice on large streams and rivers can possibly result in drowning of muskoxen (Sharma et al. 2009).

Red foxes prey on and are superior hunters to Arctic foxes. Their expansion into the range of the Arctic fox, which has already begun, will continue as the tundra warms. In addition, Arctic fox prey (lemming and voles) are expected to have their population cycles disrupted and their numbers decrease as the climate changes (Hersteinsson and Macdonald 1992; Sillero-Zubiri and Angerbjorn 2009).

Because brown bears are opportunistic, omnivorous, and highly adaptable, climate change it is not expected to threaten their populations due to ecological threats or constraints; however, it may lead to an increase in brown bear/human interactions, in part from later den entry and earlier den exit (Servheen and Cross 2010).

3.8.2 Marine and Coastal Birds

3.8.2.1 Marine and Coastal Birds of the Northern Gulf of Mexico

The northern GOM and its ecoregions possess a diverse bird fauna composed of resident marine and coastal species (Clapp et al. 1983; Sibley 2000). The bird fauna of the region also includes many species that inhabit northern latitudes and pass through the region in large numbers during spring and fall migrations (Russell 2005), or move into coastal habitats of the GOM to overwinter. For example, in the fall, many migratory species arrive at the northern GOM coast and then fly several hundred miles directly across the open waters or westward along the coast to wintering areas in Central and South America (Lincoln et al. 1998).

3.8.2.1.1 Nonendangered Species. The northern GOM, with its diverse array of terrestrial and aquatic habitats, supports a diverse avifauna of well over 600 species (Table 3.8.2-1). Many of these species may be found in more than one of the five GOM States, while a much smaller subset are largely restricted to a particular State or locale. For example, the brown pelican (*Pelecanus occidentalis*) is ubiquitous throughout the GOM States, while the endangered Mississippi sandhill crane (*Grus canadensis pulla*) is only found in Mississippi.

Although more than 400 species have been reported in the northern GOM, many of these species would not be likely to occur in marine and coastal habitats where they could encounter OCS oil and gas activities. Instead, these species occur in more interior, terrestrial habitats.

TABLE 3.8.2-1 Number of Bird Species Reported from the Gulf Coast States

State	Total Number of Reported Species	Number of Aquatic/Semi-aquatic Species that Could Occur in Coastal and Marine Habitats[a]	Number of Aquatic/Semi-aquatic Species that are Very Uncommon or Incidental in Occurrence[b]
Florida[c]	510	189 (37%)	29 (6%)
Mississippi[d]	408	155 (38%)	37 (9%)
Alabama[e]	413	165 (40%)	35 (8%)
Louisiana[f]	471	172 (37%)	45 (10%)
Texas[g]	636	215 (34%)	65 (10%)

[a] Species that use coastal and marine aquatic habitats for nesting and/or foraging. Values in parentheses indicate the percent contribution of the aquatic/semi-aquatic species to the total number of species reported for the State.

[b] Species that are infrequently observed; many are currently in review regarding occurrence. Values in parentheses indicate the percent contribution of aquatic/semiaquatic species to the total number of species reported for the State.

[c] Source: Florida Ornithological Society 2010.

[d] Source: Mississippi Ornithological Society 2007; Mississippi Coast Audubon Society 2010.

[e] Source: Alabama Ornithological Society 2006.

[f] Source: Louisiana Bird Records Committee 2010.

[g] Source: Texas Ornithological Society 2010.

Species that would be most likely to encounter, and thus be potentially affected by, OCS oil and gas activities are the aquatic/semi-aquatic species that rely on coastal and marine habitats. Within any individual GOM State, these species account for between 34 and 40% of all species reported from the State. Among these aquatic/semi-aquatic species, several species are very uncommon or incidental in occurrence, being occasional visitors or transients that in some cases may only be observed once every few years (Table 3.8.2-1). These species account for no more than 10% of all species reported from any of the GOM States. The occurrence of some other species is based on observations of individuals following large storm events such as hurricanes. For example, the brown noddy (a type of tern) has been reported only six times from Alabama, and three of those were following the passage of Hurricanes Frederick (1979), Isidore (2002), and Ivan (2004) (Alabama Ornithological Society 2011).

There are six general categories of marine and coastal birds that occur in the GOM region for at least some portion of their life cycle: seabirds, shorebirds, wetland birds, waterfowl, passerines, and raptors (Table 3.8.2-2). The first four categories represent birds that greatly utilize marine and coastal habitats (such as beaches, mud flats, salt marshes, coastal wetlands, and embayments), and thus these birds have the greatest potential for interacting with at least some phases of OCS-related oil and gas development activities, and for being affected by

TABLE 3.8.2-2 Marine and Coastal Birds of the Gulf of Mexico

Category	Order	Common Name	Representative Types
Seabirds	Charadriiformes	Gulls and terns Phalaropes	Ring-billed gull, laughing gull, common tern, Caspian tern
	Pelicaniformes	Frigatebirds Pelicans Tropicbirds Gannets and boobies	Magnificent frigatebird, brown pelican, northern gannet
	Procellariiformes	Storm-petrels Shearwaters	Band-rumped storm-petrel, Audubon's shearwater
Shorebirds	Charadriiformes	Plovers Oystercatchers Stilts and avocets Sandpipers, snipes, and allies	Semipalmated plover, American oystercatcher, willet, black-necked stilt
Wetland birds	Ciconiiformes	Bitterns, egrets, and herons Storks Ibises and spoonbills	Great blue heron, snowy egret, wood stork, white ibis
	Gruiformes	Cranes Limkins Rails and coots, and gallinules	Sandhill crane, sora, American coot
	Pelicaniformes	Cormorants	Double-crested cormorant
	Podicipediformes	Grebes	Pied-billed grebe, horned grebe
Waterfowl	Anseriformes	Ducks, geese, and swans	Blue-winged teal, mallard, red-breasted merganser, ring-necked duck, bufflehead, surf scoter
	Gaviiformes	Loons	Common loon
Passerines	Passeriformes	Perching birds	Warblers, swamp sparrow, thrushes, marsh wren, boat-tailed grackle
Raptors	Falconiformes	Birds of prey	Osprey, bald eagle

accidental oil spills that reach those habitats. For any of these categories, the occurrence and abundance of individual species and types of birds varies considerably, both spatially and temporally.

Seabirds spend a large portion of their lives on or over seawater and may be found in both offshore and coastal waters of the northern GOM, where they feed on fish and invertebrates. This category is represented by four orders of birds, and includes gulls, terns, and phalaropes; loons; frigatebirds, pelicans, tropicbirds, cormorants, gannets, and boobies; and storm-petrels and shearwaters (Table 3.8.2-2). Some birds (such as the boobies, petrels, and shearwaters) inhabit only pelagic habitats in the GOM, including deeper waters of the continental slope and GOM basin. Most GOM seabird species, however, inhabit waters of the continental shelf and adjacent coastal and inshore habitats of the estuarine and neritic ecoregions. The temporal occurrence of seabirds in the GOM varies greatly among species and groups. Some species (e.g., northern gannet [*Morus bassanus*], black tern [*Chlidonias niger*]) may be fairly common in some areas in winter although they breed outside the GOM, while others (e.g., least tern [*Sternula antillarum*]) are most common in summer months when they breed in the GOM. Still other species, such as many of the gulls and other terns and the brown pelican, may be present year round and nest in appropriate habitats in the GOM.

Shorebirds are represented by a single order and include the plovers, oystercatchers, stilts, avocets, sandpipers, and other similar forms (Table 3.8.2-2). These are typically small wading birds that feed on invertebrates in shallow waters and along beaches, mudflats, sand bars, and other similar areas. Shorebirds may be solitary or occur in small- to moderate-sized single-species flocks, although large aggregations of several species may be encountered, especially during migration. Shorebirds are generally restricted to coastline margins except when migrating, and would not be expected to occur over open waters of the continental shelf, slope, and basin areas of the GOM. Many North American shorebirds seasonally migrate between the high Arctic and South America, passing through the GOM during migration (Lincoln et al. 1998). Certain coastal and adjacent inland GOM wetlands serve as important habitats for overwintering shorebirds, and as temporary feeding and resting habitats for migrating shorebirds (see the later discussion on important bird areas of the GOM).

Overwintering shorebird species remain within specific areas throughout the season and typically utilize the same areas year after year; many of these areas in the northern GOM have been identified important bird areas (for example, ABC 2011; Audubon Society 2011a; see later discussion in this section). Overwintering shorebirds, as well as those that nest in spring and summer in specific areas, may be especially susceptible to habitat loss or degradation unless they move to other suitable habitats (if available) when their habitats are disturbed.

The wetland birds include a diverse array of birds from four orders (Table 3.8.2-2) that typically inhabit most coastal aquatic habitats of the northern GOM, including freshwater swamps and waterways, brackish and saltwater wetlands, and embayments. This group includes the large and small wading birds such as herons, egrets, cranes, rails, and storks, as well as diving birds such as cormorants and grebes. Most wetland birds are year-round residents of GOM coastal areas, with colonial or solitary nesting behaviors. Colonial nesting sites may be used year after year, typically being abandoned only following some sort of major disturbance (such as severe storm damage). Wetland birds feed on primarily fish and invertebrates (Sibley 2000). Similar to the shorebirds, this category may be especially susceptible to habitat loss or degradation unless they move to other suitable habitats when their current habitats are disturbed; colonial nesting habitats would be most difficult to replace.

Waterfowl are a diverse and important group that includes ducks, geese, loons, and swans. More than 30 species have been reported from coastal waters, beaches, flats, sandbars, and wetland habitats throughout the northern GOM (Sibley 2000). These birds forage on surface and submerged aquatic vegetation and aquatic invertebrates. There are three general groups of ducks. The surface-feeding ducks, such as the mallard (*Anas platyrhynchos*) and American widgeon (*A. americana*), use shallow freshwater and saltwater marshes throughout the northern

GOM, and many are present throughout the year. In contrast, bay ducks (such as the ring-necked duck [*Aythya collaris*]) are diving ducks that frequent coastal bays and river mouths, typically overwintering in the northern GOM and nesting elsewhere. The sea ducks are diving ducks that occur in marine habitats except during the breeding season. Some species have developed salt glands to aid them in using saltwater habitats. Example species include the bufflehead (*Bucephala albeola*) and Barrow's goldeneye (*B. islandica*). The mergansers are fish-eating diving birds that overwinter in coastal habitats in the GOM. Geese and swans forage on vegetation in coastal lakes, rivers, and marshes and, with the exception of the Canada goose (*Branta canadensis*), they overwinter in the GOM and spend the rest of the year in other areas.

The passerines are perching birds, and include the sparrows, warblers, thrushes, blackbirds, wrens, and many other types of birds (Table 3.8.2-2). While the northern GOM provides suitable habitat and supports a wide diversity of year-round resident passerine species, many species are winter residents that move into the GOM in the fall from farther north to overwinter before returning to breeding areas in more northern latitudes.

Raptors are the birds of prey. While most prey on birds and small mammals in terrestrial habitats, two species are fish eaters and if present may forage in coastal freshwater and saltwater habitats. These species are the bald eagle and the osprey, and they may be found year round in the GOM and nesting in suitable habitats.

3.8.2.1.2 Endangered Species. The ESA was passed in 1973 to address the decline of fish, wildlife, and plant species in the United States and throughout the world. The purpose of the ESA is to conserve "the ecosystems upon which endangered and threatened species depend" and to conserve and recover listed species (ESA; Section 2). The law is administered by the Department of the Interior's USFWS and the Department of Commerce's NMFS. The USFWS has primary responsibility for terrestrial and freshwater organisms, while the NMFS is responsible primarily for marine species such as salmon and whales.

Under the law, species may be listed as either "endangered" or "threatened." The ESA defines an endangered species as any species that is in danger of extinction throughout all or a significant portion of its range (ESA; Section 3(6)). A threatened species is one that is likely to become an endangered species within the foreseeable future throughout all or a significant part of its range (ESA; Section 3(20)). All species of plants and animals, except pest insects, are eligible for listing as endangered or threatened. The ESA also affords protection to "critical habitat" for threatened and endangered species. Critical habitat is defined as the specific areas within the geographical area occupied by the species at the time it is listed on which are found physical or biological features essential to the conservation of the species and that may require special management considerations or protection (ESA; Section 3(5)(A and B)). Except when designated by the Secretary of the Interior, critical habitat does not include the entire geographical area that can be occupied by the threatened or endangered species (ESA; Section 3(5)(C)).

Some species may also be listed as "candidate" species (ESA; Section 6(d)(1) and Section 4(b)(3)). The USFWS defines candidate species as plants and animals for which the

USFWS has sufficient information on their biological status and threats to propose them for listing as endangered or threatened under the ESA, but for which development of a listing regulation is precluded by other higher priority listing activities (USFWS 2001). The NMFS defines candidate species as those whose status is of concern but about which more information is needed before they can be proposed for listing. Candidate species receive no statutory protection under the ESA, but by definition these species may warrant future protection under the ESA.

Several species of federally endangered, threatened, or candidate species of birds occur in the northern GOM during at least part of the year (Table 3.8.2-3). These include species that use primarily coastal beach and wetland habitats. The threatened or endangered species are the Audubon's crested caracara (*Polyborus plancus audobonii*), the Mississippi sandhill crane, the piping plover (*Charadrius melodus*), the roseate tern (*Sterna dougallii dougallii*), the whooping crane (*Grus americana*), and the wood stork (*Mycteria americana*). A single candidate species, the red knot (*Calidris canutus rufa*), is also reported from coastal habitats along the northern GOM. Among the threatened and endangered species, five are found in habitats within the OCS GOM Planning Areas where they could be affected by OCS oil and gas activities, and four are reported from Florida (two species are exclusive to Florida) in areas where they could be affected by a catastrophic oil spill but not by normal OCS oil and gas operations.

The threatened Audubon's crested caracara is a large, diurnal raptor that is primarily associated with open country (pastureland, cultivated fields, and semidesert) but has been reported from coastal lowlands and beaches in some areas (NatureServe 2011). Because of its habitat preferences, this species is not expected to occur in areas where it could be affected by shore-based OCS-related oil and gas activities. However, this species has been reported from four coastal counties in Texas, Louisiana, and Florida (USFWS 2011d; Figure 3.8.2-1). In the

TABLE 3.8.2-3 Species Listed as Endangered, Threatened, or Candidate under the Endangered Species Act That May Occur in Coastal or Marine Habitats of the Northern Gulf of Mexico[a]

Species	Status	FL	AL	MS	LA	TX
Audubon's Crested Caracara	T	+	–	–	+	+
Mississippi Sandhill Crane	E	–	–	+	–	–
Piping Plover	T	–	+	–	+	+
Red Knot	C	+	–	–	+	
Roseate Tern	T	+	–	–	–	–
Whooping Crane	E	–	–	–	–[b]	+
Wood Stork	E	+	+	–	–	–

[a] Source: U.S. Fish and Wildlife Service, Environmental Conservation Online System (ECOS), Species Reports. Accessed March 31, 2011 at http://ecos.fws.gov/tess_public.

[b] Reintroduced as non-essential experimental population (USFWS 2011c).

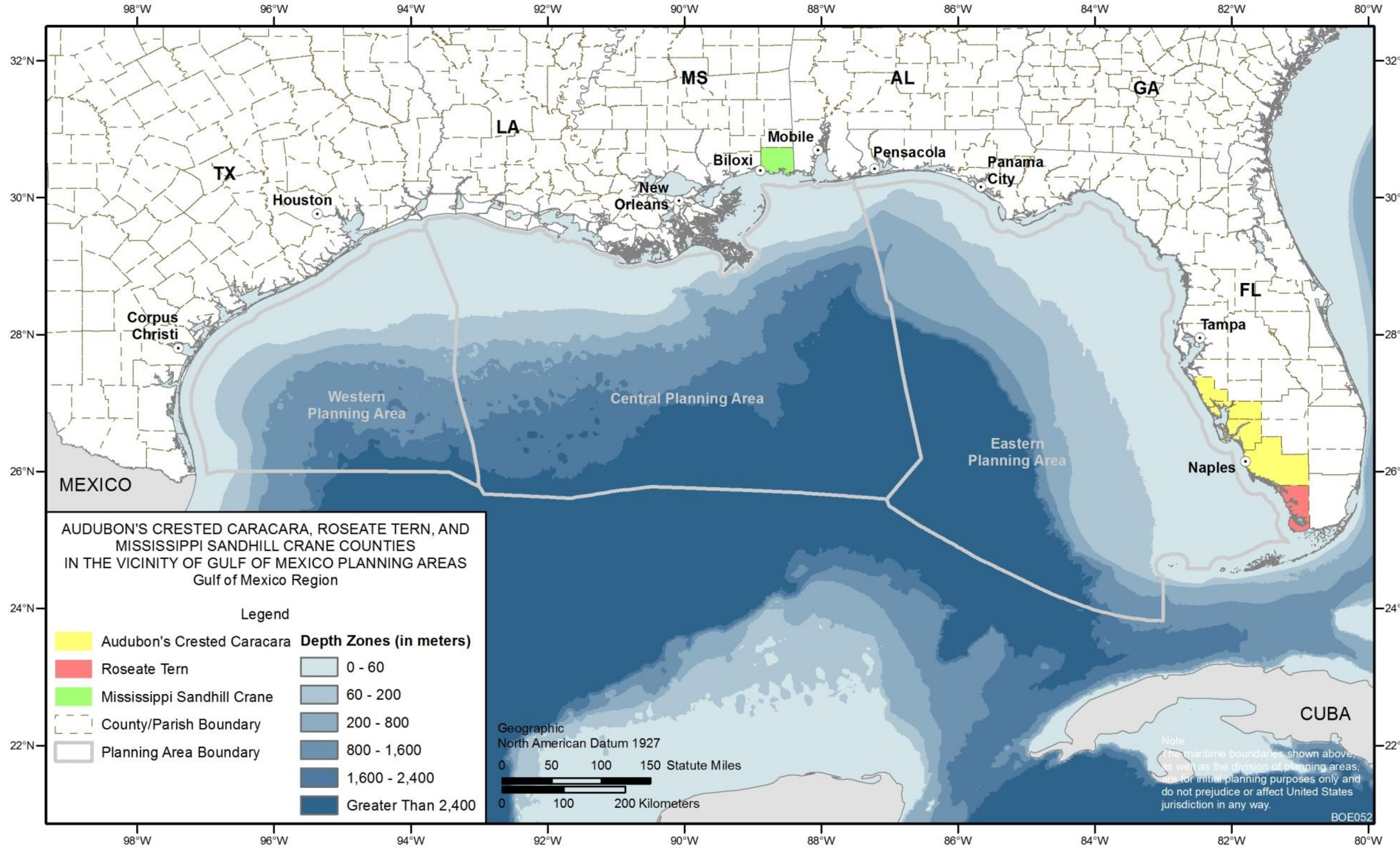

FIGURE 3.8.2-1 Coastal Counties from Which the Federally Endangered Mississippi Sandhill Crane and Roseate Tern, and the Federally Threatened Audubon's Crested Caracara, Have Been Reported (Source: USFWS 2011d)

event of an oil spill contacting coastlines in these counties, this species could be affected, if present.

The endangered Mississippi sandhill crane is a long-necked, long-legged wading bird that stands about 1.2 m (4 ft) tall. Habitats for this species include open savannas, swamp edges, young pine plantations, and wetlands along pine forests (NatureServe 2011). It feeds on aquatic invertebrates, reptiles, amphibians, insects, and aquatic plants, picking food items from the ground surface or probing into the substrate. The only known wild population (about 120 individuals) occurs on or near the Mississippi Sandhill Crane Wildlife Refuge in Jackson County, Mississippi (Figure 3.8.2-1). Major reasons for the decline of this species include habitat loss, human predation, and human disturbance (USFWS 1991b).

The roseate tern is a seabird that commonly ventures into oceanic waters; however, its western Atlantic population is known to occur in the far southeastern GOM to breed in scattered colonies along the Florida Keys (NatureServe 2001; Saliva 1993; USFWS 2011d). It is currently listed as endangered for populations along the U.S. Atlantic Coast from Maine to North Carolina, Canada, and Bermuda; it is listed as threatened in Florida, Puerto Rico, the Virgin Islands, and the remaining western hemisphere and adjacent oceans. Historically, this species ranged along the Atlantic temperate coast south to North Carolina; in Newfoundland, Nova Scotia, and Quebec, Canada; and in Bermuda (USFWS 2011d). In the northern GOM, this species has only been reported from Monroe County at the extreme southwest tip of Florida (Figure 3.8.2-1).

The piping plover is a shorebird that inhabits coastal sandy beaches and mudflats. This species is currently in decline and listed as endangered in the Great Lakes watershed (breeding range of the Great Lakes population of this species) and as threatened in the remainder of its range. It is listed as a result of historic hunting pressure, and loss and degradation of habitat (USFWS 2011d). This species is reported from coastal counties in each of the GOM States except Mississippi, and critical wintering habitat has been designated in each of the GOM Coast States for all three populations (Atlantic, Great Lakes, and Great Plains) of the piping plover (66 FR 36038–36143) (Figure 3.8.2-2).

The whooping crane is a wetland species that nests within western Canada and the north-central United States, and overwinters on salt flats and wetland habitats along the Aransas National Wildlife Refuge on the Texas Coast (USFWS 2011d). It is currently listed as endangered over its entire range, except where listed as an experimental population (Louisiana) (Figure 3.8.2-3). It is endangered because of historic hunting pressure and habitat loss and degradation. Critical habitat has been designated for this species in the GOM along the Texas coast (including Aransas National Wildlife Refuge) (43 FR 20938–20942).

The red knot is the only candidate bird species currently identified as occurring in the northern GOM. This highly migratory species travels between nesting habitats in mid- and high-arctic latitudes and southern non-breeding habitats in South America and portions of North America (southern Atlantic and GOM coasts). Its population has exhibited a large decline in recent decades, and is now estimated in the low ten thousands (NatureServe 2011). Horseshoe crab eggs are a critical food resource for this species, and it is believed that overharvest and population declines of horseshoe crabs may be a major reason for the decline of red knot

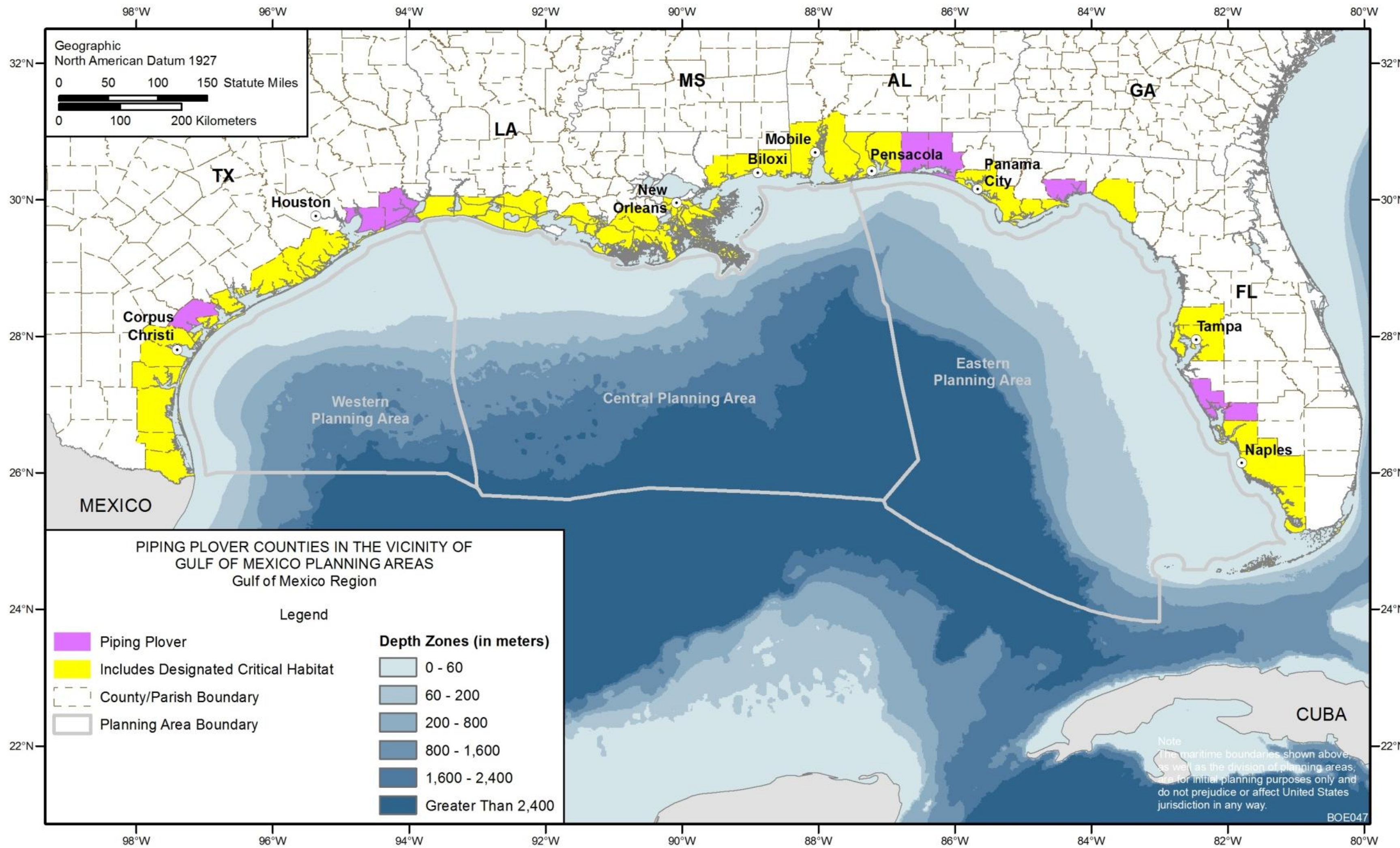

FIGURE 3.8.2-2 Coastal Counties from Which the Federally Threatened Piping Plover Has Been Reported (USFWS 2011d)

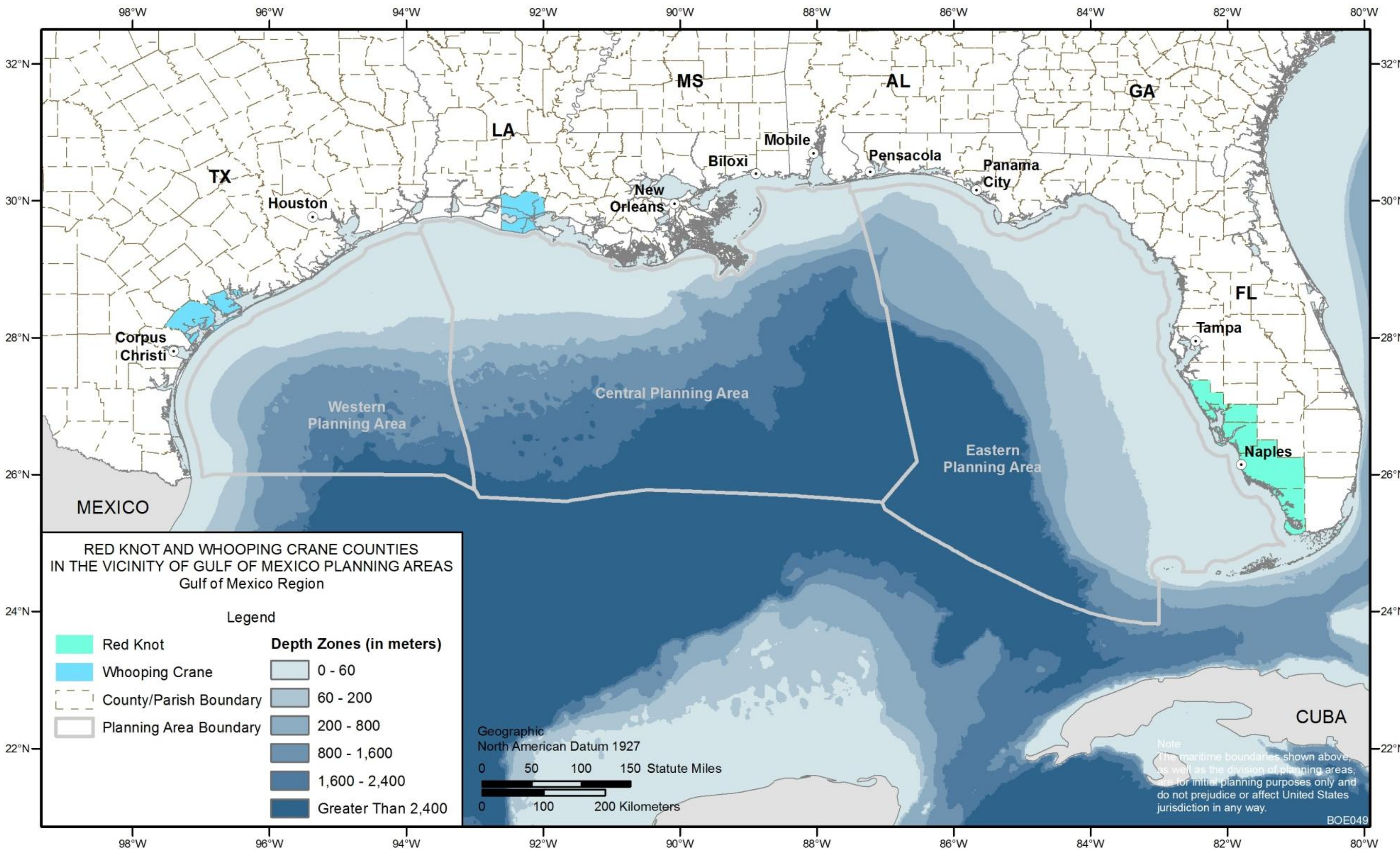

FIGURE 3.8.2-3 Coastal Counties from Which the Federally Endangered Whooping Crane and the Federal Candidate Red Knot Have Been Reported (Source: USFWS 2011d)

numbers. Within the northern GOM, this species has been reported from five counties along the far southwestern Florida coast (USFWS 2011d) (Figure 3.8.2-3), and has been reported to occur in Louisiana (Louisiana Bird Records Committee 2010). Because of its limited distribution and occurrence in the GOM, this species is not expected to be affected by shore-based OCS-related oil and gas activities that could occur in coastal areas along the Central and Western Planning Areas. In the event of an oil spill contacting the far southwestern coastline of Florida, this species could be exposed if present there.

The wood stork is the only stork that regularly occurs in North America. The published range of this wading bird is Alabama, Florida, Georgia, and South Carolina, where this species is classified as endangered (USFWS 2011d). While a year-round resident of Florida and Georgia, the wood stork does occur in other GOM coast States (Figure 3.8.2-4). Wood storks frequent freshwater and brackish coastal wetland habitats. No critical habitat has been designated for this species.

3.8.2.1.3 Migratory Birds. The GOM is an important pathway for migratory birds, including many coastal and marine species and large numbers of terrestrial species (Lincoln et al. 1998; USGS 2005). Most of the migrant birds (especially passerines or perching birds) that overwinter in the neotropics (tropical south Florida, Mexico, the Caribbean, Central America, and South America) and breed in eastern North America either directly cross the GOM (trans-GOM migration) or move north or south by traversing the GOM or the Florida peninsula (Figure 3.8.2-5) (Lincoln et al. 1998; Russell 2005).

Birds migrate in large, broad fronts that at times may number 2 million birds or more (USGS 2005). During the migration seasons, nearly all of the migratory birds of the eastern United States, as well as many western species, use the coastal plains of the northern GOM. Florida migrants then remain in place, cross to the Bahamas Archipelago, or travel directly across the Florida Straits and into the Antilles (Lincoln et al. 1998). Recent studies indicate that the flight pathways of the majority of the trans-GOM migrant birds during spring are directed toward the coastlines of Louisiana and eastern Texas (Morrison 2006). As many as 300 million birds may cross the GOM each spring (Russell 2005). During overwater flights, migrant birds (other than seabirds) sometimes use offshore structures, such as oil and gas production platforms, for rest stops or as temporary shelter from inclement weather. Spring migrants fly northward across the GOM, arrive on coastal habitats (especially those in Louisiana) with depleted energy reserves, and use those habitats for resting and rebuilding energy reserves. In the fall, migrants use food resources in the coastal habitats to build up energy reserves for migration southward either directly across the open waters of the GOM or along the GOM coast to Mexico and beyond.

3.8.2.1.4 Important Bird Areas. The northern GOM coast provides a diverse range of habitats that support the many migratory and resident bird species of the area. These habitats include coastal wetlands and marshes, mud flats, and beaches, which may be used for nesting, foraging, and for some species staging areas during spring and fall migration. While these habitats occur along the entire northern GOM coastline, some coastal areas may be especially

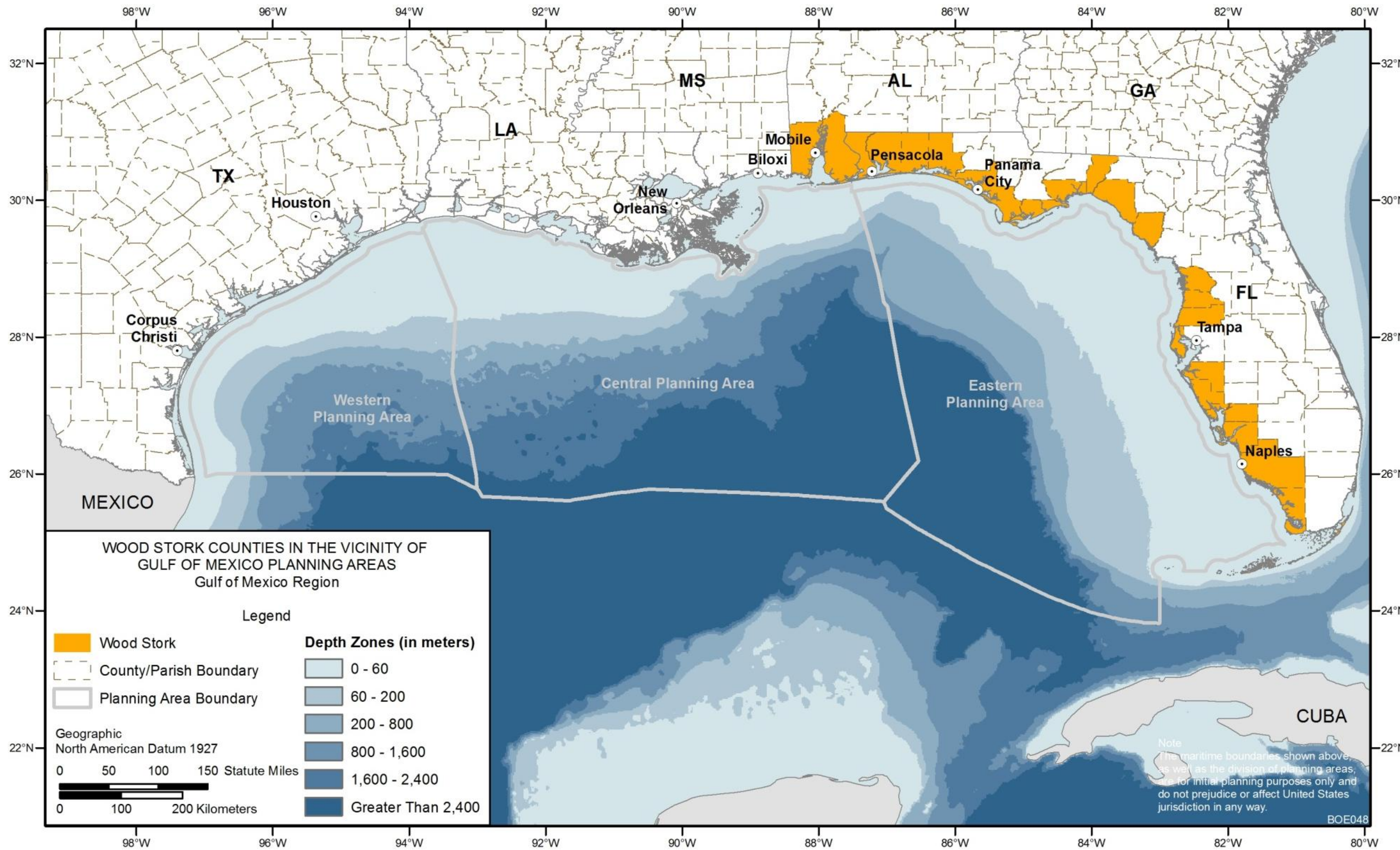

FIGURE 3.8.2-4 Coastal Counties from Which the Federally Endangered Wood Stork Has Been Reported (Source: USFWS 2011d)

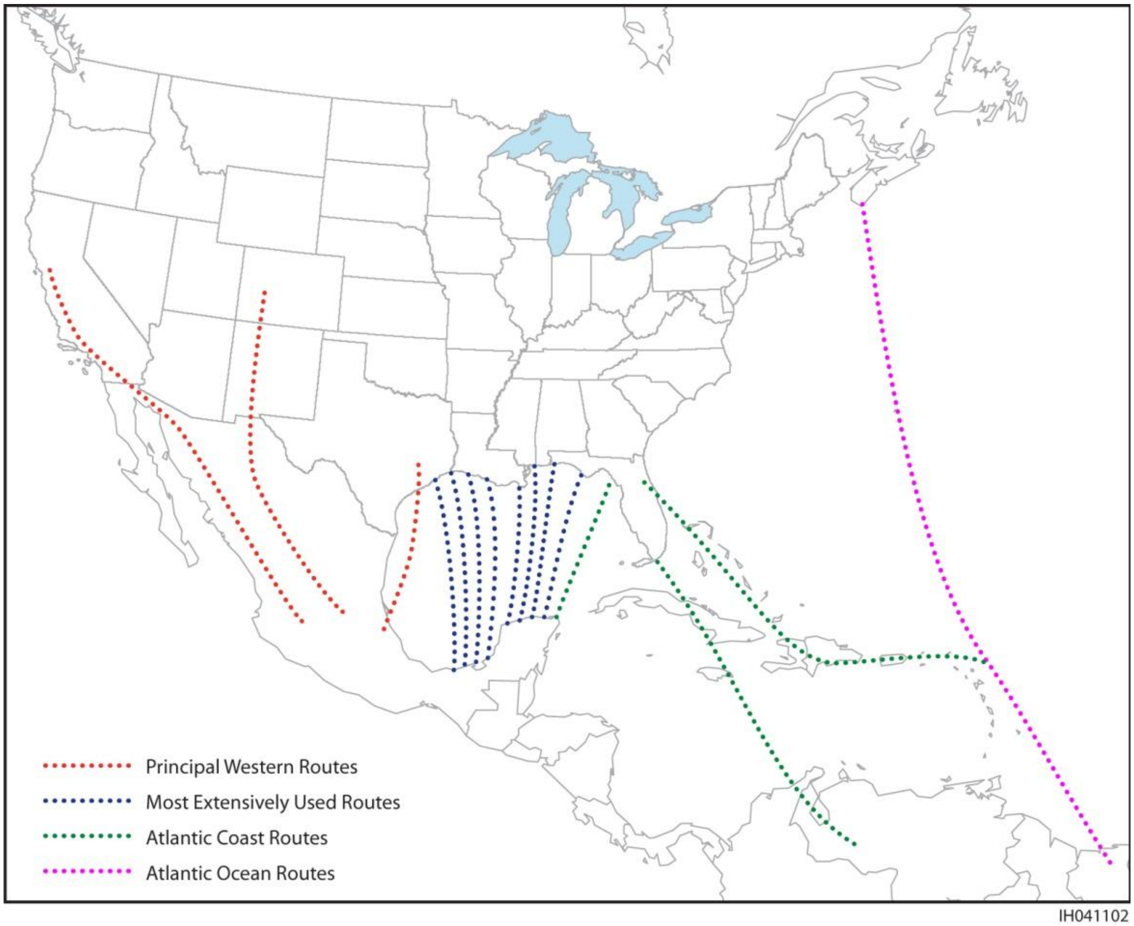

FIGURE 3.8.2-5 Primary Migration Routes Used by Birds in Passing from North America to Winter Quarters in the West Indies, Central America, and South America (The routes crossing the Gulf of Mexico are those most extensively used by birds and are also used by many species returning to North America in spring; specific routes taken by migrating birds may vary within and between years, depending on local and regional weather conditions, including storms and prevailing winds.) (Lincoln et al. 1998)

important to birds living along or using the northern GOM, and it is areas such as these that, if impacted by oil and gas activities or accidental oil spills, could impact local or regional populations of the species relying on the affected habitats provided. Some of these areas are protected by Federal or State regulations (e.g., National Wildlife Refuges and National Parks), while others may have no legal protection.

Since its start in Europe in the 1980s, the Important Bird Area (IBA) concept has led to the identification and protection of some 3,500 sites worldwide that are considered as exceptionally important, even essential, for bird conservation (ABC 2011). Both the American Bird Conservancy (ABC) and the Audubon Society have identified a number of IBAs along the northern GOM coast (ABC 2011; Audubon Society, see http://web4.audubon.org/bird/iba). These IBAs are not afforded regulatory protection unless they occur on protected Federal (such as USFWS National Wildlife Refuges) or State lands or include ESA-designated critical habitat.

The ABC has identified 37 important bird areas in coastal counties along the northern GOM coast (Figure 3.8.2-6). Many of these sites include national wildlife refuges, national parks, national forests, State lands, conservation organization lands, and even some private lands. To be included, a site must, during at least some portion of the year, contain habitat that supports:

1. A significant population of a threatened or endangered species;

2. A significant population of a U.S. Watch List species;

3. A significant population of a species with a limited range; or

4. A significantly large concentration of breeding, migrating, or wintering birds, including waterfowl, seabirds, wading birds, raptors, or land birds (ABC 2011).

The IBAs along the northern GOM include 17 areas in Texas, 9 in Florida, 5 in Louisiana, and 3 each in Alabama and Mississippi (Table 3.8.2-4). Because these areas are located in coastal areas and, in some cases, are islands and seashores, they have a greater likelihood of interacting with OCS oil and gas activities in the GOM.

The Audubon Society has identified 52 IBAs for the northern GOM coast (Audubon Society 2011a). These include 8 sites in Texas, 6 in Louisiana, 7 in Mississippi, 4 in Alabama, and 27 in Florida; and only 7 of the Audubon IBA sites overlap with the ABC sites (Figure 3.8.2-7; Table 3.8.2-5).

Some of these IBAs are associated with specific, individual species. For example, the Aransas National Wildlife Refuge in Texas was established in 1937 as a refuge and breeding ground for migratory birds, and hosts the largest wild flock of endangered whooping cranes each winter. Similarly, the Gulf Coast Least Tern Colony Globally Important Bird Area in Mississippi supports the largest colony of the least tern.

Other sites provide important overwintering habitat for federally threatened piping plover, or provides foraging and resting habitat for large variety of waterfowl, shorebirds, wading birds, and migrating passerines. For example, Dauphin Island in Alabama is one of the few known breeding localities for snowy plover (*Charadrius alexandrines*), mottled duck (*Anas fulvigula*), and seaside sparrow (*Ammodramus maritimus*) (Audubon Society 2011b).

3.8.2.1.5 Effect of the Deepwater Horizon Event on Marine and Coastal Birds. With the exception of the passerines, most of the bird groups that occur in the northern GOM are associated with aquatic habitats, whether coastal and estuarine shorelines, wetlands, mudflats, and beaches, or open water areas such as bays and marine waters on the OCS. The DWH event resulted in the release of oil in the open waters of the OCS, with some of this oil moving to the coast and contacting coastal and shoreline habitats, and marine and coastal birds were exposed to the oil in affected coastal and open water habitats. The USFWS, as part of a multi-agency

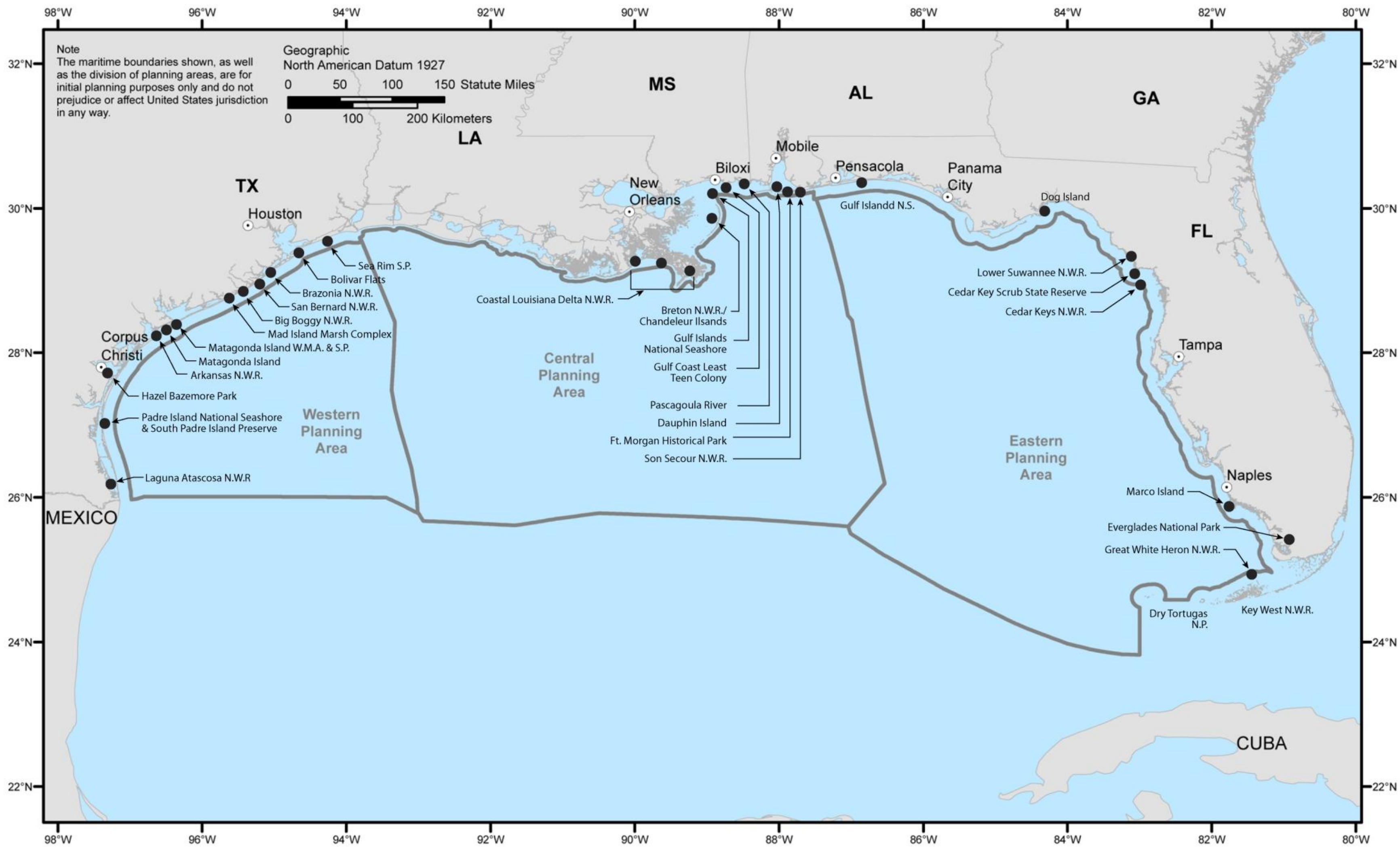

FIGURE 3.8.2-6 Important Bird Areas along the Northern Coast of the Gulf of Mexico (ABC 2011)

TABLE 3.8.2-4 Important Bird Areas Identified by the American Bird Conservancy for the Coastal Counties of the Northern Gulf of Mexico

State	Important Bird Area	County
Texas	Aransas National Wildlife Refuge	Aransas
	Columbia Bottomlands	Brazoria
	San Bernard National Wildlife Refuge	Brazoria
	Matagorda Island	Calhoun
	Laguna Atascosa National Wildlife Refuge	Cameron
	South Padre Island Preserve	Cameron
	Anahuac National Wildlife Refuge	Chambers
	Smith Point	Chambers
	High Island	Galveston
	McFadden National Wildlife Refuge	Jefferson
	Texas Point National Wildlife Refuge	Jefferson
	Sea Rim State Park	Jefferson
	Kings Ranch	Kenedy, Kleberg, Neuces, Willacy
	Padre Island National Seashore	Kenedy, Kleberg, Willacy
	Big Boggy National Wildlife Refuge	Matagorda
	Mad Island Marsh Wildlife Complex	Matagorda
	Hazel Bazemore County Park	Neuces
Louisiana	Breton National Wildlife Refuge	St. Bernard
	Catahoula National Wildlife Refuge	LaSalle
	Delta National Wildlife Refuge	Plaquemines
	Coastal Louisiana Islands	Cameron, Vermillion, Iberia, St. Mary, Terrebonne, LaFourche, Jefferson, Plaquemines, St. Bernard
Mississippi	Gulf Coast Least Tern Colony	Harrison
	Gulf Islands National Seashore[a]	Harrison, Jackson
	Mississippi Sandhill Crane National Wildlife Refuge	Jackson
Alabama	Bon Secour National Wildlife Refuge[a]	Baldwin
	Dauphin Island[a]	Mobile
	Fort Morgan Historical Park	Baldwin
Florida	Apalachicola National Forest	Wakulla, Franklin
	Cedar Key Scrub State Reserve	Levy
	Cedar Keys National Wildlife Refuge	Levy
	Dog Island[a]	Franklin
	Elgin Air Force Base[a]	Okaloosa
	Gulf Islands National Seashore[a]	Escambia, Santa Rosa
	Honeymoon Island State Recreation Area	Pinellas
	Ochlockonee River State Park	Franklin
	St. Marks National Wildlife Refuge[a]	Wakulla

[a] Also identified as an IBA by the Audubon Society; see Table 3.8.2-5.

Source: ABC 2011.

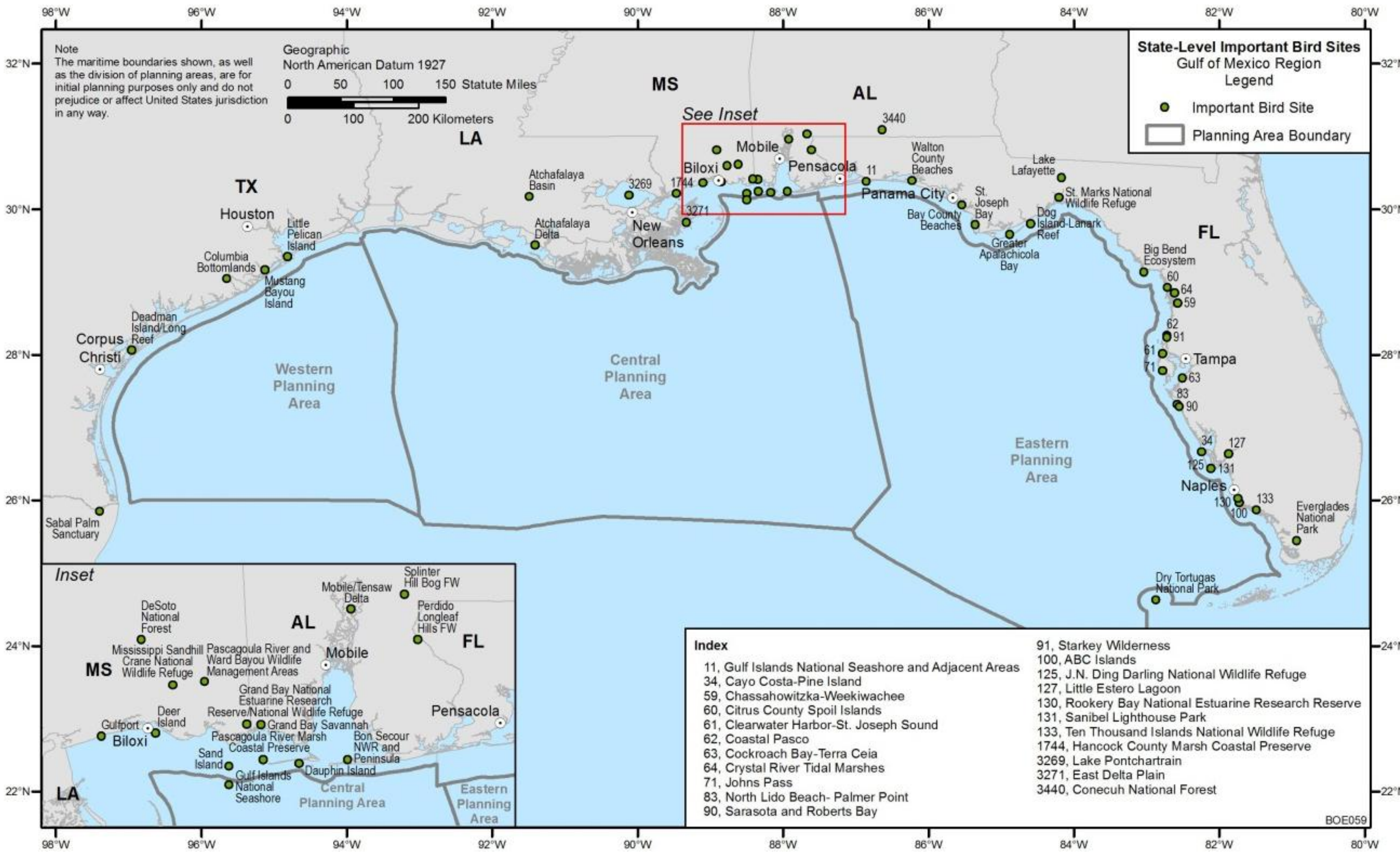

FIGURE 3.8.2-7 Important Bird Areas Identified by the Audubon Society for the Northern Coast of the Gulf of Mexico (Audubon Society 2011a)

TABLE 3.8.2-5 Important Birds Areas Identified by the Audubon Society for the Coastal Counties of the Northern Gulf of Mexico

State	Important Bird Area	County
Texas	Deadman Island/Long Reef	Aransas
	Islands South of South Bird Island	
	Little Pelican Island	Galveston
	Mustang Bayou Island	Brazonia
	Pelican Island	
	Port Bolivar Bird Sanctuaries-Horseshoe Marsh	
	Second Chain of Islands	
	Shamrock Island	
Louisiana	Active Delta (Mississippi River Birdsfoot Delta)	Plaquemines
	Atchafalaya Delta	Assumption, St. Mary, Terrebonne
	Barataria Terrebonne	Assumption, Jefferson, LaFrouche, Plaquemines, St. Charles, St. James, St. John the Baptist, St. Mary, Terrebonne
	Chenier Plain	Calcasieu, Cameron, Iberia, Jefferson Davis, St. Mary, Vermillion
	East Delta Plain	Orleans, Plaquemines, St. Bernard, St. Tammany
	Isles Dernieres-Timbalier Islands	Terrebonne
Mississippi	Deer Island	Harrison
	Grand Bay National Estuarine Research Reserve/National Wildlife Refuge	Jackson
	Gulf Islands National Seashore[a]	Harrison, Jackson
	Gulfport	Harrison
	Hancock County Marsh Coastal Preserve	Hancock
	Pascagoula River Marsh Coastal Preserve	Jackson
	Sand Island	Jackson
Alabama	Bon Secour National Wildlife Refuge[a] and Peninsula	Baldwin
	Dauphin Island[a]	Mobile
	Grand Bay Savannah	Mobile
	Mobile/Tensaw Delta	Baldwin, Mobile
Florida	ABC Islands	Collier
	Bay County Beaches	Bay
	Big Bend Ecosystem	Dixie, Levy, Taylor
	Cayo Costa-Pine Island	Lee
	Chassahowitzka-Weekiwachee	Citrus, Hernando, Pasco
	Citrus County Spoil Islands	Citrus
	Clearwater Harbor-St. Joseph Sound	Pinellas
	Coastal Pasco	Pasco
	Cockroach Bay-Terra Ceia	Manatee, Hillsborough
	Crystal River Tidal Marshes	Citrus
	Dog Island[a] -Lanark Reef	Franklin

TABLE 3.8.2-5 (Cont.)

State	Important Bird Area	County
Florida (Cont.)	Dry Tortugas National Park	Monroe
	Elgin Air Force Base[a]	Okaloosa
	Great White Heron National Wildlife Refuge	Monroe
	Gulf Islands National Seashore[a] and Adjacent Areas	Escambia, Santa Rosa
	J.N. Ding Darling National Wildlife Refuge	Lee
	Johns Pass	Pinellas
	Little Estero Lagoon	Lee
	North Lido Beach-Palmer Point	Sarasota
	Oscar Scherer State Park	Sarasota
	Pelican Shoal	Monroe
	Rookery Bay National Estuarine Research Reserve	Collier
	Sanibel Lighthouse Park	Lee
	Sarasota and Roberts Bay	Manatee, Sarasota
	St. Joseph Bay	Gulf
	St. Marks National Wildlife Refuge[a]	Jefferson, Wakulla, Taylor
	Starkey Wilderness	Pasco
	Ten Thousand Islands National Wildlife Refuge	Collier
	Walton County Beaches	Walton

[a] Also identified as an IBA by the ABC; see Table 3.8.2-4.

Source: Audubon Society 2011a.

response to the DWH event, began reporting of oiled and dead birds, and established a program to provide accurate data regarding not only oiled and dead birds but also marine mammals and sea turtles (USFWS 2011e). Observations of direct exposure of birds included signs of visible oiling of feathers and other body surfaces. Indirect exposure through ingestion of oil or of food items contaminated with oil is expected to have occurred as well. In addition, the shoreline cleanup efforts of the DWH event may have disturbed nesting populations and degraded or destroyed habitat in some localized areas.

Table 3.8.2-6 presents a summary of the most recent DWH event bird impact data collected by the USFWS (USFWS 2011e). Over 6,600 individuals representing at least 129 bird taxa had been collected in the DWH event potential impact area as of May 12, 2011. Birds were reported as dead or alive in one of three categories: visibly oiled from the DWH event, visibly oiled from an undetermined source; and not visibly oiled. Of the birds most closely associated with aquatic habitats, seabirds represented the majority (79–90%) of birds reported for any of these categories, followed by wetland birds (5–10%) and shorebirds (3–7%). In contrast, relatively few waterfowl ($\leq$1%), passerines ($\leq$3%), and raptors (<1%) were collected.

Birds that are heavily oiled usually do not survive. Oiled birds that do not perish shortly after oiling may experience more chronic physiological effects of oil exposure. Birds exposed through the ingestion of oil during feeding or grooming, or through inhalation, may also incur chronic, sublethal physiological effects. Post-DWH event exposure may occur in habitats and

TABLE 3.8.2-6 Deepwater Horizon Event Bird Impact Data through May 12, 2011

Avian Category	No. of Taxa	Visibly Oiled; Attributed to DWH Event			Not Visibly Oiled			Visibly Oiled; Unknown Source			Grand Total
		Dead[a]	Live	Total	Dead	Live	Total	Dead	Live	Total	
Seabirds	32	1,822	480	2,302	2,324	0	2,324	654	271	925	5,551
Shorebirds	16	70	8	78	205	2	207	52	10	62	347
Wetland Birds	28	118	19	137	249	0	249	88	29	117	503
Waterfowl	14	9	3	12	34	0	34	10	8	18	64
Passerines	30	17	3	20	54	0	54	17	20	37	111
Raptors	9	2	1	3	15	0	15	4	3	7	25
Total	129	2,038	514	2,552	2,881	2	2,883	827	341	1,168	6,603

[a] Includes birds that were recovered live but subsequently died.

Source: USFWS 2011e.

media where oil in an unweathered toxic form may remain indefinitely. Chronic effects may not yet be evident, but may become realized at a later date. It is not known how sublethal exposure to oil from the DWH event may have affected marine and coastal birds of the GOM; any such effects may not be realized for several years. This information, however, is not needed at the programmatic stage to make a reasoned choice among alternatives (see Section 1.3.1.1, Incomplete and Unavailable Information).

3.8.2.2 Marine and Coastal Birds of Alaska – Cook Inlet

More than 492 naturally occurring species in 64 families and 20 orders have been identified in Alaska (University of Alaska 2011), and more than 80 species may occur in the Cook Inlet Planning Area. Birds traveling to and from breeding areas in interior Alaska, the North Slope, and west coast areas of Alaska use Cook Inlet during these movements. Annual use patterns of the Cook Inlet are characterized by the sudden and rapid occurrence of very large numbers of birds in early May followed by an abrupt departure in mid-to-late May; surveys conducted at this time have had counts of 150,000 birds or more per day (Gill and Tibbitts 1999).

3.8.2.2.1 Nonendangered Species. Representatives of six major groups of birds occur in the Cook Inlet Planning Area (Table 3.8.2-7). Among these groups, three may have the greatest potential for being affected by oil and gas leasing and development: (1) seabirds, which occur in open ocean waters; (2) waterfowl, which utilize a variety of freshwater and nearshore marine habitats; and (3) shorebirds, which utilize shoreline habitats throughout the planning area. Many of these species are migratory and may seasonally occur in locally large concentrations such as nesting colonies or as mobile flocks.

In the summer, seabirds and sea ducks are found along the coastlines of Cook Inlet. Colonial seabirds, except for gulls and terns, are mostly confined to the lower portions of the inlet where foraging areas are more abundant (USFWS 1978; Nature Conservancy 2003). The intertidal habitats of Cook Inlet are used by millions of shorebirds (such as western sandpipers [*Calidris mauri*] and dunlin [*C. alpine*]) during spring migration, and several species breed in the planning area. In the summer, Cook Inlet provides breeding habitat for migratory waterfowl, and during fall migration the inlet may be used by as many as 1 million migrating waterfowl. Waterfowl are valued as subsistence resources, and they also provide a sport-hunting resource. In contrast to conditions that lead to large numbers of birds being present in spring, summer, and fall, ice conditions limit overwinter use of the upper portions of the inlet by birds.

A number of large seabird colonies (i.e., ranging from 20,000 to multiple hundreds of thousands of individuals) occur in the subregion, including on the Chisik and Gull Islands in Cook Inlet, the Barren Islands south of Cook Inlet, and the Kodiak Island group (Stephensen and Irons 2003). Many smaller colonies, whose aggregate population represents a substantial concentration of seabirds, also occur in these areas.

The factors most responsible for the status of bird populations in the Cook Inlet Planning Area are associated with the availability and quality of wintering, migratory, and nesting habitats

TABLE 3.8.2-7 Major Groups of Marine and Coastal Birds of the Cook Inlet Planning Area

Category	Order	Common Name	Representative Types
Seabirds	Charadriiformes	Gulls Terns Phalaropes Alcids	Mew gull, glaucius-winged gull, Arctic tern, red-necked phalarope, common murre, pidgeon guillomot, ancient murrelet
	Procellariiformes	Storm-petrels Shearwaters Albatrosses	Fork-tailed storm-petrel, northern fulmer, short-tailed albatross
Shorebirds	Charadriiformes	Jaegers Plovers Oystercatchers Sandpipers, snipes, and allies	Parasitic jaeger, black-bellied plover, black oystercatcher, dunlin, western sandpiper
Wetland birds	Gruiformes	Cranes	Sandhill crane
	Pelicaniformes	Cormorants	Double-crested cormorant
	Podicipediformes	Grebes	Horned grebe
Waterfowl	Anseriformes	Ducks, geese, and swans	Trumpeter swan, mallard, greater scaup, common goldeneye, harlequin duck
	Gaviiformes	Loons	Pacific loon, common loon
Passerines	Passeriformes	Perching birds	Warblers, boreal chickadee, American pipet, common redpoll
Raptors	Falconiformes	Birds-of-prey	Osprey, bald eagle

and the availability of food in those habitats. Changes in breeding habitat availability or quality and food resources during breeding could affect egg production and nesting success.

Bird density and diversity is lowest in winter. Typically, only a single species of shorebird, the rock sandpiper (*Calidris ptilocnemis*), remains through the winter in upper Cook Inlet, although some black turnstones (*Arenaria melanocephala*) and dunlins also may stay. The approximately 20,000 individuals may represent the entire Bering Sea breeding population of the rock sandpiper (Gill and Tibbitts 1999; Gill et al. 2002). The Kodiak area is also an important wintering ground for several species of waterfowl and seabirds (Forsell and Gould 1981; Larned and Zwiefelhofer 2001), including cormorants, scoters, long-tailed ducks (*Clangula hyemalis*), eiders, common murres (*Uria aalge*), murrelets, and crested auklets (*Aethia cristatella*). Estimates of total birds in the area exceed one-half million, with an excess of 800,000 wintering over the Kodiak shelf region. Emperor geese winter from the Aleutians to Kodiak. Lower Cook Inlet also is relatively important for overwintering waterfowl, murres, fulmars, and storm-petrels (Agler et al. 1995).

3.8.2.2.2 Threatened and Endangered Species. Several species of federally endangered, threatened, or candidate species (see Section 3.8.2.1.2 for a discussion of the ESA and definitions of these categories) occur in the Cook Inlet Planning Area. These species are the federally endangered short-tailed albatross (*Phobastria albatrus*) and the federally threatened Steller's eider (*Polysticta stelleri*). Two candidate species, and Kittlitz's murrelet (*Brachyramphus brevirostris*) and the yellow-billed loon (*Gavia adamsii*), also occur in the planning area.

The short-tailed albatross is a long-winged seabird that was listed in 2000 as endangered in the United States (65 FR 46643), making it so designated throughout its range. This species was originally listed in 1970 under the then-Endangered Species Conservation Act of 1969, before passage of today's ESA. As a result of an administrative error and not because of any biological evaluation, this species was listed as endangered throughout its range except within the United States. This error was corrected in 2000 when this species was listed as endangered throughout its range. No critical habitat has been designated in marine waters within U.S. jurisdiction. The greatest current threat to this species is the potential volcanic eruption of Torishima, where most breeding occurs. Other existing threats include incidental catch in commercial fisheries, ingestion of plastics, contamination by oil and other pollutants, the potential for habitat usurpation or degradation by non-native species, and the adverse effects of climate change (USFWS 2008c).

Short-tailed albatross occurs in waters throughout the North Pacific, primarily along the east coasts of Japan and Russia; in the continental shelf edge of the Gulf of Alaska, along the Aleutian Islands; and in the Gulf of Alaska south of 64°N latitude (USFWS 2008c), and is a relatively frequent visitor to the South Alaska subregion. While once thought to number 5 million individuals, about 2,400 birds were known to exist in June 2008, with about 450–500 breeding pairs. This albatross is known to breed on only two small islands near Japan, with 80–85% of all breeding occurring on the active volcanic island of Torishima in the western Pacific.

During the non-breeding season, short-tailed albatrosses range along the Pacific Rim from southern Japan to northern California, primarily along continental shelf margins (USFWS 2008c). On the basis of ship-based observations and telemetry data, this species may be relatively common nearshore where upwellings occur near the coast; this species should be considered a "continental shelf-edge specialist" rather than a coastal or nearshore species (Piatt et al. 2006). The shelf edge in the vicinity of the Cook Inlet Planning Area occurs about 121 km (75 mi) from the southern boundary of the planning area.

The Steller's eider is the smallest of the four eider duck species. This species breeds in the Arctic, and the Alaska breeding population was listed as threatened in 1997 (62 FR 31748). There are three breeding populations, two in Russia and one in Alaska (USFWS 2002). The Alaska breeding population nests primarily on the Arctic coastal plain, and is the only one of the three populations listed under the ESA as threatened. While the causes for the population decline observed for this species are unknown, possible factors affecting the Alaska population may include predation, hunting, ingestion of spent lead shot, habitat loss or degradation, and exposure to contaminants (USFWS 2002; NatureServe 2010b).

On the coastal plain, Steller's eiders breed on grassy edges of tundra lakes and ponds, or within drained lake basins. Although they nest in terrestrial environments, they spend the majority of their time in shallow marine waters. Steller's eider does not breed in the Southern

Alaska Subregion. After nesting in the Arctic coastal plains, they move to protected marine areas to molt. Molting occurs at a number of locations in southwest Alaska, with the largest numbers of birds concentrating in four areas along the north side of the Alaska Peninsula (USFWS 2002). Three lagoons on the north side of the Alaska Peninsula have been designated as critical habitat for the Steller's eider (66 FR 8850).

After molting, many of the birds disperse to the Aleutian Islands, the south side of the Alaska Peninsula, Kodiak Island, and lower Cook Inlet (USFWS 2002; Larned 2006). Wintering birds usually occur in shallow waters (<10 m [30 ft] in depth) within 400 m (1,300 ft) of shore, unless the shallows extend farther offshore into bays and lagoons. Substantial numbers of Steller's eiders remain in lagoons on the north side of the Alaska Peninsula in winter until freezing conditions force them out. In Cook Inlet, the largest concentrations of sightings in 2004 were from the Homer Spit north to about Ninilchik and along the south central shore of Kamishak Bay on the inlet's west side (Larned 2004).

The Kittlitz's murrelet is a small diving seabird related to the puffins and murres. All of the North American and most of the world population of this species breed, molt, and winter in Alaska (USFWS 2006d). The North American population of this small diving seabird occupies coastal waters discontinuously from northern Southeast Alaska in the Gulf of Alaska, north to Point Lay in the Chukchi Sea during the nesting season. Wintering areas are not well known, and are assumed to include offshore waters in at least the Gulf of Alaska and Bering Sea portions of the range (USFWS 2006d). Spring migration extends from the third week of March to mid-June, fall migration from mid-July to late October, and breeding from mid-May to late August.

This species is an uncommon and secretive breeder, choosing unvegetated scree slopes, coastal cliffs, talus above timberline, and barren ground, especially in the vicinity of advancing or stable glaciers or in recently glaciated areas, primarily in coastal areas but also up to 80 km (50 mi) inland (USFWS 2006d). Nests have been found in most coastal regions from southeast to western Alaska (Day et al. 1999). During breeding, Kittlitz's murrelets are found in several core population centers in Alaska, including Lower Cook Inlet (Agler et al. 1998; USFWS 2006d). Based on apparent evidence of a population decline in the Prince William Sound area, the Kittlitz's murrelet was petitioned for listing in 2001 and became a candidate for listing in a May 2004 Candidate Notice of Review (69 FR 24877). Possible threats to this species include marine oil pollution, decreases in food stock, gillnet fisheries, and melting of glaciers (USFWS 2006d; NatureServe 2010c).

The yellow-billed loon is a migratory, fish-eating seabird that in Alaska nests in solitary pairs on the Arctic Coastal Plain and winters in more southern coastal waters of the Pacific Ocean (USFWS 2011d). This species became a candidate for listing as endangered or threatened in March 2009, primarily due to subsistence use of this species during migration (74 FR 12932). Yellow-billed loons typically nest near large, deep tundra lakes on low islands or near the edges of lakes to avoid terrestrial predators. In Alaska, nesting occurs from the Canning River westward to Point Lay, and migration occurs along coastlines of the Beaufort and Chukchi Seas (North 1994; NatureServe 2010d). During nesting, this species uses nearshore and offshore marine waters adjacent to their breeding areas for foraging in summer (74 FR 12932).

During non-breeding, this species spends most of its time in marine waters and uses open water leads for resting and feeding during migration. In Alaska, the yellow-billed loon winters in sparse numbers in nearshore marine waters from Kodiak Island to Prince William and throughout southeast Alaska (North 1994). Wintering habitats include sheltered marine waters less than 30 m (98 ft) deep, from 1.6 to 32 km (1 to 20 mi) offshore (74 FR 12932). Lower Cook Inlet is used in winter by overwintering birds and by immature and possibly non-breeding adults throughout the year.

3.8.2.2.3 Use of the Cook Inlet Planning Area by Migratory Birds. The coastal wetlands and bays along Cook Inlet provide important staging habitats for migratory birds, with large seasonal aggregations of waterfowl and shorebirds. The highest diversity and density of birds in coastal waters, particularly over the continental shelf, occur in spring when large numbers of loons, waterfowl, shorebirds, and seabirds return to nesting areas or stage there before migrating to areas farther north.

During spring migration (April–May), large numbers of birds arrive from southern wintering areas either to occupy breeding habitats along the northern Gulf of Alaska coast or to use habitats in the area as they stage for further migration northward to breeding areas in interior Alaska and along the Arctic Coastal Plain. During spring migration, species diversity and density along the northern Gulf of Alaska are greatest in exposed inshore waters and in bays and lagoons and associated tidal mudflats (e.g., Kachemak Bay), river deltas (e.g., Copper River Delta), and salt marshes, as well as along exposed outer coasts where large numbers of seabirds gather prior to nesting. This latter topography is common in many areas of this subregion, including the exposed outer coast between Prince William Sound and the lower Kenai Peninsula, much of the Kodiak Island archipelago, numerous islands and headlands along the south side of the Alaska Peninsula, and virtually all of the Aleutian Islands. Seabirds most frequently occupy bays and exposed inshore waters. Geese and dabbling ducks primarily use river floodplains and marshes, while diving ducks are most prevalent in bays. Shorebirds are found mainly on mudflats and gravel beaches, and gulls use a variety of habitats. During spring migration, millions of shorebirds make a critical stop on coastal intertidal mudflats to feed before continuing their northward migration. The largest number of migrating shorebirds occurs on the Copper River Delta where 10–12 million birds may stop each spring. At least 20 species of shorebirds migrate through the northern Gulf of Alaska each spring; their numbers are dominated by the western sandpiper, representing most of the world’s population of 3-4 million.

Pelagic bird densities begin to decline in September, as shearwaters depart for the southern hemisphere breeding areas. Postbreeding alcids disperse from coastal nesting colonies for offshore areas, where they will spend the winter. Migration of waterfowl and shorebirds is more protracted in the fall than in the spring, and there is some evidence that some shorebird species bypass the Gulf of Alaska during fall. Only goose and dabbling duck densities increase in fall, as migrating birds move in from areas to the north and west.

Winter bird densities along the northern Gulf of Alaska are perhaps 20–50% of those in the summer. Most of the decrease reflects seasonal changes in species composition as many seabirds leave areas they occupied in summer. While seabird numbers are lowest during the winter, the Gulf of Alaska still is important for species that winter offshore such as the northern fulmar (*Fulmarus glacoalis*), fork-tailed storm-petrel (*Oceanodroma furcata*), black-legged kittiwake (*Rissa tridactyla*), and both murre and puffin species. Coastal wintering species along the northern Gulf of Alaska coast include Pacific (*Gavia pacifica*), red-throated (*G. stellate*), and yellow-billed loons; red-necked grebe (*Podiceps grisegena*); herring (*Larus argentatus*), mew (*L. canus*), and glaucous-winged (*L. glaucescens*) gulls; ancient (*Synthliboramphus antiquus*) and marbled (*Brachyramphus marmortus*) murrelets; and Cassin's (*Ptychoramphus aleuticus*) and parakeet (*Aethia psittacula*) auklets. In the winter, waterfowl densities increase substantially as a number of species migrate south from breeding areas on the Arctic coastal plain to overwinter along the coast; sea ducks are the most abundant waterfowl present in winter. These include king (*Somateria spectablis*) and common (*S. mollissima*) eiders; long-tailed and harlequin (*Histrionicus histrionicus*) ducks; black (*Melanitta Americana*) and surf scoters (*M. perspicillata*) and Barrow's goldeneye.

3.8.2.2.4 Important Bird Areas of the Cook Inlet Planning Area. As discussed above, Cook Inlet and the Cook Inlet Planning Area provide a diversity of habitats for resident and migratory marine and coastal birds. While habitats such as mudflats, sand and gravel beaches, lagoons, and islands may be found throughout Cook Inlet and some areas are considered as being particularly important to birds living along or using the northern Gulf of Alaska. Areas in Cook Inlet that may be considered as important to overwintering and migratory birds have been identified by a number of organizations.

Because of its importance to shorebirds of the Pacific Flyway, Kachemak Bay in Lower Cook Inlet has been designated as Western Hemisphere Shorebird Reserve. Western Hemisphere Shorebird Reserves (WHSR) are designated by the WHSR Network (WHSRN), a multinational shorebird conservation organization whose mission is to conserve shorebirds and their habitats through a network of key sites across the Americas[12] (http://www.whsrn.org/western-hemisphere-shorebird-reserve-network). The first WHSR designated site was Delaware Bay in the United States; there are currently 85 sites in 13 countries. Kachemak Bay in Cook Inlet is a WHSR of international importance, being designated in 1994. WHSR sites are considered of international importance if they support at least 100,000 shorebirds annually, or at least 10% of the biogeographic population for a species. Kachemak Bay received international importance status on the basis of it supporting more than 100,000 shorebirds annually. The bay has about 515 km (320 mi) of shoreline, which together with tides of as much as 9 m (30 ft), provides an abundance of intertidal habitat for migrating shorebirds. In addition, 36 species of shorebird have been reported from the area (http://www.whsrn.org/site-profile/kachemak-bay). Within Kachemak Bay, the Fox River Flats Critical Habitat Area (managed by the Alaska Department of Fish and Game) serves as a major staging area for thousands of waterfowl and a million or more shorebirds during spring migration.

[12] U.S. members of the WHSRN council include, among others, the National Audubon Society, the U.S. Department of Agriculture Forest Service, the U.S. Geologic Survey, the U.S. Fish and Wildlife Service National Wildlife Refuge System, and the Nature Conservancy.

Kachemak Bay and Fox River Flats are two of 21 sites that have been identified by the Audubon Society as Important Bird Areas (IBAs) in the Cook Inlet area (Audubon Alaska 2011; see discussion of IBAs in Section 3.8.2.1.4). This identification has no regulatory consequences but does provide information on avian habitats of Cook Inlet. Among these 21 sites (Table 3.8.2-8), 14 occur adjacent to or within the Cook Inlet Planning Area, and because of their locations these areas and their avian fauna have a greater likelihood of interacting with OCS oil and gas activities in the Cook Inlet Planning Area. The remaining sites occur in the upper reaches of Cook Inlet, above Kalgin Island (Figure 3.8.2-8), and would not be expected to be affected by normal oil and gas exploration and development activities. While the Swanson Lakes IBA is located inland of the Cook Inlet coast, the waterfowl and shorebirds that use this area likely also use Cook Inlet waters and shorelines for foraging, and thus could also be affected by oil and gas activities. All of the sites provide migratory staging, resting, foraging, and/or breeding habitat for a wide variety of marine and coastal birds, and especially seabirds, waterfowl, and shorebirds. Except for the Swanson Lakes IBA, most of the Cook Inlet IBAs are coastal in nature, several are islands, and one (Cook Inlet, Marine IBA) is an open water area.

3.8.2.3 Marine and Coastal Birds of the Beaufort and Chukchi Seas Planning Areas

As discussed earlier, more than 492 naturally occurring species in 64 families and 20 orders have been identified from Alaska (Johnson and Herter 1989; Armstrong 2003; University of Alaska 2011). Because of the limited seasonal nature of open water and snow-free conditions, the Beaufort and Chukchi Seas support a much smaller number of avian species. For example, only about 180 species have been reported from the Arctic National Wildlife Refuge (Willms 1992), while a 1999–2001 summer survey of birds in the western Beaufort Sea detected 30 species (primarily waterfowl) (Fischer and Larned 2004). Most birds occurring in the Beaufort and Chukchi Seas and their adjacent coastal habitats are migratory, being present for all or part of the period between May and early November. The avian fauna of these regions largely falls into two categories: (1) birds that arrive in spring at coastal breeding areas, breed and raise young, and then depart in fall to southern wintering areas; and (2) birds that migrate along the coast on their way to and from breeding areas elsewhere on the arctic coast. Some groups, such as the passerines, are largely absent from coastal habitats along the arctic coast, generally occurring as rare, casual, or accidental visitors.[13] A majority of species nesting in coastal areas are waterfowl and shorebirds, although in some locations seabirds occur in large nesting colonies.

3.8.2.3.1 Nonendangered Species. Although representatives of six major groups of birds have been reported from the planning areas (Table 3.8.2-9), three may be especially important because they have the greatest potential for being affected by oil and gas leasing and development: (1) seabirds, which occur in open ocean waters; (2) waterfowl, which use a variety of freshwater and nearshore marine habitats; and (3) shorebirds, which use shoreline habitats

[13] "Rare" — occurring regularly within its normal range, but in very small numbers; "casual" — beyond normal range, but irregular observations occur over several years; "accidental" — far from normal range and observations are unlikely and not expected.

TABLE 3.8.2-8 Important Birds Areas in Cook Inlet (Audubon Alaska 2011)

Important Bird Area	County	Importance/important Species/Bird Groups
Kachemak Bay, South Shore[a]	Kenai Peninsula	Waterfowl, shorebirds, Steller’s eider
Redoubt Bay	Kenai Peninsula	Hosts 70% of all migrating shorebirds in spring; largest known world concentration of Tule white-fronted goose; waterfowl
Swanson Lakes	Kenai Peninsula	Trumpeter swan; highest density of nesting common loons in North America; significant assemblage of migratory terrestrial species
Trading Bay	Kenai Peninsula	Entire population of Wrangell Island snow goose use site and mouth of Kenai River as spring migratory staging area; spring stopover site for shorebirds
Tuxedni Bay[a]	Kenai Peninsula	Supports up to 20% of the estimated 1.2 million shorebirds using western Cook Inlet intertidal areas; western sandpiper; waterfowl
Barren Islands[a]	Kenai Peninsula	One of largest populations of nesting seabirds in Gulf of Alaska; 18 breeding species, >400,000 seabirds
Clam Gulch[a]	Kenai Peninsula	Supports >1% of the biogeographic population of wintering Steller’s eider
Homer Spit[a]	Kenai Peninsula	Steller’s eider; large numbers of shorebirds in spring migration; 5% global population of rock sandpipers overwinter
Fox River Flats[a]	Kenai Peninsula	Major world site for migratory birds; thousands of waterfowl and millions of shorebirds; major spring staging area for geese and ducks, large wintering waterfowl population
Cook Inlet, Marine[a]	Kenai Peninsula Kodiak Island	Short-tailed albatross, shearwaters, seabirds, storm-petrels, fulmers, murres, tufted puffins
Uganik Bay and Viekoda Bay[a]	Kodiak Island	14 seabird colonies, >100 resident breeding pairs of black oystercatcher; foraging/nesting habitat for Kittlitz’s murrelet and other alcids
Wide Bay[a]	Kodiak Island	Waterfowl use in spring and fall; Steller’s eider; overwintering by Emperor goose; seabird colonies; Kittlitz’s murrelet
Susitna Flats	Matanuska-Susitna	Waterfowl and shorebirds, especially during spring migration; among highest shorebird diversity of any site in Cook Inlet; entire world population of rock sandpiper winters here (October–April)
Kenai River Flats	Kenai Peninsula	Supports nearly entire population of Wrangell Island (Siberia) snow goose during spring migration; shorebirds, waterfowl, sandhill crane; large colonies of herring and mew gulls
Amakdedulia Cove[a]	Kenai Peninsula	Supports 1% of a subspecies of the double-crested cormorant; large numbers of sea ducks in summer

TABLE 3.8.2-8 (Cont.)

Important Bird Area	County	Importance/important Species/Bird Groups
Northwest Afognak Island[a]	Kodiak Island	Nesting and foraging habitat for variety of seabirds and shorebirds; 125–150 breeding pairs of black oystercatcher
Goose Bay	Matanuska-Susitna	Important spring and fall migratory resting/feeding habitat for waterfowl; snow goose, Canada goose, trumpeter swan, tundra swan
Anchor River[a]	Kenai Peninsula	Multi-species assemblages of migratory terrestrial birds
Chugach Islands[a]	Kenai Peninsula	Significant foraging area for seabirds; albatrosses, puffins, cormorants, gulls, all three murrelet species
Contact Point[a]	Kenai Peninsula	Over 1,000 seabirds of seven species nest here; high numbers of seaducks, gulls, diving ducks, and dabbling ducks in spring
Palmer Hay Flats	Matanuska-Susitna	Large numbers of waterfowl in spring

[a] Site occurs adjacent to or within the Cook Inlet Planning Area.

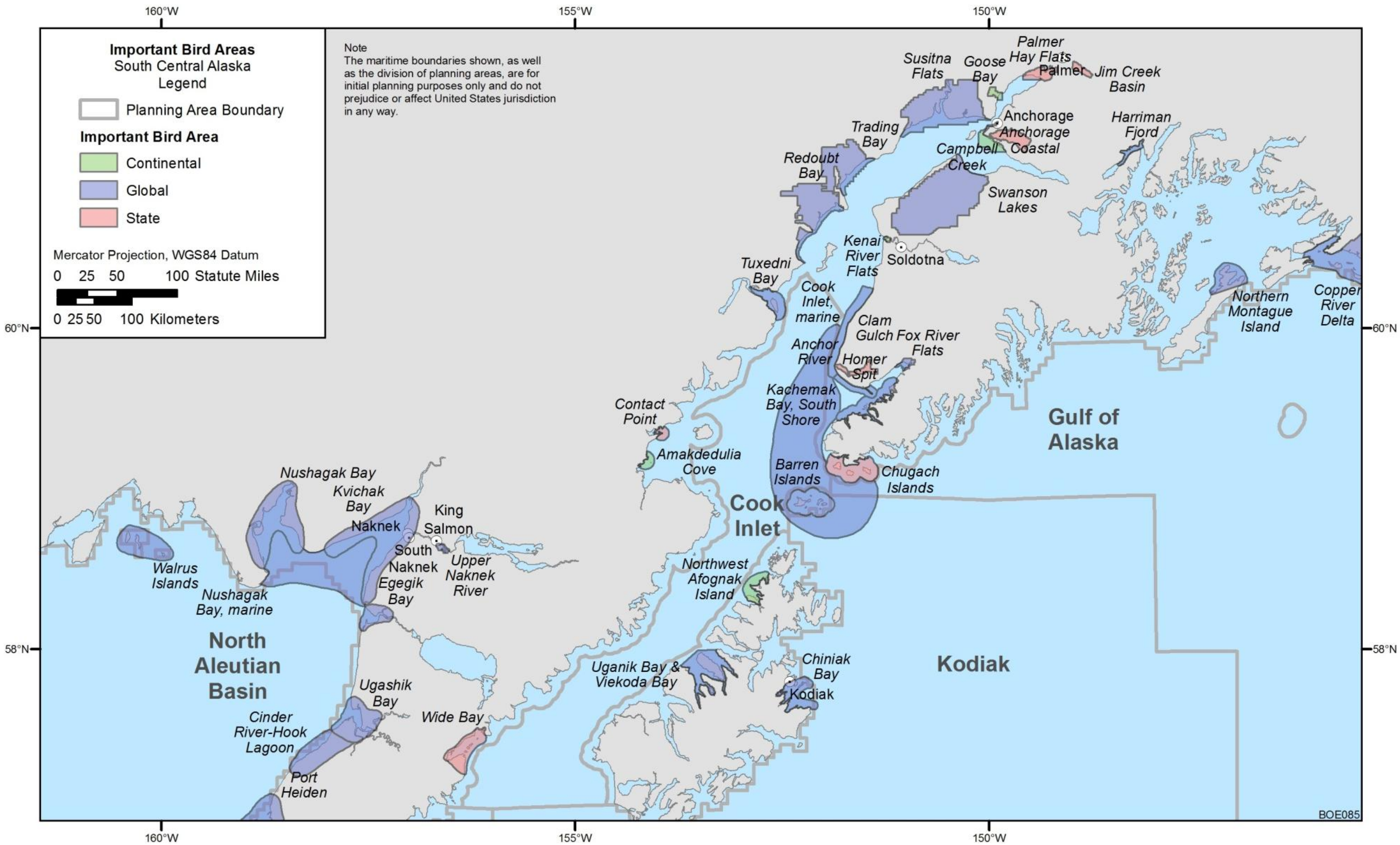

FIGURE 3.8.2-8 Important Bird Areas of the Cook Inlet Planning Area (Source: Audubon Alaska 2011)

TABLE 3.8.2-9 Marine and Coastal Birds of the Beaufort and Chukchi Seas Planning Areas

Category	Order	Common Name	Representative Types
Seabirds	Charadriiformes	Gulls Terns Alcids Jaegers	Glaucous gull, common murre, horned puffin, Arctic tern, parasitic jaeger
	Procellariiformes	Storm-petrels Shearwaters Albatrosses	Short-tailed shearwater
Shorebirds	Charadriiformes	Phalaropes Plovers Oystercatchers Sandpipers, snipes, and allies	Dunlin, red phalarope
Wetland birds	Gruiformes	Cranes	Sandhill crane
	Podicipediformes	Grebes	Horned grebe
Passerines	Passeriformes	Perching birds	Warblers, sparrows, raven
Waterfowl	Anseriformes Gaviiformes	Ducks, geese, and swans Loons	Long-tailed duck, common eider, king eider, greater white-fronted goose, lesser snow goose, tundra swan, Pacific loon, red-breasted merganser
Raptors	Falconiformes	Birds-of-prey	Snowy owl

throughout the planning area. Members of these groups are migratory and occur seasonally, and some may occur in locally large concentrations in locations such as nesting colonies or as mobile flocks. The bays, inlets, and river mouths along the Beaufort and Chukchi Seas provide breeding, foraging, and staging areas for millions of shorebirds, seabirds, and waterfowl (Johnson 1993).

Seabirds. There are three general categories of seabirds: cliff-nesting species, Bering Sea breeders and summer residents of the Beaufort and Chukchi Seas, and high-Arctic species. The cliff dwelling species, such as the common and thick-billed (*Uria lomvia*) murres, the horned (*Fratercula corniculata*) and tufted (*F. cirrhata*) puffins, and the black-legged kittiwake, typically nest on cliffs, rock ledges, and sloping island surfaces on mainland cliffs, rocky headlands, and islands (Ainley et al. 2002; Audubon Alaska 2011; Baird 2009; Piatt and Kitaysky 2002a, b). These birds typically feed on fish and invertebrates, and many breed in colonies (some in mixed colonies) which in some locations may number 100,000 birds or more (Ainley et al. 2002; Audubon Alaska 2011). During breeding, these species may travel as much as 80 km (50 mi) from nest sites or colonies to forage on the continental slope and shelf (Gaston and Hipfner 2000; Hatch et al. 2000; Ainley et al. 2002; Baird 2009). The current status of many of these species in the Beaufort and Chukchi Seas is largely unknown.

The Bering Sea breeders and summer residents of the Beaufort and Chukchi Seas include species such as the northern fulmar, the short-tailed shearwater (*Puffinus tenuirostris*), and the parakeet least (*Aethia pusilla*) and crested auklets. These species feed mostly on fish and invertebrates, and may forage as much as 100 km (62 mi) from breeding areas. They are colonial breeders (Jones 1993a, b; Jones et al. 2001; USFWS 2006e; Hatch and Nettleship 1998). Some of these species are among the most abundant birds in Alaskan waters. For example, the least auklet is one of the most abundant seabirds in North America (Jones 1993a), while the short-tailed shearwater is one of the most abundant species in pelagic Alaskan waters. Hundreds of thousands of shearwaters may be found in pelagic areas of the Chukchi Sea in late summer (USFWS 2006a; Audubon Alaska 2011). The northern fulmar is another very abundant species. About half of all North American colonies of this species occur in Alaska. Although there are no known nesting colonies along the Beaufort or Chukchi Seas, tens of thousands of this species may be found in pelagic waters of the Chukchi Sea in late summer (Audubon Alaska 2011).

The high-arctic seabirds are species that either breed in or migrate through arctic habitats along the Arctic Ocean. Representative species include the black guillemot (*Cepphus gyrlle*), several species of gull (Ross's gull [*Rhodostethia rosa*], ivory gull [*Pagophila eburnean*], and glaucous gull [*Larus hyperboreus*]), several species of jaegers (pomerine jaeger [*Stercorarius pomarinus*], parasitic jaeger [*S. parasiticus*], and long-tailed jaeger [*S. longicaudus*]), and the Arctic tern (*Sterna paradisaea*). The black guillemot occurs in both planning areas, nesting in isolated pairs or in small colonies along rocky coasts with adjacent shallow waters (Butler and Buckley 2002). Cooper Island (east of Barrow) supports the largest breeding colony in Alaska, and the easternmost colony occurs on the Beaufort coast of the Yukon Territory (Butler and Buckley 2002; Audubon Alaska 2011). Some of the gulls (e.g., Ross's and ivory) do not breed in Arctic Alaska habitats, but are present in fall before moving to wintering areas in the Bering Sea (Divoky et al. 1988; Mallory et al. 2008). The glaucous gull occurs in both the Beaufort and Chukchi Seas and breeds along marine and freshwater coasts, tundra, offshore islands, cliffs, shorelines, and ice edges, and may breed in mixed avian colonies with geese, ducks, and cliff-breeders (Gilchrist 2001). The jaegers are common in summer in the Chukchi Sea, moving into the Bering Sea in the fall. The Arctic tern is a rare species that may be found in pelagic waters of the Chukchi Sea.

Waterfowl. A variety of waterfowl occur in the Beaufort and Chukchi Sea Planning Areas, including loons (Pacific, yellow-billed, and red-throated), ducks (including the long-tailed duck, common eider, king eider) and geese (Pacific brant [*Branta bernicla nigricans*], greater white-fronted goose [*Anser albifrons frontalis*], lesser snow goose [*Chen caerulescens caerulescens*], and tundra swan [*Cygnus columbianus*]). Many of the waterfowl migrate along the west coast of Alaska into the Chukchi Sea and/or Beaufort Sea in spring, where they breed in freshwater and coastal habitats (e.g., Divoky 1987; Ely and Dzubin 1994; Goudie et al. 2000; Robertson and Savard 2002). Some species, such as the common eider, breed colonially along marine coasts (Goudie et al. 2000), while others such as the king eider may breed in more interior locations. Following nesting, many of the species move to molting areas in coastal areas of the Beaufort Sea and Chukchi Sea, where they may stay for several weeks before continuing their fall migrations to wintering grounds farther south. Important molting and fall migration station areas include Peard Bay, Kasegaluk Lagoon, and Teshekpuk Lake along the Chukchi Sea coast (Johnson 1993; Lysne et al. 2004).

Shorebirds. Many of the shorebirds associated with the Beaufort and Chukchi Seas breed on the tundra, but also rely on coastal areas such as beaches, barrier islands, lagoons, and mudflats for some portion of their lifecycle. These coastal areas provide important feeding grounds that prepare the birds for their fall migration to southern winter grounds (Powell et al. 2010). As many as 29 shorebird species have been reported to breed on the Arctic Coastal Plain; the National Petroleum Reserve-Alaska has been estimated to have as many as 6 million breeding shorebirds in summer (Alaska Shorebird Group 2008). Common shorebird species that breed on or migrate through the Arctic Coastal Plain include the dunlin, pectoral sandpiper (*Caldris melanotos*), semipalmated sandpiper (*C. pusilla*), and red phalarope (*Phalaropus fulicarius*) (Alaska Shorebird Group 2008; Powell et al. 2010).

Breeding species typically use shallow freshwater tundra ponds (polygons), marshes, and freshwater rivers and deltas (Alaska Shorebird Group 2008). Following breeding, migrating birds use a number of staging areas along the Chukchi and Beaufort Sea coasts, including river deltas and coastal lagoons (Alaska Shorebird Group 2008). Important post-breeding shorebird areas include Elson Lagoon and the Coleville River Delta along the Beaufort Sea, and Peard Bay and Kasegaluk Lagoon on the Chukchi Sea (Figure 3.8.2-9). Kasegaluk Lagoon is one of the longest lagoon-barrier island systems in the world, and is used by 19 different species of shorebirds during fall migration (Alaska Shorebird Group 2008).

3.8.2.3.2 Threatened and Endangered Species. There are two species that are listed as threatened under the ESA (see Section 3.8.2.1.2 for a discussion of the ESA and for definitions of listing categories) that occur in the Beaufort and Chukchi Sea Planning Areas and that could be affected by OCS oil and gas activities. These species are the spectacled eider (*Somatria fischeri*) and the Alaska breeding population of the Steller's eider. In addition, Kittlit's murrelet and the yellow-billed loon, both Federal candidate species, occur in the coastal and inland waters of the Chukchi Sea Planning Area.

The spectacled eider was listed in 1993 as threatened throughout its range in Alaska and Russia (58 FR 27474). The USFWS also has designated critical habitat (wintering area) considered to be essential for the conservation of spectacled eider (66 FR 9146). On Alaska's North Slope or Arctic Coastal Plain (ACP), an average of 6,841 spectacled eiders (about 2% of the world population) are present each summer (Larned et al. 2005). Spectacled eiders generally nest at low density (about 0.22–0.25 birds/km^2) within about 80 km (50 mi) of the coast, primarily west of the Sagavanirktok River (Larned and Balogh 1997; Larned et al. 1999). Highest densities occur south of Oliktok Point, from Harrison Bay to south of Smith Bay, and Admiralty Bay/Barrow southwest to Wainwright (Larned et al. 2003, 2005).

Male and female spectacled eiders pursue quite different schedules and movement patterns between the nesting period and arrival at the wintering area. Males leave the breeding grounds as incubation begins, usually early June to early July, and begin a molt migration, stopping in bays and lagoons to molt and stage prior to fall migration. Important molting and staging areas include Harrison Bay, Smith Bay, Peard Bay (east of Point Belcher), Kasegaluk Lagoon (south of Icy Cape), and Ledyard Bay (a critical habitat unit) (east of Cape Lisburne) (Figure 3.8.2-9) (Johnson et al. 1992; Larned et al. 1995a, b; TERA 1999). The median

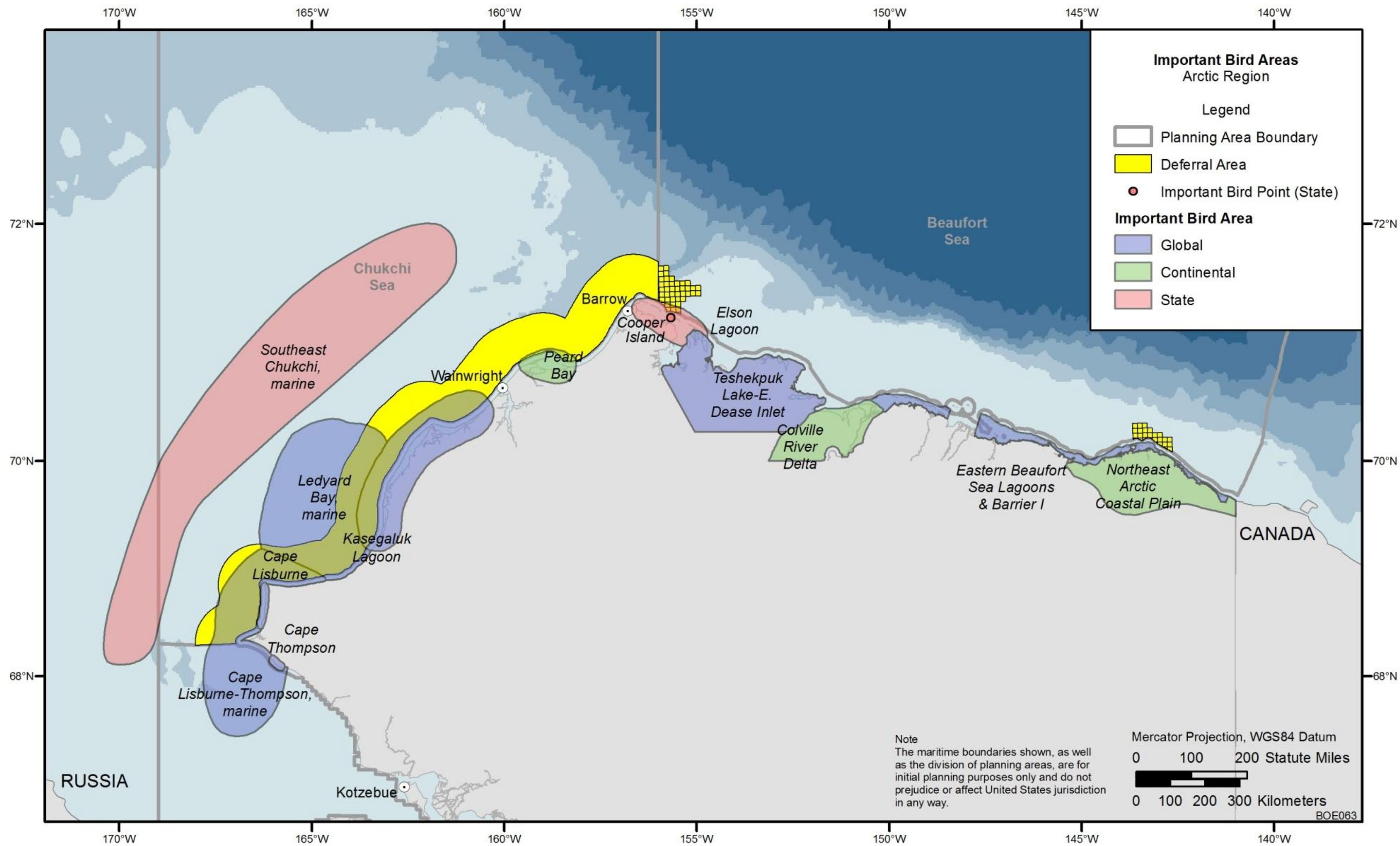

FIGURE 3.8.2-9 Important Bird Areas along the Beaufort Sea and Chukchi Sea Coasts (Audubon Alaska 2011)

departure of females and young-of-the-year from the breeding grounds is late August (Petersen et al. 2000). Ledyard Bay is one of the primary molting areas for females breeding on the ACP (Larned et al. 1995a).

The Steller's eider is the smallest of the four eider species. The Alaskan breeding population of Steller's eider has been listed since 1997 as threatened under the ESA (62 FR 31748). The USFWS also has designated (2001a) critical habitat for the Steller's eider (66 FR 8850). See Section 3.8.2.2.2 for a discussion of the status of this species. There are three breeding populations, two in Russia and one in Alaska (USFWS 2002). The Alaska breeding population nests primarily on the ACP, and is the only one of the three populations listed under the ESA. On the ACP, this species breeds on grassy edges of tundra lakes and ponds or within drained lake basins (Fredrickson 2001). Although they nest in terrestrial environments, they spend the majority of their time in shallow marine waters. After nesting in the ACP, they move to protected marine areas to molt. Molting occurs at a number of locations in southwest Alaska, with largest numbers of birds concentrating in four areas along the north side of the Alaska Peninsula (USFWS 2002).

The Kittlitz's murrelet is a small diving seabird related to the puffins and murres. All of the North American and most of the world population of this species breed, molt, and winter in Alaska (USFWS 2006d), where this species may be found in coastal waters discontinuously from northern southeast Alaska in the Gulf of Alaska, north to Point Lay in the Chukchi Sea during the nesting season (Day et al. 1999). Although wintering areas remain largely unknown, they are assumed to include offshore waters in this region. This species is an uncommon and secretive breeder, choosing unvegetated scree slopes, coastal cliffs, talus above timberline, and barren ground, primarily in coastal areas but also up to 80 km (50 mi) inland. Because of the absence of suitable habitat, this species is not believed to nest east from Cape Beaufort in the western Chukchi Sea (Day et al. 1999).

The yellow-billed loon is a migratory seabird that in Alaska nests in solitary pairs on the Arctic Coastal Plain and winters in more southern coastal waters of the Pacific Ocean (USFWS 2011d). Yellow-billed loons typically nest near large, deep tundra lakes on low islands or near the edges of lakes to avoid terrestrial predators. In the Alaskan Arctic, nesting occurs from the Canning River westward to Point Lay, and migration occurs along coastlines of the Beaufort and Chukchi Seas (North 1994; NatureServe 2010d). During nesting, this species uses nearshore and offshore marine waters adjacent to their breeding areas for foraging in summer (74 FR 12932).

3.8.2.3.3 Use of the Chukchi and Beaufort Sea Planning Areas by Migratory Birds. As previously discussed in Section 3.8.2.3.1, the Chukchi and Beaufort Sea Planning Areas undergo extreme weather variability that results in a very distinct seasonal availability of habitat. As a consequence of these conditions, virtually all species of birds that have been reported from the Beaufort and Chukchi Sea Planning Areas are seasonal visitors that for the most part are absent in winter. In general, birds migrate to or through the area in spring. Some species (i.e., greater white-fronted goose) migrate to breeding habitats where they nest and raise young. Other species (i.e., ivory gull) pass through the two planning areas on their way to arctic habitats in Canada, while still others (i.e., short-tailed shearwater) move into the area to forage in summer in offshore waters. In late summer and early fall, many species move to molting and staging areas in preparation for their fall migrations out of the arctic habitats to southern wintering areas.

Spring. Many of the species that move into the Beaufort and Chukchi Sea Planning Areas in spring migrate into the area along the Bering Sea coast (e.g., Dickson and Gilchrist 2002). Arrival times generally coincide with the formation of ice leads. Migration times vary by species, but for most species spring migration occurs between late March and late May. For example, waterfowl species such as the long-tailed duck and common eider migrate northward in spring along the Chukchi Sea coast following the recurrent lead system in the ice and then migrate eastward in the Beaufort Sea region along a broad front, which may include inland, coastal, and offshore routes, from early May to mid-June (Johnson and Herter 1989; Goudie et al. 2000; Robertson and Savard 2002). Arrival dates for various species range from late April to early June. The availability of open water off river deltas and in leads determines migratory routes and distribution of loons, waterfowl, and seabirds during this time (Johnson and Herter 1989).

Summer. As discussed earlier, birds migrate into the Chukchi and Beaufort Sea Planning Areas in spring to breed, moving into appropriate habitats where they nest and raise young. Depending on the species, nesting habitats include islands, rocky coastlines, river deltas, lagoons, and all types of tundra habitat on the ACP. Shorebirds nest in virtually all types of tundra habitats in the Arctic subregion, shifting to wetter marine littoral, saltmarsh, and barrier island shoreline types for brood rearing where insects are more abundant (Alaska Shorebird Group 2008).

Late Summer and Autumn. After breeding, many species of waterfowl, particularly sea ducks, undergo a migration to molting areas prior to fall migration to southern wintering areas (Goudie et al. 2000; Fredrickson 2001; Robertson and Savard 2002; Larned et al. 2006). Most brood rearing and molting of loons, swans, and geese occurs on large lakes or in coastal habitats. Major concentrations of molting waterfowl occur from late June through August in several areas along the Beaufort and Chukchi Sea coasts, including Teshekpuk Lake, Simpson Lagoon, Peard Bay, Kasegaluk Lagoon, and Ledyard Bay (Figure 3.8.2-9) (Audubon Alaska 2011).

Fall migration times also vary by species, and in some cases by gender and age group. For example, male and nonbreeding or failed-breeding female common eiders migrate to coastal molting areas in Chukchi Sea lagoons and bays beginning in late June and early July (Johnson and Herter 1989). Some females with young may molt in Beaufort coastal lagoons before moving south to wintering areas from August to as late as November (Johnson and Herter 1989; Goudie et al. 2000). Male king eiders undertake a molt migration to Chukchi and Bering Sea areas from early July through August (Suydam 2000; Dickson et al. 2000). Females migrate from mid-August into September, staging an average of 14 km (9 mi) offshore for 9–32 days in the Beaufort. Young leave the breeding areas in September and October.

Along the Chukchi Sea and Beaufort Sea coastlines, non-incubating members of shorebird pairs concentrate in coastal habitats as early as mid-June (Alaska Shorebird Group

2008; Powell et al. 2010). In late June to early July, individuals and flocks of non-breeding and post-breeding adults of several species move to habitats surrounding small coastal lagoons and river deltas (Taylor et al. 2010). In late July and early August, adults relieved of parental duties flock in shoreline areas, followed by juveniles in August and September. Parents with fledged young follow in several weeks, and juveniles form large flocks in mid- to late August, and most have departed the area by mid-September. From late September to mid-October, a majority of the world's Ross's gull population (4,500–16,000) migrates from the Russian Chukchi to shoreline habitats from Wainwright to Point Barrow and eastward to the Plover Islands (Divoky et al. 1988), returning in mid-October. Most black guillemots probably overwinter in leads in the Beaufort and Chukchi Seas.

3.8.2.3.4 Important Bird Areas. The Beaufort Sea and Chukchi Sea Planning Areas and adjacent coastal areas include 11 sites that have been identified as IBAs (Table 3.8.2-10) (Audubon Alaska 2011; see discussion of IBAs presented in Section 3.8.2.1.4).

3.8.2.3.5 Climate Change and Arctic Birds. Climate change effects have been observed to be occurring on all continents and oceans, with atmospheric and ocean warming being observed in many locations, but especially in the Arctic (see climate change discussions presented in Section 3.3). Environmental responses in the Beaufort and Chukchi Sea Planning Areas include loss of sea ice (Parkinson 2000) and permafrost thawing (Lemke et al. 2007), changes in precipitation, and additional concerns that are associated with the climate change-related sea level rise and potential for high erosion of Beaufort and Chukchi Sea coasts (Proshutinsky et al. 2001; Mars and Housenecht 2007).

The potential effects of sea ice loss, permafrost thawing, and sea level rise may have a variety of adverse effects on marine and coastal birds of the two planning areas, with potential impacts mostly associated with loss of food and habitat. Sea level rise and altered precipitation, temperature, and river discharge regimes may affect littoral zone invertebrate communities in terms of both species composition and total productivity (see discussion of climate change impacts on aquatic invertebrates in Section 3.8.5.3). Changes in this prey base could affect shorebirds and waterfowl that forage on these invertebrates during nesting, staging, and migrating (Rehfisch and Crick 2003; Galbraith et al. 2002; Moller et al. 2008; Lovvorn et al. 2009; NABCI 2010). Atmospheric warming, coupled with altered precipitation regimes, is predicted to cause boreal forests to expand northward, displacing tundra-breeding birds into narrower coastal areas (NABCI 2010) (see Section 3.7.1.3 for a discussion of potential climate effects on arctic tundra and coastal habitats). The loss of tundra wetlands on the coastal plain would reduce nesting habitat for a variety of birds as well as affect prey abundance and distribution of tundra-nesting species. If climate change alters the timing of food abundance, this could affect both nesting and migrating birds. The arrival, nesting, and hatching of many shorebird species are closely tied to the emergence of insects upon which the hatchlings depend (Alaska Shorebird Group 2008).

The presence of sea ice and landfast ice in the Arctic creates a productive marine ice biome that is essential for a variety of marine biota. Sea ice in the Arctic has been estimated to

TABLE 3.8.2-10 Important Birds Areas in the Beaufort Sea and Chukchi Sea Planning Areas

Important Bird Area	Area Importance/Important Species or Bird Groups
Teshekpuk Lake-E. Dease Inlet	High densities of breeding shorebirds; large numbers (>50,000) of molting geese, including up to 30% of the Pacific Flyway Brant goose population; breeding populations of spectacled and Steller’s eider; some of the highest breeding densities of the yellow-billed loon in the Western Hemisphere.
Ledyard Bay, marine	Site supports large numbers of sea birds and waterfowl. As many as 100,000 common murres and thick-billed murres and 10,000 black-legged kittiwake have been reported during the breeding season, and more than 30,000 spectacled eider have been reported outside of the breeding season.
Kasegaluk Lagoon	Nineteen shorebird species have been reported from the site, with more than 25,000 birds present. Most abundant shorebirds include the red phalarope and dunlin. Peak single-day bird counts in August of as many as 2,500 birds.
Eastern Beaufort Sea lagoons and barrier islands	Used by breeding and post-breeding migratory waterfowl; long-tailed ducks are the most abundant species in late summer and early fall; lagoons used during molting by Canadian-breeding and Alaska-breeding ducks; 10,000+ phalaropes regularly use the lagoons.
Cape Thompson	Supports only one of two known seabird colonies on the east coast of the Chukchi Sea. Total seabird population estimated to be on the order of 350,000 birds; species include thick-billed and common murres and black-legged kittiwakes.
Cape Lisburne	Supports only one of two known seabird colonies on the east coast of the Chukchi Sea. Total seabird population on the order of 500,000 birds, primarily thick-billed and common murres and black-legged kittiwakes.
Peard Bay	A large deep bay used for breeding by Brant goose, common eider, and spectacled eider, and as a resting/staging area by waterfowl and shorebirds during migration.
Northeast Arctic Coastal Plain	Used by post-breeding lesser snow goose for pre-migration foraging, with peak annual numbers in excess of 300,000.
Cooper Island	Supports largest black guillemot colony in Alaska, and is the most northerly known breeding site for horned puffins. Also supports very large Arctic tern colony.
Southeast Chukchi, marine	Tens of thousands of northern fulmers and hundreds of thousands of short-tailed shearwaters can be found in this area in late summer; thousands of auklets (primarily 1st and 2nd year birds) as far north as Cape Lisburne.
Elson Lagoon	Site estimated to support as many as 20,000 shorebirds; wide offshore zone important for waterfowl; and common eiders nest on the barrier islands. This site is pending global/continental status.

Source: Audubon Alaska 2011.

be decreasing by 3% per decade since the 1970s (see Section 3.3 for a more detailed discussion of sea ice and climate change). Loss of sea ice may affect marine productivity as well as the distribution, composition, and abundance of marine invertebrates (ACIA 2005; Moline et al. 2008) (see Section 3.8.5.3). Such changes could affect the prey base for seabirds, affecting their ability to provide food for chicks as well as preparing for the fall migration.

Climate change in the Arctic may be expected to result in short-term and long-term effects on marine and coastal birds of the region. These effects may be beneficial or detrimental in nature and could result in population-level effects on marine and coastal birds. Which species may be most affected and how they may respond to climate change over the several decades are unknown.

3.8.3 Reptiles

3.8.3.1 Life Stages and Habitats in the Gulf of Mexico

Five species of sea turtles — the green, hawksbill, Kemp's ridley, leatherback, and loggerhead — are known to inhabit the GOM (Pritchard 1997), and all occur in coastal and offshore habitats in each of the GOM Planning Areas included in this PEIS. In addition to these turtles, the federally protected American crocodile occurs in the GOM's Eastern Planning Area along Florida's southern coast (Table 3.8.3-1). All six reptile species are listed as either endangered or threatened species under the ESA. Other reptile species not discussed in this section that could occur in coastal or brackish environments may be listed as sensitive or species of concern by the USFWS or the States in the GOM Planning Region (e.g., diamondback terrapin [*Malaclemys terrapin*], gulf salt marsh snake [*Nerodia clarkia*]).

The life history of sea turtles includes four developmental stages: embryo, hatchling, juvenile, and adult. Habitats used and turtle mobility at each developmental stage are summarized in Table 3.8.3-2.

Habitat utilization and migrations of sea turtles vary depending upon these specific developmental stages and result in differential distributions (Marquez 1990; Ackerman 1997; Hirth 1997; Musick and Limpus 1997). Consequently, the degree of sea turtle vulnerability to specific human impacts may also vary between developmental stages. Sea turtle eggs deposited in excavated nests on sandy beaches are especially vulnerable to coastal impacts. After hatching, hatchling turtles move immediately from these nests to the sea. Most species ultimately move into areas of current convergence or to mats of floating *Sargassum*, where they undergo primarily passive migration within oceanic gyre systems (Carr and Meylan 1980). The passive nature of hatchling turtles, along with their small size, make them vulnerable in open-ocean environments. After a period of years, most juvenile turtles (defined as those which have commenced feeding but have not attained sexual maturity) actively recruit to nearshore developmental habitats within tropical and temperate zones. Juvenile turtles in some temperate zones also make seasonal migrations to foraging habitats at higher latitudes in summer months. The movements of turtles in tropical areas are typically more localized. When approaching

TABLE 3.8.3-1 Reptiles of the Gulf of Mexico That Are Listed under the Endangered Species Act

Species	Status	Juveniles or Hatchlings Potentially Present?	Habitat and Relative Abundance in the Gulf of Mexico
Family Cheloniidae			
Loggerhead turtle (*Caretta caretta*)	T[a]	Yes	Estuarine, coastal, and shelf waters. The most abundant sea turtle in the GOM (Dodd 1988). Total estimated nesting in the U.S. is approximately 68,000 to 90,000 nests per year (NOAA 2011c). Main U.S. nesting beaches are in southeast Florida and Florida Panhandle. Some reported nests in Texas through Alabama (NMFS and USFWS 1991).
Green turtle (*Chelonia mydas*)	T,E[b]	Yes	Shallow coastal waters, seagrass beds. Nesting in the U.S. primarily occurs along the central and southeast coasts of Florida where an estimated 200 to 1,100 females nest annually (NOAA 2011d).
Hawksbill turtle (*Eretmochelys imbricata*)	E	Yes	Coral reefs, hard-bottom areas in coastal waters; adults not often sighted in northern GOM. Least common of all sea turtles in the GOM; nesting limited to southeast Florida and the Florida Keys (NOAA 2011e).
Kemp's ridley turtle (*Lepidochelys kempi*)	E	Yes	Shallow coastal waters, seagrass beds. Nests mainly at Rancho Nuevo, Mexico. Nesting also occurs along the Texas coast and portions of western Florida and Alabama. As many as 127 nests have been recorded annually along coastal Texas since 2000, and as many as 8,000 nests have been recorded annually at Rancho Nuevo, Mexico, since 2000 (NOAA 2011f).
Family Dermochelyidae			
Leatherback turtle (*Dermochelys coriacea*)	E	Yes	Slope, shelf, and coastal waters; considered the most pelagic of the sea turtles. Some nesting in the northern GOM, especially Florida Panhandle; nearest major nesting concentrations are in Caribbean and southeast Florida. In Florida, about 35 nests are observed each year (USFWS 2001b).

TABLE 3.8.3-1 (Cont.)

Species	Status	Juveniles or Hatchlings Potentially Present?	Habitat and Relative Abundance in the Gulf of Mexico
Family Crocodylidae			
American crocodile (*Crocodylus acutus*)	T,E[c]	Yes	In the continental U.S., this species is known from coastal mangrove swamps, brackish bays, and inshore freshwater habitats in southern Florida. Nests at edges of riparian thickets, sandy beaches, or on banks of coastal creeks or mangrove swamps. The crocodile population in Florida is estimated between 1,400 and 2,000 individuals, not including hatchlings (USFWS 2007c).

Status: E = endangered species and T = threatened species under the Endangered Species Act of 1973.

[a] The loggerhead turtle is currently listed under the ESA as nine distinct population segments (DPSs). The south Atlantic DPS, which occurs in the GOM, is listed as threatened under the ESA (NOAA 2011c).

[b] Green sea turtles are listed as threatened, except in Florida, where breeding populations are listed as endangered.

[c] American crocodiles are listed as threatened in Florida; endangered elsewhere.

TABLE 3.8.3-2 Sea Turtle Life Stages, Habitats, and Mobility in the Gulf of Mexico

Developmental Stage	Habitat	Mobility
Embryo	Beaches	Stationary
Hatchling	Ocean/*Sargassum*	Passive migration
Juvenile	*Sargassum*/nearshore	Swimmers
Adult	Ocean	Swimmers

sexual maturity, juvenile turtles move into adult foraging habitats. Thus, both juvenile and adult sea turtles may be vulnerable to impacts in both open-ocean and near-coastal environments but (unlike hatchlings) may actively avoid or escape certain impact-producing factors or conditions. Near the onset of nesting season, adult turtles move between offshore foraging habitats and nesting beaches. Mating may occur directly off the nesting beaches or remotely, depending on the species and population. During the nesting season, females become resident in the vicinity of the nesting beaches and may be more vulnerable to impacts within these near-coastal waters and on nesting beaches.

Sea turtles are highly migratory and therefore have a wide geographic range. For this reason, each turtle species has the potential to occur throughout the entire GOM and may occur at suitable nesting beaches along the entire northern GOM coast. Areas of greater coastal and off-shore turtle observations have been provided to the Ocean Biogeographic Information System-Spatial Ecological Analysis of Megavertebrate Populations (OBIS-SEAMAP) (Read et al. 2011) and are shown in Figure 3.8.3-1. Also illustrated in Figure 3.8.3-1 are approximate locations of turtle nesting locations cataloged by the Wider Caribbean Sea Turtle Nesting Beach Atlas (Dow et al. 2007). Most observations and nesting activity occurs along western and northwestern Florida and consists of primarily loggerheads, green, leatherback, and a few Kemp's ridley turtles. There are reports of recent nesting in Alabama (loggerhead, Kemp's ridley, and green turtles) along Dauphin Island and the Gulf Islands National Seashore; in Mississippi (loggerhead turtles) along the Gulf Islands National Seashore; and in Louisiana (loggerhead turtles) within the Breton National Wildlife Refuge (Figure 3.8.3-1). All five sea turtle species have been observed to nest along areas of the Texas coast (Padre Island National Seashore) (NPS 2011). Hatchling turtles found in the offshore waters of the northern GOM may have originated from these nesting beaches or nest beaches in the southern GOM and Caribbean Sea. Juvenile turtles may move into shallow water developmental habitats across the entire northern GOM. In some species or populations, adult foraging habitats may be geographically distinct from their developmental habitats (Musick and Limpus 1997).

There are no designated critical habitats or migratory routes for sea turtles in the northern GOM. However, many coastal areas of the GOM may be used as preferred habitats (i.e., important sensitive habitats that are essential for the species within a specific geographic area). For example, seagrass beds in Texas lagoons and other nearshore or inshore areas (including jetties) for green sea turtles (Renaud et al. 1995) and bays and lakes, especially in

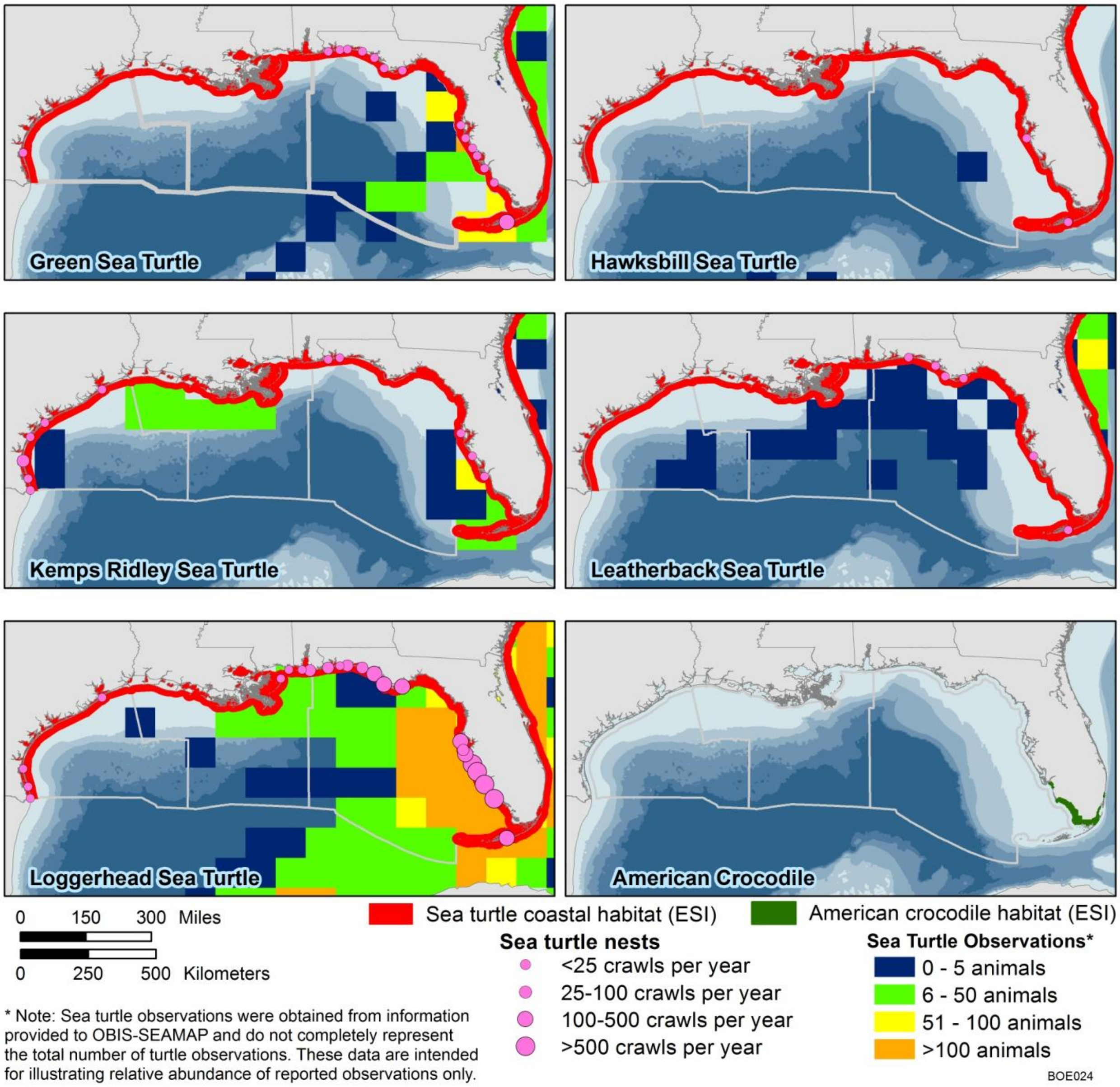

FIGURE 3.8.3-1 Reported Observations of Reptiles and Suitable Habitat in the GOM (Data presented in these maps were obtained from various sources including the Environmental Sensitivity Index [NOAA 1996], OBIS-SEAMAP [Read et al. 2011], and the Wider Caribbean Sea Turtle Nesting Beach Atlas [Dow et al. 2007].)

Louisiana and Texas, for Kemp's ridley sea turtles. *Sargassum* mats are also recognized as preferred habitat for hatchlings (Carr and Meylan 1980). In general, however, the entire GOM coastal and nearshore areas can serve as habitat for marine turtles, as shown in the plot of marine turtle potential habitat from the USGS's GAP database in Figure 3.8.3-1.

The American crocodile occurs in the continental U.S. in southern Florida. It primarily inhabits coastal mangrove swamps, brackish bays, and inshore freshwater habitats. This species does not occur in pelagic regions of the GOM. Nesting occurs in riparian thickets, swamps, beaches, or along creeks. Designated critical habitat for the American crocodile occurs in southern Florida, including Everglades National Park and the Florida Keys. Areas of suitable habitat for the American crocodile, as determined by the Environmental Sensitivity Index (NOAA 1996), are illustrated in Figure 3.8.3-1.

Factors That Could Affect Baseline Conditions during the Program.

Extreme Weather Events. Hurricanes Katrina and Rita, which hit the GOM coast in August and September 2005, respectively, adversely affected sea turtle habitats. Some nesting sites (approximately 50 nests) for Kemp's ridley sea turtles were destroyed along the Alabama coast (Congressional Research Service 2005; USFWS 2006c), and the loss of beaches through the affected coastal areas has probably affected other existing nests and nesting habitats of this species as well as the loggerhead turtle. Similarly, impacts to seagrass beds may affect the local distribution and abundance of species that use these habitats, such as the green sea turtle and the Kemp's ridley sea turtle.

Catastrophic Oil Spills**.** The recent oil spill associated with the DWH event may have had detrimental consequences to sea turtles that had direct contact with spilled oil. Following the DWH event, a total of 1,146 sea turtles were recovered from the GOM that had come in contact with or were in the vicinity of spilled oil. The recovered turtles included adults or free-swimming juveniles of four species: green, hawksbill, Kemp's ridley, and loggerhead. However, the species of some recovered sea turtles could not be identified (Table 3.8.3-3). Of the total number of turtles recovered, 608 (53%) were found dead and 537 (47%) were found alive. Most of the recovered sea turtles (dead or alive) were Kemp's ridley sea turtles (Table 3.8.3-3). Approximately 85% of the live turtles recovered were visibly oiled; approximately 3% of the dead turtles recovered were visibly oiled (Restore the Gulf 2010). The cause of death of the deceased turtles remains unclear, but it is possible for turtles to ingest or inhale oil that could be potentially fatal without any noticeable external indications.

The DWH event also had the potential to affect sea turtle populations by fouling habitats such as seagrass beds and nesting beaches. Preliminary reports from the NOAA Natural Resource Damage Assessment Team have indicated that about 1,600 km (1,000 mi) of shoreline along the GOM has tested positive for oil, including salt marshes, beaches, mudflats, and mangroves (NOAA 2010b). The presence of oil in these areas likely affected foraging and nesting habitats for sea turtles, although the true ecological consequences of these effects are not known. This information, however, is not needed at the programmatic stage to make a reasoned choice among alternatives (see Section 1.4, Analytical Issues).

TABLE 3.8.3-3 Sea Turtle Species Recovered, Turtle Nests Translocated, and Turtle Hatchlings Released in the Atlantic Ocean Following the Deepwater Horizon Event

Species	Recovered Alive	Recovered Dead	Total Recovered	Translocated Nests	Hatchlings Released
Green turtle (*Chelonia mydas*)	172	29	201	4	455
Hawksbill turtle (*Eretmochelys imbricata*)	16	0	16	0	0
Kemp's ridley turtle (*Lepidochelys kempii*)	328	473	801	5	125
Loggerhead turtle (*Caretta caretta*)	21	66	87	265[a]	14,216
Unknown turtle species	0	40	40	0	0
Total	537	608	1,145	274	14,796

[a] Does not include one nest that included a single hatchling and no eggs.

Source: NOAA 2010c.

As a measure to prevent oil fouling of turtle nests and hatchlings, sea turtle nests along the GOM were collected and hatchlings were translocated to eastern Florida along the Atlantic coast. In total, turtle nests of three species were translocated following the DWH event: green, Kemp's ridley, and loggerhead. Nests of the Kemp's ridley turtle were most commonly translocated (Table 3.8.3-3) (NOAA 2010c).

Catastrophic spills such as the DWH event have the potential to affect other reptile species that may inhabit coastal or estuarine environments. Such species in the GOM Planning Areas include the American crocodile (*Crocodylus acutus*). This species inhabits brackish and freshwater environments and is primarily known to occur in coastal mangrove swamps in southern Florida (Table 3.8.3-3). Depending upon location and magnitude, catastrophic oil spills in the GOM have the potential to affect coastal mangrove and beach habitats in southern Florida for the American crocodile. However, there is no evidence that the DWH event affected habitat for this particular species.

3.8.3.2 Climate Change Effects on Sea Turtles

Climate change also has the potential to affect marine and coastal reptile species in the GOM Planning Areas over the next 40–50 yr. Climate change effects, including warming air and water temperatures, rising sea levels, and more intense storms, have been reported in many U.S. coastal regions. These climate change effects have been scientifically correlated with atmospheric concentrations of greenhouse gases. Rising water temperatures, increased sea levels, and intense storms may affect the availability and suitability of foraging and nesting habitats for coastal and marine reptiles (Hawkes et al. 2009). For reptiles that rely on temperature to determine the gender of offspring in incubating eggs (referred to as temperature-dependent sex determination), including sea turtles and crocodilians, subtle increases in atmospheric temperatures could skew sex ratios of hatchlings, which could have future population implications (Walther et al. 2002). It is also predicted that global warming and increased precipitation rates associated with climate change will cause sea levels to rise (Church et al. 2001). This phenomenon could alter or eliminate sea turtle coastal habitat in many areas (Hawkes et al. 2009). For example, a study in Hawaii predicted that as much as 40% of green sea turtle nesting habitat could be affected with a 0.9-m (2.7-ft) sea level rise (Baker et al. 2006).

3.8.4 Fish

3.8.4.1 Gulf of Mexico

In the northern GOM, fish assemblages can be categorized by habitat use. Demersal fishes live on the seafloor and near bottom waters and are distinct from pelagic fishes, which reside in the water column. Within these categories, fish can be further classified by their depth preference and their location along the gradient from the continental shelf to the abyssal plain. Habitat use also varies across life stages. For example, many species of both pelagic and demersal fish inhabit coastal estuaries during their early life stages to take advantage of the shelter and abundant food resources provided by coastal habitat. Similarly, demersal fishes may spend their egg and larval stages in the upper water column, where phytoplankton resources are concentrated, before ultimately moving to bottom waters. There are also unique categories of fish, for example, diadromous species (fish migrating between fresh and salt water) that spend most of their adulthood in saltwater but spawn in freshwater (anadromous) or that live primarily in freshwater and spawn in saltwater (catadromous).

3.8.4.1.1 Diadromous Fishes. There are three anadromous fish species in the GOM: Gulf sturgeon (*Acipenser oxyrinchus desotoi*), striped bass (*Morone saxatilis*), and Alabama shad (*Alosa alabamae*). Anadromous species spawn in rivers but spend part of their lives in oceans. Gulf sturgeon populations have declined in the last century and they are now a federally listed threatened species. Striped bass are native to rivers entering the GOM from Florida to Texas, although existing data suggests their numbers were historically small and not sufficient to support a large commercial fishery. Striped bass populations began declining earlier this century, and by the mid-1960s had disappeared from all GOM rivers except for the Apalachicola-Chattahoochee-Flint River System and the Mobile-Alabama-Tombigbee River System of Alabama, Florida, and Georgia (GSMFC 2006). The decline has been attributed to pollution and dams that reduced access to spawning habitat and created adverse hydrologic conditions for eggs. The USFWS and the GOM States initiated cooperative efforts to restore and maintain striped bass populations in the late 1960s, primarily through stocking of hatchery-raised fingerlings, and this effort continues today.

The historic range of Alabama shad was similar to that of the striped bass but extended well up the Mississippi River drainage. Populations of Alabama shad have declined significantly over the years, and they were designated a species of concern by the NMFS in 1997 (http://www.nmfs.noaa.gov/pr/pdfs/species/alabamashad_detailed.pdf). Spawning populations exist in the Apalachicola River, Florida; the Choctawhatchee and Conecuh Rivers, Alabama; and the Pascagoula River, Mississippi. Dams that have been built on many southeastern rivers are thought to be a major reason for the decline of anadromous fish species in the GOM. Little is known about their distribution or habitat use in marine environments.

The catadromous American eel (*Anquilla rostrata*) also occurs within waters of the GOM, with young and maturing individuals found in nearly all the rivers, bays, lakes, and estuaries associated with the GOM. Adult American eels spend most of their lives in freshwater but eventually swim to the Sargasso Sea where they spawn and die (Eales 1968). The young eventually migrate to inland waters. Commercial fishing has significantly reduced eel numbers, but they have not been extended protected species status (http://www.fws.gov/news/NewsReleases/showNews.cfm?newsId=73C49E66-CA1E-2EC5-22EBD499912EC3E3).

3.8.4.1.2 Pelagic Fishes. Coastal pelagic fishes include larger predatory species such as mackerels (*Scomberomorus* spp.), bluefish (*Pomatomus saltatrix*), cobia (*Rachycentron canadum*), dolphin fish (*Coryphaena hippurus*), jacks (family Carangidae), and little tunny (*Euthynnus alletteratus*), as well as smaller forage species such as Gulf menhaden (*Brevoortia patronus*), Atlantic thread herring (*Opisthonema oglinum*), Spanish sardine (*Sardinella aurita*), round scad (*Decapterus punctatus*), and anchovies (family Engraulidae). Coastal pelagic species typically form schools, undergo migrations, grow rapidly, mature early, and exhibit high fecundity. These species are either managed by GMFMC or are important prey fish for other species. The larger predatory species may be attracted to large concentrations of anchovies, herrings, and silversides (family Atherinidae) that sometimes congregate in nearshore areas.

Fish inhabiting oceanic waters can be divided into epipelagic, mesopelagic, and bathypelagic, on the basis of their depth preference. Epipelagic fishes inhabit the upper 200 m (700 ft) of the water column in oceanic waters, typically beyond the continental shelf edge (Bond 1996). In the GOM, this group includes several shark species, swordfish (family Xiphiidae), billfishes (family Istiophoridae), flyingfish (*Parexocoetus brachypterus*), halfbeaks (family Hemiramphidae), jacks, dolphinfish, and tunas (family Scombridae). A number of the epipelagic species, such as dolphin fish, sailfish (*Istiophorus albicans*), white marlin (*Tetrapturus albidus*), blue marlin (*Makaira nigricans*), and tunas, are in decline and have important spawning habitat in the GOM. All of these epipelagic species are migratory, but specific patterns are not well understood. Many oceanic species are associated with floating seaweed (*Sargassum* spp.), jellyfishes, siphonophores, and driftwood, because they provide forage and/or nursery habitat. Most fish associated with floating seaweed are temporary residents, for example, juveniles of species that reside in shelf or coastal waters as adults. However, several larger species, such as dolphinfish, tuna, and wahoo, feed on the small fishes and fish attracted to *Sargassum* (GMFMC 2004).

Below the epipelagic zone, the water column may be layered into mesopelagic (200–1,000-m [656–3,281-ft]) and bathypelagic (>1,000-m [>3,281-ft]) zones. Recent surveys over the continental slope found 126 species (30 families) of juvenile and adult mesopelagic fishes, which were numerically dominated by lanternfishes (family Myctophidae), bristlemouths (family Gonostomatidae), and hatchetfishes (family Sternoptychidae) (Ross et al. 2010). Mesopelagic fishes spend the daytime at depths of 200–1,000 m (656–3,281 ft), but migrate vertically at night into food-rich near-surface waters. Mesopelagic fishes, while less commonly known, are important ecologically because they transfer significant amounts of energy between mesopelagic and epipelagic zones over each daily cycle. The lanternfishes are also important prey for meso- and epipelagic predators (e.g., tunas) (Hopkins et al. 1997).

Deeper dwelling (bathypelagic) fishes inhabit the water column at depths greater than 1,000 m (3,000 ft). This group is composed of little-known species such as snipe eels (family Nemichthyidae), slickheads (family Alepocephalidae), bigscales (family Melamphaidae), and whalefishes (family Cetomimidae) (McEachran and Fechhelm 1998; Rowe and Kennicutt 2009). Most species are capable of producing and emitting light (bioluminescence) to aid communication. In general, deep-water species produce demersal eggs (Bond 1996) that are attached to the substrate.

3.8.4.1.3 Demersal Fishes. Demersal fish in the GOM can be generally characterized as soft-bottom fishes or hard-bottom fishes, according to their association with particular substrate types. Soft-bottom habitat is relatively featureless and has much lower species diversity than the more structurally complex hard bottom habitat. Thus species richness is lower in the Central and Western Planning Area compared to the Eastern Planning Area, where hard-bottom habitat is abundant.

In recent trawl surveys, Atlantic croaker (*Micropogonias undulatus*), longspine porgy (*Stenotomus caprinus*), and Atlantic bumper (*Chloroscombrus chrysurus*) were the most abundant demersal soft-bottom fishes on the continental shelf from south Texas to Alabama (Table 3.8.4-1; SEAMAP 2010). However, geographic divisions exist because soft-bottom fishes generally prefer certain types of sediments over others; this tendency led to the naming of three primary fish assemblages according to the dominant shrimp species found in similar sediment/depth regimes (Chittenden and McEachran 1976; reviewed in GMFMC 2004). In the GOM, pink shrimp are found in waters up to about 45 m (148 ft) over calcareous sediments. Common members of the pink shrimp assemblage include Atlantic bumper, sand perch (*Diplectrum formosum*), silver jenny (*Eucinostomus gula*), dusky flounder (*Syacium papillosum*), and pigfish (*Orthopristis chrysoptera*). This assemblage is typified by the west Florida shelf in the Eastern Planning Area. Fishes associated with brown shrimp and white shrimp are found on more silty sediments and are typical of the Western and Central Planning Areas. The brown shrimp assemblage extends to 91 m (299 ft). Porgies (family Sparidae), searobins (family Triglidae), batfish (family Ogcocephalidae), goatfish (family Carangidae), lefteye flounders (family Bothidae), lizardfishes (family Synodontidae), butterfishes (family Stromateidae),

TABLE 3.8.4-1 The Ten Most Abundant Demersal Fish Species in Trawl Surveys of the Continental Shelf from Texas to Alabama

Species	Total number	% Frequency[a]
Summer		
Atlantic croaker (*Micropogonias undulates*)	119,000	52.0
Longspine porgy (*Stenotomus caprinus*)	77,667	69.9
Atlantic bumper (*Chloroscombrus chrysurus*)	44,374	48.9
Blackwing sea robin (*Prionotus rubio*)	10,610	37.8
Gulf butterfish (*Peprilus burti*)	9,531	46.0
Largescale lizard fish (*Saurida brasiliensis*)	8,989	40.6
Silver seatrout (*Cynoscion nothus*)	8,230	33.8
Striped anchovy (*Anchoa hepsetus*)	6,381	25.6
Atlantic cutlassfish (*Trichiurus lepturus*)	5,869	34.4
Blackear bass (*Serranus atrobranchus*)	5,219	28.7
Fall		
Atlantic croaker (*Micropogonias undulates*)	74,515	70.2
Longspine porgy (*Stenotomus caprinus*)	38,520	61.0
Atlantic bumper (*Chloroscombrus chrysurus*)	13,713	37.9
Silver seatrout (*Cynoscion nothus*)	99,881	50.6
Shoal flounder (*Syacium gunteri*)	9,874	53.7
Spot (*Leiostomus xanthurus*)	8,666	45.5
Blackear bass (*Serranus atrobranchus*)	7,328	27.0
Inshore lizardfish (*Synodus foetens*)	5,580	60.4
Star drum (*Stellifer lanceolatus*)	5,440	18.8
Bigeye searobin (*Prionotus longispinosus*)	4,510	31.2

[a] Percentage of all trawls in which the species was collected.

Source: SEAMAP 2010.

cusk-eels (family Ophidiidae), toadfishes (family Batrachoididae), and scorpionfishes (family Scorpaenidae) characterize the brown shrimp assemblage. The white shrimp assemblage exists in 3.5 to 22 m (11 to 72 ft) of water, and dominant fish include drums (family Scianenidae), Atlantic croaker, snake mackerels (family Trichiuridae), threadfins (family Polynemidae), sea catfishes (family Ariidae), herrings (family Clupeidae), jacks (family Carangidae), butterfishes (family Stromateidae), and flounders (family Bothidae). Many fish species in the white and brown shrimp assemblages spawn in shelf waters and spend their early life stages in estuaries (GMFMC 2004).

Another important habitat for demersal fishes on the continental shelf is the hard bottom. The term "hard bottom" generally refers to exposed rock, but can refer to other substrata such as coral and clay, or even artificial structures. Reef fishes such as sea basses (family Serranidae), snappers (family Lutjanidae), grunts (family Haemulidae), porgies (family Sparidae), squirrelfishes (family Holocentridae), angelfishes (family Pomacanthidae), damselfishes (family Pomacentridae), butterflyfishes (family Chaetodontidae), surgeonfishes (family Acanthuridae), parrotfishes (family Scaridae), and wrasses (family Labridae) inhabit hard-bottom habitats in the

GOM (Dennis and Bright 1988). Recent surveys of reef fish from Texas to Florida indicate vermillion snapper (*Rhomboplites aurorubens*), red snapper (*Lutjanus campechanus*), and red porgy (*Pagrus pagrus*) are the most abundant large reef fish (Table 3.8.4-2; SEAMAP 2010).

Although reef fish are associated with hard-bottom habitat as adults, some species can be found over soft sediments as well. Like soft sediment species, many hard-bottom demersal fish are estuarine dependent and spend their juvenile states in coastal habitat. Oil and gas platforms serve as artificial hard-bottom sites and attract reef-associated species. Almaco jack, amberjack, red snapper, gray snapper (mangrove snapper), and gray triggerfish dominate the large fish assemblage near the platforms in the GOM (Stanley and Wilson 1997). Fish density is elevated near the platforms but declines to background densities within 10–50 m (33–164 ft) of the structure (Stanley and Wilson 1997).

The deep-sea demersal fish fauna occur from the shelf-slope transition down to the abyssal plain in the GOM. Recent trawl studies sponsored by BOEM have investigated deep-sea demersal fish assemblages from the edge of the continental shelf to the abyssal regions (Rowe and Kennicutt 2009). Overall, 119 species were collected and distinct depth-species relationships were observed. The most diverse group are the cod-like fishes such as hakes and grenadiers (family Macrouridae), followed by cusk-eels (family Ophidiidae) and slickheads (Alepocephalidae). In general, water depth and proximity to canyons were the primary determinants of community structure. Fish species richness and abundance were highest in the upper and mid slope. Across the station transects, the abundance and diversity of fishes was greatest near the Mississippi Trough and the DeSoto Canyon and lowest at the stations to the west of the Mississippi River (Rowe and Kennicutt 2009).

There are few studies of the impacts of the DWH event on fish communities in the GOM. The spill has the potential to cause population-level impacts to fish species, particularly species

TABLE 3.8.4-2 The Ten Most Abundant Reef Fish Species Collected in SEAMAP Trap Collections from South Texas to South Florida

Species	Total Number	% Frequency[a]
Vermillion snapper (*Rhomboplites aurorubens*)	210	1.5
Red snapper (*Lutjanus campechanus*)	139	2.3
Red porgy (*Pagrus pagrus*)	45	2.0
Red grouper (*Epinephelus morio*)	24	1.7
Gray triggerfish (*Balistes capriscus*)	6	0.6
Lane snapper (*Lutjanus synagris*)	6	0.3
Bank sea bass (*Centropristis ocyura*)	5	0.3
Greater amberjack (*Seriola dumerili*)	4	0.3
Whitebone porgy (*Calamus leucosteus*)	3	0.3
Scamp (*Mycteroperca phenax*)	3	0.3

[a] Percentage of all traps in which the species was collected.

Source: SEAMAP 2010.

that have already depressed populations or with early life stages that rely heavily on marine and coastal habitats affected by the spill. Several years may be required to fully assess the impacts of the DWH event on fish populations, given the lag between fish hatching and recruitment. This information, however, is not needed at the programmatic stage to make a reasoned choice among alternatives (see Section 1.4, Analytical Issues). The few initial studies suggest that, despite occurring during the spawning period for many GOM fishes, the DWH event did not have an immediate negative impact on fish populations (including juvenile age classes, although there remains the potential for long-term populations impacts from sublethal and chronic exposure (Fodrie and Heck 2011).

3.8.4.1.4 Threatened or Endangered Species

Gulf Sturgeon. The Gulf sturgeon (*Acipenser oxyrinchus desotoi*) is a geographic subspecies of the Atlantic sturgeon. The Gulf sturgeon is an anadromous fish that migrates from the sea upstream into coastal rivers to spawn in freshwater. Historically, it ranged from the Mississippi River to Charlotte Harbor and Florida Bay; today, this range has contracted to encompass major rivers and inner shelf waters from the Mississippi River to the Suwannee River, Florida (USFWS and NMFS 2009). Populations have been depleted or driven to localized extirpation by fishing, boat collision, shoreline development, dredging, erosion, dam construction, declining water quality, and the species' low population growth rate (USFWS and NMFS 2009). These declines prompted the listing of the Gulf sturgeon as a threatened species in 1991 (56 FR 49653). Subsequently, a recovery plan was developed to ensure the preservation and protection of Gulf sturgeon spawning habitat (USFWS and Gulf States Marine Fisheries Commission 1995).

Females lay large numbers of eggs (>3 million) usually in deep areas or holes with hard bottoms and where some current is present (Sulak and Clugston 1998; Fox et al. 2000). The young fish remain in freshwater reaches of the rivers for about 2 yr, then begin to migrate back downstream to feed in estuarine and marine waters. The adults spend March through October in the rivers and November through February in estuarine or shelf waters. Near the river mouths and on the inner continental shelf, adults feed on clams, snails, crabs, shrimps, worms, brachiopods, amphipods, isopods, and small fishes (Gilbert 1992). Genetic studies show that the populations among different rivers are fairly distinct and that the Gulf sturgeon may even be river-specific (Stabile et al. 1996). In marine waters, however, Gulf sturgeon from different river systems were found to inhabit the same winter foraging grounds along the GOM barrier islands (Ross et al. 2009). In marine and estuarine habitats, Gulf sturgeon are found over coarse sand and shell substrates in clear and well oxygenated waters less than 7 m (23 ft) deep (Harris et al. 2005; Ross et al. 2009).

Currently, seven rivers are known to support reproducing populations of Gulf sturgeon (USFWS and NMFS 2009). After a review by NMFS in 2003, critical habitat for Gulf sturgeon was designated (68 FR 13370) and includes multiple areas of riverine, estuarine, and marine habitat from Louisiana to the Florida Panhandle. Recent trends in abundance over the last decade indicate populations in Florida rivers are stable or increasing slightly. Populations in

Mississippi and Louisiana Rivers are unknown due to the lack of recent comprehensive surveys (USFWS and NMFS 2009).

Smalltooth Sawfish. The smalltooth sawfish (*Pristis pectinata*) was listed as federally endangered in 2003 (68 FR 15674). Smalltooth sawfish are usually found over muddy and sandy bottoms in sheltered bays, on nearshore shallow banks, and in estuaries or river mouths at all ages (NMFS 2009). Juveniles appear to prefer shallow mud or sand bottom (often less than 1 meter [3 ft]) as well as mangrove root habitat. As they grow, sawfish move to deeper water, and large adults can be found in marine waters in depths up to at least 122 m (400 ft). Smalltooth sawfish take more than 10 yr to reach maturity. They are livebearers, producing litters of 15 to 20 pups. Small fish and benthic invertebrates compose most of their diets. The decline in smalltooth sawfish abundance has been largely attributed to their capture as bycatch in various fisheries, loss and limited availability of appropriate habitat, and the species' low reproductive rate. Historically, smalltooth sawfish were common throughout the GOM from Texas to Florida. However, the current range of this species has contracted to peninsular Florida, and, although no accurate estimates of abundance are available, smalltooth sawfish are now relatively common only in the Everglades region at the southern tip of the State. In the Western and Central Planning Areas, smalltooth sawfish were relatively abundant as recently as the 1960s, but are now rare. Most recent records from Texas or the Florida Panhandle occur from April to August only, suggesting that most smalltooth sawfish are not resident, but rather seasonal migrants to the northern GOM from south Florida or Mexico (NMFS 2009). Critical habitat for the smalltooth sawfish was designated in October 2, 2009 (74 FR 45353), and consists of two units: the Charlotte Harbor Estuary Unit and the Ten Thousand Islands/Everglades Unit (TTI/E). The two units are located along the southwestern coast of Florida between Charlotte Harbor and Florida Bay, in the Eastern Planning Area. There is no critical habitat for smalltooth sawfish located in the Central or Western Planning Areas.

3.8.4.1.5 Climate Change. Climate change could affect fish communities through direct physiological action, through habitat loss, and by altering large-scale oceanographic and ecosystem processes (Twilley et al. 2001; Rosenzweig et al. 2007; Portner and Peck 2010). At the level of individual behavior and physiology, increasing water temperature could alter reproductive rates by speeding growth and altering the timing of migrations (including reproductive movements). Fish could also be forced to move to other areas if temperatures rise above their physiological tolerance. Higher temperatures may also increase the spread and virulence of new and existing pathogens. Fish in river-influenced systems such as the GOM would be particularly susceptible to changes in salinity, turbidity, and temperature linked to changes in the hydrology of the Mississippi River and Atchafalaya River. In addition, aqueous concentrations of CO_2 projected to exist under certain climate change scenarios have been demonstrated to reduce the fitness of fish by reducing their ability to detect predators and adult habitat using olfactory and auditory cues (Munday et al. 2009, 2010; Simpson et al. 2011).

In addition to direct physiological stress, climate change could reduce or eliminate critical fish habitats. Many fish in the GOM, including commercially important species, are estuarine-dependent, meaning they spend some portion of their life in estuarine waters. The predicted rise in sea level and increased storm frequency and severity could accelerate the loss of critical estuarine habitats such as salt marshes, lagoons, and barrier islands (Trenberth et al. 2007; CCSP 2009). In offshore areas, climate change may increase the size of the GOM "dead zone," reducing the amount of benthic habitat available to demersal fishes (Rabalais et al. 2010). However, the extent and duration of hypoxia could also be decreased by the projected increase in tropical storms (Rabalais et al. 2010). Similarly, reef fish could suffer habitat loss if coral reefs decline as predicted by most climate change scenarios because of increased temperatures and/or ocean acidification (Hoegh-Guldberg et al. 2007).

Large-scale changes in oceanographic and ecosystem processes resulting from climate change could indirectly affect fish population in the GOM in several ways. For example, climate is a key determinant of fish abundance because climate influences critical recruitment processes such as the transport of larval fishes and the amount and seasonality of planktonic food resources. In addition, rising ocean temperatures could promote the expansion and establishment of tropical fish or allow the establishment of non-native fishes introduced by human activities. These species could in turn displace existing species and create changes in food web dynamics. Some have also speculated that climate change could increase the abundance of jellyfish, which prey heavily on fish larvae (Purcell et al. 2007). However, evidence for this hypothesis is limited (Purcell et al. 2007). Overall, predictions about the indirect effects of climate change on fish populations are subject to great uncertainty, given the complexity and compensatory mechanisms of the ecosystem (see Section 1.3.1.1, Incomplete and Unavailable Information).

3.8.4.2 Alaska – Cook Inlet

Waters of South Alaska support at least 314 fish species representing 72 families (Mecklenburg et al. 2002), and most of these species can be found in Cook Inlet. Fish species within Cook Inlet have a variety of habitat preferences and life history traits. Demersal fishes exist on the sea floor and near bottom waters and are distinct from pelagic fishes, which exist in the water column. In addition, there are anadromous fishes that that spend their adulthood in saltwater but spawn in freshwater.

3.8.4.2.1 Diadromous Fishes. Cook Inlet serves as a critical migratory corridor and early-life rearing area for several fish species, including all five species of Pacific salmon (Shields 2010a). Salmonids spawn in freshwater, where their eggs and juveniles develop and eventually migrate to the ocean as smolts. Salmon grow to maturity in the ocean and then return to their natal stream to spawn and die. Dolly Varden and steelhead trout also migrate through Cook Inlet; their life histories are similar to Pacific salmon, except that they are capable of spawning more than once and therefore make multiple migrations from freshwater to the ocean. The eulachon (*Thaleichthys pacificus*), known locally as hooligan, is a non-salmonid anadromous member of the smelt family that migrates through Cook Inlet. Both salmonids and eulachon provide critical food to marine mammals, predatory fish, and seabirds, and are important in recreational, commercial, and subsistence fisheries. Large schools of anadromous fish that seasonally enter freshwater habitat play an important role in the ecosystem; their carcasses provide food for terrestrial and stream consumers and release nutrients that are ultimately taken up by riparian forests and stream algae.

The *Catalog of Waters Important for the Spawning, Rearing or Migration of Anadromous Fishes* and its associated Atlas (the Catalog and Atlas, respectively) specify which streams, rivers, and lakes within and adjacent to the Cook Inlet Planning Area are important to anadromous fish species and therefore are afforded protection under State law. Water bodies that are not "specified" within the Catalog and Atlas are not afforded that protection. The ADF&G is solely responsible for maintaining anadromous waters data as well as revision to and publication of the Catalog and Atlas, which can be found at http://www.adfg.alaska.gov/sf/SARR/AWC/index.cfm?ADFG=maps.maps.

3.8.4.2.2 Pelagic Fishes. Pelagic species found in Cook Inlet waters include smelt (*Osmerus* spp.), Pacific herring (*Clupea pallasi*), Pacific sand lance, (*Ammodytes hexapterus*), eulachon, and capelin (*Mallotus villosus*). Walleye pollock, capelin, and eulachon made up 93% of all fish collected by mid-water trawls near Shelikof Strait (Wilson 2009). The Shelikof Strait has important spawning and juvenile nursery areas for pollack and herring (Nagorski et al. 2007). Pelagic species provide critical food to marine mammals, predatory fish, and seabirds, and are important in recreational, commercial, and subsistence fisheries. Forage fish are historically subject to large fluctuation in population size due to variation in environmental conditions (Robards et al. 1999; Robards et al. 2002; NMFS 2005). Populations of capelin, herring, and eulachon have been reported at historically low levels, possibly due to natural oscillations in sea temperatures (NMFS 2005; Litzow 2006; Arimitsu et al. 2008). In addition, sand lance, herring, and capelin spawn in nearshore and intertidal areas and are therefore extremely vulnerable to oil spills that contact the shoreline. For example, herring underwent a significant decline following the *Exxon Valdez* spill; while numbers have fluctuated since the spill, they remain at very low levels. However, there is still debate about whether the population crash was due to the *Exxon Valdez* spill, disease, climactic shifts, or a combination of these factors (*Exxon Valdez* Oil Spill Trustee Council 2009).

3.8.4.2.3 Demersal Fishes. Cook Inlet has a variety of substrates and shorelines, including a significant proportion of hard substrates. The resulting habitat complexity allows multiple species of demersal fish to inhabit Cook Inlet. These fish are collectively referred to as groundfish, because they have a common preference for seafloor habitat. Examples found in Cook Inlet include rockfish (*Sebastes* spp.), Pacific cod (*Gadus macrocephalus*), pollock (*Theragra chalcogramma*), lingcod (*Ophiodon elongates*), Pacific halibut (*Hippoglossus stenolepis*), sculpin (family Cottidae), and skates (Nagorski et al. 2007; Trowbridge et al. 2008). Many groundfish are of great commercial and recreational importance. Halibut are an important subsistence resource, and other groundfish are taken incidentally. The rockfish are particularly diverse, and at least 32 rockfish species have been reported to occur in the Gulf of Alaska (Eschmeyer et al. 1984). Groundfish can have distinct habitat preferences and may specialize in a particular sediment type. For example, species such as rockfish and lingcod prefer hard substrate and submerged vegetation, while cod prefer soft sediments. Groundfish typically use Cook Inlet as a seasonal feeding area, while spawning occurs offshore, often on the continental shelf edge of the GOA. Most groundfish deposit their eggs on the sea floor, but egg and larval development occur in the upper water column. Juveniles and adults ultimately transition to bottom habitat (NMFS 2005).

3.8.4.2.4 Protected Species. While Alaskan stocks of Pacific salmon are considered healthy, there are federally endangered stocks of Chinook salmon, sockeye salmon, and steelhead trout present in the GOA, and most have natal streams in Washington, California, and Oregon (NMFS 2005). The ESA-listed salmon are mixed with Alaskan and Asian salmon stocks and are not visually distinguishable from Alaskan salmon stocks (NMFS 2005). Critical habitat designations for stocks of Pacific salmon do not include any Alaskan waters.

3.8.4.2.5 Climate Change. Climate change may have a number of effects on fish communities, including direct effects on physiology and behavior and indirect effects caused by habitat loss and large-scale changes in ecological processes (Portner and Peck 2010). Under most climate change models, coastal fish habitats will be subject to hydrologic and thermal regimes that will be very different from present conditions. Hydrologic changes in Cook Inlet could result from changes in precipitation and increased glacial and snow pack melt in the mountains around Cook Inlet. The behavior and physiology of fish in river-influenced systems such as Cook Inlet would be particularly affected by changes in salinity, turbidity, and temperature linked to changes in hydrology. In addition, rising surface water temperature has the potential to affect all aspects of fish growth, feeding, and movement (Portner and Peck 2010). Similarly, aqueous concentrations of CO_2 projected to exist under certain climate change scenarios have been demonstrated to reduce the fitness of fish by reducing their ability to detect predators and adult habitat using olfactory and auditory cues (Munday et al. 2009, 2010; Simpson et al. 2011).

Climate change also has the potential to affect the large number of anadromous fishes that migrate through Cook Inlet. For example, the migratory behaviors of Pacific salmon at all life stages are adapted to existing hydrology (Bryant 2009). Current behaviors may be maladaptive if expected changes in sea level and the timing and intensity of rainfall occur, resulting in mismatches between salmon emergence and the availability of their food resources. In addition to habitat alteration, critical coastal habitats could be reduced or eliminated by rising sea levels and increased storm damage to nearshore areas. For species spawning in low-lying areas or the intertidal zone, or species using coastal estuaries as nursery grounds, rising sea levels could also eliminate spawning or juvenile habitat. Anadromous fish and species using nearshore marshes are likely to be most affected. Temperature monitoring in the Kenai watershed also suggests that salmon stream temperatures are increasing and often exceed water quality guidelines in the summer (Mauger 2005).

Climate change could potentially effect large-scale changes in ecological processes. In response, the distribution and species composition of fish communities in Cook Inlet may change. For example, temperature is a critical ecosystem control in the Gulf of Alaska; fish communities appear to undergo major shifts following natural oscillations in water temperature related to the Pacific Decodal Oscillation and the El Niño–Southern Oscillation (Anderson and Piatt 1999; Litzow 2006; NPFMC 2010). During periods of cold water temperatures, benthic crustaceans and pelagic forage fish such as capelin and herring dominate the ecosystem biomass. After the climate cycles to warmer water temperatures, the biomass of forage species declines and the biomass of higher trophic level fish such as groundfish and salmon increases. These cycles occur naturally on multi-decadal scales. The current trend of steadily increasing sea surface temperature may favor higher trophic-level fish by increasing their local productivity or by promoting the expansion of large temperate predators into Alaskan waters (Litzow 2006). The establishment of temperate species and non-native fish introduced by human activities could come at the expense of native species, particularly forage fish like herring and capelin. However, given the complexity and compensatory mechanisms of the ecosystem, predictions about the indirect effects of climate change on fish populations are subject to great uncertainty (see Section 1.3.1.1, Incomplete and Unavailable Information).

3.8.4.3 Alaska – Arctic

Aquatic systems of the Arctic undergo extended seasonal periods of frigid and harsh environmental conditions. Important environmental factors that arctic fishes must contend with include reduced light, seasonal darkness, prolonged low temperatures and ice cover and low seasonal productivity (McAllister 1975; Craig 1984, 1989). The lack of sunlight and the extensive ice cover in arctic latitudes during winter months affect primary and secondary productivity, making food resources very scarce during this time, so most of a fish's yearly food supply must be acquired during the brief arctic summer. In addition, most fish species inhabiting the frigid polar waters are thought to grow slowly relative to individuals or species inhabiting boreal, temperate, or tropical systems. Because of the harsh conditions, many species found in the Beaufort and Chukchi Seas are at the northern limits of their range.

Fishes of the Arctic may use one or more aquatic habitats to carry out their respective life cycles. Such habitats may include, but are not limited to bays; ice; reefs such as the Boulder Patch; and nearshore, coastal, continental shelf, oceanic, and bathypelagic waters and/or substrates. The Beaufort and Chukchi Seas support at least 98 fish species from 23 families (Mecklenburg et al. 2002). The greatest number of species is found in the Chukchi Sea (Hopcroft et al. 2008). Other species are likely to be found in the Arctic when deeper marine waters are more thoroughly surveyed. Additional information concerning the biology, ecology, and behavior of the fish species of Arctic Alaska is in Moulton and George (2000), Fechhelm and Griffiths (2001), Mecklenburg et al. (2002), and Childs (2004). More recent assessments of fish populations in the Chukchi Sea can be found in Norcross et al. (2009) and Mecklenburg et al. (2007, 2011). Recent fish surveys for the Beaufort Sea can be found in Logerwell and Rand (2010) and Logerwell et al. (2011).

Subsistence fishing has long been an integral part of Native life in the U.S. Arctic, and abundant local fisheries knowledge exists among these people (see Section 3.15.2.1). Commercial fishing, which occurred only infrequently and on a very small scale in the past, does not currently occur in the region, and therefore the typically published stock assessments and monitoring data do not exist. Because of the logistical difficulties of research and the lack of commercial fishing data, the published information on fish in the U.S. arctic seas is relatively small compared to published information on fish in seas bordering other areas of the State of Alaska and the United States.

3.8.4.3.1 Diadromous Fishes. Common diadromous fishes found in the Beaufort and Chukchi Seas are salmonids and include arctic cisco (*Coregonus autumnalis*), least cisco (*Coregonus sardinella*), humpback whitefish (*Coregonus pidschian*), broad whitefish (*Coregonus nasus*), and Dolly Varden (*Salvelinus malma*) (Craig 1989). The Colville River Delta and the Sagavanirktok River Delta have a particularly high abundance and diversity of diadromous fishes. Spawning occurs in the warmer months of the year. Life history traits of individual fish species in the Beaufort/Chukchi region are not well understood (DeGange and Thorsteinson 2011). Although present in arctic waters, all five Pacific salmon species significantly decrease in abundance north of the Bering Strait (Craig and Haldorson 1986; Babaluk et al. 2000) and from west to east along the Beaufort and Chukchi Seas. Pink salmon and chum salmon are the most common Pacific salmon in arctic waters (Augerot 2005; Stephenson 2005). Salmon appear to be rare in the Beaufort Sea and extremely rare in the eastern Beaufort Sea, although chum salmon are natal to the Mackenzie River and are consistently found there in low numbers (Irvine et al. 2009). Chum and pink salmon may be natal to other rivers on the North Slope, but this is unconfirmed (Irvine et al. 2009). Recent studies indicate that most of the juvenile chum salmon caught in the Chukchi Sea site were genetically related to populations in northwestern Alaska (Kondzela et al. 2009).

3.8.4.3.2 Pelagic Fishes. Common pelagic fish in the Beaufort Sea and Chukchi Sea include pacific sand lance (*Ammodytes hexapterus*), pacific herring (*Clupea pallasii*), arctic cod (*Boreogadus saida*), capelin (*Mallotus villosus*), snailfish (Liparidae), and lanternfish (*Benthosema glaciale*). Anandromous species of salmonids are found in shallow nearshore waters. Mid-water trawl sampling in the Beaufort Sea indicated that young-of-the-year fish arctic cod, sculpin (Cottidae), snailfish, poacher (Agonidae), and capelin dominated the pelagic biomass and the distribution of fish was related to depth, salinity, water temperature, and proximity to the Chukchi Sea (Logerwell and Rand 2010). Pelagic fishes can occupy benthic habitats as well at certain life stages. For example, arctic cod are often demersal as adults, but young arctic cod are closely associated with the underside of sea ice. Arctic cod are an ecologically important species because of their numerical dominance (Logerwell et al. 2011) and their role in linking zooplankton and sea ice invertebrates to higher trophic levels such as marine mammals and seabirds (Gradinger and Bluhm 2004).

3.8.4.3.3 Demersal Fishes. Most fish in the Beaufort Sea and Chukchi Sea are demersal species living on or near the bottom. Demersal fish in arctic waters are often migratory species that originate from the Bering Sea or North Atlantic waters. In recent bottom trawl surveys in the Chukchi Sea, a total of 33 species were collected and 79% of all fishes caught were arctic staghorn sculpin (*Gymnocanthus tricuspis*), shorthorn sculpin (*Myoxocephalus scorpius*), Bering flounder, or arctic cod (Mecklenburg et al. 2007). Other recent surveys of the Chukchi Sea indicated cod (family Gadidae), poachers (family Agonidae), Bering flounder (*Hippoglossoides robustus*), and sculpins (family Cottidae) are the most abundant demersal fishes in the Chukchi Sea (Barber et al. 1997; Norcross et al. 2009). Greenlings (family Hexagrammidae), eelpouts (family Zoarcidae), smelts (family Osmeridae), wolfish (family Anarhichadidae) and snailfish (*Lycodes* spp.) are also present in arctic waters (Barber et al. 1997; Norcross et al. 2009).

NOAA and BOEM have sponsored recent surveys of benthic fishes in the Beaufort Sea. In the Beaufort Sea, Arctic cod, eelpouts, and walleye pollock (*Theragra chalcogramma*) comprised the majority of the catch in benthic trawl surveys (Logerwell and Rand 2010) (Table 3.8.4-3). With the exception of arctic cod, fish catch per unit effort (CPUE) is much lower in the Beaufort Sea compared to trawl CPUEs in the Chukchi and Bearing Seas (Logerwell and Rand 2010). Species distributions were primarily influenced by depth, temperature, and salinity (Logerwell et al. 2011). Sculpins were more strongly associated with relatively warm, low-salinity water, while polar cod and eelpouts were associated with cold, high-salinity bottom water. Depth was also significant (Logerwell et al. 2011). Sculpin were generally found in waters less than 100 m (328 ft) deep, in contrast to eelpouts, walleye Pollack, and Arctic cod, which were most abundant in waters greater than 100 m (328 ft).

Rocky substrate is uncommon in subtidal areas of the Beaufort and Chukchi Seas and occurs primarily in the form of scattered boulders (Figure 3.7.2-4). Data on fish communities inhabiting these boulder patches are limited. Clingfish (*Liparis herschelinus*), four-horned sculpin (*Myoxocephalus quadricornis*), and the eelpout (*Gymnelis viridis*) have been observed in boulder patch habitat, and fish have been observed to lay eggs on boulders or associated vegetation (Dunton et al. 1982).

3.8.4.3.4 Climate Change. Climate change may have a number of effects on fish communities, including direct effects on physiology and behavior and indirect effects caused by habitat loss and large-scale changes in ecological processes. Changes in the magnitude or seasonality of water temperatures could affect growth rate, food demand, and reproductive behavior because water temperature is an important trigger for the seasonal fish migrations. Hydrologic changes in rivers flowing into the Beaufort and Chukchi Seas could result from changes in precipitation and ice melt. The behavior and physiology of fish in river-influenced systems such as the Beaufort and Chukchi Seas would be particularly affected by the alteration of salinity, turbidity, and temperature linked to changes in hydrology. In addition, rising surface water temperature has the potential to affect all aspects of fish growth, feeding, and movement (Portner and Peck 2010). Similarly, aqueous concentrations of CO_2 projected to exist under

TABLE 3.8.4-3 The Five Most Abundant Fish Taxa Collected during 2008 Bottom Trawls in the Beaufort Sea

Common Name	Total Number	Total Weight (kg)
Arctic cod (*Boreogadus saida*)	66,278	1,242
Marbled eelpout (*Lycodes raridens*)	1,642	142
Walleye pollock (*Theragra chalcogramma*)	1,082	34
Canadian eelpout (*Lycodes polaris*)	772	38
Bering flounder (*Hippoglossoides robustus*)	231	35
Greenland turbot (*Reinhardtius hippoglossoides*)	221	16

Source: Logerwell and Rand (2010).

certain climate change scenarios have been demonstrated to reduce the fitness of fish by reducing their ability to detect predators and adult habitat using olfactory and auditory cues (Munday et al. 2009, 2010; Simpson et al. 2011).

In addition to habitat alteration, critical coastal habitats could be reduced or eliminated by rising sea levels and increased storm damage to nearshore areas as the amount of open water increases. Anadromous fish and species that use coastal habitats are likely to be most affected. In addition, species such as the arctic cod that depend on sea ice will lose habitat with the reduction in seasonal ice. However, arctic cod may gain from the increase in open water plankton productivity. The impacts of climate change on arctic habitat in the Beaufort and Chukchi Seas is discussed in Sections 3.7.2.3 and 3.7.3.3.

Climate change is also likely to change fish community composition. For example, the cold temperatures in Alaska are a critical ecosystem feature that limits species distribution. Historical records suggest that rising seawater temperatures could allow the establishment of sub-arctic species in arctic waters (reviewed in Loeng 2005). As a consequence of the range expansions of subarctic species, true Arctic species such as Arctic cod and capelin may be pushed northward (Loeng 2005). In offshore waters, Logerwell and Rand (2010) noted that comparison of their recent fish collections with earlier trawl data suggested that pollock and Pacific cod (*Gadus macrocephalus*) may have expanded northward into the Beaufort Sea as a result of rising surface water temperatures. There is also speculation that increasing water temperatures could allow Pacific salmon to expand their range and numbers into arctic waters (Irvine et al. 2009). However, recent reviews (Stephenson 2005; Irvine et al. 2009) found there was no evidence of increased catches of most salmon species, and there is not enough information to state definitively that salmon are increasing in frequency in the Arctic due to climate change.

Large-scale changes in oceanographic and ecosystem processes resulting from climate change could indirectly affect fish populations in the Arctic in several ways. For example, climate change could alter ocean currents that govern the transport of larval fish. Temperature is another climate variable that is a critical feature in arctic ecosystems that influences the amount and seasonal availability of planktonic food resources. Under the existing temperature regime, the Chukchi Sea has a food web dominated by benthic consumers and cryopelagic (sea ice-associated) fishes. The loss of sea ice and the increased surface water temperature may promote a shift to a pelagic-based food web with high phytoplankton and zooplankton productivity and greater numbers of predatory fish (Loeng 2005). Ultimately, however, predictions about the indirect and cascading ecological impacts of climate change on fish populations are subject to great uncertainty, given the complexity of the ecosystem (see Section 1.3.1.1, Incomplete and Unavailable Information).

3.8.5 Invertebrates and Lower Trophic Levels

Invertebrates (animals without a backbone) occupy multiple habitat types from the intertidal zone to the deep sea. Invertebrates can occupy benthic (bottom) or pelagic (water column) habitats, depending on their life histories. Invertebrates that occupy the benthos can be categorized by their size, location in the substrate, and feeding guild. Benthic invertebrates that burrow into the sediment are called infauna, and invertebrates that move on the sediment surface are called epifauna. Size classifications for benthic infauna are mieofauna (typically 43–500 µm), which are dominated by copepods and nematodes, and macroinfauna (>500 µm), which are usually dominated by polychaete worms, amphipods, and bivalves. Benthic invertebrates can be further classified into several trophic guilds, including (1) predators and scavengers, which feed on live animals or carrion; (2) scrapers, which remove biofilms from hard substrate; (3) suspension (filter) feeders, which filter food from the water; and (4) deposit feeders, which consume surface or subsurface sediment organic matter. Invertebrates in the various feeding guilds often occupy specific sediment types. For example, suspension feeders prefer clean sandy sediment or hard surfaces where they can avoid fine sediments that tend to clog their filtering organs. In contrast, deposit feeders prefer silty sediments that are rich in organic matter.

Pelagic invertebrates may drift with the current (zooplankton) or actively swim (nekton). Pelagic invertebrates can range in size from microscopic protozoans to large megafauna, such as squid and jellyfish. They play a critical role in the recycling of nutrients and organic matter in the water column and in the amount of and timing at which these food resources reach benthic consumers.

3.8.5.1 Gulf of Mexico

Following are brief descriptions of the classes of prokaryotes, viruses, and eukaryotic invertebrates common in marine environments, including the Northern GOM Shelf and Slope Marine Ecoregions:

- *Prokaryotes*. Prokaryotes are distinguished from invertebrates by not having a nucleus. Based on their genetics and cell membranes, prokaryotes are divided into Eubacteria and Archaea. Eubacteria are dominant in the benthos and the water column and are key drivers in a number of ecosystem processes. One primary function of bacteria is the break down and recycling of organic matter. In addition, bacteria are critical in nutrient (e.g., nitrogen, phosphorous, and sulfur) transformation in both the sediment and water column. Bacteria are heterotrophic and subsist on dissolved and particulate organic matter. They are consumed by protists and a variety of zooplankton and macroinvertebrates in the sediment. Although bacterial consumption of organic matter is an important ecological process, it facilitates the development of seasonal bottom-water hypoxia in the GOM. Archaea are prokaryotes found throughout the ocean but are strongly associated with extreme environments. Prokaryotes are the key biological components of cold seeps communities in the GOM, where methanogenesis (archaea) and coupled sulfate reduction (eubacteria) and methane oxidation (archaea) provide the substrates that support the cold seeps macroinvertebrate communities and their bacterial symbionts. Prokaryotic communities in the sediment and water column also play a critical role in the break down of hydrocarbons released by natural processes and human activities. These activities prevent the accumulation of hydrocarbons to toxic levels in the environment. Studies following the DWH event demonstrated that the amount of menthanotropic and oil-eating bacteria increased greatly after the DWH event (Camilli et al. 2010; Kessler et al. 2011).

- Viruses are simple life forms consisting of DNA and RNA in a protein covering. They reproduce by injecting their genetic material into the cells of other organisms and replicate their DNA using the cellular machinery of the host cell after which the host cell lyses and releases the replicated viruses. Viruses serve as a significant population control on bacteria in the ocean.

- *Protozoans*. Protozoans are a broad and diverse group of microorganisms that include foraminifierans, ciliates, radiolarians, and flagellates. They can occupy both benthic and pelagic habitats, where they act as parasites or free-living consumers of phytoplankton, bacteria, or other zooplankton. Protozoans with carbonate or silicate shells create oozes of relict shells on the seafloor of the deep ocean. Protozoans are abundant in the water column and sediments, and they are often dominant planktonic consumers in pelagic food webs in areas where biological productivity is low and nutrients and carbon are tightly cycled between small phytoplankton, microplankton, and bacteria.

- *Porifera*. Poriferans (sponges) are primitive sessile animals consisting of cellular aggregations held in a flexible protein/carbonate housing. Poriferans are suspension feeders that consume phytoplankton and particulates from the water column. They are found in all sediment types from the Northern GOM Shelf to the Slope Ecoregions. They may reproduce sexually or asexually.

- *Cnidarians and Ctenophores*. Cnidarians (jellyfish, hydrozoans, sea anemones, corals) are defined by their radial symmetry and the use of nematocysts (stinging cells) to capture prey. Comb jellies (Ctenophora) are similar to cnidarians but lack nematocysts. Cnidarians can reproduce sexually and asexually; they typically produce free-floating planktonic larvae that eventually settle to the seafloor. Ctenophores are pelagic throughout their life cycle. Cnidarians can be found across the shelf and slope of the GOM in both benthic habitats and water column habitats. Corals form ecologically significant benthic habitat (see Section 3.7.2.1.2). Jellyfish appear to be increasing in abundance in the GOM (Graham 2001), possibly because of higher water temperatures, lack of predators, and their hypoxia tolerance. The increase in jellyfish abundance could have negative consequences on the eggs and larvae of fish and invertebrates that they prey upon.

- *Worms*. Worms cover a wide range of taxa that have soft, elongated bodies and bilateral symmetry in common. As adults, most worms are sediment dwellers, but some species are pelagic (arrow worms [Chaetognatha]). Although benthic as adults, many worms produce free-living planktonic larvae. The GOM supports a diverse array of worms, such as peanut worms (Sipunculans), flatworms (Platyhelminthes), ribbonworms (Nemertea), nematodes (Nematoda), and segmented worms (Annelida; including polychaetes and oligochaetes). Nematodes and polychaetes are particularly abundant in sediments and are important food sources for higher trophic levels. In addition to their role as food sources, polychaetes continually displace and mix the sediments, thereby promoting biogeochemical cycling. Polychaetes can also significantly modify their environment by forming tubes from sediment particles; thus, they create microhabitats for other benthic organisms. Worms have a range of diets and feeding strategies; for example, they may be suspension feeders, predators, or deposit feeders. Worms show a range of tolerance to contaminants and therefore are important ecological indicators for assessments of human disturbance.

- *Mollusks*. Mollusks (bivalves, gastropods, and cephalopods) are characterized by having a muscular foot and mantle tissue that in most species produces a calcium carbonate shell. Bivalves, which have two shells joined by a hinge, can be found across coastal and marine sediments from estuaries to the deep sea. Bivalves reproduce by releasing sperm and eggs into the water column, where fertilization occurs. Their larvae undergo a temporary planktonic period before settling to the bottom and developing into adults. The common bivalves present in the GOM are clams, oysters (*Crassostrea virginica*), scallops, and mussels. Clams burrow into the sediments, where they deposit or suspension feed on small organisms or organic particles. Oysters are common in estuarine habitats, where they attach to hard substrates and feed by filtering plankton and particulate organic matter from the water column. Oysters are ecosystem engineers that provide critical reef habitat in estuaries. Mussels are relatively rare in marine waters but are common in estuaries and in deepwater methane seep communities. Bivalves can perform several ecological functions. Filter-feeding species have historically increased light penetration by removing particulates and phytoplankton from the water column. Also, because they produce feces that are consumed by other sediment biota, they can be an important link in the transfer of water column production to benthic consumers.

  Gastropods (snails and slugs) typically have a single whorled shell. Most species are sediment-dwelling, but species with reduced shells or no shell can also occupy the water column. Soft-sediment marine gastropods typical of the central and western portions of the Northern GOM Ecoregions are usually carnivores or scavengers. Most marine gastropods fertilize internally and lay eggs in the sediment. After larvae hatch, they may undergo a planktonic stage.

  Cephalopod mollusks are the octopi and squid, which are characterized by a pronounced head and complex eye development. Cephalopods like the octopus are benthic, while the squid may be found from relatively shallow to very deep portions of the water column. Cephalopods are carnivorous and, in turn, are important food sources for fish and marine mammals.

- *Crustaceans*. Crustaceans possess an exoskeleton and can be found as free-swimming water column forms, bottom-dwelling mobile forms, and attached forms. Copepod crustaceans are important phytoplankton grazers; in turn, they are often the primary food source for fish during their early life stages, and they represent a key link in transferring energy from primary producers to predatory consumers at higher trophic levels. Barnacles are examples of crustaceans that attach to hard substrate (including oil and gas platforms), where they filter food from the water column. Common epifaunal (on the sediment surface) crustaceans are the decapods, which include portunid crabs, stone crabs, and penaeid shrimp, many of which are commercially important. Decapods are found from the estuarine to the deep sea over soft and hard substrates and are key food resources for demersal fishes. Decapods usually have a pelagic larval life stage but are benthic as adults. Many decapods are estuarine-dependent (reside in an estuary during some period of their life cycle), and, given their abundance and high biomass, they are important in transferring nutrients and organic matter between estuarine and marine habitats.

- *Echinoderms*. Echinoderms are defined by their radial symmetry, tube feet, and an endoskeleton. Common examples in the Northern GOM Marine Ecoregions include sea stars (Asteroidea), brittle stars (Ophiuroidea), sea urchins (Echinoidea), and sea cucumbers (Holothuroidea). Sea stars, brittle stars, and sea cucumbers, in particular, are common throughout the marine environment — on soft and hard substrates from coastal waters to the deep sea. Echinoderms can be grazers (sea urchins), deposit feeders (sea cucumbers), or predators (sea stars). Echinoderms usually produce planktonic larvae that settle to the seafloor after some period of time in the water column.

- *Chordates*. Chordates have a primitive spinal cord at some point in their development, yet they are classified as invertebrates because they lack a backbone. In the GOM, the most common chordates are the filter-feeding tunicates (sea squirts, salps, and larvaceans). The most important chordate grazer in the northern GOM is the planktonic larvacean *Oikopleura dioica*, which filters bacteria and small phytoplankton out of the water column. Larvaceans have been reported to consume an average of 20% of the particles from the upper 5 m (16.4 ft) of the Mississippi River plume each day. Their abundance is so great that the deposition of their fecal pellets and discarded gelatinous houses may be great enough to contribute significantly to the bottom-water hypoxia that occurs seasonally in the GOM (Dagg et al. 2007).

There are few studies of the impacts of the DWH event on invertebrate communities in the GOM. Some researchers have reported seeing dead and dying benthic animals as well as what appear to be thick deposits of oil or flocculants of oil and organic matter on the seafloor

(BOEMRE 2010b). There is some evidence that the DWH event affected habitat-forming deepwater corals, and investigations are ongoing (http://www.boemre.gov/ooc/press/2010/ press1104a.htm). Landings of shrimp do not suggest any reduction in shrimp populations (http://gomos.msstate.edu/ gomosshrimplandingimpactGOM.html). However, several years may be required to fully assess the impacts of the DWH event on invertebrate populations. This information, however, is not needed at the programmatic stage to make a reasoned choice among alternatives (see Section 1.4, Analytical Issues).

Climate Change. Several major classes of invertebrates could be affected by the environmental changes predicted to result from climate change. A significant loss of corals could result from increased water temperature and ocean acidification. The impacts of climate change on habitat-forming invertebrates, such as corals, are discussed in detail in Section 3.7.2.1. As described in Sections 3.7.4.1 and 3.7.3.1, climate change might increase the range and temporal variability of a water column's oxygen, salinity, and temperature, all of which are critical determinants of invertebrate community distribution, density, and species composition. Such large-scale changes in benthic and pelagic habitats could significantly alter the existing invertebrate community structure and ecosystem services. In particular, invertebrates in nearshore areas would be likely to experience more differences in the physical and chemical variables brought about by the change in the hydrologic regime. Invertebrates have specific physiological tolerances; thus, more fluctuations in environmental variables, especially salinity (Attrill 2002), would probably reduce their abundance and diversity as the more-tolerant species replaced the less-tolerant ones. Nonmobile or slow-moving benthic invertebrates, such as echinoderms, mollusks, and macroinfauna, would be most vulnerable to physiological stress. Invertebrate communities in the Mississippi Estuarine Area Ecoregion would be especially likely to undergo significant changes, because of the strong influence of Mississippi River discharge on biological communities. The rise in temperatures could also alter species compositions as more tropical species expanded north, potentially replacing existing fauna.

With the expected increase in water column stratification and nutrient delivery to the GOM, the extent and duration of hypoxia might increase (Section 3.7.3.1). Mortality to adult stages of larger mobile invertebrates might be limited because of their ability to avoid hypoxic waters; however, smaller zooplankton could be affected by hypoxia in several ways. First, more sensitive species, like copepods, might be replaced by smaller more tolerant species (Marcus 2001). Hypoxia might also increase the abundance of jellies, which can tolerate low-oxygen areas (Purcell et al. 2001). In addition, it has been found that hypoxia can disrupt daily zooplankton migrations from the lower to the upper water column, which could affect food intake of zooplankton and their predators (Qureshi and Rabalais 2001).

The increasing inputs of CO_2 into the ocean are expected to reduce oceanic pH and, with it, the availability of calcite and aragonite. Calcifying marine organisms — such as shallow and deepwater corals, echinoderms, foraminiferans, and mollusks — might decline in abundance because they require calcite or aragonite to lend structural support to their exoskeletons (Royal Society 2005).

3.8.5.2 Alaska – Cook Inlet

See Section 3.8.5.1 for a general description of invertebrate groups and their ecological roles, and see MMS (1996b, 2003a) for a comprehensive description of the invertebrate zooplankton community of Cook Inlet. The water column invertebrates in Cook Inlet are similar to those in other subarctic waters (Speckman et al. 2005) and are composed of a mix of oceanic and coastal species (MMS 1996b). Several species of copepods dominate the macrozooplankton assemblage. Measurements of zooplankton productivity indicate a peak in late spring and summer (MMS 1996b). Lower Cook Inlet has a complicated physical and chemical environment as a result of the mixing of fresh and marine water, and the zooplankton community appears to be primarily structured by temperature, salinity, bottom depth, and turbidity (Speckman et al. 2005).

Benthic invertebrates are important trophic links connecting primary producers to higher-trophic-level organisms found in Cook Inlet and the Gulf of Alaska, such as crabs, flatfishes, and cod. In Lower Cook Inlet, there are spatial differences in the compositions of the benthic invertebrate communities related to differences in ice formation, with arctic species being more common on the western side of Cook Inlet and the temperate species being more common in the eastern portion of Cook Inlet (MMS 1996b, 2003a). In addition, benthic invertebrate species differ by substrate type and tidal zone. The lower rocky intertidal zone contains a diverse mix of echinoderms (sea urchins and sea stars), mollusks (bivaves, limpets, and snails), polychaete worms, and crustaceans (barnacles and crabs). Sandy intertidal sediments are dominated by polychaetes and amphipods, with clams increasing in abundance in deeper waters. Several distinct subtidal communities have been identified on substrates of rock, sand, silt, and/or shell debris (Feder and Jewett 1986). Clams were dominant in sandy subtidal sediment, and clams and polychaetes dominated in muddy sediment. Substrates consisting of shell debris generally have the most diverse communities and are dominated by mollusks and bryozoans (Feder and Jewett 1986). Epifauna (invertebrates on the sediment surface) in the region are primarily crustaceans (tanner crabs, king crabs, pandalid and cragonid shrimp) and echinoderms (sea cucumbers and sea urchins). Studies in the western side of Shelik of Strait indicated that limpets, snails, crabs, chitons, barnacles, and mussels dominated the lower and mid rocky intertidal. Several clam species are found in intertidal and subtidal soft substrates (Nagorski et al. 2007).

Climate Change. It is predicted that physical and chemical changes to subarctic invertebrate habitat would result from climate change. These changes could alter the existing distribution, composition, and abundance of invertebrates in Cook Inlet, since physical and chemical parameters are the primary influence on invertebrate communities.

For example, the increase in seawater temperature will facilitate a northward expansion of subarctic and temperate invertebrate species. Rising sea water temperatures are also expected to decrease winter ice extent and duration. Currently, ice formation primarily occurs on the western side of Cook Inlet, and changes in benthic invertebrate community structure could result from the reduction in ice scour. Also, hydrologic change can rapidly alter existing invertebrate communities in the water column and benthos if the new chemical conditions are not within the physiological tolerance of the existing communities. Changes in the magnitude, frequency, and timing of river discharge are expected to result from climate change (Arctic Council 2005). Thus, invertebrates in the Cook Inlet Ecoregion where there are strong riverine inputs would likely be affected by alterations in the salinity, temperature, and sediment delivery regime.

Another significant source of physiological stress is the expected increase in ocean acidification. Crustaceans, echinoderms, foraminiferans, and mollusks could have greater difficulty in forming shells, which could result in a reduction in their fitness, abundance, and distribution (Fabry et al. 2008). The loss of shelled invertebrates could affect higher trophic levels, including benthic mollusks, that are critical food sources for birds and marine mammals.

3.8.5.3 Alaska – Arctic

See Section 3.8.5.1 for a general description of invertebrate groups and their ecological roles. At the lowest invertebrate trophic levels, microbes such as bacteria and protists are known to be important in arctic waters for breaking down and recycling nutrients and organic matter (Hopcroft et al. 2008). Cilliates and dinoflagellates dominate the microzooplankton biomass in the Chukchi Sea, but their role in the Beaufort and Chukchi Seas is not well studied (Hopcroft et al. 2008). The most common water column macroinvertebrates in the Arctic are the copepods (typically *Pseudocalanus* spp.). In the Chukchi Sea, much of the copepod biomass originates in the Bering Sea, while true arctic species are most common in the Beaufort Sea (Hopcroft et al. 2008). Riverine inputs also create an estuarine zone with a distinct zooplankton assemblage. Other common zooplankton include larvaceans, jellies, euphasid shrimp, amphipods, pteropod mollusks, and arrow worms. In the Beaufort and Chukchi Seas, invertebrate zooplankton productivity is highly seasonal as a result of the extremely cold winter temperatures. Many invertebrates (i.e., copepods) have adapted by storing lipids for the winter and undergoing a winter dormant period during which they rest in the sediment or lower water column.

Across the Beaufort and Chukchi shelf, the benthic infaunal community is dominated primarily by echinoderms, polychates, sponges, anemones, bivalves, gastropods, and bryozoans (Grebmeier and Dunton 2000; Dunton et al. 2005). Studies in the Beaufort Sea indicated brittle stars, crabs (*Opilio* spp.), ascidians, mussels, sea anemones, and echinoderms dominated the epifaunal assemblage (NMFS 2010e). Overall, however, larger invertebrate infauna are relatively sparse in much of the Beaufort Sea when compared to their presence in the Chukchi Sea, where echinoderms, crabs, and shrimp are more abundant (Hopcroft et al. 2008).

There are several strong spatial gradients in benthic invertebrate biomass and species composition across the Beaufort/Chukchi shelf. Benthic biomass is higher in Chukchi Sea compared to the Beaufort Sea (Grebmeier et al. 2006). Within the Beaufort Sea, benthic biomass is slightly lower in the eastern and deepwater portions of the Beaufort Sea and slightly higher to the west, adjacent to the Chukchi Sea. South of the Chukchi Sea Planning Area, the Chukchi Sea contains some of the highest benthic biomass in the Arctic (Grebmeier et al. 2006; Hopcroft 2008). The high benthic biomass and richness in the Chukchi Sea have been attributed to currents that move nutrients onto the shallow Chukchi shelf from the Bering Sea, the resulting sudden and intense springtime phytoplankton bloom during a period of relative inactivity for zooplankton, and the subsequent deposition of large amounts of phytoplankton food on the seafloor (Hopcroft 2008). Nearshore infauna diversity and abundance can be low because of ice scour and freshwater inputs. Invertebrate biomass also decreases from the mid-shelf to the slope. For example, trawls in the western Beaufort Sea indicated that invertebrate biomass was dramatically higher between 100 and 500 m (328 and 1,640 ft) than between 40 and 100 m (131 and 328 ft) (NMFS 2010e).

Invertebrate species associated with boulder habitats are located primarily on the Beaufort shelf. These habitats vary according to their post-disturbance successional stage. Pioneer colonizing invertebrates include polychaetes, followed by encrusting bryozoans and hydroids, and ultimately a diverse community of kelp, soft coral, tubeworms, and sponges. Multiple studies have demonstrated that if significantly physically disturbed, communities associated with boulders are slow (2 or more years) to begin recovery and that full recovery of boulder invertebrate communities may take 10 or more years (MMS 2002b; Konar 2007 and references therein).

Sea ice invertebrates include microbes, polychaetes, copepods, nematodes, and amphipods. Like zooplankton, sea ice invertebrates are important in connecting the water column to the benthos by depositing food on the seafloor and by providing habitat for benthic invertebrates in their early life stages (Gradinger and Bluhm 2005). Sea ice invertebrates are also an important food source to certain pelagic fish like arctic cod.

Climate Change. It is predicted that physical and chemical changes to arctic and subarctic invertebrate habitat would result from climate change (Section 3.3). Any of these changes could alter the existing distribution, composition, and abundance of invertebrates, since physical and chemical parameters are the primary influence on invertebrate communities. In general, the increase in seawater temperature will facilitate a northward expansion of subarctic invertebrate species from the Bering Sea. Weslawski et al. (2011) identified the Bering Strait as a major corridor through which new invertebrate species will expand their range northward. Such expansion will likely increase overall invertebrate species diversity in the Arctic, but the new species may displace existing species or alter existing inter-specific species interactions. For example, the movement of large decapod crabs into the Arctic may dramatically alter existing food webs (Weslawski et al. 2011). The change in species composition may be greatest in the eastern Beaufort Sea where arctic species currently predominate. The timing and duration of copepod recruitment as well as copepod biomass are also likely to be affected by the rise in surface water temperatures.

It is predicted that a decrease in sea ice habitat would result from increasing water temperature. Consequently, the distribution of invertebrates specialized to inhabit sea ice will contract if they are unable to occupy new habitats. Also, the seasonal deposition of food from melting sea ice may be reduced, but settled phytoplankton may make up for the loss as the productivity of open water increases. Overall, an increase in the productivity of water column invertebrates is expected (Hopcroft et al. 2008). The abundance of benthic invertebrates may also increase in nearshore areas with the reduction in ice scour extent and duration and the consequent increase in the area of the seafloor available for colonization by invertebrates

(Weslawski et al. 2011). However, loss of sea ice could also increase benthic disturbance from severe weather as the amount of open water increases.

Changes in the magnitude, frequency, and timing of river discharge into the Beaufort and Chukchi Seas are expected to result from climate change (Arctic Council 2005). Invertebrates in marine ecoregions with strong riverine inputs — like the Beaufort Neritic Ecoregion — would likely be affected by alterations in the salinity, temperature, and sediment delivery regime. Hydrologic change can rapidly alter existing invertebrate communities in the water column and benthos, if the new chemical conditions are not within the physiological tolerance of the existing communities. The greater variability in hydrologic conditions could favor tolerant and opportunistic species, thereby homogenizing invertebrate species composition and decreasing overall species diversity in the Beaufort and Chukchi Seas (Weslawski et al. 2011).

The expected increase in ocean acidification is considered to be another significant source of physiological stress. Crustaceans, echinoderms, foraminiferans, and mollusks could have greater difficulty in forming shells, which could reduce their fitness, abundance, and distribution (Fabry et al. 2008). The loss of shelled invertebrates could affect higher trophic levels. For example, benthic mollusks are critical food sources for birds and marine mammals, and pteropods (pelagic snails) are abundant in arctic waters and are an important food resource for salmon (Groot and Margolis 1991).

3.9 AREAS OF SPECIAL CONCERN

3.9.1 Gulf of Mexico

Areas of special concern include federally managed areas (e.g., Marine Protected Areas [MPAs], National Marine Sanctuaries, National Parks, National Wildlife Refuges), all of which are discussed in the following sections. In addition, a number of locations that have been given special designations by Federal, State, and nongovernmental organizations (e.g., National Estuarine Research Reserves, National Estuary Program Sites, and Military and National Aeronautics and Space Administration [NASA] Use Areas) are also included as areas of special concern.

3.9.1.1 Coastal Areas of Special Concern

3.9.1.1.1 Marine Protected Areas. Executive Order 13158 on Marine Protected Areas defines a MPAs as “any area of the marine environment that has been reserved by federal, state, territorial, tribal, or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein.” Thus MPAs have greater protection than the surrounding waters and can also vary widely in purpose, legal authorities, agencies, management approaches, level of protection, and restrictions on human uses (National Marine Protected Areas Center 2008a).

To strengthen and enhance the nation's system of MPAs, Executive Order 13158 directed the U.S. Department of Commerce and U.S. Department of the Interior, in consultation with other departments, to create a National System of MPAs. Section 5 of the Order calls for Federal agencies to "avoid harm" to National System MPAs and identify any actions that do harm to National System sites. Each Federal agency is responsible for its own implementation of its responsibilities under Section 5. As directed by the Order, the National Marine Protected Areas Center (http://www.mpa.gov), directed by NOAA, has developed a planning and coordination process for adding existing MPAs into the National System. As described in *Framework for the National System of Marine Protected Areas of the United States of America* (National Marine Protected Areas Center 2008a), to be eligible for National System membership, an MPA must:

1. Meet the definitional criteria of an MPA, including each of its key terms — area, marine environment, reserved, lasting, and protection;

2. Have a management plan; and

3. Support at least one priority goal and conservation objective of the national system.

4. Cultural heritage MPAs also must conform to criteria for including sites on the *National Register of Historic Places*.

The *Framework for the National System of Marine Protected Areas of the United States of America* outlines the working relationship for building National System MPA sites, networks, and systems for areas managed by Federal, State, tribal, or local governments. No existing Federal, State, local, or tribal MPA laws or programs are altered by the National System or the Order, and no new legal authorities were established to designate, manage, or change MPAs.

Most National System MPAs encompass the National Marine Sanctuaries, National Parks, and National Wildlife Refuges, and are therefore managed by existing authorities.

At present, 14 National System MPAs have been designated in the Western and Central GOM Planning Areas, and 7 National System MPAs have been designated in the Eastern Planning Area from the Florida/Alabama border to Tampa Bay (Table 3.9.1-1; Figure 3.9.1-1). Most National System MPAs are National Wildlife Refuges and are described in Section 3.9.1.1.3.

In addition to the National System MPA member sites in Table 3.9.1-1, there are several State-designated and State-managed MPAs, federally managed areas, and partnership areas under State and Federal management that may or may not be eligible for membership in the National System MPA program. A complete listing and descriptions of the locations of these areas can be obtained from the lists on the Marine Protected Areas of the United States website at http://www.mpa.gov/helpful_resources/inventoryfiles/gulf_june_2010.pdf. Florida has 87 State-designated MPAs from the Panhandle to Tampa Bay. The vast majority are Outstanding Florida Waters, although many are also State Parks and aquatic preserves. Louisiana and Mississippi have 26 and 10 State-designated MPAs, respectively, most of which

TABLE 3.9.1-1 National System Marine Protected Area Member Sites in the Western and Central GOM Planning Area and the Eastern GOM Planning Area from Alabama to Tampa, Florida

Site Name[a]	State	Managing Agency[b]
Bon Secour National Wildlife Refuge	AL	USFWS
Jean Lafitte National Historical Park and Preserve, Barataria Preserve	LA	NPS
Flower Garden Banks National Marine Sanctuary	LA	NOAA
Big Branch Marsh National Wildlife Refuge	LA	USFWS
Breton National Wildlife Refuge	LA	USFWS
Delta National Wildlife Refuge	LA	USFWS
Sabine National Wildlife Refuge	LA	USFWS
Shell Keys National Wildlife Refuge	LA	USFWS
Grand Bay National Wildlife Refuge	MS/AL	USFWS
Cedar Keys National Wildlife Refuge	FL	USFWS
Chassahowitzka National Wildlife Refuge	FL	USFWS
Crystal River National Wildlife Refuge	FL	USFWS
Lower Suwannee National Wildlife Refuge	FL	USFWS
Pinellas National Wildlife Refuge	FL	USFWS
St. Marks National Wildlife Refuge	FL	USFWS
St. Vincent National Wildlife Refuge	FL	USFWS
Anahuac National Wildlife Refuge	TX	USFWS
Aransas National Wildlife Refuge	TX	USFWS
Big Boggy National Wildlife Refuge	TX	USFWS
Brazoria National Wildlife Refuge	TX	USFWS
San Bernard National Wildlife Refuge	TX	USFWS

[a] Includes sites designated by the USDOI and NOAA. Sites designated by State, Territory, and Commonwealth agencies are not included but can be obtained from the lists on the Marine Protected Areas of the United States website at http://www.mpa.gov/helpful_resources/inventoryfiles/gulf_may_2011.pdf.

[b] NPS = National Park Service, NOAA = National Oceanic and Atmospheric Administration, USFWS = U.S. Fish and Wildlife Service.

Source: NOAA 2010d.

are coastal preserves and wildlife management areas. Texas has nine State-designated MPAs, most of which are State Parks or Wildlife Management Areas.

Federally managed areas that are eligible for MPA status but are not members of the National System MPA consist of Habitat Areas of Particular Concern (see Section 3.7.4.1), offshore banks, chemosynthetic communities, and deepwater corals (see Section 3.7.2.1). National Estuarine Research Reserves are partnership-managed areas under Federal and State management and are described below.

3.9.1.1.2 National Park System. The National Park System ensures the protection and interpretation of the country’s natural, cultural, and recreational resources. Descriptions of

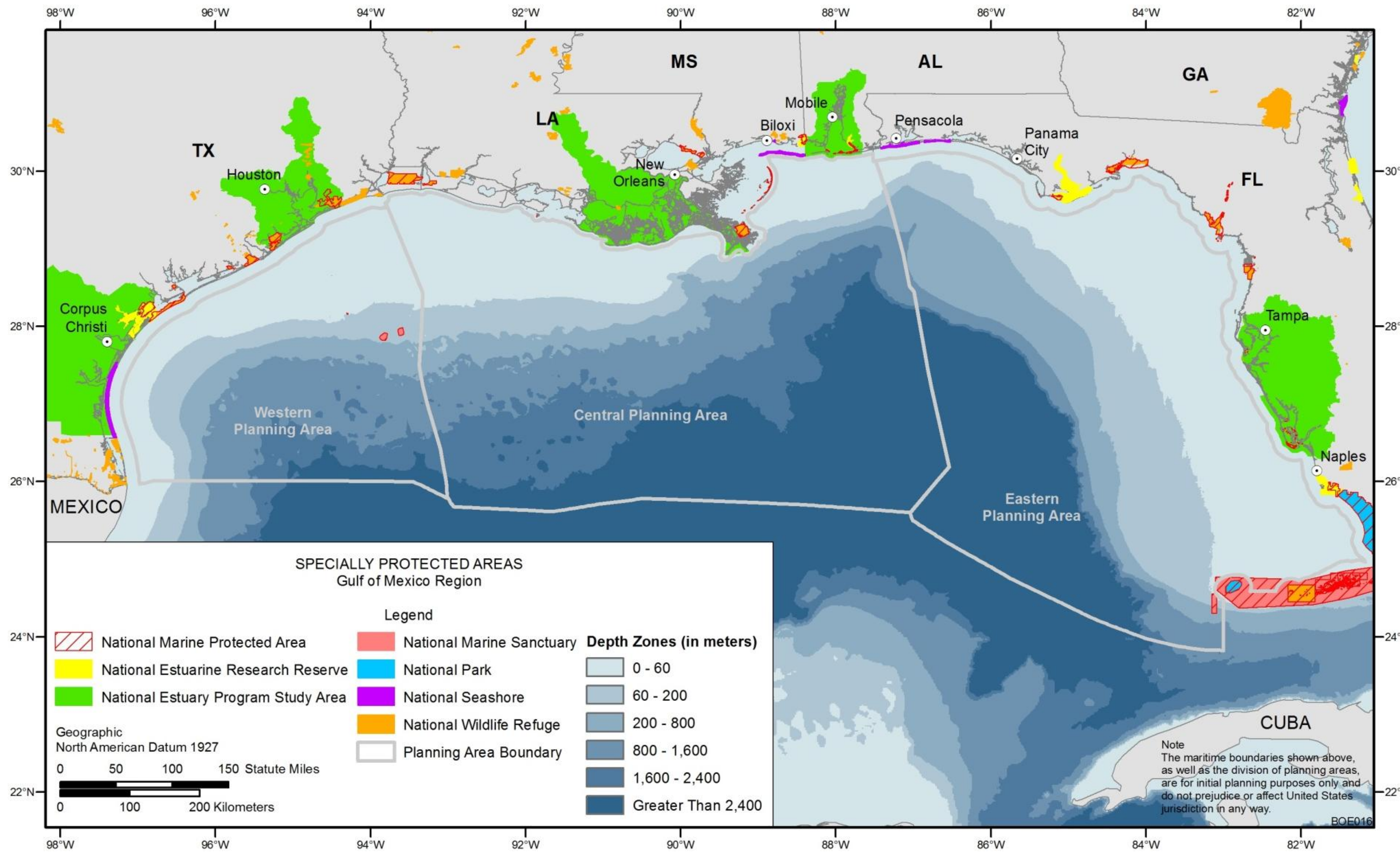

FIGURE 3.9.1-1 Map Showing the Location of Specially Protected Areas in the Western, Central, and Eastern Planning Areas

National Parks given below are based on information for individual parks on the National Park Service (NPS) website (http://www.nps.gov). NPS lands along the coast or in coastal areas of the GOM include the Padre Island National Seashore (Texas), Jean Lafitte National Historic Park (Louisiana), Gulf Islands National Seashore (Mississippi and Florida), and DeSoto National Memorial (Florida). More than 177 km (110 mi) of coastal beaches and barrier islands in Texas, Mississippi, and Florida are used by millions of visitors each year at Padre Island National Seashore and Gulf Islands National Seashore. In addition to being a popular tourist destination, Padre Island National Seashore protects the largest portion of undeveloped barrier island in the world, supports a wide variety of flora and fauna, and is the most important nesting site for the Kemp's ridley sea turtle in the United States. Padre Island National Seashore also includes approximately 8,094 ha (20,000 ac) of the Laguna Madre, which is one of only five hypersaline lagoons in the world. Outside of the Central and Western Planning Areas, the Dry Tortugas National Monument is located offshore of the southern tip of Florida in the Eastern Planning Area.

The Gulf Islands National Seashore includes major portions of the barrier islands off the coasts of Florida and Mississippi, including beaches, coastal marshes, maritime forests, and offshore areas. The park also contains historic sites dating to 16th century European exploration and occupation. DeSoto National Memorial contains information on Hernando DeSoto's exploration of Florida in the 16th century and on Florida's history from the Civil War to the present. Oil from the DWH event reached the shoreline of the Gulf Island National Seashore. Cleanup efforts continue and the Seashore remains open. Monitoring efforts are ongoing (http://www.nps.gov/aboutus/oil-spill-response.htm).

The Jean Lafitte National Historic Park comprises six sites located in southern Louisiana: Acadian Cultural Center in Lafayette, Prairie Acadian Cultural Center in Eunice, Wetlands Acadian Cultural Center in Thibodaux, Barataria Preserve in Marrero, Chalmette Battlefield and National Cemetery in Chalmette, and French Quarter Visitor Center in New Orleans. Barataria Preserve covers more than 9,308 ha (23,000 ac) and contains bayous, swamps, marshes, forests, alligators, nutrias, and more than 300 species of birds. The other five sites are dedicated to the history and cultural preservation of southern Louisiana.

3.9.1.1.3 National Wildlife Refuges. The National Wildlife Refuge System is a network of U.S. lands and waters managed by the USFWS specifically for the enhancement of wildlife. There are 27 National Wildlife Refuges located along the coastline or within the coastal areas of the Western and Central GOM Planning Areas and the Eastern Planning Area from the Florida/Alabama border to Tampa Bay (Figure 3.9.1-1 and Table 3.9.1-2). Information on individual refuges can be found at http://www.fws.gov/refuges/refugeLocatorMaps. Most refuges along the GOM coastline were established to provide wintering areas for ducks, geese, coots, and other migratory waterfowl and shorebirds. Threatened and endangered species, including the American alligator and manatee, also use the refuges along the GOM.

Delta NWR, Breton NWR, Grand Bay NWR, and Bon Secour NWR were all contacted by oil from the DWH event (http://www.fws.gov/refuges/RefugeUpdate/MarchApril_2011/oneyear.html). Breton NWR and Bon Secour NWR appear to have been the most affected.

TABLE 3.9.1-2 National Wildlife Refuges along the GOM Coast from Texas through Tampa Bay, Florida

National Wildlife Refuge	Total Area (ha)[a]
Texas	**141,498**
Anahuac	13,880
Aransas	46,296
Big Boggy	2,023
Brazoria	17,767
Laguna Atascosa	23,402
McFadden	22,258
San Bernard	12,249
Texas Point	3,623
Louisiana	**34,422**
Shell Keys	3
Bayou Sauvage	9,009
Delta	19,749
Breton	3,661
Mississippi	**2,072**
Grand Bay	2,072
Alabama	**3,713**
Grand Bay	1,010
Bon Secour	2,703
Florida (Panhandle to Tampa Bay)	**45,400**
St. Vincent	5,055
St. Marks	27,164
Cedar Keys	361
Chassahowitzka	12,482
Crystal River	19
Pinellas	160
Egmont Key	133
Passage Key	26
Matlacha Pass	159

[a] To convert hectares to acres, multiply by 2.47.

Breton NWR was closed immediately following the spill but has since reopened (http://www.fws.gov/home/dhoilspill/pdfs/Breton2010OilSpillFactSheet.pdf). Monitoring efforts at Breton NWR are ongoing. Bon Secour NWR was heavily oiled and samples collected in winter 2010–2011 indicated elevated PAHs in beach sediments (OSAT 2011). The models of oil degradation for beaches at Bon Secour suggest alkanes and PAHs would degrade to approximately 15–20% of their current concentration within 2.5 to 5 yr (OSAT 2011).

3.9.1.1.4 National Estuarine Research Reserves. The National Estuarine Research Reserve Program was established by the Coastal Zone Management Act of 1972 and is administered by NOAA. One of the primary objectives for establishing this program was to provide research information that could be used by coastal managers and the fishing industry to help assure the continued productivity of estuarine ecosystems. Four estuarine research reserves have been established in the GOM area from Texas to Tampa Bay, as detailed below (Figure 3.9.1-1). Summary descriptions of the reserves described below were gathered through the National Estuarine Research Reserve website (http://nerrs.noaa.gov/ReservesMap.aspx). Detailed site profiles are available at http://nerrs.noaa.gov/BGDefault.aspx?ID=602.

1. Weeks Bay National Estuarine Research Reserve in coastal Alabama includes a small estuary covering about 2,641 ha (6,525 ac). The reserve is composed of open shallow waters, with an average depth of less than 1.5 m (5 ft) and extensive vegetated wetland areas. Freshwater enters from the Fish and Magnolia Rivers, and the reserve connects with Mobile Bay through a narrow opening.

2. The Apalachicola National Estuarine Research Reserve, southeast of Panama City, Florida, covers about 99,553 ha (246,000 ac). It consists of forested flood plains, saltwater and freshwater marshes, barrier islands, and open bays. A Federal Refuge and a State Park are within the reserve boundaries. A commercially important oyster fishery is located in the Apalachicola area.

3. The Grand Bay National Estuarine Research Reserve supports several rare or endangered plant and animal species, numerous important marine fishery resources, diverse habitat types, and important archaeological sites. It contains a diverse range of habitats, including coastal bays, saltwater marshes, maritime pine forests, pine savannas, and pitcher plant bogs. It supports extensive and productive oyster reefs and seagrass habitats, and it serves as a nursery area for many important recreational and commercial marine species, such as shrimp, blue crab, speckled trout, and red drum. Grand Bay NERR received oil from the DWH event. Baseline mapping of sensitive resources such as seagrasses and oyster beds was conducted to determine any long-term impacts from the spill (htpp://grandbaynerr.org/archives/13).

4. The Mission Aransas National Estuarine Research Reserve is located in Aransas and Refugio Counties, Texas, about 48 km (30 mi) northeast of Corpus Christi. It covers about 75,153 ha (185,708 ac) and was designated a

reserve in 2006. Habitats present on the site include coastal prairies, coastal and freshwater marshes, ponds, bays, seagrass beds, oyster reefs, mangrove forests, and tidal flats. The University of Texas' Marine Science Institute is the lead State agency overseeing the site. The site is home to wintering populations of the federally endangered whooping crane (*Grus americana*).

3.9.1.1.5 National Estuary Program. In 1987, an amendment to the Clean Water Act, known as the Water Quality Act (P.L. 100-4), established the National Estuary Program. The purposes of the program are to (1) identify nationally significant estuaries, (2) protect and improve their water quality, and (3) enhance their living resources. Under the administration of the USEPA, comprehensive administration plans are generated to protect and enhance the environmental resources of estuaries designated to be of national importance. The governor of a State may nominate an estuary for the program and may request that a comprehensive conservation and management plan be developed. Over a 5-yr period, representatives from Federal, State, and interstate agencies; academic and scientific institutions; and industry and citizens groups work to define objectives for protecting the estuary, select the chief problems to be addressed in the plan, and ratify a pollution-control and resource-management strategy to meet each objective. The GOM estuaries currently falling within the National Estuary Program include: Coastal Bend Bays and Estuaries, Corpus Christi Bay, Galveston Bay, Barataria-Terrebonne Estuarine Complex, Mobile Bay, Tampa Bay, Sarasota Bay, and Charlotte Harbor (USEPA 2011d; Figure 3.9.1-1).

3.9.1.2 Marine Areas of Special Concern

3.9.1.2.1 Marine Protected Areas. The only National System MPA in the Western and Central GOM Planning Areas located in marine waters is the FGBNMS. The FGBNMS is described below. In addition, there are *de facto* MPAs that are waters where access or activities are restricted by law for reasons other than conservation or natural resource management, such as to protect public health and safety, and public and private infrastructure, as well as those that provide training areas for the military (National Marine Protected Areas Center 2008). Military installations, anchoring sites, navigational channels, oil and gas transfer areas, and safety, security, and restricted areas (e.g., power plants) are all examples of *de facto* MPAs in the northern GOM. Almost 25% of the GOM regional waters (approximately 200,000 km^2 [7,7220 mi^2]) can be considered *de facto* MPAs. The GOM has 217 individual *de facto* MPAs and 64% of the nation's total *de facto* MPA area. Most of these sites are military use areas (Section 3.9.1.2.3) and areas restricted to protect the oil and shipping industries of the region. Most *de facto* MPAs allow multiple commercial and recreational uses with some periodic activity restriction. Fewer than 1% (approximately 100 km^2 [39 mi^2]) of *de facto* MPAs (primarily oil platforms and certain military use areas) are permanent no-access areas (National Marine Protected Areas Center 2008). Military use areas are discussed in more detail below. Maps and additional information on *de facto* MPAs can be found at http://www.mpa.gov/helpful_resources/inventoryfiles/defacto_mpa_report_0608.pdf.

3.9.1.2.2 Marine Sanctuaries. The only National Marine Sanctuary in the Western and Central GOM Planning Areas is the FGBNMS. The FGBNMS is located about 175 km (109 mi) southeast of Galveston, Texas (Figure 3.9.1-1). The area containing both the East and West Banks covers 143 km^2 (55 mi^2) and has 142 ha (351 ac) of reef crest (Gardner et al. 1998). In October 1996, Congress expanded the sanctuary by adding a small third bank, Stetson Bank, which is located about 113 km (70 mi) south of Galveston. The FGBNMS represents the northernmost coral reef system in the United States (Figure 3.9.1-1) and is described in detail in Section 3.7.2.1.2.

The most recent FGBNMS management plan (NOAA 2010e) suggests expanding the current FGBNMS boundary to include banks and topographic features that currently exist outside it but that may be vulnerable to anthropogenic impacts.

BOEM has protected the biological resources of the FGBNMS from potential damage due to oil and gas exploration by establishing a No Activity Zone and other operational restrictions in the vicinity of the banks. BOEM management and protection of the FGB and other topographic features began in 1973 prior to the establishment of the Sanctuary in 1992. Designating the area as a National Marine Sanctuary has provided other protective measures by regulating the following (available at http://flowergarden.noaa.gov/about/regulations.html):

- Injuring, removing, possessing, or attempting to injure or remove a living or nonliving sanctuary resource;

- Feeding fish and certain methods of taking fish;

- The speed, anchoring, and mooring of vessels;

- Destroying sanctuary property, or discharging or depositing outside the sanctuary boundaries polluting materials that could subsequently enter the sanctuary and injure a sanctuary resource or worsen its quality; and

- Altering the seabed or constructing, placing, or abandoning any structure or material on the seabed.

Recent surveys indicate that the FGBNMS appears to be healthy, with a coral cover of 50 to 70% on both the east and west banks and a low incidence of bleaching or other coral disease (Precht et al. 2008; Robbart et al. 2009). Data collected from the east and west banks from 1978 to 2006 do not indicate any long-term trends in the percentage of coral cover (Hickerson et al. 2008; Robbart et al. 2009). Ongoing stressors on the FGBNMS include mechanical disturbance from anchors and discarded fishing gear, coastal runoff, and disease (Hickerson et al. 2008).

3.9.1.2.3 Military and NASA Use Areas. Military Use Areas, established off all U.S. coastlines, are required by the U.S. Air Force, Navy, Marine Corps, and Special Operations Forces for conducting various testing and training missions. Military activities can be quite varied, but they normally consist of air-to-air, air-to-surface, and surface-to-surface naval fleet training, submarine and antisubmarine training, and Air Force exercises (Figure 3.9.1-2). Military dumping areas are also shown in Figure 3.9.1-2. Dumping areas can be classified according to whether spoil, ordinance, chemical waste, or vessel waste is deposited in the area.

The U.S. Air Force has established multiple surface danger zones and restricted areas. Danger zones are defined as water areas used for a variety of hazardous operations (Marine Protected Areas Center 2008; U.S. Fleet Forces 2010). Danger zones may be closed to the public on a full-time or intermittent basis. Restricted areas are water areas defined as such for the purpose of prohibiting or limiting public access. Restricted areas generally provide security for Federal Government property and/or protect the public from the risks of damage or injury that could arise from the Federal Government's use of that area. The regulations pertaining to the identification and use of these areas are found in 33 CFR Part 334. Units of the U.S. Department of Defense (USDOD) and NASA use surface danger zones and restricted areas in coastal and offshore waters for rocket launching, weapons testing, and conducting a variety of training and readiness operations. Most danger zones and restricted areas in the northern GOM are associated with Elgin Air Force Base (AFB) and Tyndall AFB, both of which are located in the Florida Panhandle. The danger zones extend from nearshore areas to hundreds of kilometers off the coast of Florida. There is also a danger zone associated with MacDill AFB in Tampa Bay.

The GOM Range Complex is a combined air, land, and sea space that provides realistic training areas for Navy personnel. In coastal and marine areas, the GOM Range Complex includes military operating areas (OPAREAs) and overlying Special Use Airspaces (SUAs), the Naval Support Activity Panama City Demolition Pond, security group training areas, and supporting infrastructure (U.S. Fleet Forces 2010). Four offshore OPAREAs are located in the northern GOM: Corpus Christi, New Orleans, Pensacola, and Panama City (Figure 3.9.1-2). These offshore surface and subsurface areas total 59,817 km^2 (17,440 NM^2) and include 41,406 km^2 (12,072 NM^2) of shallow ocean area less than 185 m (590 ft) deep (U.S. Fleet Forces 2010). OPAREAs define where the U.S. Navy conducts surface and subsurface training and operations. The Navy conducts various training activities at sea (e.g., surface target sinking exercises and mine warfare exercises) and shakedown cruises for newly built ships.

Aircraft operated by all USDOD units train within SUAs that overlie the OPAREAs, as designated by the Federal Aviation Administration (U.S. Fleet Forces 2010). SUAs, also called warning areas, are the most relevant to the oil and gas leasing program because they are largely located offshore, extending from 5.6 km (3 NM or 3.5 mi) outward from the coast over international waters and in international airspace. These areas are designated as airspace for military activities, but because they occur over international waters, there are no restrictions on nonmilitary aircraft. The purpose of designating such areas is to warn nonparticipating pilots of potential danger. When they are being used for military exercises, the controlling agency notifies civil, general, and other military aviation organizations of the current and scheduled status of the area (U.S. Department of the Navy 2004). Aircraft operations conducted in warning areas primarily involve air-to-air combat training maneuvers and air intercepts, which are rarely conducted at altitudes below 1,524 m (5,000 ft) (U.S. Department of the Navy 2002).

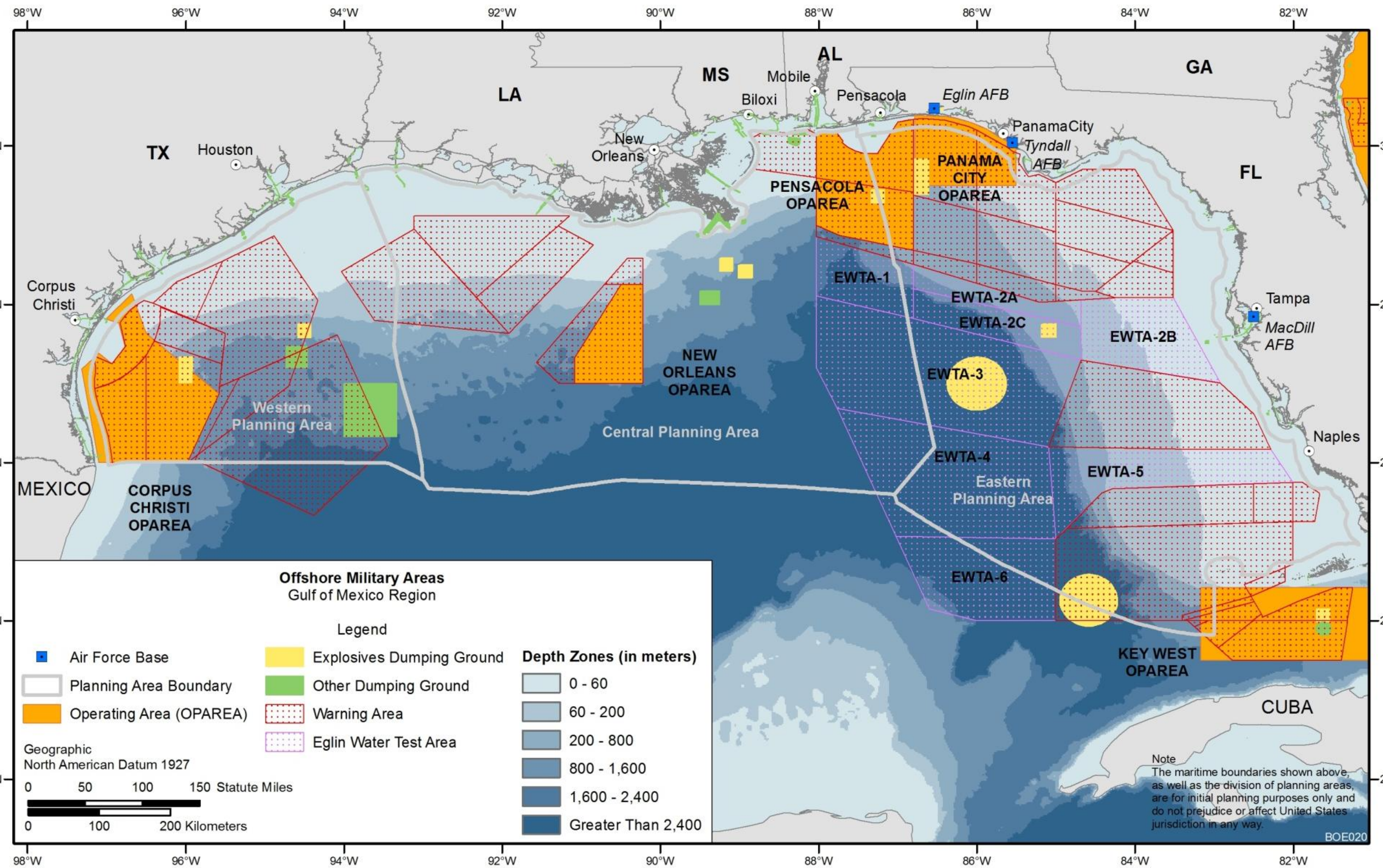

FIGURE 3.9.1-2 Location of Military Use Areas in the GOM

Security group training areas are also located in marine waters of the GOM Range Complex. There are two group training areas: one is located 13 km (8 mi) off the coast of Panama City, Florida; the other is 13 km (8 mi) off the coast of Corpus Christi, Texas. These areas are used for machine gun and explosives training (U.S. Fleet Forces 2010).

3.9.2 Alaska – Cook Inlet

The Alaska National Interest Lands Conservation Act of 1980 designated certain public lands in Alaska as units of the NPS, NWR, Wild and Scenic Rivers, National Wilderness Preservation, and National Forest systems. This section describes Alaskan lands managed by the NPS, USFWS, and USFS. It also describes MPAs, National Estuarine Research Reserves, National Estuary Program areas, MUAs, and NOAA-designated HCAs.

3.9.2.1 National Park Service Lands

Lands managed by the NPS include National Parks, National Monuments and Preserves, National Historic Areas, and designated Wild and Scenic Rivers. Onshore oil facilities are permissible only on private land holdings within NPS-managed lands. Even in some of these units, development of onshore oil-support facilities is unlikely because of the associated logistical difficulties that are perceived. Subsistence harvesting is allowed in some NPS units and may be affected by offshore oil and gas development.

There are three National Parks and one National Monument that could be affected by OCS oil and gas activities, including accidental spills. The information on each park provided below was gathered from NPS websites for individual parks. More information can be found at http://www.nps.gov/state/ak/index.htm.

The Katmai National Park and Preserve (which, for management purposes, includes the Alagnak Wild River and Aniakchak National Monument and Preserve) encompasses 1.9 million ha (4.7 million ac) (Figure 3.9.2-1). Katmai National Park is located in the Cook Inlet Planning Area on the western shore of Shelikof Strait, about 300 km (186 mi) southwest of Anchorage.

The Aniakchak National Monument and Preserve is located on the Alaskan peninsula about 161 km (100 mi) south of the Cook Inlet Planning Area (Figure 3.9.2-1). The park contains Aniakchak caldera and the Aniakchak River, which flows 43 km (27 mi) from Surprise Lake (inside the Aniakchak caldera) to the Pacific Ocean. Sockeye salmon make spawning runs up the Aniakchak River. The park is relatively pristine because of its remote location and harsh weather, both of which limit the number of visits by humans.

The Lake Clark National Park and Preserve, which borders Cook Inlet, spans 1.6 million ha (4 million ac) and extends roughly 150 km (93 mi) inland. It is a composite of ecosystems representative of many regions of Alaska, including lakes, rivers, and streams. The park receives more than 4,000 visitors annually.

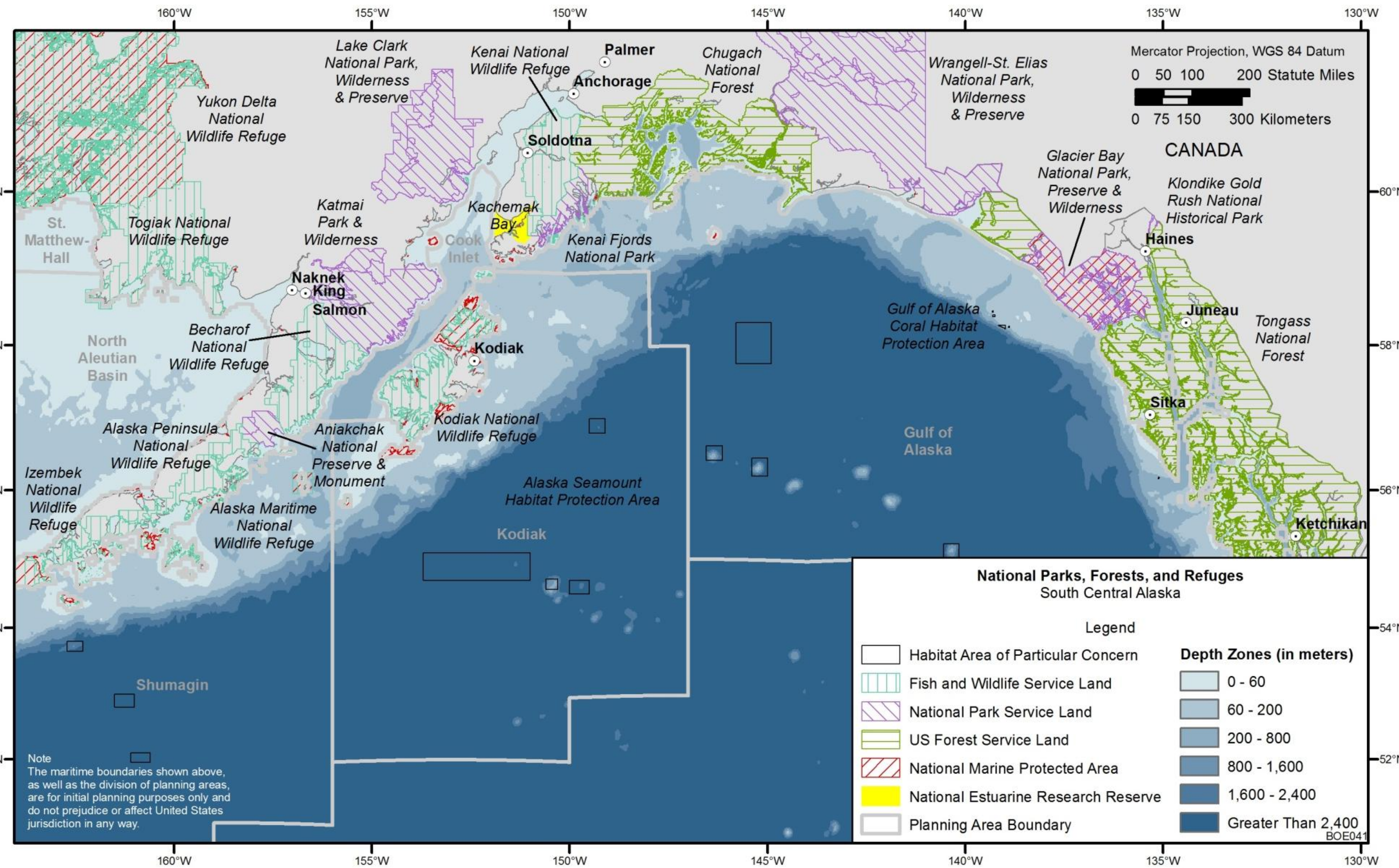

FIGURE 3.9.2-1 Map Showing the Location of Specially Protected Areas in the Cook Inlet Planning Area

Kenai Fjords National Park is east of Cook Inlet on the GOA, but it could be affected by an oil spill associated with OCS activities in Cook Inlet. This park contains the Harding Icefield and 38 glaciers.

3.9.2.2 Fish and Wildlife Service Lands

The USFWS has jurisdiction over NWRs for carrying out the responsibilities of Federal laws. Oil facility development is discretionary on NWRs in Alaska. Potential use of USFWS lands as bases for offshore oil and gas exploration as well as onshore oil and gas development will be determined in part by Title XI (see also Title III) of the Alaska National Interest Lands Conservation Act (ANILCA). Title XI ROWs are issued according to both ANILCA and the NWR System Administration Act of 1966 (16 USC 668dd), as amended by the NWR System Improvement Act of 1997 (P.L. 105-57). Title XI provides a procedural framework for permitting the use of USFWS lands and access to these lands for transportation and utility systems, which includes an application and extensive review process.

Information on each refuge provided below was gathered from NWR websites for individual refuges. More information can be found at http://www.fws.gov/refuges. There are six NWRs in Cook Inlet and the Kenai Peninsula. These include two units of the Alaska Maritime NWR: (1) the GOA Unit, which includes 1,287 km (800 mi) of coast from southeast Alaska's rainforests across the arc of Prince William Sound to Kodiak Island, and (2) the Alaska Peninsula Unit, which extends west more than 644 km (400 mi) from Kodiak Island to the southern tip of the peninsula (Figure 3.9.2-1).

The Alaska Peninsula NWR (managed jointly with the Becharof NWR) encompasses 1.5 million ha (3.7 million ac) and contains a variety of habitats, including mountains, rivers, lakes, volcanoes, and fjords.

The Becharof NWR encompasses roughly 485,623 ha (1.2 million ac), of which 202,343 ha (500,000 ac) is designated wilderness. The Becharof NWR is located south of Katmai National Park and Preserve and contains Becharof Lake. Sockeye spawn in Becharof's rivers, and Becharof Lake serves as a nursery for the world's second-largest run of sockeye salmon. The refuge includes vast areas of pristine wildlife and fish habitat and includes a diversity of mammalian, avian, and fish species.

The Izembek NWR encompasses 121,406 ha (300,000 ac), most of which is forest land containing critical streams and land for salmon, waterfowl, seabirds, and mammalian predators and herbivores. The refuge is located on the Alaska Peninsula near Cold Bay, Alaska, more than 322 km (200 mi) from the Cook Inlet Planning Area. Within the refuge is the Izembek Lagoon, which contains extensive eelgrass beds used by fish and birds as feeding and resting areas. The American Bird Conservancy designated the Izembek Refuge as a Globally Important Bird Area in 2001. Marine mammals, including steller sea lions and gray, minke, killer, and humpback whales, also inhabit or pass through the refuge.

The Kenai NWR encompasses roughly 809,371 ha (2 million ac). The refuge is located on the Kenai Peninsula on the eastern side of upper Cook Inlet. The Kenai NWR attracts many visitors because of its closeness to Anchorage and general accessibility. The area contains important moose habitat and also a rich array of habitats for an estimated 200 different vertebrate species. The refuge, including the rivers (Russian and Kenai), streams, and lakes within its borders, provides important spawning and rearing habitat for trout and all five species of Pacific salmon. The Harding Icefield lies partially within the refuge boundaries and nearby Kenai Fjords National Park. The Chickaloon watershed and estuary is a major waterfowl and shorebird staging area and is the only such area on the refuge. Oil and gas development activities occur on roughly 89,000 ha (220,000 ac).

The Kodiak NWR, encompassing about 768,903 ha (1.9 million ac), covers roughly two thirds of Kodiak Island, Uganik Island, the Red Peaks area on northwestern Afognak Island, and all of Ban Island. Biologists have identified 250 species of fish, mammals, and birds (including both residents and migrants) on the refuge. About 1.5 million marine birds overwinter in nearshore habitats surrounding Kodiak Island. There are 117 salmon streams on Kodiak Island that provide spawning and rearing habitat for all five species of Pacific salmon.

3.9.2.3 Forest Service Lands

Coastal lands managed by the USFS are at risk from potential impacts from outer continental shelf oil and gas development. The U.S. Bureau of Land Management (BLM), in cooperation with the USFS, manages oil/gas lease operations. The USFS has approval authority for the surface-use portion of the Federal oil/gas operation (36 CFR Part 228, Subpart E – Oil & Gas Resources). The USFS will carry out its statutory responsibilities when issuing Federal oil and gas leases and managing subsequent oil and gas operations on National Forest system lands.

The Chugach National Forest borders Prince William Sound and Turnagian Arm and is the closest National Forest (300 km [186 mi]) to the Cook Inlet Planning Area (Figure 3.9.2-1). It encompasses 2.2 million ha (5.5 million ac), of which 567,000 ha (1.4 million ac) have been proposed and are currently managed as wilderness. Though a variety of land uses are permitted on USFS lands (including timber harvest and mining activities), wilderness areas generally are exempt from such “multiple-use” activities. The Chugach Forest Management Plan identifies lands that are open or closed to leasing. Currently, the plan provides for oil and gas exploration and development in the Katalla area.

3.9.2.4 Marine Protected Areas

The Alaska Peninsula Unit and GOA Unit of the Alaska Maritime NWR are the only National System MPAs in the vicinity of the Cook Inlet Planning Area and are described in Section 3.9.2.2. The Alaska Maritime MPA is categorized as a Natural and Cultural Heritage Conservation Area and a Sustainable Production Conservation Area. Commercial fishing and recreational fishing are restricted.

Although not National System MPAs, there are several State and Federal MPAs present in Cook Inlet. Cook Inlet itself is eligible for National System membership, and fishing within Cook Inlet is restricted. There are also several NOAA-designated HCAs and Habitat Protection Areas (HPAs) in the Gulf of Alaska, including three federally managed steller sea lion protection areas: the Gulf of Alaska HCA located near Prince William Sound, the Aleutian Islands Coral HPA, and the Aleutian Islands Habitat HCA located to the west of Cook Inlet. These areas have prohibitions against specific fishing activities or that target certain species. In addition, Cook Inlet and the waters around Kodiak Island contain State marine protected areas that are eligible for MPA membership and that contain shrimp and scallop fishing closure areas and restrictions on types of commercial fishing gear. A detailed map of State and federally eligible MPAs can be found at http://www.mpa.gov/helpful_resources/inventoryfiles/AK_Map_090831_final.pdf.

There are no de facto MPAs (waters whose use is restricted to protect military property, public health, and private and public infrastructure) within Cook Inlet (National Marine Protected Areas Center 2008). However, to the east, there are several de facto MPAs within Prince William Sound. Most are administered by the U.S. Coast Guard to protect shipping. Maps and additional information on de facto MPAs can be found at http://www.mpa.gov/helpful_resources/inventoryfiles/defacto_mpa_report_0608.pdf.

3.9.2.5 Other Areas of Special Concern

There are multiple State parks and State recreation areas near the Cook Inlet Planning Area, many of which border Cook Inlet or are located in areas that could be contacted by accidental oil spills. Such areas include Captain Cook State Recreation Area, Clam Gulch State Recreation Area, Chugach State Park, Kachemak Bay State Park and State Wilderness Park, and Ninilchik State Recreation Area.

Kachemak Bay, Alaska, is a National Estuarine Research Reserve located in Cook Inlet on the southern end of the Kenai Peninsula. The reserve covers 149,734 ha (370,000 ac), and the bay itself has more than 515 km (320 mi) of shoreline. There is a variety of marine and estuarine habitat in the reserve, including mudflats, rock shore, beaches, open water, and submerged aquatic vegetation. Marine mammals use the bay heavily, as do commercially important fish and shellfish. More information on the Kachemak Bay NERR can be found at http://nerrs.noaa.gov/Reserve.aspx?ResID=KBA.

There are no military use restrictions (i.e., danger zones and restricted areas) in the waters of the Cook Inlet Planning Area (National Marine Protected Areas Center 2008). The closest danger zone is Blying Sound, which is managed by the U.S. Navy and located to the east of Cook Inlet near Prince William Sound. The Blying Sound Danger Zone is rarely activated, and there are no use restrictions for most of the year.

3.9.3 Alaska – Arctic

The Alaska National Interest Lands Conservation Act of 1980 designated certain public lands in Alaska as units of the National Park, NWR, Wild and Scenic Rivers, National Wilderness Preservation, and National Forest systems. This section describes Alaskan lands managed by the NPS and USFWS. There are no USFS lands adjacent to the Beaufort or Chukchi Sea Planning Areas. Also described are MPAs, National Estuarine Research Reserves, National Estuary Program Areas, Military Use Areas, and NOAA-designated HCAs.

3.9.3.1 National Park Service Lands

The Iñupiat Heritage Center in Barrow, Alaska, is the only NPS-managed area along the coast of the Beaufort and Chukchi Planning Areas (Figure 3.9.3-1). The Iñupiat Heritage Center uses exhibits, classes, performances, and educational activities to promote and protect Iñupiaq culture, history, and language. More information on the Iñupiat Heritage Center is available at http://www.nps.gov/inup/index.htm. The Cape Krusenstern National Monument is located along the northern shore of Hope Basin, about 150 km (93 mi) south of the Chukchi Planning Area. The Bering Land Bridge National Preserve is located along the southern shore of Hope Basin, about 300 km (186 mi) south of the Chukchi Sea Planning Area (Figure 3.9.3-1). Also located in Hope Basin are the deltas of Noatak and Kobuk National Park Units. More information on these parks is available at http://www.nps.gov.

Onshore oil facilities are permissible only on private land holdings within NPS-managed lands. In some of these units, development of onshore oil-support facilities is unlikely because of the logistical difficulties perceived. In addition, subsistence harvesting is allowed in some NPS units.

3.9.3.2 Fish and Wildlife Service Lands

The Arctic NWR and the Chukchi Sea Unit of the Alaska Maritime NWR are the closest NWRs to the Beaufort and Chukchi Sea Planning Areas. The Arctic NWR consists of about 7.65 million ha (18.9 million ac) of land in northeastern Alaska along the Beaufort Sea coast (Figure 3.9.3-1). An additional 277,000 ha (684,000 ac) are either selected for conveyance or have been conveyed, under the terms of the Alaska Native Claims Settlement Act of 1971 (ANCSA), to the State or to Native corporations. All federally owned land within the refuge is currently designated as wild rivers, or minimal or wilderness management status. Under the ANILCA, production of oil and gas from the Arctic NWR is prohibited, and no leasing or other development leading to production of oil and gas can be undertaken until authorized by an Act of Congress. However, under the same Act, 607,028 ha (1.5 million ac) along the northern coast, known as the 1002 Area, has been set aside for further study and possible oil development, per ANILCA (ANILCA Sec. 1002). More information on the Arctic NWR is available at http://arctic.fws.gov.

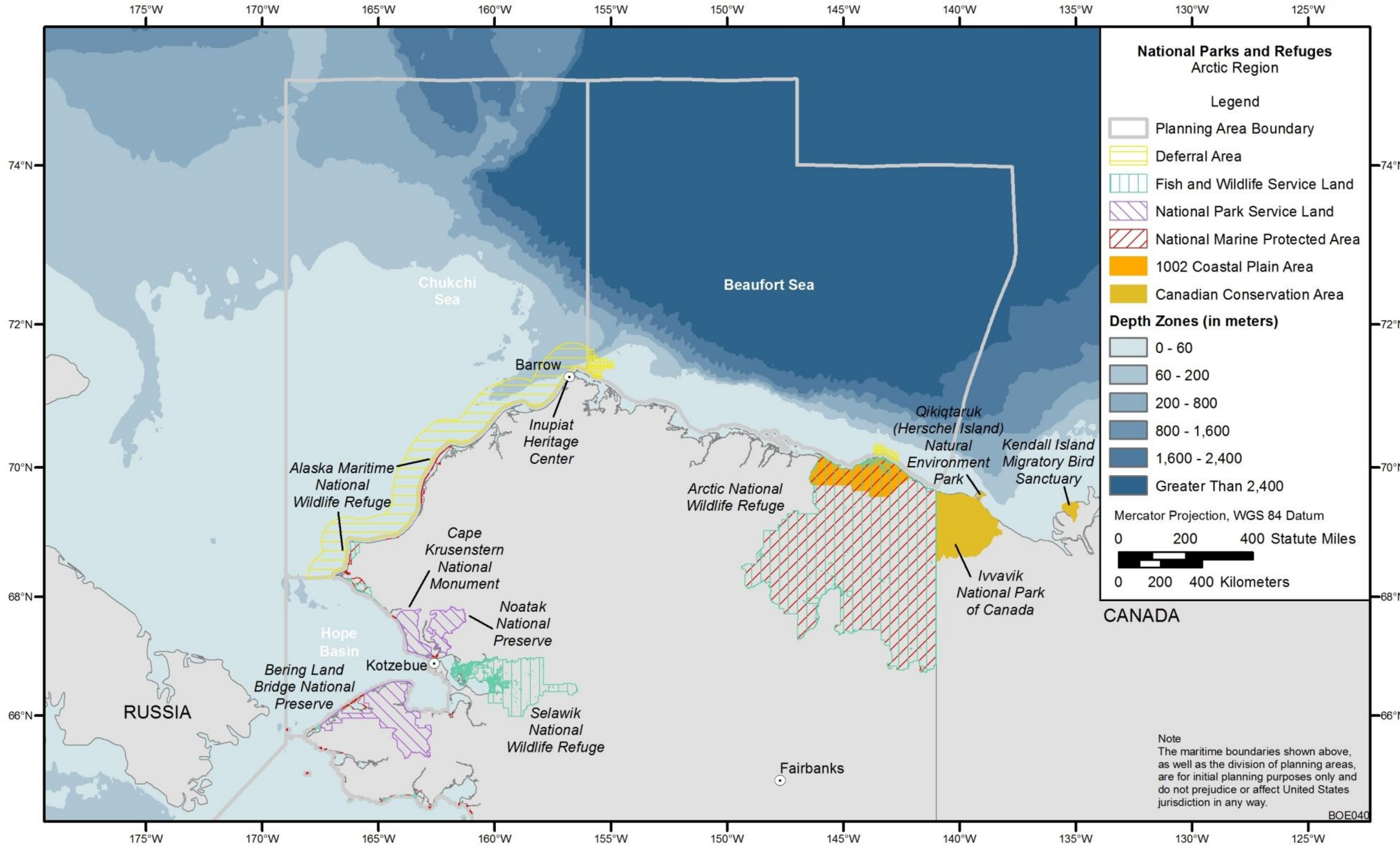

FIGURE 3.9.3-1 Map Showing the Locations of Specially Protected Areas in the Beaufort and Chukchi Sea Planning Areas

The Chukchi Sea Unit of the Alaska Maritime NWR includes coastal and offshore islands and extends 805 km (500 mi) from south of Barrow to south of Cape Thompson (Figure 3.9.3-1). The Chukchi Sea Unit contains several islands and coastal habitats important to marine birds. More information on the Chukchi Sea Unit of the Alaska Maritime NWR is available at http://alaskamaritime.fws.gov.

3.9.3.3 Marine Protected Areas

The Arctic NWR and the Chukchi Sea Unit of the Alaska Maritime NWR are the two National System MPAs in or near the Beaufort and Chukchi Sea Planning Areas and are described in Section 3.9.3.2 (Figure 3.9.3-1). Both NWRs are classified as Natural and Cultural Heritage Conservation Areas and Sustainable Production Conservation Areas. Commercial fishing is prohibited in the Arctic NWR and is restricted in the Chukchi Sea Unit of the Alaska Maritime NWR. There are no State MPAs or *de facto* MPAs in the Beaufort and Chukchi Planning Areas (http://www.mpa.gov/helpful_resources/inventoryfiles/AK_Map_090831_final.pdf).

3.9.3.4 Other Areas of Special Concern

There are no National Estuarine Research Reserves, National Estuary Program Areas, or Habitat Conservation Areas in or adjacent to the Beaufort and Chukchi Planning Areas. There are four active U.S. Air Force radar sites located on the coast bordering the Beaufort and Chukchi Sea Planning Areas. They are all Long-Range Radar Sites (LRRSs): Cape Lisburne LRRS, Point Barrow LRRS, Oliktok LRRS, and Barter Island LRRS. Each site has restricted areas within certain facilities. Access to each is only for personnel on official business and with approval of the commander of the USAF's 611th Air Support Group.

A pipeline linking the Chukchi Sea Planning Area to the North Slope will likely cross the Bureau of Land Management NPR-A. Oil and gas leasing in the NPR-A is authorized under the Naval Petroleum Reserves Production Act of 1976 (42 USC 6501 et seq.), as amended, including the Department of the Interior and Related Agencies Appropriation Act of 1981 (94 Stat. 2964). Several lease tracts of NPR-A lands have been sold by BLM for oil and gas development (http://www.blm.gov/ak/st/en/prog/energy/oil_gas/npra.html).

Other areas of special concern include Ivvavik National Park, Herschel Island Territorial Park, and Kendall Island Bird Sanctuary, all of which are located in Canada on the eastern side the Beaufort Sea Planning Area.

3.10 POPULATION, EMPLOYMENT, AND INCOME

Offshore waters of the Western, Central, and Eastern GOM Planning Areas lie adjacent to coastal Texas, Louisiana, Mississippi, Alabama, and Florida. For the purposes of the analysis, the GOM coast region consists of counties (and parishes in Louisiana) in each of the five States that constitute functional economic areas, defined on the basis of inter-county commuting patterns using a method suggested by Tolbert and Sizer (1996). There are 129 counties in the 23 Labor Market Areas (LMAs) in the five States located along the GOM coast (MMS 2006b). Counties in the LMAs adjacent to the Western GOM Planning Area are all within Texas and include the cities of Brownsville, Corpus Christi, Victoria, Brazoria, Houston-Galveston, and Beaumont-Port Arthur. Counties in the LMAs adjacent to the Central GOM Planning Area include Lake Charles, Lafayette, Baton Rouge, Houma, and New Orleans, Louisiana; Biloxi-Gulfport, Mississippi; and Mobile, Alabama. Counties in the LMAs adjacent to the Eastern Planning Area are all within Florida and include Pensacola, Panama City, Tallahassee, Lake City, Gainesville, Ocala, Tampa-St. Petersburg, Sarasota, Ft. Myers, and Miami.

The south central Alaska region (which corresponds with the Cook Inlet Planning Area) is the most densely populated part of Alaska and includes Anchorage Municipality, and the entirety of the Kenai Peninsula, Kodiak Island, and Matanuska-Susitna Boroughs. The area corresponds to the area where many workers on offshore oil and gas platforms would live, at least temporarily if they live permanently outside Alaska, and spend their wages and salaries when they are in residence, and the area in which much of the oil and gas infrastructure associated with development in Cook Inlet and many of the supporting industries would be located. The Arctic region (Beaufort and Chukchi Sea Planning Areas) consists of the North Slope Borough and the Northwest Arctic Borough. The area corresponds to the area where some of the workers on the offshore oil and gas platforms would live, at least temporarily if they live permanently elsewhere in Alaska or the U.S., and spend their wages and salaries when they are in residence, and the area in which much of the oil and gas infrastructure associated with development would be located.

3.10.1 Population

3.10.1.1 Gulf of Mexico

Population in the counties in the GOM coast region increased at an average annual rate of 1.6% between 1980 and 1990, 1.2% between 1990 and 2000, and 1.5% between 2000 and 2009 (Table 3.10.1-1). Total population in 2009 was 23.2 million. Within the region, recent annual population growth has been higher in the Texas counties, with growth of 2% between 1990 and 2000 and 2.1% between 2000 and 2009. Population in the Mississippi counties grew annually at 1.7% between 1990 and 2000, slowing to 0.2% between 2000 and 2009, while growth rates in the Florida counties have been higher between 2000 and 2009 compared to the previous period; population growth was negative in the Alabama counties between 1990 and 2000.

As is the case for the U.S. population as a whole, there is a relative decline in lower age cohorts over time (Table 3.10.1-2), while the region has shown a steady improvement in the level of educational attainment; the percentage of persons having attended or graduated from college increased from 31% in 1980 to 48% in 2000.

TABLE 3.10.1-1 Gulf of Mexico Coastal Region Population (thousands)

State	1980	1990	Average Annual Percent Change (1980–1990)	2000	Average Annual Percent Change (1990–2000)	2009	Average Annual Percent Change (2000–2009)
Texas	4,931.67	5,726.76	1.5	6,969.83	2.0	8,376.1	2.1
Louisiana	3,021.66	3,056.77	0.1	3,343.69	0.9	3,354.07	0.0
Mississippi	370.07	389.02	0.5	458.67	1.7	466.59	0.2
Alabama	581.23	609.33	0.5	599.4	–0.2	647.09	0.9
Florida	6,424.37	8,178.85	2.4	8,955.93	0.9	10,320.23	1.6
Total region	15,329.00	17,960.74	1.6	20,327.54	1.2	23,164.08	1.5

Source: USCB 2010d.

TABLE 3.10.1-2 Gulf of Mexico Coastal Region Population Composition

Population Segment	1980	1990	2000
Total Population	15,329,000	17,960,740	20,327,536
Age Structure (%)			
Under 5	7.4	7.6	7.0
5 to 14	15.4	14.5	14.7
15 to 24	18.1	14.2	13.7
25 to 34	16.3	16.9	13.8
35 to 44	11.1	14.6	15.6
45 to 54	9.7	9.8	13.0
55 to 64	9.5	8.6	8.8
65+	12.6	13.8	13.5
Education of Persons Age 25+ (%)			
0 to 8 yr schooling	20.5	12.6	9.6
9 to 11 yr schooling	15.8	15.9	14.1
High school graduates	32.1	28.6	27.8
13 to 15 yr schooling	15.9	24.4	26.9
College graduates	15.6	18.4	21.6

Source: MMS 2006b.

3.10.1.2 Alaska – Cook Inlet

Population in the south central Alaska region increased at an average annual rate of 3.5% between 1980 and 1990, 1.8% between 1990 and 2000, and 1.5% between 2000 and 2009 (Table 3.10.1-3). Total population in Alaska in 2009 was 698,473. Within the region, recent annual population growth has been higher in the Matanuska-Susitna Borough, with growth of 8.3% between 1980 and 1990 and 4.1% between 1990 and 2000, and 4.1% between 2000 and 2009. Population in Kenai Peninsula grew annually at 4.9% between 1980 and 1990, slowing to 2.0% between 1990 and 2000. Recent growth rates in Anchorage have also declined, from 2.6% between 1980 and 1990 to 1.4% between 1990 and 2000. Growth rates in Anchorage and Kenai Peninsula between 2000 and 2009 are similar to those experienced in the State as a whole.

3.10.1.3 Alaska – Arctic

Population in the Arctic region increased at an average annual rate of 3.0% between 1980 and 1990, 1.9% between 1990 and 2000, and –0.3% between 2000 and 2009 (Table 3.10.1-3). Total population in the Northwest Arctic Borough was 7,444 in 2009, with 6,752 residents in the North Slope Borough.

TABLE 3.10.1-3 Alaska Regional Population (thousands)

Borough, Region, and State	1980	1990	Average Annual Percent Change (1980–1990)	2000	Average Annual Percent Change (1990–2000)	2009	Average Annual Percent Change (2000–2009)
Anchorage	174,431	226,338	2.6	260,283	1.4	286,174	1.0
Kenai Peninsula	25,282	40,802	4.9	49,691	2.0	54,665	1.0
Kodiak Island	9,939	13,309	3.0	13,913	0.4	13,946	–0.4
Matanuska-Susitna	17,816	39,683	8.3	59,322	4.1	88,379	4.1
Total region	227,468	320,132	3.5	383,209	1.8	442,564	1.5
North Slope	4,199	5,979	3.6	7,385	2.1	6,752	–1.0
Northwest Arctic	4,831	6,113	2.4	7,208	1.7	7,444	0.3
Total region	**9,030**	**12,092**	**3.0**	**14,593**	**1.9**	**14,196**	**–0.3**
Alaska	**401,851**	**550,043**	**3.2**	**626,932**	**1.3**	**698,473**	**1.2**

Source: Department of Labor and Workforce Development 2011; USCB 2011d.

3.10.2 Community Population and Income

3.10.2.1 Alaska – Cook Inlet

Anchorage Municipality had 280,389 residents over the period 2005–2009, almost 45% of the total population of Alaska (Table 3.10.2-1). Median household income in Anchorage was $70,151 over the period 2005–2009, per capita income stood at $33,436 over the same period. Only 7.8% of individuals in the borough were living in poverty, and 5.6% of the population classified themselves as American Indian or Alaska Native.

Although Kenai Peninsula Borough had 41,109 residents in 22 communities, only three had more than 3,000 residents over the period 2005 to 2009 (Kenai, 7,661; Kalifornsky, 7,020; Homer, 5,667; Nikiski 4,683; Soldotna 4,266, and Seward 3,083), constituting 37% of the population of the Borough (Table 3.10.2-1). While five communities had median household incomes of more than $60,000 over the period 2005–2009 (Halibut Cove, $127,010; Kasilof, $77,188; Salamatof, $72,958; Nikiski, $70,000; and Kalifornsky, $66,652), there were nine communities with median household income of less than $40,000. Nine communities in the borough had per capita incomes higher than the borough community average over the period 2005–2009 ($25,864), while 13 communities had per capita incomes less than the borough average over the same period, and per capita incomes in three communities stood at half the borough average.

The percentage of individuals living in poverty was greater than the borough average in 11 communities, with a higher number of individuals in two communities (Clam Gulch, 45.1%, and Port Graham, 40.5%). Two of the larger communities in the borough, Nikiski and Seward, had higher than average poverty levels. Three communities in the borough (Tyonek, 100%; Nanwalek, 97.2%; and Port Graham, 82.4%) had a high percentage of American Indian or Alaska Natives, with higher than average percentages in ten other communities.

Population in the Kodiak Peninsula Borough is concentrated in Kodiak, with 6,291 residents between 2005 and 2009 constituting more than 47% of the population of the borough. Two communities had median household incomes of more than $50,000 over the period 2005–2009 (Kodiak, $57,930, and Larsen Bay, $54,375), while two communities had median household incomes of less than $10,000. Four communities in the borough had per capita incomes higher than the borough community average over the period 2005–2009 ($21,288), while three communities had per capita incomes less than the borough average over the same period, and per capita incomes in one community stood at less than half the borough average.

The percentage of individuals living in poverty was higher than the borough average in four communities, with a high number of individuals in two communities (Karluk, 71.7%; Old Harbor, 39.9%). Two communities in the borough, Karluk (100%) and Akhiok (90.1%), had a high percentage of American Indian or Alaska Natives, with higher than average percentages in four other communities.

TABLE 3.10.2-1 South Central Alaska Region Community Population, Income, and Poverty Status (2005–2009 Average)

Community	Total Residents	Median Household Income (2009 $)	Per Capita Income (2009 $)	Percent of Individuals Living in Poverty	Percent American Indian/ Alaska Native
State of Alaska	683,142	64,635	29,382	9.6	13.5
Anchorage					
Anchorage	280,389	70,151	33,436	7.8	5.6
Kenai Peninsula Borough	41,109	52,934	25,864	10.5	8.1
Anchor Point	1,743	50,710	25,615	7.0	2.5
Clam Gulch	104	32,639	25,075	45.1	0.0
Cohoe	808	52,125	29,090	9.3	5.3
Fox River	559	51,750	12,735	18.6	0.0
Fritz Creek	1,865	44,773	20,694	7.9	1.9
Halibut Cove	60[a]	127,010[a]	89,895[a]	0.0[a]	0.0[a]
Happy Valley	498	51,875	25,191	16.4	2.2
Homer	5,667	54,730	30,317	8.2	3.0
Kalifornsky	7,020	66,652	29,789	11.3	8.5
Kasilof	370	77,188	36,044	7.0	5.4
Kenai	7,661	51,875	27,597	8.1	4.5
Nanwalek	179	29,306	7,731	29.1	97.2
Nikiski	4,683	70,000	25,713	14.8	8.7
Nikolaevsk	332	44,333	17,797	9.0	5.1
Ninilchik	490	42,917	26,121	12.0	5.9
Port Graham	153	26,875	11,939	40.5	82.4
Salamatof	969	72,958	19,158	8.1	12.4
Seldovia City	326	51,111	28,378	7.7	17.5
Seldovia Village	109	50,417	20,939	12.8	32.2
Seward	3,083	44,457	18,189	13.5	17.6
Soldotna	4,266	47,031	26,686	9.1	9.1
Tyonek	164	22,813	14,149	28.7	100.0
Kodiak Island Borough	7,124	33,937	21,288	12.3	17.9
Akhiok	101	9,107	10,556	23.8	90.1
Karluk	53	6,250	7,502	71.7	100.0
Kodiak	6,291	57,930	24,058	10.8	10.9
Larsen Bay	79	54,375	43,038	1.3	69.6
Old Harbor	233	22,813	10,910	39.9	68.7
Ouzinkie	214	48,333	23,698	13.1	50.5
Port Lions	153	38,750	29,271	6.5	79.1
Matanuska-Susitna Borough					
Houston	1,628	43,750	20,957	15.0	1.7
Palmer	7,696	60,000	21,105	14.4	7.8
Wasilla	9,616	53,977	24,221	14.2	3.4

[a] 2000 data.

Source: USCB 2011e.

Population in the Matanuska-Susitna Borough is dispersed among a large number of smaller communities. The largest, Wasilla, had 9,616 residents between 2005 and 2009, and Palmer had 7,696 residents. The population in these communities constituted 20% of the population of the borough. Two communities had median household incomes of more than $50,000 over the period 2005–2009 (Palmer, $60,000; Wasilla, $53,977).

The percentage of individuals living in poverty was slightly higher than the borough average in one community, Palmer (15.0%). Palmer (7.8%) had a higher than average percentage of American Indian or Alaska Natives.

3.10.2.2 Alaska – Arctic

Population in the North Slope Borough is concentrated in Barrow, with 4,078 residents between 2005 and 2009 constituting 64.7% the population of the borough (Table 3.10.2-2). Two communities had median household incomes of more than $70,000 over the period 2005–2009 (Nuiqsut, $85,156; Point Hope, $73,438), while two communities had median household incomes of less than $50,000. Three communities in the borough had per capita incomes higher than the borough average over the period 2005–2009 ($19,602), while four communities had per capita incomes less than the borough average over the same period. In the Northwest Arctic Borough, population is concentrated in Kotzebue, with 3,152 residents between 2005 and 2009, constituting 42% of the Borough population. Three communities had median household incomes of more than $60,000 over the period 2005–2009 (Kobuk, $88,333; Kotzebue, $69,306; and Noatak, $63,125), while one community (Deering, $21,653) had a median household income of less than $30,000. Six communities in the borough had per capita incomes higher than the borough average over the period 2005–2009 ($14,237), while five communities had per capita incomes less than the borough average over the same period.

The percentage of individuals living in poverty in the North Slope Borough was higher than the borough average in one community (Barrow, 17.9%). All but one of communities in the borough had a high percentage of American Indian or Alaska Natives, with a lower than average percentage in Barrow. In the Northwest Arctic Borough, the percentage of individuals living in poverty was higher than the borough average in one community (Barrow, 17.9%). All but one of communities in the borough had a high percentage of American Indian or Alaska Natives, with a lower than average percentage in Barrow.

3.10.3 Employment, Unemployment, and Earnings

3.10.3.1 Gulf of Mexico

Employment in the GOM coast region in 2009 was concentrated in Florida (4.5 million employed in 2009) and Texas (3.6 million); together these States provide more than 81% of employment in the region (10.1 million) (Table 3.10.3-1). Unemployment rates for 2009 vary across the GOM coast region; the highest rates were 10.3% in Alabama and Florida, with rates

TABLE 3.10.2-2 Arctic Region Community Population, Income, and Poverty Status (2005–2009 Average)

Community	Total Residents	Median Household Income ($)	Per Capita Income ($)	Percent of Individuals Living in Poverty	Percent American Indian/Alaska Native
State of Alaska	683,142	64,635	29,382	9.6	13.5
North Slope Borough	6,307	64,334	19,602	14.7	66.8
Barrow	4,078	67,411	27,786	17.9	54.9
Kaktovik	260	44,375	19,022	10.4	87.3
Nuiqsut	366	85,156	17,849	0.6	94.3
Point Hope	875	73,438	18,825	8.0	80.7
Point Lay	194	46,875	14,067	16.8	99.0
Wainwright	534	68,750	20,063	12.7	94.2
Northwest Arctic Borough					
Ambler	279	41,406	14,741	40.5	82.4
Buckland	491	44,688	10,478	19.4	98.4
Deering	78	21,563	14,565	10.3	75.6
Kiana	344	35,000	15,581	32.3	92.2
Kivalina	446	59,821	13,727	12.3	96.7
Kobuk	90	88,333	16,130	16.7	82.2
Kotzbue	3,152	69,306	22,535	15.5	70.8
Noatak	506	63,125	15,365	9.3	78.7
Noorvik	676	46,042	13,766	22.1	90.7
Selawik	801	36,563	10,633	33.0	91.3
Shungnak	303	36,875	9,090	26.1	98.7

Source: USCB 2011e.

between 8.1% and 8.2% in Texas and Mississippi, and a lower rate of 6.5% in Louisiana. The average for the region as a whole was 8.9%.

The distribution of earnings in the GOM coast region reflects the concentration of employment across the five States, the $433.1 billion in combined compensation in Florida ($218.6 billion) and Texas ($214.5 billion) representing more than 80% of earnings in the region as a whole in 2009 ($537.7 billion).

3.10.3.2 Alaska – Cook Inlet

Employment in the south central Alaska region in 2009 was concentrated in Anchorage (144,403 employed in 2009), which provides almost 83% of employment in the region (188,218) (Table 3.10.3-2). Unemployment rates for 2009 vary across the south central Alaska region; the highest rate was 10.1% in Anchorage, with rates between 6.6% and 7.3% in Anchorage and Kodiak Island. The average for the region as a whole was 7.2%.

TABLE 3.10.3-1 Gulf of Mexico Coastal Region Labor Force, Unemployment, Earnings, and Employment Composition

Employment	Alabama	Florida	Louisiana	Mississippi	Texas	Total
Labor Force (2009)						
Total	283,507	5,073,188	1,554,441	210,766	3,964,812	11,086,714
Employed	254,298	4,553,309	1,453,757	193,507	3,644,160	10,099,031
Unemployment rate	10.3%	10.3%	6.5%	8.2%	8.1%	8.9%
Earnings ($billion)	12.2	218.6	82.1	10.2	214.5	537.7
Employment by Industrial Sector (2008)						
Farm employment[a]	6,875	79,691	31,553	6,085	86,928	211,132
Non-farm proprietors	75,417	1,306,323	395,915	47,781	1,019,572	2,845,008
Forestry and fishing	1,936	26,788	11,600	2,326	18,126	60,777
Mining	1,483	8,609	54,474	1,577	142,824	209,267
Utilities	1,633	14,275	5,954	1,809	22,060	45,731
Construction	32,661	395,711	165,576	23,982	398,417	1,016,348
Manufacturing	26,469	195,115	121,830	24,228	329,400	697,042
Wholesale and retail trade	55,713	864,588	268,537	30,277	668,588	1,887,704
Transportation and warehousing	12,958	189,625	81,448	6,093	200,447	490,571
Finance, insurance, and real estate	31,960	644,080	151,177	15,803	403,318	1,246,339
Services	145,577	2,631,238	818,446	93,704	1,933,388	5,622,353
Federal civilian government	3,054	75,075	22,278	9,515	46,285	156,207
Federal military government	3,935	63,428	26,600	13,196	26,275	133,434
State and local government	39,067	595,626	241,896	30,478	493,954	1,401,021

[a] Farm employment includes farm proprietors and agricultural services employment.

Source: USDOL 2011; USDOC 2011a,b.

The distribution of earnings in the south central Alaska region reflects the concentration of employment across the four boroughs, the $11.2 billion in compensation in Anchorage representing almost 82% of earnings in the region as a whole in 2009 ($13.6 billion).

Personal incomes in Alaskan Native villages are lower than in the State as a whole, and unemployment, especially in smaller villages, is high, particularly during the winter when there is little alternate market-based activity. Because of the key role of subsistence in many village economies, economic data that is collected for these communities may not fully represent their economic well-being. For example, many transactions between individuals involving the exchange of subsistence products that would otherwise provide income if they took place in the marketplace are not reflected in personal income statistics. Similarly, unemployment data may not reflect the extent to which additional economic activity may be required if subsistence activities provide a sufficient alternative to participation in the marketplace. In addition, the large differences in prices between urban and rural Alaska may exaggerate the corresponding differences in economic well-being depending on the extent to which local community members in rural areas have to participate in the local market economy for key consumer items, such as

TABLE 3.10.3-2 South Central Alaska Region Labor Force, Unemployment, Earnings, and Employment Composition

	Anchorage	Kenai Peninsula	Kodiak Island	Matanuska-Susitna	South Central Alaska Region Total
Labor Force (2009)					
Total	154,562	27,045	6,611	42,425	230,643
Employed	144,303	24,326	6,127	38,497	213,253
Unemployment rate	6.6	10.1	7.3	9.3	8.3
Earnings ($b)	11.2	1.0	0.4	1.0	13.6
Employment by Industrial Sector, 2008					
Farm employment[a]	0	225	0	574	799
Non-farm proprietors	37,222	11,742	2,613	12,001	63,578
Forestry and fishing	1,232	2,095	976	832	5,135
Mining	3,811	1,489	24	345	5,669
Utilities	557	263	42	143	1,006
Construction	12,393	2,366	349	3,630	18,738
Manufacturing	2,750	1,035	1,616	658	6,059
Wholesale and retail trade	26,606	3,610	885	5,291	36,392
Transportation and warehousing	12,404	1,233	316	1,360	15,313
Finance, insurance & real estate	15,768	2,139	329	2,484	20,720
Services	85,191	11,782	2,869	13,653	113,496
Federal civilian government	9,464	405	345	207	10,421
Federal military government	13,425	462	1,049	595	15,531
State and local government	20,302	4,655	1,108	3,630	29,695

[a] Farm employment includes farm proprietors and agricultural services employment.

Source: USDOL 2011; USDOC 2011a, b.

food, clothing, and energy, and the extent to which these items can be obtained through participation in subsistence activities.

A significant portion of income for lower-income Alaskans is the Alaska Permanent Fund Dividend, an annual per capita payment from a savings account established in 1976 using a portion of royalties paid to the State from oil production on State land. Although the fund principal is constitutionally protected from being spent, the majority of the earnings from the fund are distributed to every State resident as an annual cash payment. Dividends were first paid in 1982, and the annual payment has become a growing portion of per capita personal income in the State (USDOI 2002).

3.10.3.3 Alaska – Arctic

Employment by place of residence in the North Slope Borough in 2009 was 5,140 (Table 3.10.3-3); in the Northwest Arctic Borough employment stood at 2,623 (Table 3.10.3-3). The unemployment rate for the North Slope Borough 2009 was 4.7%, and earnings were $1.4 billion; the unemployment rate for the Northwest Arctic Borough in 2009 was 12.0%, and earnings were $0.2 billion.

Personal incomes in Alaskan Native villages are lower than in the State as a whole, and unemployment, especially in smaller villages, is high, particularly during the winter when there is little alternate market-based activity (see Section 3.10.3.2). A significant portion of income for many Alaskans is the Alaska Permanent Fund Dividend, an annual per capita payment from a savings account established in 1976 using a portion of royalties paid to the State from oil production on State land (see Section 3.10.3.2).

3.10.4 Employment by Industry

3.10.4.1 Gulf of Mexico

The largest employing sectors in the GOM coast region in 2008 were services (43.1% of total employment), retail and wholesale trade (14.5%), and State and local government (10.7%) (Table 3.10.3-1). The share of total State employment in services — wholesale and retail trade and finance and insurance and real estate — was slightly higher than the GOM coast average in Florida, and the share of employment in State and local government was slightly higher in Louisiana and Mississippi.

In addition to sectoral employment distributions, counties on the GOM coast can be classified into economic types indicating primary land use patterns. Using this approach, only 5 of the 129 counties in the GOM coast region are classified as farming-dependent; 9 counties are defined as mining-dependent, suggesting the importance of oil and gas development to these local economies (MMS 2005b). Manufacturing dependence is noted for another 27 of the counties. Local school districts and public facilities, such as hospitals and prisons, are often the largest employers in sparsely populated rural areas; 16 rural counties and 14 metropolitan counties are classified as government employment centers. Another 21 counties have economies tied to service employment. Thirty-nine of the 132 counties are considered major retirement destinations, and 7 of the rural counties are classified as recreation-dependent.

3.10.4.2 Alaska – Cook Inlet

The largest employing sectors in the south central Alaska region in 2008 were services (41.0% of total employment), with retail and wholesale trade at 13.1% and State and local government at 10.7% (Table 3.10.3-2). Of the share of total State employment in services, wholesale and retail trade was slightly higher than the south central Alaska region average in

TABLE 3.10.3-3 Arctic Region Labor Force, Unemployment, Earnings, and Employment Composition

	North Slope Borough	Northwest Arctic Borough	Arctic Region Total
Labor Force (2009)			
Total	5,394	2,980	8,374
Employed	5,140	2,623	7,763
Unemployment rate	4.7	12.0	7.3
Earnings ($b)	1.4	0.2	1.6
Employment by Industrial Sector, 2008[a]			
Farm employment[b]	0	0	0
Forestry and fishing	25	68	93
Mining	8,342	135	8,477
Utilities	61	15	76
Construction	272	201	473
Manufacturing	12	10	22
Wholesale and retail trade	498	241	740
Transportation and warehousing	207	197	404
Finance, insurance and real estate	890	217	1,107
Services	5,043	983	6,025
Federal civilian government	24	47	71
Federal military government	46	52	98
State and local government	1,757	1,102	2,859

[a] As labor force data is by place of residence, and employment by sector is by place of work, not all individuals working in the North Slope Borough are included in the labor force statistics, with many employees commuting to the Borough from other parts of Alaska and the United States.

[b] Farm employment includes farm proprietors and agricultural services employment.

Source: USDOL 2011; USDOC 2011a, b.

Anchorage, and the share of employment in State and local government was slightly higher in the Kenai Peninsula Borough and in the Kodiak Island Borough. Employment in manufacturing and military employment was more important in the Kodiak Island Borough than elsewhere in the region.

3.10.4.3 Alaska – Arctic

The largest employing sectors by place of work in the Arctic region in 2008 were mining (including oil and gas) with 8,477 people employed (49.3% of total employment), services with 6,025 employees (35.0%), and State and local government with 2,859 employees (16.6%) (Table 3.10.3-3). Between 2001 and 2007, approximately 70% of North Slope workers in the oil and gas industry in 2001 and 2006 commuted to and from permanent residences elsewhere in Alaska, primarily in south central Alaska and Fairbanks (MMS 2008).

The North Slope Borough itself is the largest employer of the resident workforce through government positions, primarily in Barrow; Borough-provided services; and Capital Improvement Program construction projects (MMS 2006b). The regional and village corporations established by the ANCSA also provide local employment.

3.10.5 Oil and Gas Employment

3.10.5.1 Gulf of Mexico

Oil and gas employment in the GOM coast States is concentrated in Texas, with 1,639 establishments employing roughly 38,549 people in 2008, representing nearly 62% of oil and gas industry employment in the GOM States (62,314) (USCB 2011f). Louisiana is second most important State, with 767 establishments employing 23,061 people. The Houston LMA had the largest oil and gas sector employment in the GOM coast in 2004, with 564 establishments employing roughly 11,882 people, followed by the New Orleans LMA, where 70 establishments employed 3,578 people (MMS 2006b).

3.10.5.2 Alaska – Cook Inlet

Oil and gas employment in the south central region in 2007 stood at 8,636, with 3,418 employed directly in oil and gas extraction activities, pipeline and refinery activities, and 5,218 in support activities (AOGA 2011). Oil and gas employment was concentrated in Anchorage, where there were 5,192 total employees, with 1,649 direct and 3,543 support workers. Kenai Peninsula (2,213) and Matanuska-Susitna (1,231) supported lower levels of oil and gas employment.

3.10.5.3 Alaska – Arctic

Large numbers of Arctic region oil and gas workers reside in other parts of Alaska and the U.S., relocating temporarily to work locations in the Arctic region as required. Employment statistics are typically presented by place of residence, meaning that oil and gas employment for the Arctic region on this basis would be relatively small. Employment by place of work data show that there were 7,540 oil and gas workers in the Arctic region in 2007, all of whom were located in the North Slope Borough (AOGA 2011). Of these workers, 1,741 were employed directly in oil and gas extraction activities, pipeline and refinery activities, and 5,799 in support activities.

3.10.6 Population, Labor Force, and Income Projections

3.10.6.1 Gulf of Mexico

Projections of demographic and economic data assume the continuation of existing social, economic, and technological trends at the time of the forecast, including employment associated with the continuation of current OCS leasing activity, as well as the continuation of trends in other industries important to the region. Projections in this section are based on growth rates provided in MMS (2006b) and the most recent population employment and earnings data.

The GOM coast region is projected to experience average annual increases in population of 1.3% between 2010 and 2020, with slightly lower average annual rate of 1.2% over the period 2020 to 2030 (Table 3.10.6-1). Differences in age structure, as well as net migration, among the coastal commuting zone areas could create variations in population growth within the GOM coast region. Southern Florida and western Texas areas are projected to have the highest growth rates, exceeding those expected for Louisiana and Mississippi.

Average annual growth in employment of 1.5% between 2010 and 2030 is primarily driven by growth in services, and while the farming labor force is not expected to experience a high growth rate over the period, related activities in agricultural services are projected to realize rapid growth rates over the 25-yr period (MMS 2006b).

Earnings in the GOM coast region (in 2009 dollars) are projected to grow at an average annual rate of 2.4% between 2005 and 2025, and 2.5% between 2025 and 2030. Earnings in services are projected to increase rapidly during this period, contributing more to this increase than any other industry. In other industries, such as manufacturing, rapid growth in projected average wages compensate for moderate employment growth, making these industries strong contributors to overall regional income (MMS 2006b).

3.10.6.2 Alaska – Cook Inlet

Projections of demographic and economic data assume the continuation of existing social, economic, and technological trends at the time of the forecast, including employment associated with the continuation of current OCS leasing activity, as well as the continuation of trends in other industries important to the region. Projections in this section are based on population forecasts provided by the State of Alaska (Alaska Department of Labor and Workforce Development 2007) and employment and earnings data for 2009.

The south central Alaska region is projected to experience average annual increases in population of 1.27% between 2010 and 2020, with a slightly lower average annual rate of 1.07% over the period 2020 to 2030 (Table 3.10.6-2). Differences in age structure, as well as net migration, could create variations in population growth within the south central Alaska region. Between 2010 and 2020, Matanuska-Susitna (2.83%) and Anchorage (0.94%) are projected to have higher growth rates in the region, with lower rates in the Kenai Peninsula (0.77%). Rates in

TABLE 3.10.6-1 Gulf of Mexico Coastal Region Projections

Regional Characteristics	2010	2015	2020	2025	2030
Population	23,478,203	25,067,221	26,702,229	28,398,512	30,19 5,698
Employment	10,253,294	11,049,871	11,907,349	12,835,229	13,842,305
Earnings ($billion 2009)	550.8	620.9	700.0	789.7	891.7

Source: MMS 2005b, 2006b.

TABLE 3.10.6-2 South Central Alaska Region Projections

Regional Characteristics	2010	2015	2020	2025	2030
Population	444,735	473,994	504,529	534,084	561,076
Employment	214,416	228,115	242,476	256,434	269,103
Earnings ($billion 2009)	13.8	14.5	15.3	16.1	16.7

Source: MMS 2006b; Department of Labor and Workforce Development 2007.

Kodiak Island are expected to decline, by 0.32% between 2010 and 2020 and by 0.63% between 2020 and 2030.

Based on unemployment and labor force participation rates from 2009, employment in the south central Alaska region is expected to grow from 214,416 in 2010 to 269,103 in 2030, with the majority of employment growth occurring in Anchorage during this period. Growth rates over the 25-yr period will be driven primarily by growth in mining (including oil and gas), fisheries, and services (MMS 2006b). Earnings in the south central Alaska region (in 2009 dollars) are projected to grow from $13.8 billion in 2010 to $16.7 billion in 2030, with earnings growth concentrated in Anchorage.

3.10.6.3 Alaska – Arctic

Projections of demographic and economic data assume the continuation of existing social, economic, and technological trends at the time of the forecast, including employment associated with the continuation of current OCS leasing activity, as well as the continuation of trends in other industries important to the region. Projections in this section are based on population forecasts provided by the State of Alaska (Alaska Department of Labor and Workforce Development 2007) and employment and earnings data for 2009.

The Arctic region is projected to experience average annual increases in population of 1.08% between 2010 and 2020, with a slightly lower average annual rates of 0.95% over the period 2020 to 2030 (Table 3.10.6-3). Differences in age structure, as well as net migration, could create variations in population growth within the Arctic region.

Based on unemployment and labor force participation rates from 2009, employment in the Arctic region is expected to grow from 5,550 in 2010 to 10,091 in 2030. Growth rates over the 25-yr period are driven primarily by growth in mining (including oil and gas), fisheries, and services (MMS 2006b). Earnings in the Arctic region (in 2009 dollars) are projected to grow from $1.7 billion in 2010 to $2.1 billion in 2030.

3.10.7 Economic Impacts of the Deepwater Horizon Event

The DWH event has produced significant economic impacts throughout the GOM region, affecting population, employment, and regional earnings and incomes. Impacts coming as a result of lost production will have indirect impacts in the various industries serving oil and gas production and providing retail and other services to oil and gas workers. The 6-month moratorium imposed in May 2010 on all deepwater drilling projects is projected to reduce GOM production by roughly 31,000 bbl per day in the fourth quarter of 2010 and 82,000 bbl per day in 2011 (EIA 2010b), and could lead to the loss of 8,200 jobs in oil and gas and associated sectors in the GOM coast region, $487 million in lost wages, and $98 million in State and local tax revenues (Mason 2011). Short-term losses to the tourism and recreation industry are also expected (see Section 3.13.6).

The relative decline in the housing market in the GOM coastal States, already stagnant as a result of the 2008 U.S. housing crisis, was further compounded by the event. Stigmatization associated with uncertainty surrounding coastal housing markets as a result of the spill have led to a reported 5–15% decrease in housing value (Seaford 2011). In addition, jurisdictions in coastal communities may have experienced a decline in property taxes, which could mean a reduction in services or a necessary increase in revenue to maintain current levels of public service provision. States that are more dependent on sales taxes from tourist activity (e.g., Florida) may experience more of an impact than other States.

TABLE 3.10.6-3 Arctic Region Projections

Regional Characteristics	2010	2015	2020	2025	2030
Population	15,002	15,887	16,699	17,449	18,348
Employment	8,267	8,755	9,194	9,597	10,091
Earnings ($billion 2009)	1.7	1.8	1.9	2.0	2.1

Source: MMS 2006b; Alaska Department of Labor and Workforce Development 2007.

The long-term economic and financial impact in the GOM coast States may be offset to some extent by the short-term economic boom associated with oil spill cleanup efforts. In some communities, cleanup crews have replaced oil field workers and fishermen in some hotels and restaurants, and some fishermen have used their boats to assist cleanup activities. Companies that specialize in booms, chemical dispersant, hazardous materials training, and other spill-related services have experienced a significant boom in business. In communities where cleanup operations are based, such as Louisiana's Plaquemines Parish, State revenue increased by 80% as rental properties, hotels, restaurants, and other facilities were besieged by cleanup personnel (Associated Press 2010). For the 20,000 workers hired by BP in response to the oil spill, many have taken up staging areas along the coast in Florida, Alabama, Mississippi, and Louisiana (Seaford 2011).

Timely payment of damage claims may also mitigate some of the impacts in smaller fishing communities where property damage has occurred. To assist those affected by the event, BP established a $20 billion compensation fund, and by September 2010, the fund had already paid more than $240 million to 19,000 claimants (Kollewe 2010).

The full extent, magnitude, and duration of spill-related socioeconomic impacts on the GOM will continue to be evaluated. BOEMRE will continue to update baseline population, employment, and regional income numbers in future documents as new information becomes available from Woods & Poole Economics, Inc., the U.S. Department of Labor's Bureau of Labor Statistics, individual State data, and published reports. This information, however, is not needed at the programmatic stage to make a reasoned choice among alternatives (see Section 1.4, Analytical Issues).

3.11 LAND USE AND INFRASTRUCTURE

3.11.1 Gulf of Mexico

There are five coastal States within the GOM region containing approximately 2,600 km (1,600 mi) of coastline. Land use is a heterogeneous mix of urban areas; manufacturing, marine, shipping, agricultural, and oil and gas activities; recreational areas; and tourist attractions. There are numerous urban areas in the region, and a complexity of land uses associated with urbanization can be found there. The area is composed of 67 metropolitan and 65 rural counties. The GOM coastal region contains one of the United States' ten most populous cities (Houston) (as of 2010; Mackum and Wilson 2011), approximately16% of the nation's coastal population (as of 2008; Wilson and Fischetti 2010), and 12 of the nation's 20 largest ports (USACE 2009).

The GOM region contains a mix of bays, estuaries, wetlands, barrier islands, and beaches of great environmental and economic value. Some of these areas support fishing, shrimping, and related economic activities, and although accessibility is sometimes limited, many of these areas are very popular for recreation and tourism. Along the GOM coast are numerous State Parks and beaches as well as units of both the NPS and the USFWS. For a listing and discussion of many of these areas, see Section 3.9 (Areas of Special Concern). Notable features in the area include

Padre Island National Seashore, the Atchafalaya Basin, the Mississippi Delta, Mobile Bay, and Everglades National Park.

All of the States in the GOM region participate in the National Coastal Zone Management (CZM) Program and have taken various approaches to managing their coastal lands. The National CZM Program is a voluntary partnership between the Federal Government and U.S. coastal and Great Lakes States and territories (States) authorized by the Coastal Zone Management Act of 1972 (CZMA) to address national coastal issues. Key elements of the National CZM Program include the following:

- Protecting natural resources;
- Managing development in high hazard areas;
- Giving development priority to coastal-dependent uses;
- Providing public access for recreation; and
- Coordinating State and Federal actions.

The coastal area of the States in the GOM region is very diverse. Military facilities and training areas in this region are discussed in Section 3.9.2.3. Areas of Special Concern, including the National Marine Sanctuaries, National Parks, National Wildlife Refuges, and National Marine Protected Areas, are discussed in Section 3.9. The States along the GOM coast have authority over submerged lands out to approximately 5.6 km (3 NM [3.5 statute mi]) with the exception of Texas and Florida, which have jurisdiction out to approximately 14.5 km (3 leagues [9 statute mi]).

The U.S. Department of Agriculture's Economic Research Service (ERS) classifies nonmetropolitan counties into economic types that indicate primary land use patterns (ERS 2011). Land use patterns for counties near the GOM (as of 2004, the latest year for which figures are available) are shown in Figure 3.11.1-1. Five of the 90 nonmetropolitan counties are classified by ERS as farming-dependent. Eight counties are defined as mining-dependent, suggesting the importance of oil and gas activities to these local economies. Manufacturing dependence is noted for another 25 of the nonmetropolitan counties; while 30 of the 90 nonmetropolitan counties are classified by ERS as government employment centers, and 18 of the nonmetropolitan counties have economies tied to service employment. The ERS also classifies counties in terms of their status as a retirement destination. Thirty-eight of the 90 nonmetropolitan counties are considered major retirement destinations by ERS. Of these, ten are inshore of the Eastern GOM Planning Area where little offshore development has taken place (see Figure 3.11.1-2).

Oil and gas development and production play an important role in determining land uses in many communities surrounding the GOM. These are the locations from which offshore operations are staged and where the exploration and production equipment, personnel, and

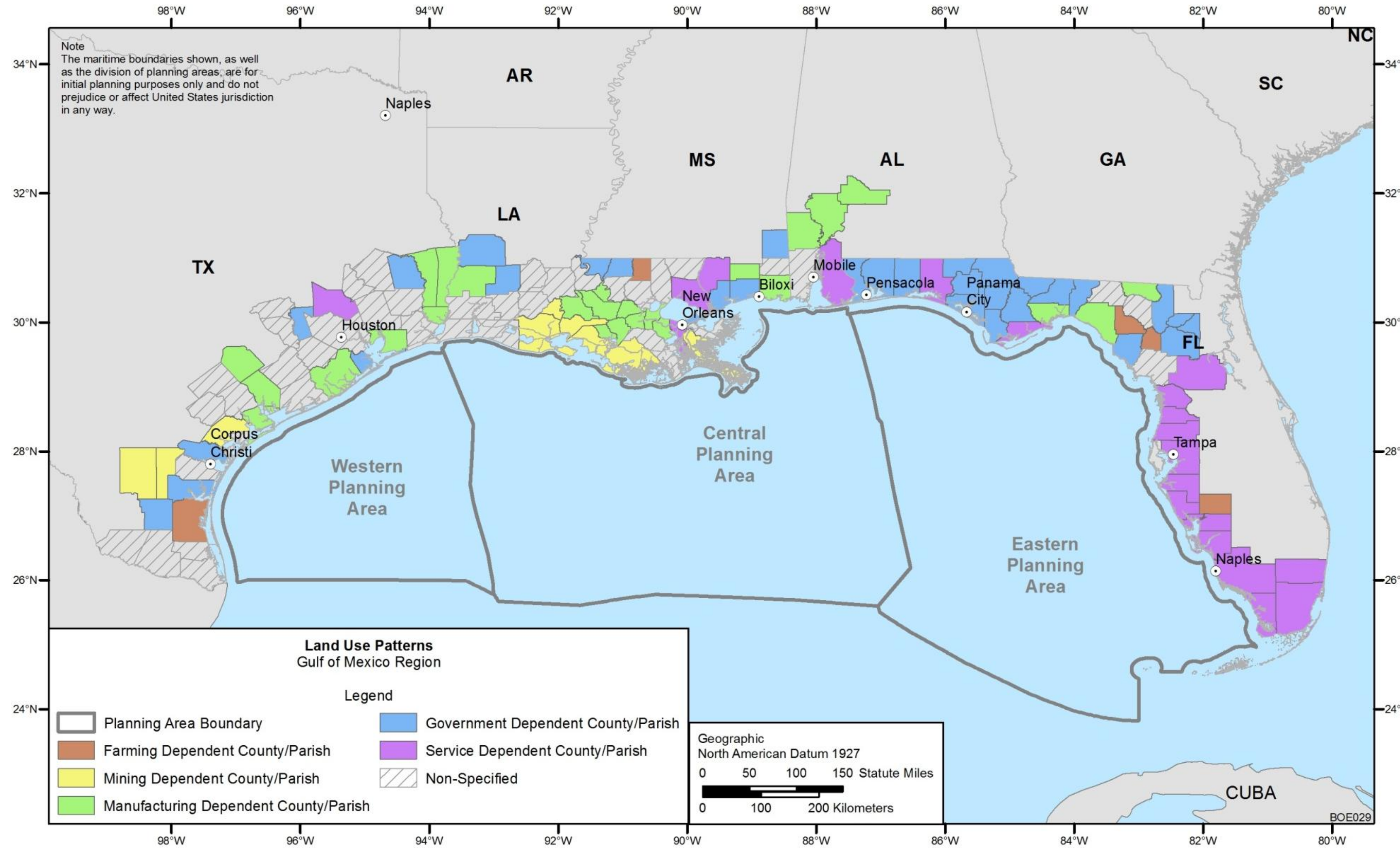

FIGURE 3.11.1-1 Land Use Patterns for Coastal Counties in the GOM Region

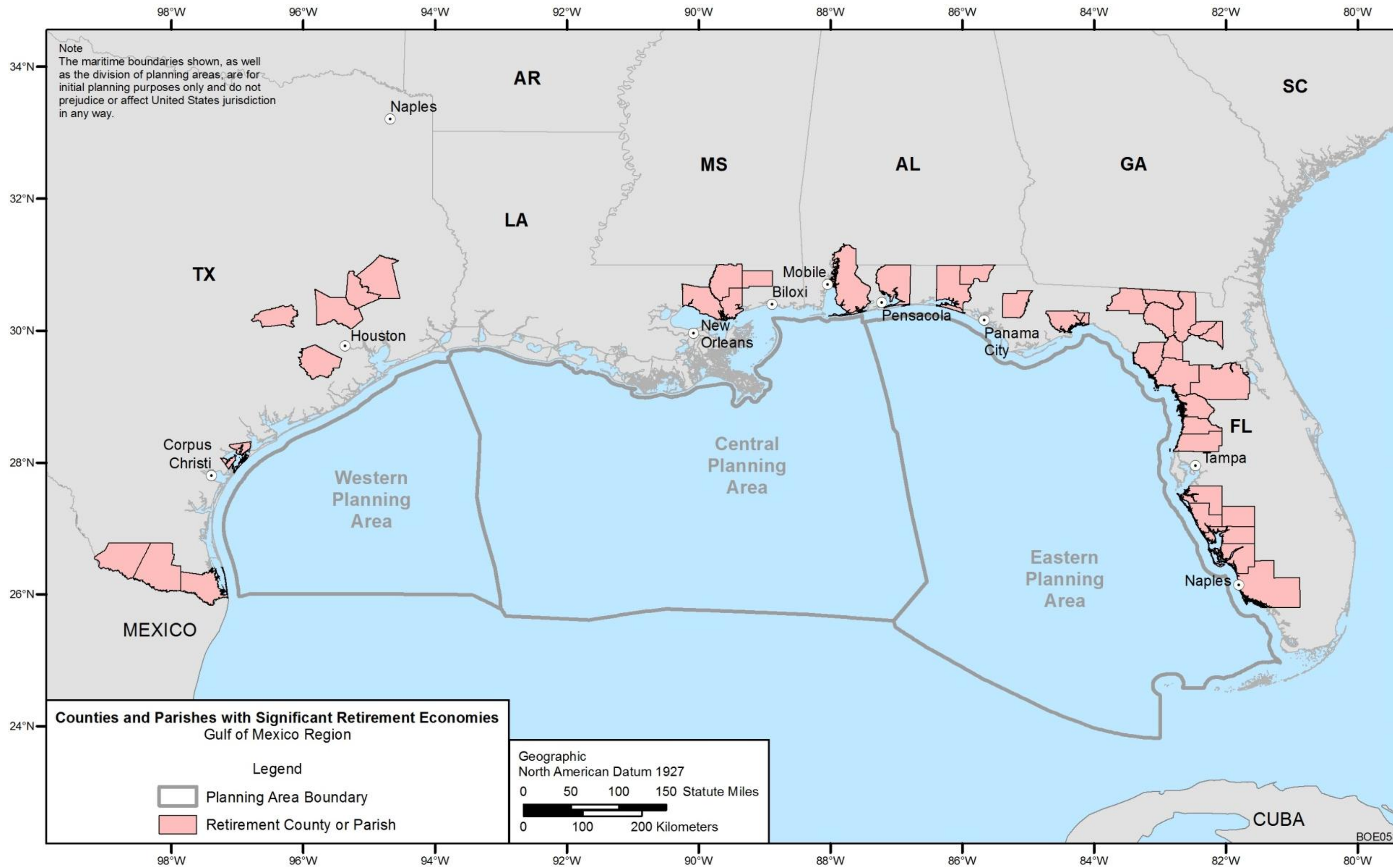

FIGURE 3.11.1-2 Counties with Significant Retirement Economies in the GOM Region

supplies used for oil and gas operations on the OCS in the GOM originate (Louis Berger Group, Inc. 2004). The use of these facilities and trends in new facility development closely follow the level of activity in offshore drilling, with increased deepwater drilling having provided an important stimulus for increased facility use and development in recent decades. Because of the large size of the structures involved, construction and servicing of remote deepwater facilities require deeper ports than nearshore operations. There are several ports with deepwater access along the GOM coast, with deepwater development activities occurring around these ports. With the expansion of deepwater activities, some onshore facilities have migrated to these ports and nearby areas that have capabilities for handling deepwater vessels, which require more draft (see Figure 3.11.1-3). As previously indicated, the GOM contains 12 of the nation's 20 largest ports (USACE 2009).

The western and central portions of the GOM region (offshore Texas, Louisiana, Mississippi, and Alabama) are major offshore oil and gas areas, and most of the equipment and facilities supporting offshore GOM oil and gas operations are located in these areas. Only limited offshore activities (i.e., exploratory activities, a single major project) have occurred in the eastern portion of the region, and there is very little infrastructure in place to support exploration and development of offshore oil and gas off the GOM coast of Florida. Current data indicate there are more than 3,900 fixed structures located in the GOM at depths up to 518 m (1,700 ft) (Dismukes 2011).

Oil and gas activities on the OCS are supported by onshore infrastructure industries consisting of thousands of contractors responsible for virtually every facet of the activity, including supply, maintenance, and crew bases. These contractors are hired to service production areas, provide material and manpower support, and repair and maintain facilities along the coasts. Nearly all of these support industries are found near ports.

There are hundreds of onshore facilities in the GOM region that support the offshore industry. Platform fabrication facilities are located along the GOM from the Texas-Mexico border to the Florida Panhandle, and employ large numbers of workers during periods of active development. Shipbuilding and repair facilities are located in key ports along the GOM coast.

Other offshore support industries are responsible for such products and services as engine and turbine construction and repair, electric generators, chains, gears, tools, pumps, compressors, and a variety of other tools. In addition, drilling muds, chemicals, and fluids are produced and transported from onshore support facilities, and these materials and other equipment are stored in warehouses near GOM ports. Many types of transportation vessels and helicopters are used to transport workers and materials to and from OCS platforms. Crew quarters and bases are also near ports, but some helicopter facilities are located farther inland.

Existing OCS-related infrastructure in the region includes:

- *Port Facilities.* Major maritime staging areas for movement between onshore industries and infrastructure and offshore leases.

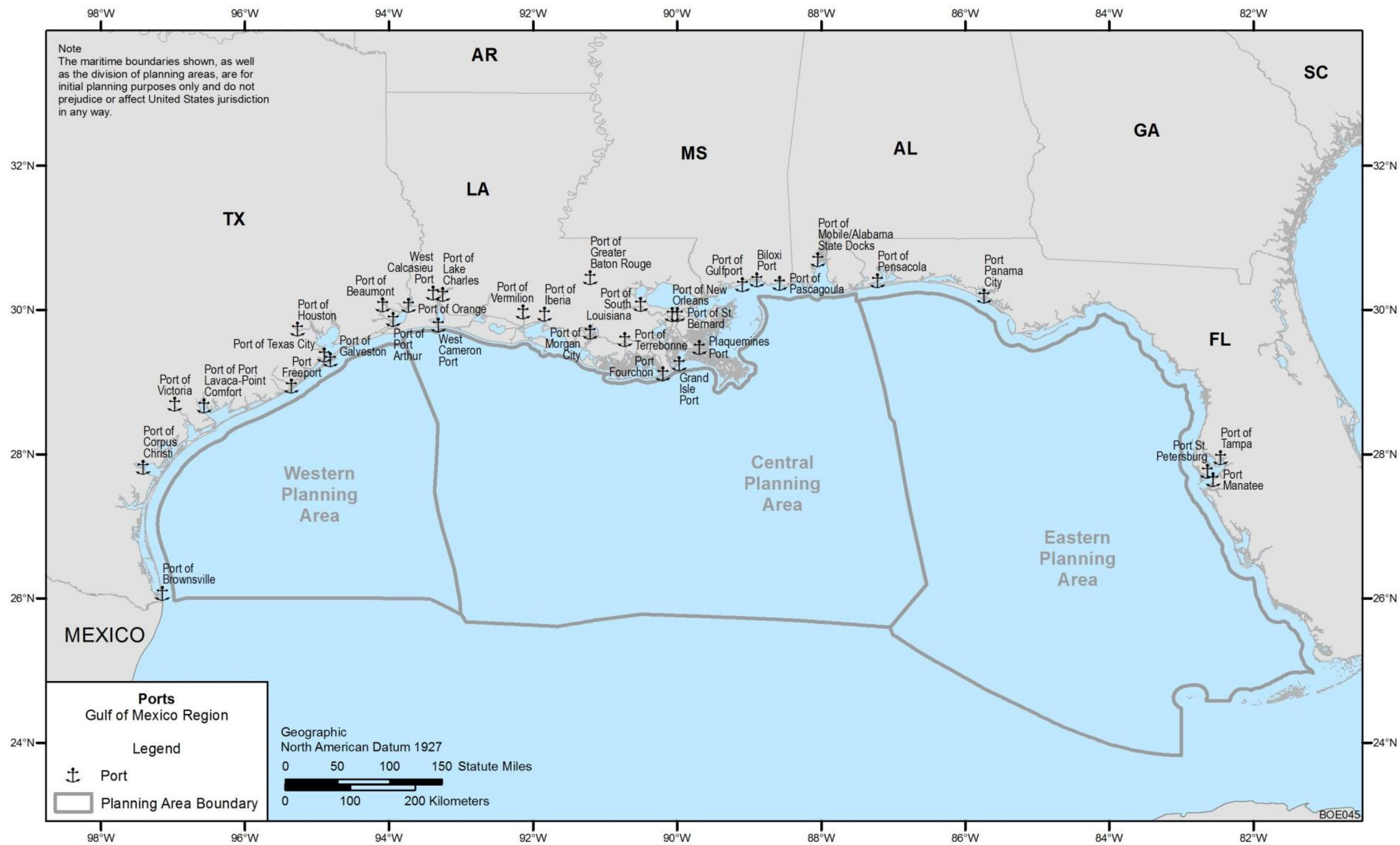

FIGURE 3.11.1-3 GOM Port Facilities

- *Platform Fabrication Yards.* Facilities in which platforms are constructed and assembled for transportation to offshore areas. Facilities can also be used for maintenance and storage.

- *Shipyards and Shipbuilding Yards.* Facilities in which ships, drilling platforms, and crew boats are constructed and maintained.

- *Support and Transport Facilities.* Facilities and services that support the offshore activities. This includes repair and maintenance yards, supply bases, crew services, and heliports.

- *Pipelines.* Infrastructure that is used to transport oil and gas from offshore facilities to onshore processing sites and ultimately to end users.

- *Pipe Coating Yards.* Sites that condition and coat pipelines used to transport oil and gas from offshore production locations.

- *Natural Gas Processing Facilities and Storage Facilities.* Sites that process natural gas and separate its component parts for the market, or that store processed natural gas for use during peak periods.

- *Refineries.* Industrial facilities that process crude oil into numerous end-use and intermediate-use products.

- *Petrochemical Plants*. Industrial facilities that intensively use oil and natural gas and their associated byproducts for fuel and feedstock purposes.

- *Waste Management Facilities*. Sites that process drilling and production wastes associated with offshore oil and gas activities (Dismukes 2011).

Figures 3.11.1-4 and 3.11.1-5 show key onshore infrastructure including ports, supply bases, shipyards, platform fabrication yards, pipe yards, oil refineries, gas processing facilities, helicopter pads, pipelines, and other infrastructure.

A short description of each type of infrastructure facility can be found below. Unless otherwise indicated, the following information is from the MMS study, *Deepwater Program: OCS-Related Infrastructure in the Gulf of Mexico Fact Book* (Louis Berger Group, Inc. 2004) and its update, *Infrastructure Fact Book, Volume I: OCS-Related Energy Infrastructure and Post-Hurricane Impact Assessment* (Dismukes 2011); more detailed information can be found in these two reports.

3.11.1.1 Ports

States along the GOM provide substantial amounts of support to service the OCS oil and gas industry. Service bases and other industries at many ports offer a variety of services and

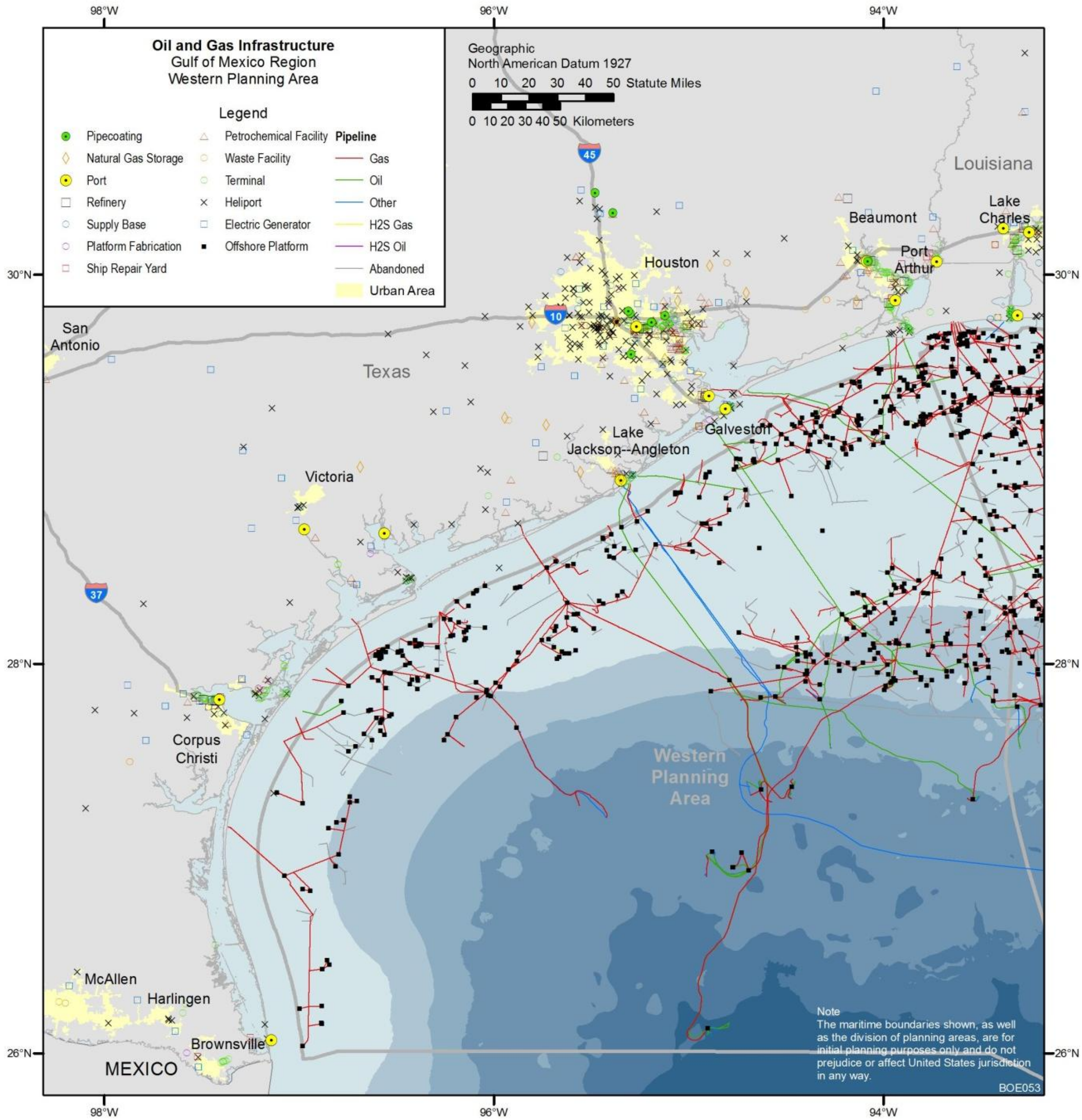

FIGURE 3.11.1-4 Oil and Gas Infrastructure Locations in the GOM Region Western Planning Area

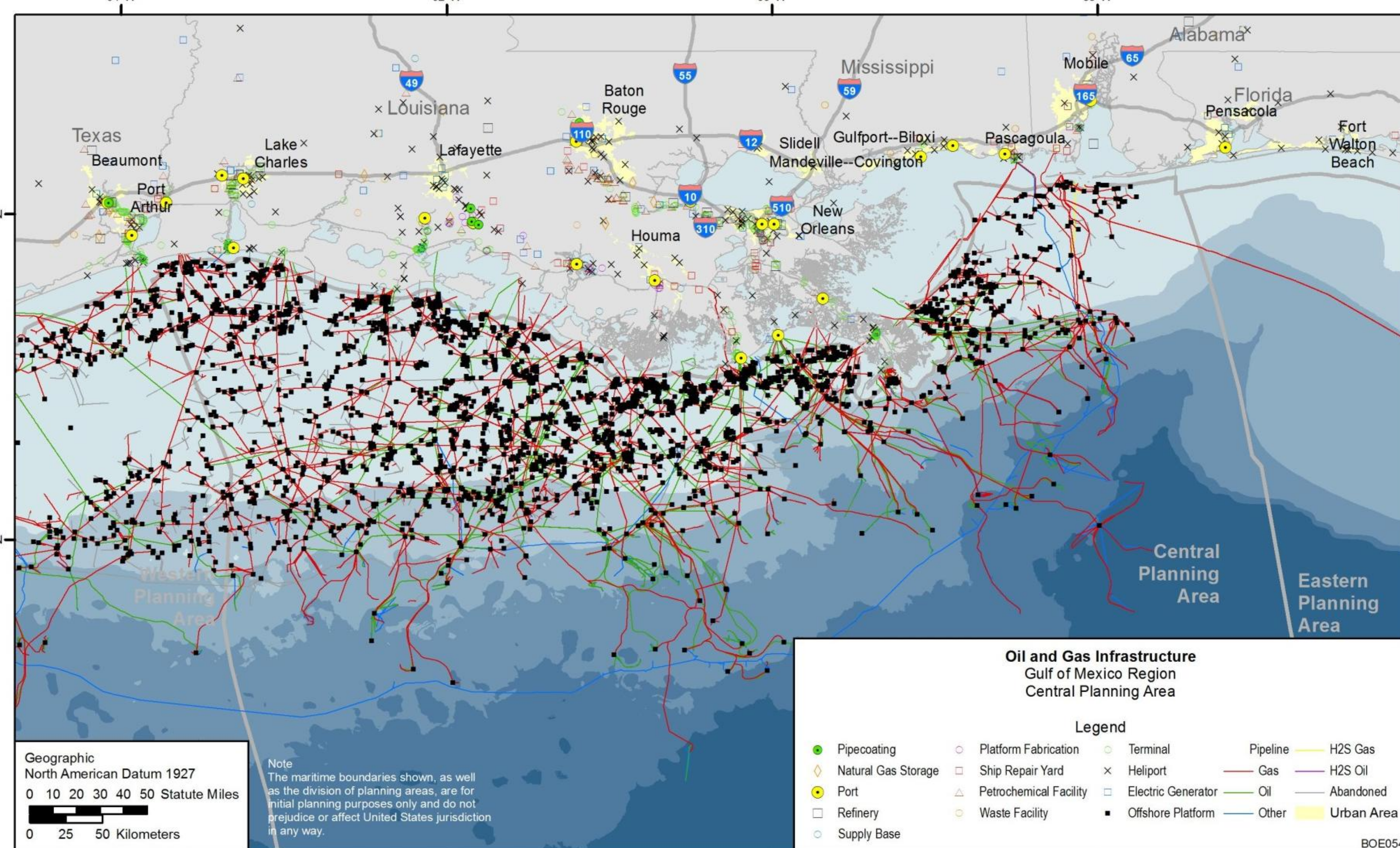

FIGURE 3.11.1-5 Oil and Gas Infrastructure Locations in the GOM Region Central Planning Area

support activities to assist the industry. Personnel, supplies, and equipment must come from the land-based support industry and pass through a port to reach drilling sites. In addition to servicing the offshore oil and gas industry, a number of GOM ports also are commercial ports, such as those in: Mobile, Alabama; Pascagoula, Mississippi; Lake Charles, Morgan City, Plaquemines and Venice, Louisiana; and Corpus Christi, Freeport, Galveston, and Port Arthur, Texas. Other ports include a combination of local recreation and offshore service activity.

GOM ports include a wide variety of shore-side operations from intermodal transfer to manufacturing. The ports vary widely in size, ownership, and functional characteristics. Private ports operate as dedicated terminals to support the operation of an individual company. They often integrate both fabrication and offshore transport into their activities. Public ports lease space to individual business ventures and derive benefit through leases, fees charged, and jobs created. GOM ports, including deepwater ports, are shown in Figures 3.11.1-3.

3.11.1.2 Platform Fabrication Yards

Offshore drilling and production platforms are fabricated onshore at platform-fabrication yards and then towed to an offshore location for installation. Production operations at fabrication yards include cutting and welding of steel components, construction of living quarters and other structures, and assembly of platform components. According to the Atlantic Communications 2006 Gulf Coast Oil Directory, there are more than 80 platform fabrication yards located in the GOM region, with the concentration in Louisiana and Texas (as cited in Dismukes 2011). The distribution of fabrication yards within the region is shown in Figures 3.11.1-4 and 3.11.1-5.

Because platform fabrication yards must be located on navigable channels large enough to allow for towing of bulky and long structures such as offshore drilling and production platforms, most fabrication yards in the region are located along the Intracoastal Waterway and within easy access of the GOM. A number of these plants have deep channel access to their facilities, which allows them to handle the deeper draft vessels used for deepwater operations.

Because of the size of the fabricated product and the need to store a large quantity of materials such as metal pipes and beams, fabrication yards typically occupy large areas, ranging from just a few acres to several hundred acres. Typical fabrication yard equipment include lifts and cranes, various types of welding equipment, rolling mills, and sandblasting machinery. Besides large open spaces required for jacket assembly, fabrication yards also have covered warehouses and shops.

Fabrication yards typically specialize in the production of one type of platform or one type of platform component. Few facilities have complete capabilities for all facets of offshore projects, and yards may cooperate in the development of platforms. Despite the large number of platform fabrication facilities in the GOM region, only a few facilities can handle large-scale fabrication. Recently, in an attempt to diversify their activities, many fabrication yards have expanded their operations into areas such as maintenance and renovations of drilling rigs, fabrication of barges and other marine vessels, drydocking, and surveying of equipment.

3.11.1.3 Shipyards

A 2007 report from USDOT indicated that only 28 private shipyards with major shipbuilding and repair bases were present within the GOM. This figure represented active shipbuilding yards, other shipyards with building positions, repair yards with dry dock facilities, and topside repair yards (USDOT 2007). A private count of shipyards dated August 2011 indicated that there were 80 shipyards[14] located on the GOM coast (MarineLog 2011).

In addition to the major shipyards, there are about 2,600 other companies that build or repair other craft such as tugboats, supply boats, ferries, fishing vessels, barges, and pleasure boats. Major shipyards in the GOM region are located primarily in Texas and Louisiana; however, several are located in Pascagoula, Mississippi, and other locations east of the Mississippi River (USDOT 2004). Recent high demand, driven in part by the expansion of deepwater oil and gas operations, has led to the expansion of capacity by smaller shipyards, which are building more and larger vessels that are technologically more sophisticated. This expansion has been accompanied by development of new pipe and fabrication shops, drydock extensions, military work enhancement programs, automated steel process buildings, and expanded design programs. The distribution of shipyards within the region is shown in Figures 3.11.1-4 and 3.11.1-5.

3.11.1.4 Support and Transport Facilities

A variety of facilities and services support offshore activities by providing supplies, equipment repair and maintenance services, services for crews, and transportation, including boats and heliports. Figures 3.11.1-4 and 3.11.1-5 show the distribution of various support and transport facilities in the GOM region.

The main types of vessels used in the GOM offshore industry include anchor handling towing supply (AHTS), offshore supply vessels (OSVs), and crewboats. There is a large fleet of offshore tugs (AHTS vessels) whose sole job is to tow rigs from one location to another and to position the rig's anchors. Offshore supply vessels deliver drilling supplies such as liquid mud, dry bulk cement, fuel, drinking water, drill pipe, casing, and a variety of other supplies to drilling rigs and platforms. Crewboats transport personnel to, from, and between offshore rigs and platforms. There are a variety of other types of vessels used by the oil and gas industry, and these vessels originate in a variety of locations along the GOM coast at or near ports.

Helicopters are one of the primary modes of transporting personnel between service bases and offshore platforms, drilling rigs, derrick barges, and pipeline construction barges. Helicopters are routinely used for normal crew changes and at other times to transport management and special service personnel to offshore exploration and production sites. In

[14] Shipyards consist of builders of large oceangoing naval and/or commercial ships; builders of mid-sized oceangoing ships, rigs, oceangoing barges; and builders of small ships, boats, and barges for coastal or inland service. It does not include repairers, builders of aluminum boats, or builders of yachts. The number was determined by hand counting the individual addresses listed for each of the facilities (MarineLog 2011).

addition, equipment and supplies are sometimes transported. For small parts needed for an emergency repair or for a costly piece of equipment, it is more economical to get it to and from offshore fast rather than by supply boat.

3.11.1.5 Pipelines

Locations where offshore pipelines cross the shoreline to land are referred to as pipeline landfalls. In the GOM region, about 60% of OCS pipelines entering State waters tie into existing pipeline systems and thus do not require pipeline landfalls. Only a small percentage of onshore pipelines in the region are a direct result of oil and gas activities on the OCS. There are more than 100 active OCS pipelines making landfall (about 80% of these are in Louisiana), resulting in about 200 km (124 mi) of pipelines onshore. About 80% of the onshore length of OCS pipelines is in Louisiana, and about 20% are in Texas. The distribution of pipelines by State is shown in Figures 3.11.1-4 and 3.11.1-5.

Inland, the pipeline network in the GOM coast States is extensive. Pipelines transport crude oil and natural gas to processing plants and refineries, natural gas from producing States in the GOM region to users in other States, refined petroleum products such as gasoline and diesel from refineries in the GOM region to markets all over the country, and chemical products.

3.11.1.6 Pipecoating Plants and Yards

Pipecoating plants are facilities where pipe surfaces are coated with metallic, inorganic, and organic materials to protect against corrosion and abrasion. These facilities generally do not manufacture or supply pipe, although some facilities are associated with mills where certain kinds of pipes are manufactured. More typically, the manufactured pipe is shipped by rail or water to pipecoating plants or their pipe yards. The coated pipe is stored at the pipe yard until it is needed offshore. It is then placed on barges or layships where the contractors weld the pipe sections together and clean and coat the newly welded joints. Finally, the pipe is laid.

Pipecoating plants in the GOM region are located primarily in Texas and Louisiana, with a small number of plants in the eastern GOM States. In recent years, pipecoating companies have been expanding capacity or building new plants to respond to increased demand from deepwater oil and gas operations. The distribution of pipecoating plants within the region is shown in Figures 3.11.1-4 and 3.11.1-5.

3.11.1.7 Natural Gas Processing Plants and Storage Facilities

After raw gas is brought to the Earth's surface (either dissolved in the crude oil, combined with crude oil deposits, or from separate non-oil-associated deposits), it is processed at a gas processing plant to remove impurities and to transform it into a sellable commodity. Centrally located to serve different fields, natural gas processing plants have two main purposes: (1) remove essentially all impurities from the gas and (2) separate the gas into its useful components for eventual distribution to consumers. After processing, the gas is then moved into a pipeline system for transportation to an area where it is sold. Because natural gas reserves are not evenly spaced across the continent, an efficient, reliable gas transportation system is essential.

As of 2006, there were 249 gas processing plants in the GOM States, representing 58% of U.S. gas processing capacity. The distribution of these plants by State is shown in Figures 3.11.1-4 and 3.11.1-5. More than half of the current natural gas processing plant capacity in the United States is located near the GOM coast in Texas and Louisiana. Four of the largest capacity natural gas processing/treatment plants are found in Louisiana, while the greatest number of individual natural gas plants is located in Texas. In 2006, Louisiana led the United States in processing capacity, followed closely by Texas. In Alabama, Mississippi, and the eastern portion of south Louisiana, new larger plants and plant expansions were built to serve new offshore production, increasing the average plant capacity significantly (EIA 2006).

3.11.1.8 Refineries

A refinery is a complex industrial facility designed to produce various useful petroleum products from crude oil. Refineries vary in size, sophistication, and cost depending on their location, the types of crude they refine, and the petroleum products they manufacture. One-third of operable U.S. petroleum refineries are located in Alabama, Louisiana, Mississippi, and Texas. Most of the GOM region's refineries are located in Texas and Louisiana. As of 2010, Texas had 23 operating refineries, with a combined crude oil capacity of 4.7 million bbl/day, while Louisiana had 17 operating refineries with 3.2 million bbl/day of capacity, with the combined capacity of the two States representing more than 40% of total operating U.S. refining capacity (EIA 2010a). The distribution of these refineries within the region is shown in Figures 3.11.1-4 and 3.11.1-5.

3.11.1.9 Petrochemical Plants

The chemical industry converts raw materials such as oil, natural gas, air, water, metals, and minerals into more than 70,000 different products. The industrial organic chemical sector includes thousands of chemicals and hundreds of processes. The non-fuel components derived from crude oil and natural gas are known as petrochemicals. The processes of importance in petrochemical manufacturing are distillation, solvent extraction, crystallization, absorption, adsorption, cracking, reforming, alkylation, isomerization, and polymerization. Laid out like industrial parks, most petrochemical complexes include plants that manufacture any combination of primary, intermediate, and end-use products. Chemical manufacturing facility sites are typically chosen for their access to raw materials and to transportation routes. And, because the chemical industry is its own best customer, facilities tend to cluster near such end-users.

As of 2007, there were 56 petrochemical manufacturing establishments in the United States, 32 of which were in Texas and Louisiana (U.S. Census Bureau 2011a). As of 2007, Texas (with 26 petrochemical manufacturing facilities) and Louisiana (with six petrochemical manufacturing facilities) contain more facilities than any other States in the United States. Alabama also had two petrochemical manufacturing facilities, primarily because petroleum and natural gas feedstocks are available from refineries. The distribution of these plants within the region is shown in Figures 3.11.1-4 and 3.11.1-5.

3.11.1.10 Waste Management Facilities

A number of different types of waste are generated as a result of offshore exploration and production activity. The physical and chemical characters of these wastes make certain management methods preferable over others. The infrastructure network needed to manage the spectrum of waste generated by OCS exploration and production activities and returned to land for management can be divided into three categories:

1. Transfer facilities at ports, where the waste is transferred from supply boats to another transportation mode, either barge or truck, toward a final point of disposition;

2. Special-purpose, oil field waste management facilities, which are dedicated to handling particular types of oil field waste; and

3. Generic waste management facilities, which receive waste from many American industries, with waste generated in the oil field being only a small part.

Regulations governing waste management facilities regarding storage, processing, and disposal vary depending on the type of waste. Waste management facilities in the GOM region that handle OCS oil and gas activity-related waste include transfer facilities, commercial salt dome disposal facilities, and landfills. Locations of major waste management facilities within the region (not including landfills) are shown in Figures 3.11.1-4 and 3.11.1-5.

3.11.1.11 Effects of Deepwater Horizon Event

As a result of the DWH event, land use experienced a short-term impact because temporary waste staging areas and decontamination areas were set up to handle the spill-related waste.

The impacts of the drilling moratorium put in place after the DWH event and subsequent permitting delays have affected some GOM ports and OCS infrastructure. Demand for services and supplies has dropped as a result. Some companies have removed a large portion of their equipment from Port Fourchon, and there has been a substantial decrease in helicopter flights and servicing of rigs. Many companies have had to cut staff hours and salaries. Support services companies, such as chemical suppliers and welders, have also been affected (Lohr 2010). The effects of this decreased demand will ripple through the various infrastructure categories (e.g., fabrication yards, shipyards, port facilities, pipecoating facilities, gas processing facilities, and waste management facilities) and will affect the oil and gas support sector businesses (e.g., drilling contractors, offshore support vessels, helicopter hubs, and mud/drilling fluid/lubricant suppliers).

It is too early to determine substantial, long-term changes in routine event impacts on land use and infrastructure as a result of the DWH event. BOEM anticipates that these changes will become apparent over time, and it will continue to monitor all resources for changes that are applicable to land use and infrastructure. This information, however, is not needed at the programmatic stage to make a reasoned choice among alternatives (see Section 1.4, Analytical Issues).

3.11.1.12 Climate Change

Coastal Louisiana provides an unstable land surface for development in many areas because of ongoing subsidence, exposure to tropical storms and hurricanes, and upstream and downstream alterations of the hydrology and sediment load and redistribution processes of the Mississippi River (see Section 3.4.4.1, Marine and Coastal Habitats). Even without considering the effects of climate change, coastal Louisiana is expected to undergo considerable landscape change during the life of the Program as a result of these processes. A 2004 U.S. Geological Survey (USGS) report includes projections of the areas of coastal Louisiana that are expected to experience land loss and land gain by 2050, a date that nearly coincides with the end of the 40–50-yr life of the Program (Barras et al. 2004). Projected areas of land gain and loss are shown in Figure 3.11.1-6 along with the locations of existing coastal OCS-related infrastructure. A visual inspection of the map shows a clear association between infrastructure locations and land loss in some areas.

The authors of the 2004 USGS report did not consider the effects of climate change on coastal processes that are expected to occur between now and 2050 as a factor affecting land loss (Barras et al. 2004). The USGS developed the data shown in Figure 3.11.1-6 by projecting into the future land loss patterns and rates that have been observed and studied for more than two decades. Climate change related effects that could affect land loss patterns include projected acceleration in the rate of rise of sea level, increase in the frequency and intensity of tropical weather systems in the GOM, and possible alterations in the hydrology and hydraulics of the Mississippi River system (IPCC 2007; Barras et al. 2004). The USGS projections should therefore be considered a minimum land loss scenario for the year 2050 because the climate change effects that were not considered in the analysis, such as accelerated submergence and increased occurrence of large storms, should act to favor land loss over land accretion.

Table 3.11.1-1 lists the types of infrastructure facilities discussed in the previous parts of this section in decreasing order of the percentage of facilities of that type that are projected to be affected by land loss. A facility was considered potentially affected by land loss if its location occurred within the 1-km^2 (0.4-mi^2) cell that the original USGS data projected would experience land loss by 2050. The table shows that 38% of all terminal locations (or 145 individual terminals) are located in cells projected to experience land loss. Only 2% of electric generator locations, in contrast, are located in cells projected to experience land loss. The table also shows

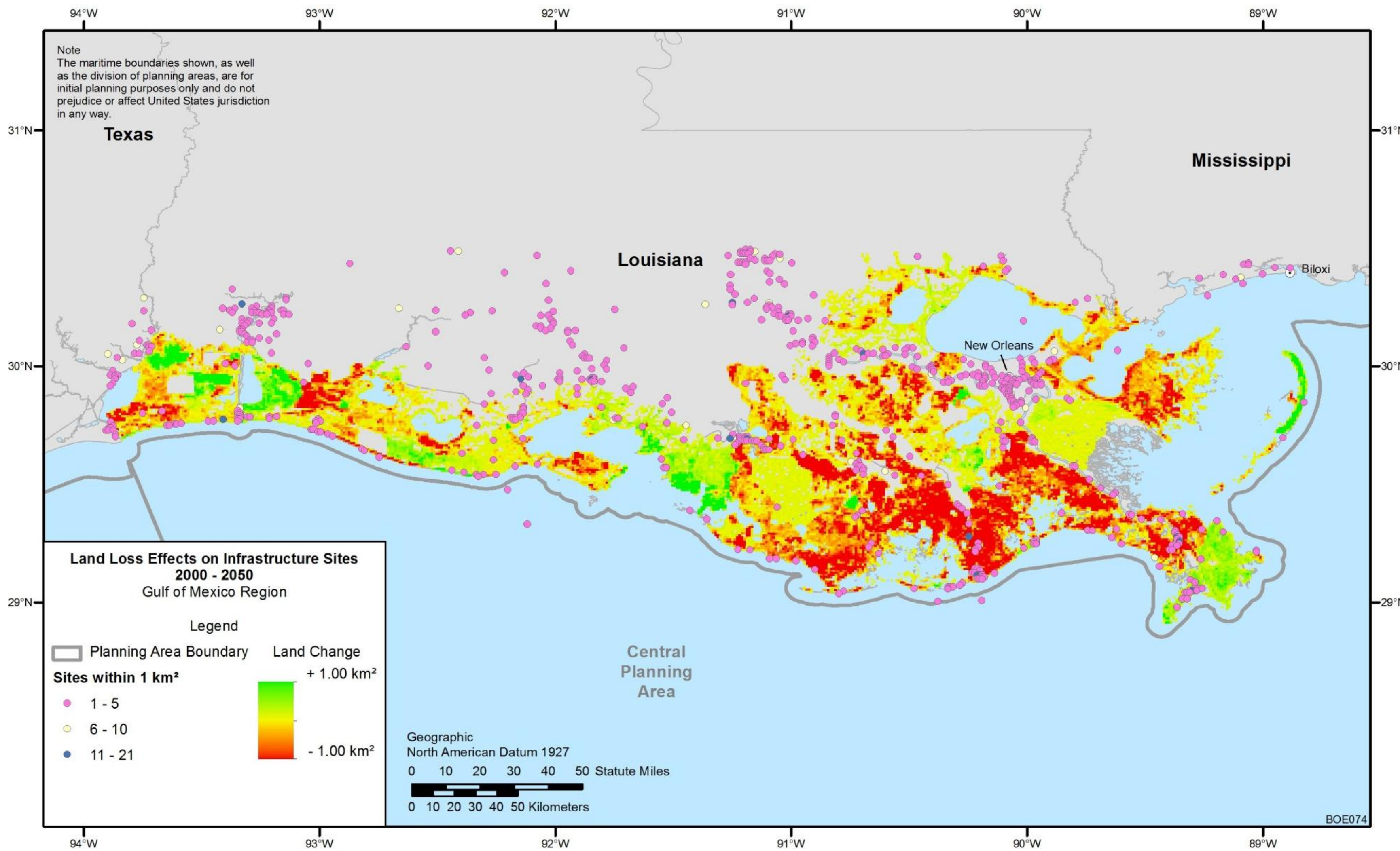

FIGURE 3.11.1-6 Land Loss Effects on Infrastructure Sites 2000-2050, GOM Region

TABLE 3.11.1-1 Land Loss Effects on OCS-Related Facilities

Facility Type	Percent of Facilities with Local Land Loss	Number of Sites Affected	Average Percent of Nearby Land Loss
Terminals	38	145	10
Ship repair yard	32	25	10
Services bases	32	18	7
Heliports	23	45	6
Ports	18	3	10
Waste handling sites	15	5	20
Platform fabrication	14	5	4
Refineries	13	2	7
Electric generators	2	4	2
Petrochemical plants	0	0	0
Pipe coating yards	0	0	0
Gas storage and processing	0	0	0

that all petrochemical plants, pipe coating yards, and gas storage and processing facilities, and nearly all electric generator facilities are located in areas where land loss is not expected to occur and therefore this would not be an issue affecting the viability of these kinds of facilities.

This analysis suggests that land conditions in coastal Louisiana could become more unsuitable for some infrastructure uses during the life of the Program. Based on the data analyzed, terminals, ship repair yards, and service bases have the highest percentages of facility sites located in areas expected to experience land loss. These facilities are also located in areas expected to experience a relatively large amount of land loss, averaging nearly 10% of the nearby land, and would therefore likely be the most affected by the land changes expected to occur by 2050. As mentioned previously, the effects of climate change during the Program will likely act to increase the land loss amounts shown in the table.

This analysis focuses on land loss in coastal Louisiana. These are the result of ongoing coastal processes. Climate change will in all probability exacerbate land loss, but there are no quantified projections of land loss resulting from climate change. The intent of the analysis is to illustrate the potential effect on the viability of existing OCS-related coastal infrastructure during the life of the Program.

The analysis suggests that this possibility exists and that the potential effect varies among infrastructure facility types. The effects of land loss and submergence on OCS-related infrastructure in coastal Louisiana have already begun to be addressed by the LA 1 Coalition, a non-profit organization working to improve transportation along the energy corridor through coastal Louisiana to the GOM. They have evaluated highway closures that could occur along LA 1 highway, a critical transportation link for OCS-related service and support bases, as a result of coastal submergence by 2050. Their analysis suggests that by 2030 critical sections of the highway could be closed up to 6% of the time and that by 2050 closures could occur 55% of the time (LA1 Coalition 2011). Such closures could have large effects on the OCS industry because of the high volume of OCS-related support and service products and materials transported across the highway.

3.11.2 Alaska – Cook Inlet

The Municipaility of Anchorage, the Kenai Peninsula Borough, and the Matanuska-Susitna Borough in south central Alaska, along with the Kodiak Island Borough along the southern Cook Inlet, are the population centers of the State, with 60–65% of its population (USCB 2011b). Anchorage is the State center for scheduled aircraft and the regional center for chartered aircraft. Anchorage has a cargo facility that is served by a railroad connecting it to Alaska's interior and the port at Seward. Anchorage is home to two military bases and the center for the State's overall road network. As of 2010, the Borough of Anchorage had a population of approximately 291,826 (USCB 2011b). This estimate is seasonally variable.

The Cook Inlet and Kenai Peninsula area has an extensive road network and is served by the Ted Stevens Anchorage International Airport in Anchorage, as well as numerous smaller airfields and facilities. The more remote west side of Cook Inlet is not connected to the road system, and is home to the village of Tyonek, Alaska, a number of commercial set-net fish sites, and a number of oil camps.

The lands in the vicinity of the Cook Inlet Planning Area include large National Parks, National Wildlife Refuges, and a National Forest, including the Lake Clark National Park and Preserve, the Katmai Park and Preserve, the Kenai Fjords National Park, the Kenai National Wildlife Refuge, the Kodiak National Wildlife Refuge, and the Chugach National Forest (for a listing and discussion of these areas, see Section 3.9.2). The region also has numerous smaller State and municipal parks and refuges, and is economically important as a transportation hub, business center, tourism destination, and area of oil and gas activities.

The Port of Anchorage is the fourth largest port in Alaska (after Valdez, Nikiski, and Kivilina), and was ranked as the 96th largest port in the United States in 2009 (USACE 2010). The Port of Anchorage generally is limited to the use of barges and small container ships because of its shallow water depths and extreme tide variations. The port also serves as a staging and fabrication site for modules that are shipped to the North Slope for use in oil and gas activities.

Two ports are located on the east side of Cook Inlet, the Port of Homer in Kachemak Bay and a collection of special-purpose docks located in and around the town of Nikiski. The Port of Nikiski is the second largest port in Alaska (after Valdez), and was ranked as the 69th largest port in the United States in 2007 (USACE 2009).

Oil and gas are produced both onshore and offshore on State lands in the region; however, there are currently no active Federal leases in Cook Inlet. There are 16 active offshore production platforms in the Cook Inlet (Cook Inlet Regional Citizens Advisory Council 2011) on State submerged lands, north of the Cook Inlet Planning Area. There are onshore treatment facilities along the shores of the upper Cook Inlet and approximately 356 km (221 mi) of undersea pipelines, 126 km (78 mi) of oil pipeline, and 240 km (149 mi) of gas pipeline. These facilities, in addition to onshore pipelines, are listed in Tables 3.11.2-1 and 3.11.2-2 and shown in Figure 3.11.2-1.

Existing Cook Inlet region crude oil production (offshore and onshore) is handled through the Trading Bay production facility (Figure 3.11.2-1) and the Tesoro Refinery. Cook Inlet–produced gas is consumed by a variety of users: it is burned for electric power at Chugach Electric Association’s Beluga power-generation plant or transported to Anchorage for local usage.

The Trading Bay facility pipelines its received crude oil production to the Drift River tanker-loading facility at the Drift River Terminal. Facilities on both the Kenai Peninsula and in Anchorage have been used to fabricate large support modules for oil and gas development and production. With oil reserves mostly depleted, development in Cook Inlet in recent years has focused on natural gas; however, the Nikiski liquefied natural gas (LNG) plant, the only LNG export facility in the United States, closed in February 2011 (LNG World News 2011). The Agrium U.S., Inc., chemical plant, which also utilized Cook Inlet-produced gas, closed in 2008 (Agrium, Inc. 2007).

Since 1996, all Drift River tanker loadings are transported to the Tesoro Nikiski refinery, north of the city of Kenai. The Tesoro Refinery can process up to 72,000 barrels per day (bpd). The refinery produces ultra low sulfur gasoline, jet fuel, ultra low sulfur diesel, heating oil, heavy fuel oils, propane, and asphalt. Crude oil is delivered by double-hulled tankers via the Cook Inlet and Kenai Peninsula pipelines. A 114-km (71-mi), 40,000 bpd common-carrier products pipeline transports jet fuel, gasoline, and diesel to the Port of Anchorage and the Anchorage International Airport. Wholesale delivery occurs through terminals in Kenai, Anchorage, Fairbanks, and Tesoro’s Nikiski dock (Tesoro Corporation 2011).

In addition to oil- and gas-related activities, the Cook Inlet Planning Area and the land surrounding it are also important for commercial and recreational fisheries and hunting, as well as tourism and recreation. Subsistence use patterns of Cook Inlet are varied. As shown in Section 3.14.2, both urban and rural populations participate in hunting and fishing activities.

While facilities are present to support exploration and development of offshore oil and gas resources, existing and planned activities associated with exploration activities still would need to be consistent with current, local plans and initiatives. Within the State, Alaska Statutes provide certain cities and boroughs (i.e., municipalities) the authority for planning and land use regulation (Alaska Department of Commerce 2007; Freer 2003); activities that occur within the boundaries of the coastal zones of these municipalities, including their offshore coastal zones, would require permitting and approval from the relevant municipality prior to those activities proceeding (MMS 2003a). The Inlet is primarily comprised of land located within the Kenai Peninsula Borough, with some portions within the municipality of Anchorage, the Kodiak Island Borough, and other governmental jurisdictions.

TABLE 3.11.2-1 Past and Present Operational Gas Pipelines in Cook Inlet and Cook Inlet Basin

ID	Current Operator	Location of Field or Pool	Location	Installed	Length in Miles[a]	Line Diameter in Inches
Offshore Cook Inlet Pipelines						
a	Unocal	Offshore	Baker to Platform A	1965	2.5	8
b	Cross Timbers	Offshore	Platform A to C	1967	2.2	8
c	Cross Timbers	Offshore	Platform C to Dillon	1967	2.2	8
d	Unocal	Offshore	Dillion to shore	1966	5.6	8
e	Unocal	Offshore	Grayling to shore	1967	6.0	10
f	Unocal	Offshore	King Salmon to shore	1967	7.0	8
g	Unocal	Offshore	Dolly Varden to shore	1967	5.7	8
h	Unocal	Offshore	Steelhead to shore	1986	6.5 (13)	2–10 lines
i	Unocal	Offshore	Monopod to shore	1966	9.0	8
j	Unocal	Offshore	Spurr to shore	1968	8.4	6
k	Marathon	Offshore	Spark to shore	1968	7.2	6
l	Unocal	Offshore	Anna to Bruce	1966	1.6	8
m	Unocal	Offshore	Bruce to shore	1974	5	6
n	Unocal	Offshore	Granite Point to shore	1966	6.0	8
o	Phillips	Offshore	Tyonek “A” to shore	1968	13 (26)	2–10 lines
p	Marathon	Offshore	Marine CIGGS, Granite Point to Nikiski[b]	1972	21 (42)	2–10 lines
Onshore Kenai Peninsula Pipelines						
q	Kenai Pipeline	Onshore	Swanson River to Nikiski	1960	19.2	16
r	Marathon	Onshore	Beaver Creek Field to Enstar Royalty Line	1982	4	12
s	Phillips	Onshore	Onshore continuation of Tyonek “A” to Nikiski	1968	26	16
t	Marathon	Onshore	Kenai Gas Field to Nikiski	1965	17	20
u	Enstar	Onshore	Kenai Mainline: Kenai Gas Field to Anchorage	Various[c]	71 (142)	2–12 lines
v	Military Pipeline (Enstar Lease)	Onshore	Anchorage to Whittier	1966[d]	47	8
w	Marathon	Onshore	Kenai Gas Field to Enstar Kenai Mainline	1965[e]	3	8
x	Enstar	Onshore	Enstar Royalty Line: Nikiski to Enstar Kenai Mainline	1978	25	8

TABLE 3.11.2-1 (Cont.)

ID	Current Operator	Location of Field or Pool	Location	Installed	Length in Miles[a]	Line Diameter in Inches
Onshore West Cook Inlet Pipelines						
y	Unocal	Onshore	Stump Lake and Ivan River Fields to Entar	1990	14	6 and 8
z	Forest Oil	Onshore	West Forelands #1 Well to Trading Bay	1994	5	6
aa	Enstar	Onshore	Lewis River Field to Enstar West Cook Mainline	1984	4	4
bb	Enstar	Onshore	West Cook Mainline, Beluga Gas Field to Anchorage	1984	99	20
cc	Marathon	Onshore	West Side CIGGS, Trading Bay to Granite Point	1972	27	16
dd	Marathon	Onshore	Granite Point to Beluga	1990	16.1	16

[a] Roughly estimated, there are 486 route miles for all gas pipelines offshore and onshore in the Cook Inlet region. Considering dual pipelines, actual pipe length is approximately 598 miles. These figures do not include gathering and connection pipelines that are internal to a field. To convert miles to kilometers, multiply by 1.6.

[b] CIGGS = Cook Inlet Gas Gathering System.

[c] Kenai Mainline pipeline: segments placed into service in various years beginning in 1961. Latest initial pipeline pressure test occurred in 1978.

[d] Year of Enstar pressure test and operational assumption.

[e] Pipeline not in use.

Source: Roberstson 2000; Enstar 2001; MMS 2002.

TABLE 3.11.2-2 Past and Present Operational Oil and Liquid Petroleum Pipelines in Cook Inlet and Cook Inlet Basin

ID	Current Operator	Location of Field or Pool	Location	Installed	Length in Miles[a]	Line Diameter in Inches
Offshore Cook Inlet Pipelines						
a	Cross Timbers	Offshore	A to shore	1965	7.0 (14)	2–8 lines
b	Cross Timbers	Offshore	C to A	1967	2.2	8
c	Unocal	Offshore	Baker to A	1965	2.5	8
d	Unocal	Offshore	Grayling to shore	1967	6.0	10
e	Unocal	Offshore	King Salmon to shore	1967	7.0	8
f	Unocal	Offshore	Dolly Varden to shore	1967	5.7	8
g	Unocal	Offshore	Steelhead to shore	1986	6.5	8
h	Unocal	Offshore	Monopod to shore	1966	9.0	8
i	Unocal[a]	Offshore	Spurr to shore[b]	1968	8.4	6
j	Marathon	Offshore	Spark to shore[b]	1968	7.2	6
k	Unocal	Offshore	Anna to Bruce	1966	1.6	8
l	Unocal	Offshore	–	1966	1.6	8.625
m	Unocal	Offshore	Granite Point to shore	1966	6.0	8
Kenai Peninsula Pipelines						
n	Tesoro	Onshore	Tesora Refinery to the Port of Anchorage	1974	70	10
o	Tesoro	Onshore	Nikiski Terminal to Tesoro Refinery	1983	<1	24
p	Kenai	Onshore	Swanson River to Kikiski	1960	19.2	8
West Cook Inlet Pipelines						
q	Cook Inlet Pipeline	Onshore	Drift River loading lines	1966	3.6	30 and 42
r	Cook Inlet Pipeline	Onshore	Granite Point to Drift River	1966	42.0	20 and 12
s	Forest Oil	Onshore	West McArthur to Trading Bay	1994	3.12	8

[a] Roughly estimated, there are 211 route miles for actual pipeline route and 218 miles of actual pipe length. This estimate does not take into account gathering lines that are internal to a producing field. To convert miles to kilometers, multiply by 1.6.

[b] Spurr and Spark oil pipelines are shut in. Marathon only operates gas lines.

Source: Robertson 2000; MMS, Alaska OCS Region.

Furthermore, much of the land within the Cook Inlet is managed by Federal land management agencies; for instance, approximately 65% of the Kenai Peninsula Borough is Federal land (Kenai Peninsula Borough, 2005) (see Figure 3.9.3-2). Therefore, each of these agencies and their respective regulations would need to be considered for exploration and production activities that might affect lands or waters managed by the agencies.

3.11.3 Alaska – Arctic

The Arctic region includes the Beaufort Sea Planning Area and the Chukchi Sea Planning Area. Only the Beaufort Sea Planning Area has a well-developed oil and gas industry infrastructure on adjacent land and in State waters.

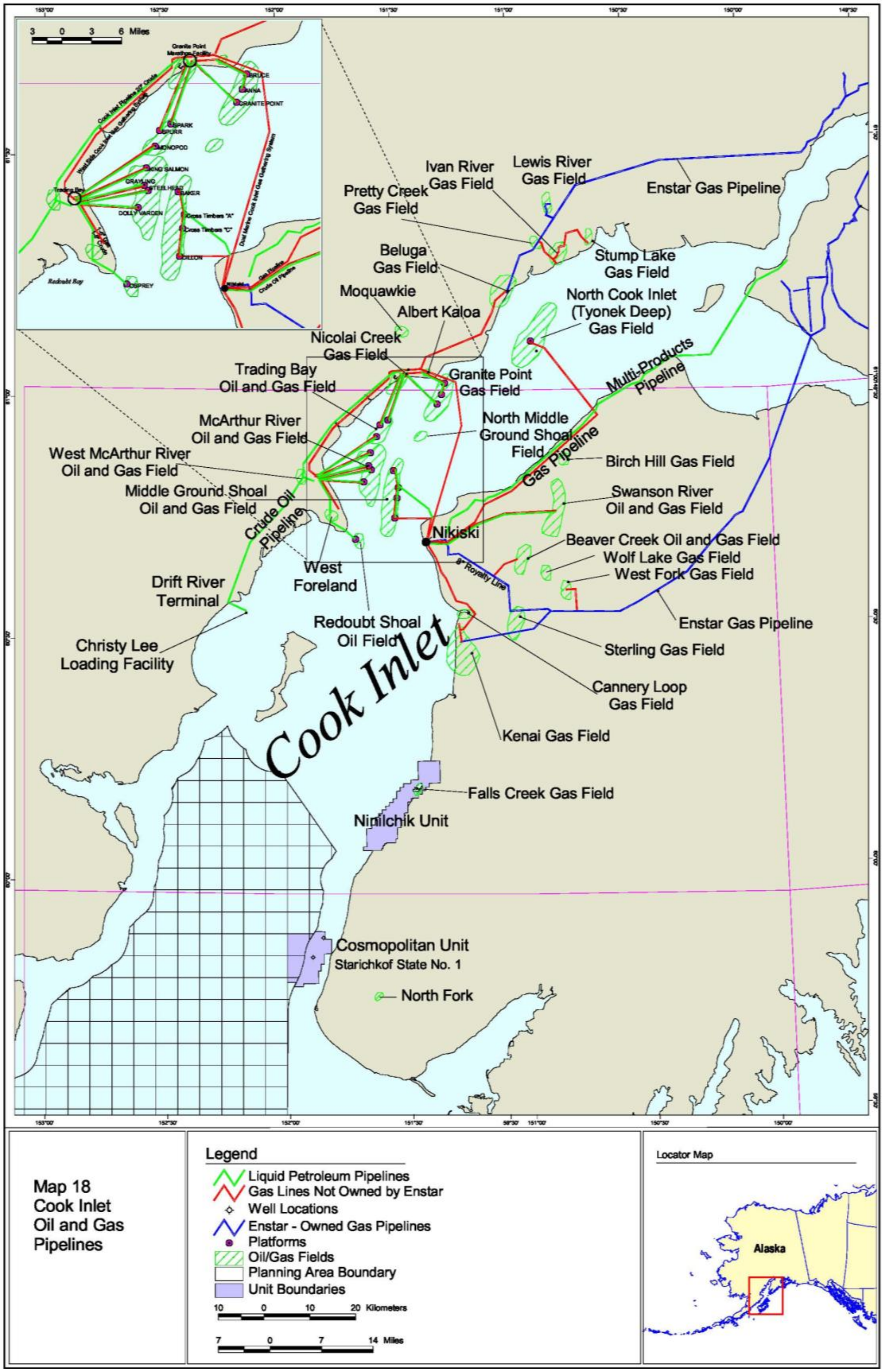

FIGURE 3.11.2-1 Oil and Gas Fields and Infrastructure Locations in Cook Inlet

Land use in much of the Arctic region is not intense, with much of the region being used primarily for subsistence pursuits, except for the oil- and gas-related activities described above. There are only a few small communities located in the area, the largest of which is the city of Barrow, with an estimated population of about 4,212 persons (USCB 2010). Barrow is the economic, transportation, and administrative center for the North Slope Borough. The North Slope Borough includes other communities adjacent to the Chukchi and Beaufort Sea Planning Areas, including Point Hope, Point Lay, Wainwright, Nuiqsut, and Kaktovik, each with populations under 1,000 persons. Deadhorse is an unincorporated oil field service community at the end of the Dalton Highway, with fewer than 50 permanent residents, but with up to 2,000 or more oil workers present at a given time.

Various Federal agencies oversee large amounts of land in the North Slope Borough. federally managed lands include the Arctic National Wildlife Refuge (USFWS), Gates of the Arctic National Park (NPS), the National Petroleum Reserve-Alaska (BLM), and a number of Chukchi Sea coastal headlands and islands administered by the Alaska Maritime National Wildlife Refuge (USFWS) (for a listing and discussion of these areas, see Section 3.9.3).

Transportation-related infrastructure is minimal, but concentrated in the Prudhoe Bay oil field area. Marine shipping to North Slope communities is by barge and by lightering (transferring cargo between vessels of different sizes) of cargo to shore because of the shallow coastal waters and the lack of dredging and heavy-lift equipment. Heavy-lift cranes and protected small boat shelters are found only at Prudhoe Bay’s West Dock. The communities within this region are not connected by a permanent road system. Paved and unpaved roads are generally limited to the area within communities. During the winter, village residents travel to other villages via snowmobile. However, the residents of the community of Nuiqsut are close enough to active oil fields that they can use winter ice roads to access Prudhoe Bay and then travel down the Dalton Highway into the interior of Alaska.

Airports and related service facilities are also limited. Airports at Barrow, Kotzebue, and Deadhorse have scheduled jet service and are owned and maintained by the State of Alaska. ConocoPhillips maintains an airport near its operating headquarters at Ugnu-Kuparuk. This airfield serves chartered corporate passenger and cargo jets, as well as other types of air traffic. The most active airfield in Arctic Alaska is the Deadhorse airport, with most flights at that airport related to oil field activities. The second-most active facility is Barrow’s Wiley Post–Will Rogers Airport; there are other smaller airports at Nuiqsut and other locations in the region as well.

Exploration activities moved offshore into the Beaufort and Chukchi seas in the 1970s, and development and production in the nearshore Beaufort Sea began in the early 1980s. Individual oil pools have been developed together as fields that share common wells, production pads, and pipelines. As of 2007, 35 fields and satellites had been developed on the North Slope and nearshore areas of the Beaufort Sea and were producing oil. Over time, fields also have been grouped into production units with common infrastructure, such as processing facilities (MMS 2008b).

Oil and gas infrastructure occurs intermittently along the arctic coast from the northeast corner of the NPR-A to the Canning River. The core of production activity occurs in an area between the Kuparuk field and the Sagavanirktok River. The Prudhoe Bay/Kuparuk oil field infrastructure is served by nearly 483 km (300 mi) of interconnected gravel roads. These roads serve more than 644 km (400 mi) of pipeline routes and related processing and distribution facilities.

According to BLM (as cited in MMS 2008b), as of 2007, oil and gas activities had resulted in the development of 202 ha (500 ac) of peat roads, 3,642 ha (9,000 ac) of gravel roads and pads, 2,428 ha (6,000 ac) of gravel mines, and 809 ha (2,000 ac) of other facilities on the North Slope. Few of these acres had been restored to their original condition.

Oil and gas exploration activities are ongoing in the northeast NPR-A. No permanent roads have been constructed into the NPR-A; all activities there are currently supported by ice roads. Some lands within the NPR-A have special designations, including the Teshekpuk Lake, Kasegaluk Lagoon, Colville River, and Utukok Uplands Special Areas, established in recognition of the areas' outstanding wildlife resources, including geese and other birds, caribou, bears, fish, and other animals.

In 2008, the BLM issued a record of decision (ROD) for the Northeast NPR-A making nearly 17,800 km^2 (4.4 million acres) available for oil and gas leasing, though it deferred leasing on 1,740 km^2 (430,000 acres) north and east of Teshekpuk Lake for 10 yr. The decision also established performance-based stipulations and required operating procedures (ROPs), which apply to oil and gas and, in some cases, to other activities (BLM 2008).

The Prudhoe Bay/Kuparuk area is also served by the Dalton Highway. This road extends more than 644 km (400 mi) from Livengood (121 km [75 mi] north of Fairbanks) to Deadhorse. The Trans-Alaska Pipeline System (TAPS) roughly parallels much of the Dalton Highway.

Because new facilities would be necessary to develop offshore oil and gas resources, exploration and production activities would need to be coordinated with local jurisdictions in order to ensure consistency with local land use plans, zoning regulations (if present), and future land use initiatives. Alaska Statutes provide certain cities and boroughs (i.e., municipalities) the authority for planning and land use regulation; as such, planning commissions and/or city councils may review projects that would impact a municipality under its jurisdiction. Comments or recommendations may be provided to the agencies undertaking the action in order to account for local needs, or if local permits are needed (Alaska Department of Commerce 2007; Freer 2003).

Furthermore, a significant percentage of the land near the Beaufort and Chukchi Seas is owned by the Federal government, although it is located within the North Slope Borough. For instance, more than half of the North Slope Borough's land is included with the NPR-A and the ANWR. Other major landholders include the State, the Arctic Slope Regional Corporation, and eight Native village corporations (BOEMRE 2010a). Each of these agencies and their respective regulations would need to be considered for exploration and production activities that might affect lands or waters managed by the agencies.

3.12 COMMERCIAL AND RECREATIONAL FISHERIES

3.12.1 Commercial Fisheries

3.12.1.1 Gulf of Mexico

Commercial fisheries are very important to the economies of the GOM coast States; in 2009, commercial fishery landings in the GOM, which includes western Florida, Alabama, Mississippi, Louisiana, and Texas, reached almost 649,000 metric tons, which was worth more than $629 million (NMFS 2011d). When related processor, wholesale, and retail businesses are included, the GOM seafood industry supports more than 200,000 jobs with related income impacts of $5.5 billion. Louisiana led the GOM coast States in total landings and value in 2009, with 455,931 metric tons worth $284 million. Mississippi was second, with landings exceeding 104,456 metric tons, worth $47 million, followed by Texas (45,132 metric tons, worth $150 million), Florida's west coast (29,626 metric tons, worth $116.1 million), and Alabama (13,469 metric tons, worth $41 million) (NMFS 2011d).

Commercially important species groups in the GOM include oceanic pelagic (epipelagic) fishes, reef (hard bottom) fishes, coastal pelagic species, and estuarine-dependent species (Table 3.12.1-1). On the basis of reported commercial fishery landing data, the two most valuable commercial fisheries in the GOM were white and brown shrimp, which accounted for 25% and 23%, respectively, of the entire GOM commercial fishery in 2009 (NMFS 2010; Table 3.12.1-1). Other invertebrates such as blue crab, spiny lobster, and stone crab (*Menippe* spp.) also contributed significantly to the value of commercial landings. Finfish species that contributed substantially to the overall commercial value of the GOM fisheries in 2009 included menhaden ($60.6 million), red grouper ($10.5 million), red snapper ($7.9 million), and yellowfin tuna ($7.9 million). In terms of landing weight, Atlantic menhaden far surpassed other commercial fish species in the GOM, accounting for approximately 70% of the total weight of landed commercial species (Table 3.12.1-1). However, Atlantic menhaden accounted for only about 9.6% of the total value of the GOM commercial fishery.

Each species or species group is caught using various methods and gear types. Shrimps are taken by bottom trawling; menhaden are caught in purse nets; yellowfin tuna are caught on surface longlines; snapper and grouper are caught by hook and line; and pots and traps are used for crab, spiny lobster, and some fish species. Generally, the GOM fishing activities with the highest potential for interactions (or conflicts) with OCS oil and gas activities (e.g., oil and gas operations) are bottom trawling (potential for snagging on pipelines, cables, and debris) and surface longlining (potential for space use conflicts with seismic survey vessels and possible entanglement with thrusters on dynamically positioned drillships). The portion of commercial fishery landings that occurred in nearshore and offshore waters of the GOM States is presented in Table 3.12.1-2.

Fishery statistics for major U.S. ports in the GOM region are presented in Table 3.12.1-3. In terms of reported total landing weight, the top U.S. ports in the GOM region in 2009 were

TABLE 3.12.1-1 Total Weights and Values of Commercially Important Fishery Species in the GOM Region

Species	Weight (metric tons)	Weight (pounds)	Value ($)	% Weight	% Value
Menhaden	454,761.20	1,002,566,613	60,603,671	70.1	9.6
Shrimp, brown	55,887.10	123,208,776	142,752,499	8.6	22.7
Shrimp, white	51,988.20	114,613,215	155,736,392	8.0	24.7
Crab, blue	26,823.20	59,134,370	43,673,691	4.1	6.9
Oyster, eastern	10,226.60	22,545,582	72,455,368	1.6	11.5
Crayfish	8,437.20	18,600,732	14,980,231	1.3	2.4
Mullet, striped	4,691.20	10,342,230	5,580,700	0.7	0.9
Shrimp, pink	3,485.80	7,684,797	14,202,829	0.5	2.2
Stone crab claws	2,389.80	5,268,490	17,567,663	0.4	2.8
Black drum	2,257.80	4,977,457	3,827,342	0.3	0.68
Red grouper	1,988.80	4,384,414	10,481,382	0.3	1.7
Lobster, Caribbean spiny	1,791.50	3,949,586	12,173,600	0.3	1.9
Vermillion snapper	1,722.20	3,796,731	8,230,448	0.3	1.3
Red snapper	1,134.30	2,500,630	7,963,886	0.2	1. 3
Bait and feed fish	1,120.50	2,470,199	471,243	0.2	0.1
Yellowfin tuna	1,118.20	2,465,234	7,935,150	0.2	1.3
Shrimp, Dendrobranchiata	1,080.60	2,382,249	9,950,718	0.2	1.6
Total	648,613.40	1,429,933,053	629,276,230		

Source: NMFS 2010g.

TABLE 3.12.1-2 Value of Gulf Coast Fish Landings by Distance from Shore and State for 2009 ($1,000)

	Distance from Shore (mi)	
State	0–3	3–200
Florida (GOM)	11,319	36,390
Alabama	2,006	1,637
Mississippi	18,211	456
Louisiana	64,164	13,213
Texas	2,443	5,045
Total	98,143	56,741

Source: http://www.st.nmfs.noaa.gov/st1/commercial/landings/ds_8850_bystate.html.

TABLE 3.12.1-3 Reported Total Landing Weights and Values for Major Ports in the GOM Region in 2009

Rank[a]	Port	State	Total Landing (million lb)	Total Landing (million $)
2	Empire-Venice	LA	411.8	67.1
5	Intracoastal City	LA	244.7	30.2
6	Pascagoula-Moss Point	MS	217.4	18.6
7	Cameron	LA	178.8	No data
22	Dulac-Chauvin	LA	42.4	50.9
27	Brownsville-Port Isabel	TX	27.0	41.0
28	Lafitte-Barataria	LA	25.9	25.9
29	Golden Meadow-Leeville	LA	25.6	27.4
33	Galveston	TX	22.0	35.0
34	Bayou La Batre	AL	21.0	30.0
37	Palacios	TX	20.0	27.0
43	Port Arthur	TX	16.0	27.0
46	Delacroix-Yscloskey	LA	13.4	19.7
47	Gulfport-Biloxi	MS	12.9	19.3

[a] Rank among all U.S. commercial fishing ports based on landings.

Source: http://www.st.nmfs.noaa.gov/st1/fus/fus09/02_commercial2009.pdf.

Empire-Venice, Louisiana; Intracoastal City, Louisiana; and Pascogoula-Moss Point, Mississippi. GOM ports with the highest reported total catch values were Empire-Venice, Louisiana ($67.2 million), and Dulac-Chauvin, Louisiana ($50.9 million).

The DWH event had immediate effects on the GOM fishing industry between April and November 2010, with up to 40% of Federal waters being closed to commercial fishing in June and July (CRS 2010). Portions of Louisiana, Alabama, Mississippi, and Florida State waters have also been closed. These areas are some of the richest fishing grounds in the GOM for major commercial species such as shrimp, blue crab, and oysters, and as prices for these items have increased, imports of these species have likely taken the place of lost GOM coast production. NOAA continued to reopen areas to fishing once chemical tests revealed levels of hydrocarbons or dispersants in commercial species were not of concern to human health.

The impact of the DWH event on fishery landings is still being investigated. This information, however, is not needed at the programmatic stage to make a reasoned choice among alternatives (see Section 1.4, Analytical Issues).

Commercial shrimp landings in the GOM in 2010 were below the 2007 to 2009 average from May to August, but equaled or exceeded the average during the remainder of the year (http://curis.msstate.edu/gomosshrimplandingimpactGOM.html). In addition, as consumer perceptions of GOM seafood and seafood products may affect demand, future sales of GOM fisheries production may be lost (CRS 2010).

3.12.1.2 Alaska – Cook Inlet

Commercial fisheries of the Gulf of Alaska and Cook Inlet are diverse and chiefly target groundfish, Pacific halibut, Pacific salmon, herring, crab, shrimp, clams, scallops, sea urchins, and sea cucumbers. An assortment of gear, such as gill nets, seines, purse seines, trawls, dredges, pots, jigs, and/or diving equipment, is employed to harvest the various target species. The groundfish fisheries accounted for the largest share ($640 million; 48%) of the ex-vessel value of all commercial fisheries in Alaska in 2009 (Hiatt et al. 2010). The Pacific salmon fishery is the second most valuable ($345 million) with 26% of the total Alaska ex-vessel value. The value of the shellfish fishery was $195 million, or 15% of the total for Alaska (Hiatt et al. 2010). Fisheries in the Gulf of Alaska are described in Hiatt et al. (2010), including gear, geographic distribution, fisheries effort, and existing economic conditions.

The State of Alaska divides Cook Inlet into the Lower Cook Inlet (LCI) Management Area comprised of all waters west of the longitude of Cape Fairfield, north of the latitude of Cape Douglas, and south of the latitude of Anchor Point; and the Upper Cook Inlet (UCI) Management Area, which consists of Cook Inlet north of the latitude of the Anchor Point Light. All five species of Pacific salmon, razor clams, Pacific herring, and smelt are commercially harvested in UCI. The LCI area supports commercial fisheries for salmon, groundfish, and scallops, but herring, king crab, Dungeness crab, and shrimp fisheries are currently restricted or closed while stocks rebuild. There are also gear restrictions in Cook Inlet, where the use of non-pelagic trawl gear is prohibited north of a line extending between Cape Douglas (58°51.10' N latitude) and Point Adam (59°15.27' N latitude).

Groundfish are primarily harvested by trawl, although hook and line (including longline and jigs) and pot gear are also used. In general, groundfish fisheries in the U.S. EEZ (5.6–370 km [3–200 NM] offshore) fall under Federal authority, while the State of Alaska manages groundfish within State territorial (0–5.6 km [0–3 NM]) waters (Trowbridge et al. 2008). The ADF&G, Division of Commercial Fisheries, manages all commercial groundfish fisheries in Cook Inlet, where groundfish are typically harvested in the LCI Management Area. Commercial fisheries of groundfish in State waters have historically targeted Pacific cod, pollock, sablefish, ling cod, and rockfish (Trowbridge et al. 2008).

Pacific halibut fishery grounds occur throughout the entire Gulf of Alaska shelf. The commercial fishery is conducted exclusively using hook and line (NMFS 2004). The Pacific halibut fishery is managed by the International Pacific Halibut Commission (http://www.iphc.washington.edu/halcom).

The Pacific salmon commercial fisheries in State waters of the Gulf of Alaska are important to the economy of the region and are the second most valuable fisheries in Alaska ($345 million in 2009 [Hiatt et al. 2010]). The UCI supports gill net fisheries targeting Chinook, coho, pink, chum, and sockeye salmon. The LCI fisheries use gill net or seine gear and target pink, chum, and sockeye salmon. Total salmon harvest in LCI and UCI was approximately 3.85 million fish ($17.9 million ex-vessel value) in 2009 (Hammarstrom and Ford 2010; Shields 2010b). Pink salmon and sockeye salmon dominate the Cook Inlet salmon fishery by weight and monetary value. Commercial fishing seasons in these areas for salmon are species-specific and are published on the ADF&G, Commercial Fisheries Division, website (http://www.cf.adfg.state.ak.us).

Pacific herring are targeted for food, bait, or herring roe. Depending on the area, herring harvested as food or bait may be commercially fished using trawl, seine, or gill net gear. Sac roe may be harvested using seine, purse seine, or gill net gear. In Cook Inlet, herring harvests are greatest in Kamishak Bay. Over the last decade, the abundance of Pacific herring has been stable, but historically very low, and the commercial Pacific herring fishery in LCI was closed during 2010 for the 12th successive season (Hammarstrom and Ford 2010). The decline in herring may be attributable to the protozoan pathogen *Ichthyophonus*. In the UCI Management Area, eulachon and smelt are commercially harvested. The smelt harvest in the UCI has generally increased from 1978 (0.2 tons) to 2010 (63 tons [Shields 2010b]). Smelt are primarily sold as bait and have low commercial value.

Commercial fisheries of crab and shrimp in the Gulf of Alaska are managed by the State of Alaska. Four species of king crab are harvested: red, blue, golden, and scarlet. Other commercially important crabs include golden king crabs, Tanner crabs, snow crabs, and Dungeness crabs. Commercial crab fisheries of the Gulf of Alaska chiefly operate in the following areas: Yakutat (king crab), Kodiak (Dungeness and Tanner crabs), and the Alaska Peninsula (Dungeness and Tanner crabs). Shrimp fisheries conducted in the Gulf of Alaska use pot, trawl, or otter-trawl gear. The commercial fisheries operate primarily in the Yakutat, Prince William Sound/Copper River, Kodiak, Chignik, and Alaska Peninsula areas. Cook Inlet historically supported king crab, Dungeness crab, and shrimp fisheries, but these fisheries are currently closed while stocks rebuild.

Commercial fisheries of bivalves (scallops or clams) occur in the Prince William Sound/Copper River, Cook Inlet, Kodiak, and Alaska Peninsula areas. Scallops are harvested using dredging gear. Razor clams are harvested exclusively by hand digging on the west shore of upper Cook Inlet, principally from the Polly Creek and Crescent River sandbar areas (Shields 2010b). The 2010 harvest of razor clams was approximately 380,000 lb and valued at $235,000. Steamer clams are also harvested in Cook Inlet.

Diver-based fisheries targeting sea cucumbers also exist around Chignik and Kodiak Island. Currently, each fishery is a competitive limited entry fishery. More information is available at http://www.adfg.alaska.gov/index.cfm?adfg=commercialbyfisherydive.main.

3.12.1.3 Alaska – Arctic

The Arctic Management Area, consisting of the U.S. EEZ of the Chukchi and Beaufort Seas from 6 km (3 NM) offshore the coast of Alaska is currently closed to commercial fishing (NPFMC 2009). In the State waters of the Beaufort Sea, there is a single commercial fishery targeting cisco and whitefish in the Colville River Delta that operates in the summer months. Markets for these fish are primarily regional, although some fish are sent to Anchorage and to more distant markets (NPFMC 2009). In the Chukchi Sea, there is a relatively small summer salmon fishery (MMS 2006a).

3.12.2 Recreational Fisheries

3.12.2.1 Gulf of Mexico

Data collected by the National Marine Fisheries Service (NMFS) for Alabama, Florida, Louisiana, and Mississippi indicate that more than 4.5 million people engaged in some form of recreational fishing in the GOM States in 2010 (Table 3.12.2-1). Of the four States, western Florida had the highest number of anglers and fishing trips in 2010 (3.0 million), followed by Louisiana (0.8 million), Alabama (0.6 million), and Mississippi (0.2 million). Almost 67% of the fishing trips in the GOM coast left out of west Florida, followed by Louisiana (17%), Alabama (7%), Mississippi (5%), and Texas (4%). These anglers took more than 23 million trips and caught more than 173 million fish (NMFS 2011e). In 2004, it is estimated that 1,059,634 fishing license holders fished for one or more days in Texas (Tseng et al. 2006).

The most popular mode of fishing in all GOM States was private/rental boat, comprising 59.7% of trips in each State, followed by fishing from shore (37.5%) and fishing from charter vessels (2.8%) (Table 3.12.2-2). More than 69% of anglers fishing from shore confined their trips to inland waters, the remaining trips taking place within 16 km (10 mi) of shore. Most anglers (75.6%) using private or rental boats also preferred inland waters for their trips, or fished less than 16 km (10 mi) from the coast (17.2%). Only 30.7% of charter boats trips were made inland, while 36.1% were made more than 16 km (10 mi) from the coast, and 27.6% of trips were less than 16 km (10 mi) from shore.

A large majority of angling trips in Mississippi (98.6%) and Louisiana (97.7%) were made in inland waters in 2010, as opposed to waters up to 5 km (3 mi) from shore and farther distances. In Florida (66.2%) and Alabama (46.5%), inland trips were less important, with the more trips in Alabama made to State and Federal waters (46.7% and 6.8%, respectively), and to the same waters in Florida (28.5% and 5.3%, respectively).

Of the 145.3 million fish caught in the four GOM coast States in 2010, the majority (95.3 million, 65.6% of the total) were landed in Florida; landings by weight are more evenly distributed across the four States, with 41.8% of landings in Florida, 40.1% in Louisiana, 12.8% in Alabama, and 5.3% in Mississippi (Table 3.12.2-3). Almost all landings were made in inland waters in Mississippi (98.6%) and Louisiana (94.8%). While the inland catch was important in Alabama (50.0%) and Florida (44.0%), the offshore catch was larger in these States, with 34.1% of the total catch landed up to 5 km (3 mi) from shore, and 16% at more than 5 km (3 mi) in Alabama and 28.7% at less than 16 km (10 mi), and 27.3% at more than 16 km (10 mi) in Florida.

Types of fish caught in 2010 varied by State and by distance from shore (Table 3.12.2-3). In Alabama and Louisiana, drum, seatrout and herring were popular fish less than 5 km (3 mi) from shore, with shark, ray, and snapper caught at this distance in Mississippi. Snapper were commonly caught more than 5 km (3 mi) from shore in Alabama, Louisiana, and Mississippi, together with drum and seatrout in Louisiana. Jack, catfish, and tuna were also caught up to 16 km (10 mi) from shore in Florida. Inland species caught in Alabama were drum, mullet,

TABLE 3.12.2-1 Estimated Number of People Participating in GOM Marine Recreational Fishing, 2010[a]

	Coastal	Non-Coastal	Out-of-State	Total
West Florida	1,542,556	0	1,473,928	3,016,485
Louisiana	601,240	66,340	118,292	785,872
Alabama	193,721	138,730	218,532	550,982
Mississippi	136,504	28,542	49,804	214,850
GOM Total	2,474,021	233,612	1,860,556	4,568,189

[a] "Coastal," "non-coastal," and "out-of-State" refer to place of residence of participants in marine recreation in each State.

Source: NMFS 2011e.

TABLE 3.12.2-2 Estimated Number of Trips and Trip Range by Trip Mode in GOM Marine Recreational Fishing, 2010

Fishing Mode	Trip Range	Number of Trips
Shore fishing	5 km (3 mi) or less	680,556
	Less than 16 km (10 mi)	1,707,550
	Inland	5,402,102
Total	–	7,790,208
Charter boats	5 km (3 mi) or less	10,378
	More than 5 km (3 mi)	21,892
	Less than 16 km (10 mi)	157,977
	More than 16 km (10 mi)	206,673
	Inland	175,939
Total	–	572,859
Private or rental boat	5 km (3 mi) or less	219,504
	More than 5 km (3 mi)	126,227
	Less than 16 km (10 mi)	2,132,905
	More than 16 km (10 mi)	540,061
	Inland	9,376,983
Total	–	12,395,680

Source: NMFS 2011e.

TABLE 3.12.2-3 Estimated Number of Trips and Catch Weights in GOM Marine Recreational Fishing, 2010

	Number of Angler Trips	Catch (pounds)	Major Fish Types Caught
Alabama			
≤5 km (3 mi)	836,397	2,582,437	Drum, seatrout, herring
>5 km (3 mi)	121,006	1,210,837	Snapper
Inland	832,027	3,789,035	Drum, mullet, flounder, porgy
Total	1,789,430	7,582,309	
West Florida			
≤16 km (10 mi)	3,998,432	7,094,311	Herring, drum, seatrout, jack, catfish, seabass, tuna, snapper
>16 km (10 mi)	746,735	6,748,134	Snapper, grunt, herring
Inland	9,287,570	10,875,884	Porgy, mullet, tuna, mackerel
Total	14,032,737	24,718,329	
Louisiana			
≤5 km (3 mi)	61,274	771,959	Drum, seatrout
>5 km (3 mi)	22,980	450,170	Snapper, drum, seatrout
Inland	3,634,782	22,460,692	Drum, seatrout, porgy, catfish
Total	3,719,036	23,682,821	
Mississippi			
≤5 km (3 mi)	12,767	34,924	Shark, ray, snapper
>5 km (3 mi)	4,132	9,237	Snapper
Inland	1,200,644	3,093,236	Drum, seatrout, flounder, porgy
Total	1,217,543	3,137,397	

Source: NMFS 2011e.

flounder, and porgy, with seatrout also caught in Mississippi and catfish in Louisiana. In Florida, porgy, mullet, seatrout, and mackerel were popular. Most fishing occurred in State and inland waters (NMFS 2010g).

In 2004, a total of 1,276,667 Texas resident fishing licenses were purchased (Tseng et al. 2006). It is estimated that 1,059,634 (or 83%) of these license holders actually fished one or more days in Texas during the year. Of those who fished, 74% participated in freshwater fishing and 61% participated in saltwater fishing. Freshwater anglers fished an average of 27 days, while saltwater anglers fished an average of 20 days (Tseng et al. 2006).

When freshwater anglers were asked to name the fish they prefer to catch in Texas, 52% indicated a first-choice preference for black bass. Other species preferred by freshwater anglers included largemouth bass, catfish, crappie, and temperate basses (white bass, striped bass, and hybrid striped bass). Most saltwater anglers in Texas (40%) indicated a first-choice preference for red drum, followed by speckled trout, the drum family, and flounder (Tseng et al. 2006).

Recreational fishing off Alabama, Mississippi, Louisiana, and Texas often occurs around oil and gas platforms. BOEMRE supports and encourages the reuse of obsolete oil and gas facilities as artificial reefs and will grant a lessee/operator a departure from removal requirements provided that (1) the structure becomes part of a State artificial reef program that complies with the criteria in the National Artificial Reef Plan; (2) the responsible State agency acquires a permit from the U.S. Army Corps of Engineers and accepts title and liability for the reefed structure once removal/reefing operations are concluded; (3) the operator satisfies any U.S. Coast Guard navigational requirements for the structure; and (4) the reefing proposal complies with Regional Engineering, Stability, and Environmental Reviewing Standards and Reef Approval Guidelines (http://www.gomr.boemre.gov/homepg/regulate/environ/rigs-to-reefs/Rigs-to-Reefs-Policy-Addendum.pdf).

The DWH event had immediate effects on recreational fishing in the GOM. By July 14, 2010, NOAA had closed 217,370 km^2 (83,927 mi^2) of the GOM to commercial and recreational fishing, or approximately 35% of the federally managed waters in the GOM (CRS 2010). Portions of Louisiana, Alabama, Mississippi, and Florida State waters have also been closed. These areas are some of the richest fishing grounds in the GOM for major species caught by recreational fishermen. Bookings and trips for recreational fishing charters have decreased, especially in Louisiana, and sport fishing tournaments have been cancelled (CRS 2010).

3.12.2.2 Alaska – Cook Inlet

Recreational fishing in the south central Alaska region includes marine sport fishing, freshwater fishing, and shellfish gathering activities, which together contribute substantially to the area's economy. Sport fishing in lower Cook Inlet is primarily for Pacific salmon, rockfish, cod, and Pacific halibut. Shellfish are collected near the shoreline as well. Kachemak Bay is particularly popular for recreational fishing, with halibut sport fishing in the Bay producing $8.7 million in angler expenditures in 1986 (Jones and Stokes Associates 1987), and for shellfish gathering. There is also a substantial salmon fishery in Kachemak Bay and in the rivers and streams flowing into Cook Inlet. Salmon fishing in the Kenai River, for example, generated up to $70 million annually in 1997 (Dorava 1999), while red salmon fishing in the Russian River generated $5.2 million in angler spending in 1986 (Jones and Stokes Associates 1987). Razor clams and other clams are gathered in Kachemak Bay and at various locations along the western side of the Kenai Peninsula and the shorelines bordering Cook Inlet.

In northern Cook Inlet, on the western bank, there exist recreational fisheries for razor clams and several species of hardshell clams, as well as Tanner crab and Dungeness crab. Extensive freshwater fishing also occurs throughout south central Alaska, and all five species of Pacific salmon can be found there, as well as trout, arctic grayling, Dolly Varden, and northern pike. The Susitna River drainage is particularly important for recreational fishing in northern Cook Inlet.

3.12.2.3 Alaska – Arctic

There is little data on recreational fishing in the Beaufort and Chukchi Seas. The North Pacific Fishery Management Council concluded that there are few recreational fisheries in the Beaufort and Chukchi Sea Planning Areas. Sport fishing likely occurs at the larger population centers such as Barrow (NPFMC 2009). Any recreational fisheries that do occur in State waters would be regulated by Alaska State law. The available data is not adequate to determine the population trends in recreational and subsistence harvests in the Arctic Management Area.

Subsistence fishing is widespread in coastal areas of the Arctic, and fisherman typically use gill nets, jigging, and hook and line methods to capture Pacific herring, Dolly Varden char, whitefish, arctic cod, and sculpin.

3.13 TOURISM AND RECREATION

3.13.1 Recreational Resources

3.13.1.1 Gulf of Mexico

The GOM coastal zone is one of the major recreational regions of the United States, with marine fishing and beach-related activities particularly popular. The tourist industry contributed 620,000 jobs and more than $9 billion in wages to the GOM region (NMFS 2011e). The coasts of Florida, Alabama, Mississippi, Louisiana, and Texas offer diverse natural and developed landscapes and seascapes, and the beaches, barrier islands, estuarine bays and sounds, river deltas, and tidal marches are visited by residents of the GOM coast States and by tourists from throughout the United States and overseas. Publicly owned and administered areas (such as national seashores, parks, beaches, and wildlife lands), as well as specially designated preservation areas (such as historic and natural sites and landmarks, wilderness areas, wildlife sanctuaries, and scenic rivers), attract residents and visitors throughout the year. Commercial and private recreational facilities and establishments, such as resorts, marinas, amusement parks, and ornamental gardens, are also popular with tourists and in-State visitors. In 2000, Florida was the most important destination for marine recreation, with more than 22 million people participating in the State (NOAA 2005). Texas ranked fifth, with a little under 6.2 million participants, while in Alabama, Louisiana, and Mississippi (2.5 million, 2.2 million, and 1.8 million, respectively) participation was lower, but still significant.

3.13.1.2 Alaska – Cook Inlet

Opportunities for recreational activities such as hunting, hiking, boating, wildlife viewing, and sightseeing are abundant in the Cook Inlet area. Tour ships from the lower 48 States regularly traverse southeast Alaska, and many independent travelers use the Alaska Maritime Highway (ferry) system to access the subregion. Helicopter and small aircraft sightseeing tours have developed locally, along with a generally robust tourism sector. This includes a fleet of small regional tour ships, river jet-boat tours, fishing charters, bed-and-breakfast operations, and associated tourism-based enterprises (MMS 2006b).

The Kenai Peninsula and Prince William Sound are in close proximity to Cook Inlet and Anchorage, which is the population and logistical center of the State. Thus, these areas receive the heaviest recreational use, both by residents and nonresidents. The Kenai Peninsula has a developed road system and is directly connected to Anchorage. Prince William Sound also is connected by road to Anchorage via Whittier. Local boat tours of Prince William Sound and Kenai Fjords National Park are popular attractions. Cook Inlet and rivers and streams in the area, especially the Kenai River, are heavily fished by sport fishers. The Kenai Peninsula also is a popular hunting area. The Chugach National Forest attracts hikers, campers, and other users. An extensive tourism infrastructure is centered in Anchorage and extends into the surrounding region (MMS 2006b).

3.13.1.3 Alaska – Arctic

Tour groups to the North Slope Borough, primarily visiting Barrow or Deadhorse, make up most of the nonresident recreational activity. Both locations have lodging available, and Barrow has developed a limited tourism sector. Travel to these areas primarily is by air, although bus tours occasionally arrive via the Dalton Highway between Deadhorse and Fairbanks. Hikers and river rafters also visit the Arctic National Wildlife Refuge and other areas, using scheduled (to Kaktovik) or chartered (for remote locations) airplanes for access. An increasing number of cruise ships enter the Chukchi and Beaufort Seas, and a growing number of hikers and rafters visit coastal areas of the Chukchi; lodging is currently available in Kaktovik. Gates of the Arctic National Park receives limited visitation, accessed through Anuktuvuk Pass or by chartered airplane. Hunters also visit the area using aircraft for access, and some hunters may enter the area using the Dalton Highway (MMS 2006b).

3.13.2 Beach Recreation

3.13.2.1 Gulf of Mexico

With 408 beaches in 22 coastal counties located on the GOM coast (USEPA 2004), beach visitation was the most important marine recreation activity, attracting tourists and residents for fishing, swimming, shelling, beachcombing, camping, picnicking, bird watching, and other activities. The Florida coast is the second longest in the United States, consisting of 13,518 km (8,400 mi) of tidally influenced shoreline, with approximately 1,328 km (825 mi) of sandy beaches on the Atlantic Ocean and GOM, attracting 15.2 million visitors in 2000. Tourists visiting Florida's beaches in 2000 spent approximately $21.9 billion, producing an indirect economic effect of $19.7 billion and a total economic impact of $41.6 billion (Florida Sea Grant 2005). Texas has 1,004 km (624 mi) of GOM coast, about 772 km (480 mi) of which are beach (National Research Defense Council 2004), with 166 distinct beaches in 14 counties

(USEPA 2004). Texas ranks fifth, with 3.9 million visitors. Most marine recreation occurs in Harris, Nueces, Cameron, and Galveston counties (NOAA 2005).

Louisiana has about 639 km (397 mi) of coastline and 12,426 km (7,721 mi) of tidal shoreline, behind only Alaska and Florida in length of marine shore. Louisiana's coastline is primarily wetlands, and much of the State's 19,829 km^2 (7,656 mi^2) of estuarine water is largely inaccessible to swimmers. There are 16 coastal beaches in seven counties along the GOM, half of which are in Cameron Parish (USEPA 2004). Louisiana beaches are primarily used by local and State residents, and use is highest during the spring and summer seasons (Louisiana Department of Health and Hospitals 2005). Over 600,000 visitors visited Louisiana beaches in 2000 (NOAA 2005). Mississippi's coastline on the GOM includes 578 km (359 mi) of beach bays, inlets, and promontories, and a series of low barrier islands, the largest being Cat, Ship, Horn, and Petit Bois Islands. The 12 coastal beaches in Harrison County, 6 in Jackson, and 3 in Hancock County (USEPA 2004) had over 1.0 million visitors in 2000 (NOAA 2005). Alabama has approximately 80 km (50 mi) of Gulf Beach (52 km [32 mi] in Baldwin County and 26 km [16 mi] on Dauphin Island) and an estimated 105 to 113 km (65 to 70 mi) of bay beaches, including Mobile Bay, Mississippi Sound, Perdido Bay, and Wolf Bay (Alabama Department of Environmental Management 2005) with a total of 95 coastal beaches in the State, 90 of which are in Baldwin County (USEPA 2004). In 2003, visitors to Baldwin County contributed more than $1.8 billion to the economy of the State (Economic Development Partnership of Alabama 2005), with more than 1.2 million visitors having visited Alabama beaches (NOAA 2005).

3.13.3 Casino Gambling

3.13.3.1 Gulf of Mexico

In addition to the variety of beach activities available to visitors to the GOM coast, casino gambling has attracted a large number of visitors to the region since 1990. There are numerous casinos in Mississippi's GOM coast area, generating $0.8 billion in 2009 (American Gaming Association 2010). Gambling is one of the most popular activities for nonresident visitors to Louisiana, with 23% of nonresident visitors having gambled on their trip to the State in 2003 (Travel Industry Association of America 2004). In Louisiana, casinos in Lake Charles generated $0.7 million in revenues in 2009, with those in the New Orleans area producing $0.7 million.

3.13.3.2 Alaska – Cook Inlet and Arctic

Casino gambling is relatively unimportant in Alaska, with only nine casinos in the State as a whole, which primarily support pull tab and bingo gambling (500 Nations.com). In the south Alaska region there were 26 gambling establishments in 2008 that employed approximately 230 people, while in the North Slope Borough there were 3 establishments, employing approximately 30 people (USCB 2011c).

3.13.4 Recreational Benefits of Offshore Oil and Gas Platforms

3.13.4.1 Gulf of Mexico

The more than 4,000 petroleum structures in the northern GOM have provided significant benefits to recreational fishing (Brashier 1988). Witzig (1986) found that approximately 60% of the fish caught near structures within 5 km (3 mi) of the shore were kept, compared to less than 10% caught at sites with no oil and gas structures. The proportion of the catch kept on fishing trips greater than 5 km (3 mi) from shore was over 70% for trips to sites with oil and gas structures and approximately 35% to sites with no structures. Gallaway and Lewbel (1982) determined that structures constitute approximately 28% of the known hard bottom habitat off the Louisiana and Texas coasts.

Of the 11,911 boats observed fishing near major offshore structures off the Louisiana coast between April 1980 and March 1981, 10,881 were recreational boats (Ditton and Auyong 1984). This included 8,983 private fishing boats, 1,624 charter/party fishing boats, and 274 scuba boats. One charter boat operator in the northern GOM stated that he takes more than 10,000 people deep sea fishing annually, with all fishing activities on these trips conducted while tied up to oil and gas structures. Approximately one-quarter of all the offshore wean fishing originating in Texas, Louisiana, and Mississippi was directly associated with oil and gas structures. Ditton and Graefe (1978) found that oil and gas structures off the Texas coast attracted 87% of the boats and 50% of all offshore recreational fishing.

Research on sport fishing in the central GOM region suggests fishermen are often prepared to travel distances of up to 42 km (26 mi) to take advantage of reef fisheries established on oil and gas structures (Myatt and Ditton 1986), while Stanley and Wilson (1989) found larger travel distances of up to 80 km (50 mi) for platforms established under the Louisiana Artificial Reef Initiative, with distances travelled sometimes being as high as 167 km (104 mi). The highly specialized marine recreational fisherman profiled by Stanley and Wilson (1989) used equipment with sophisticated navigational and safety equipment in order to use reef structures located further offshore. Beyond 161 km (100 mi), structures have been used by fishemen drawn to deepwater habitat or for charter and commercial uses. More distant offshore locations were also found to benefit the tournament fishing community, who were prepared for more offshore travel than were non-tournament anglers (Gordon 1993).

Hiett and Milon (2001) estimated demand, expenditures, and economic impact associated with recreational fishing and diving near offshore oil and gas structures and artificial reefs created from these structures in Alabama, Mississippi, Louisiana, and Texas. Data came from field surveys of fishermen and divers using private, charter, and party boats. A subsample from each group received follow-up telephone interviews to obtain expenditure data. The survey data were combined with information from regional surveys of fishermen to generate State and regional estimates of aggregate expenditures. To expand the results from the sample to an estimate of impacts for the region, the authors relied on information from an annual survey conducted by the National Marine Fisheries Service. Their resulting estimates were that

$324.6 million in economic activity and 5,560 jobs in coastal counties of the GOM region resulted annually from fishing and diving activities near oil and gas structures.

3.13.4.2 Alaska – Cook Inlet and Arctic

Although offshore oil and gas structures may provide benefits to recreational fishermen and for diving, there is little documentation of visitation numbers, either by charter vessel or individual boating trips, and the distribution of fishing trips according to the depth of structures. Given the climatic restrictions on recreational fishing and especially on diving in the Arctic, the number of visitor trips to offshore areas is not known, but is likely to be small.

3.13.5 Recreation and Tourism Employment

3.13.5.1 Gulf of Mexico

Recreation and tourism are major sources of employment along the GOM coast, with total employment of 1,015,662 in these sectors (Table 3.13.5-1). The greatest concentration of tourism-related employment in 2008 was in Florida, with 46% of GOM coast region employment in the tourism and recreation sectors. Within the State, tourism-related employment is concentrated in the Miami and Tampa-St. Petersburg LMAs (MMS 2006b). Elsewhere in the GOM coast region, Texas had 31.9% of regional employment in tourism and recreational activities and Louisiana had 16.2%, with employment concentrated in the Houston-Galveston LMA and the New Orleans LMA (MMS 2006b).

3.13.5.2 Alaska – Cook Inlet

Recreation and tourism are major sources of employment in the south central Alaska region, with total employment of 21,302 in these sectors (Table 3.13.5-2). The greatest concentration of tourism-related employment in 2008 was in Anchorage, with 78.4% of south central Alaska region employment in the various tourism and recreation sectors.

3.13.5.3 Alaska – Arctic

Recreation and tourism are not major sources of employment in the Arctic region, with total employment of 619 in these sectors (Table 3.13.5-3). The greatest concentration of tourism-related employment in 2008 was in North Slope Borough, with 79% of Arctic region employment in the various tourism and recreation sectors.

TABLE 3.13.5-1 GOM Coastal Region Recreation and Tourism Employment Composition, 2008

Employment	Alabama	Florida	Louisiana	Mississippi	Texas	Total
Sporting goods retailers	353	6,155	2,715	224	6,269	15,716
Scenic tours	50	1,440	599	25	781	2,895
Automotive rental	221	9,582	2,406	110	4,866	17,185
Museums and historic sites	277	3,049	2,272	87	3,725	9,410
Amusement and recreation	2,085	44,670	14,052	4,036	24,801	89,644
Hotels and lodging places	3,001	74,192	24,351	14,895	27,087	143,526
RV parks and campsites	93	1,336	446	102	759	2,736
Eating and drinking places	21,542	326,287	117,648	13,333	255,740	734,550
Total	27,622	466,711	164,489	32,812	324,028	1,015,662

Source: USCB 2011f.

TABLE 3.13.5-2 South Central Alaska Region Recreation and Tourism Employment Composition, 2008

	Anchorage	Kenai Peninsula	Kodiak Island	Matanuska-Susitna	South Central Alaska Region Total
Sporting goods retailers	498	10	10	96	614
Scenic tours	175	80	10	60	325
Automotive rental	324	14	10	10	358
Museums and historic sites	156	60	60	4	280
Amusement and recreation	1,511	204	60	237	2,012
Hotels and lodging places	3,076	439	59	265	3,839
RV parks and campsites	60	60	10	43	173
Eating and drinking places	10,894	1,167	295	1,345	13,701
Total	16,694	2,034	514	2,060	21,302

Source: USCB 2011f.

3.13.6 Impact of Oil Spills on Recreation and Tourism

Oil from the DWH event reached many central GOM beaches, and visits to these areas in the immediate aftermath of the accident have decreased significantly; cancellations were reported for areas that are clear of oil, with the spill contributing to negative perceptions of the GOM region (CRS 2010). To counter these perceptions, BP has funded tourism promotion programs in Alabama, Mississippi, and Florida (CRS 2010). Although oil spills can have potentially devastating impacts on the marine and coastal environment, evidence of the longer-

TABLE 3.13.5-3 Arctic Region Recreation and Tourism Employment Composition, 2008

	North Slope Borough	Northwest Arctic Borough	Arctic Region Total
Sporting goods retailers	0	0	0
Scenic tours	0	0	0
Automotive rental	0	0	0
Museums and historic sites	0	0	0
Amusement and recreation	53	60	113
Hotels and lodging places	61	10	71
RV parks and campsites	0	0	0
Eating and drinking places	375	60	435
Total	489	130	619

Source: USCB 2011f.

term impacts of spills on tourism and recreation in coastal areas impacted by oil spills is inconclusive. This information, however, is not needed at the programmatic stage to make a reasoned choice among alternatives (see Section 1.4, Analytical Issues).

Following the *Exxon Valdez* oil spill, visitor spending decreased 8% in south central Alaska and by 35% in southwest Alaska, resulting in an overall loss of $19 million in visitor spending (Alaska Visitor Statistics Program 1990a). Of all visitors who did travel to Alaska, 16% indicated that the spill influenced their trip planning; nearly half indicated they avoided Prince William Sound during their trip. One in 5 visitors to southwest and south central Alaska stated that their plans were affected significantly more than for other regions of the State. Independent visitors were more affected than package visitors, particularly those who planned to purchase sightseeing packages on arrival in Alaska (Alaska Visitors Statistic Program 1990b).

Another study found that 9% of high potential visitors reported the spill impacted travel into Alaska. As a result, 4% either changed or postponed their trip to Alaska in 1989. Of the population, 8% reported the spill impacted interest in travel to Alaska. As a result, 1% canceled, changed, or postponed a trip to Alaska in 1989. By March 1990, 5% of the general population reported the spill impacted interest in travel to Alaska, with 1% indicating that they did not want to travel to Alaska (Alaska Visitors Association 1990). The same research showed an estimated decline in visitation of 9,400 in the summer of 1989, representing a loss of $5.5 million in in-State expenditures. The 428,200 tourists visiting for vacation and pleasure or to visit friends and relatives in the summer of 1989 represents 97.8% of the total number of visitors who would have come to Alaska, meaning that only 2.2% of all vacation visits were negatively affected by the spill (Alaska Visitors Association 1990).

Perceptions of the extent of the impacts of the spill on the Alaskan economy seem to be in conflict with the results of visitor surveys. Using interviews, executives of tourist-affected businesses and relevant government agencies and organizations (The McDowell Group 1990) found decreased resident and nonresident vacation and pleasure visitor traffic in the spill-affected areas of Valdez, Homer, Cordova, and Kodiak due to lack of available accommodation, charter boats, and air taxis. Of the businesses surveyed in spill-affected areas, 43% felt their business had been significantly or completely affected by the oil spill. A severe labor shortage occurred in the visitor industry throughout the State due to traditional service industry workers seeking high-paying spill cleanup jobs, resulting in a higher cost of doing business among visitor industry businesses. Fifty-nine percent of businesses in the most spill-affected areas reported spill-related cancellations and 16% reported business was less than expected due to the spill. Business segments most negatively affected by the spill included lodges and resorts, Alaska-based tour companies, guided outdoor activities, and charter and sightseeing boats. These businesses did not have the opportunity to reap spill benefits (such as spending for accommodations) because they were located away from spill cleanup operations or operated a business that could not serve cleanup needs (The McDowell Group 1990).

There were major positive effects of the *Exxon Valdez* spill, with spill-related business in some major cleanup areas, and in recreation-related business sectors, such as hotels/motels, car and RV rental, air taxi and boat charters. This business offset the lack of vacation and pleasure business normally experienced in these areas (The McDowell Group 1990; USDOI 2002).

A study by Ellis et al. (1991) used the model proposed by David M. Dornbusch and Company (1987) to evaluate the impacts of the Huntingdon Beach, California, spill of 1990. The model was used to predict changes in beach recreational patterns in response to the closure of beaches due to an oil spill, with the results compared to independent estimates of actual impacts generated by the spill. As a result of cleanup activities and natural variations in terrain, individual beaches were closed for different lengths of time. Average beach closure times of 13.5 days in February and 3.1 days in March were used in the Dornbusch model. This results in a total of 2.28% of yearly beach attendance lost due to closures by the spill.

In the area most physically impacted by the spill, the Dornbusch model estimated a loss in water-based recreation (water-enhanced plus water-dependent) of 720,210 user days, representing a total loss of 2.28% of the yearly recreation days. Immediately south of the impacted area, there was an estimated decrease of 5,448 user days for water-based beach recreation, while immediately north of the impacted area, there was an estimated increase of 46,680 user days. There were significant increases in attendance in other beach areas. The associated consumer surplus changes for the impacted beach areas were $4,959,012 for combined water-dependent and water-enhanced recreation in the main area of impact, an increase of $253,695 in the area immediately south, and a decrease of $56,661 for the area immediately to the north. Total statewide consumer surplus decreased by $1,106,667, a 3.4% decrease from the baseline value of $32,355,916.

Oil spills present a unique set of impacts on recreation relative to the various forms of OCS development activity (A.T. Kearney, Inc. 1991). Whereas industrial development and other scenarios create permanent aesthetic impacts, oil spills are random events that have impacts for only a limited period of time. An oil spill is not considered to have a permanent impact on tourism, but rather significant impacts in the period immediately following an accident and smaller residual impacts in the succeeding months. While it is recognized that long-term ecological effects may occur, past experience with spills indicates that visitation returns to baseline levels within a number of years.

More recent research has focused on the relationship between the possibility of oil spills and the potential for a spill to degrade marine resources and inhibit recreation and tourism. Pulsipher et al. (1999) examined the social and economic impacts of a 5,000 bbl oil spill that occurred offshore in the Lake Barre region of the Louisiana coast in 1997. Based on interviews and information obtained from Texaco (responsible for cleanup), the cleanup contractors, and local area officials, business owners, and residents, the short-term social and economic effects were quite small. The major negative effect was a concern about long-term impacts on marine resources (shrimp, oysters, and fish), but there was no local consensus about whether such effects had occurred.

Although much has been learned in the aftermaths of major oil spills in the past several decades, and the nature and extent of their impacts, despite the attenuation of information from the media and other sources, social amplification of risk has tended to reduce public acceptance of the continued risk of oil production and oil transport by sea, at least in the short term (Leschine 2002) with the consequent potential impacts on recreation and tourism.

3.14 SOCIOCULTURAL SYSTEMS AND SUBSISTENCE

Sociocultural systems consist of the beliefs, ideas, tools, and behavioral patterns including social structure, culture, and institutional organizations that humans use to adapt to their physical and social environments. The sociocultural systems considered here are mostly associated with ethnic and social groups living along the coasts of the GOM and Alaska. While these coasts share the potential for offshore oil and gas development, they are ethnically and demographically dissimilar and are treated somewhat differently here. For example, the northern coast of Alaska is sparsely inhabited. Widely spaced Alaska Native communities dot the coast. They are largely isolated from enclaves of transient oil and gas workers. Few are employed in the oil and gas industry, while many are culturally and economically reliant on subsistence hunting and fishing, which are emphasized here. While subsistence harvesting exists along the GOM coast, it is of minor cultural and socioeconomic importance. Unlike Alaska’s north coast, the offshore oil and gas industry is well developed and draws the majority of its workforce from the GOM coast counties. This relationship is discussed in the sections that follow. South central Alaska supports a more ethnically diverse population than the North Slope and includes isolated Alaska Native villages, ethnically diverse towns and cities dependent on commercial fishing, and a well-developed offshore oil and gas industry along with its supporting infrastructure.

3.14.1 Gulf of Mexico

3.14.1.1 Sociocultural Systems

The counties along the U.S. coast of the GOM are home to a large and heterogeneous mix of cultures, subcultural groups, and populations. Within this region, the effects of the offshore oil and gas industry are felt most directly by populations residing within the coastal community commuting zone where industry-support facilities are located and the people who work at them reside (see Figure 3.14.1-1). Coastal cultures and populations include Hispanic enclaves in southern Texas, Acadian (Cajun) and Native American populations in the bayou country of southern Louisiana, Vietnamese communities along the coast of Texas, Louisiana, and Mississippi, and substantial Caucasian and African American populations (see tables and maps in Sections 3.10.1 and 3.15.1). Native American populations include the federally recognized (Table 3.14.1-1) and State-recognized tribes (Table 3.14.1-2). The metropolitan areas of the GOM coast are located in estuaries and are set back from the open coast. They have well-developed port facilities, with waterborne commerce playing an important role in their economies. Cities such as Houston and New Orleans and their surrounding suburban communities have served as destinations of opportunity and have attracted racially and ethnically diverse populations. However, many smaller communities maintain sociocultural environments that are less diverse, often supporting a single or small number of cultural groups in their most important activities. Beginning in the 1930s (and increasingly after World War II), coastal populations have been involved in the oil and gas industry to varying degrees.

Involvement in oil and gas industry activities has been uneven along the coast. Some areas are heavily involved, while other communities have little or no involvement. There is thus variability in the effects of the ups and downs of the industry's business cycle. However, there do appear to have been aggregate effects. These include rapid migration of workers in and out of communities, volatility in social problems, and volatility in income distribution patterns. Communities with dense social networks based on kinship, culture, and other enduring relationships are less affected by industry volatility (Tootle et al. 1999).

The most heavily affected areas are located within the states of Texas and Louisiana, where both upstream and downstream activities are concentrated. Beginning in the early 1930s, the oil industry attracted new workers to Louisiana, affecting the ethnic composition, self-identity, and cultural persistence of groups already in the area and contributing to a rich ethnic mix, as both the immigrants and receiving communities adjusted socially and culturally through the assimilation process. Industry development has also affected the identity of existing ethnic groups. Blue collar jobs in the oil and gas industry have helped to maintain the Cajun culture in Louisiana. However, involvement in the oil and gas industry has affected some aspects of certain cultures. For example, the discouragement of the use of Cajun French on oil rigs and supply boats has reduced the usage of this language in coastal Louisiana (Henry and Bankston 2002). While the oil and gas industry brought an increased exposure of the Cajun communities to a wider cultural mix and resulted in the adoption of some characteristics of broader American culture, the exposure to outsiders also reinforced behaviors held to be

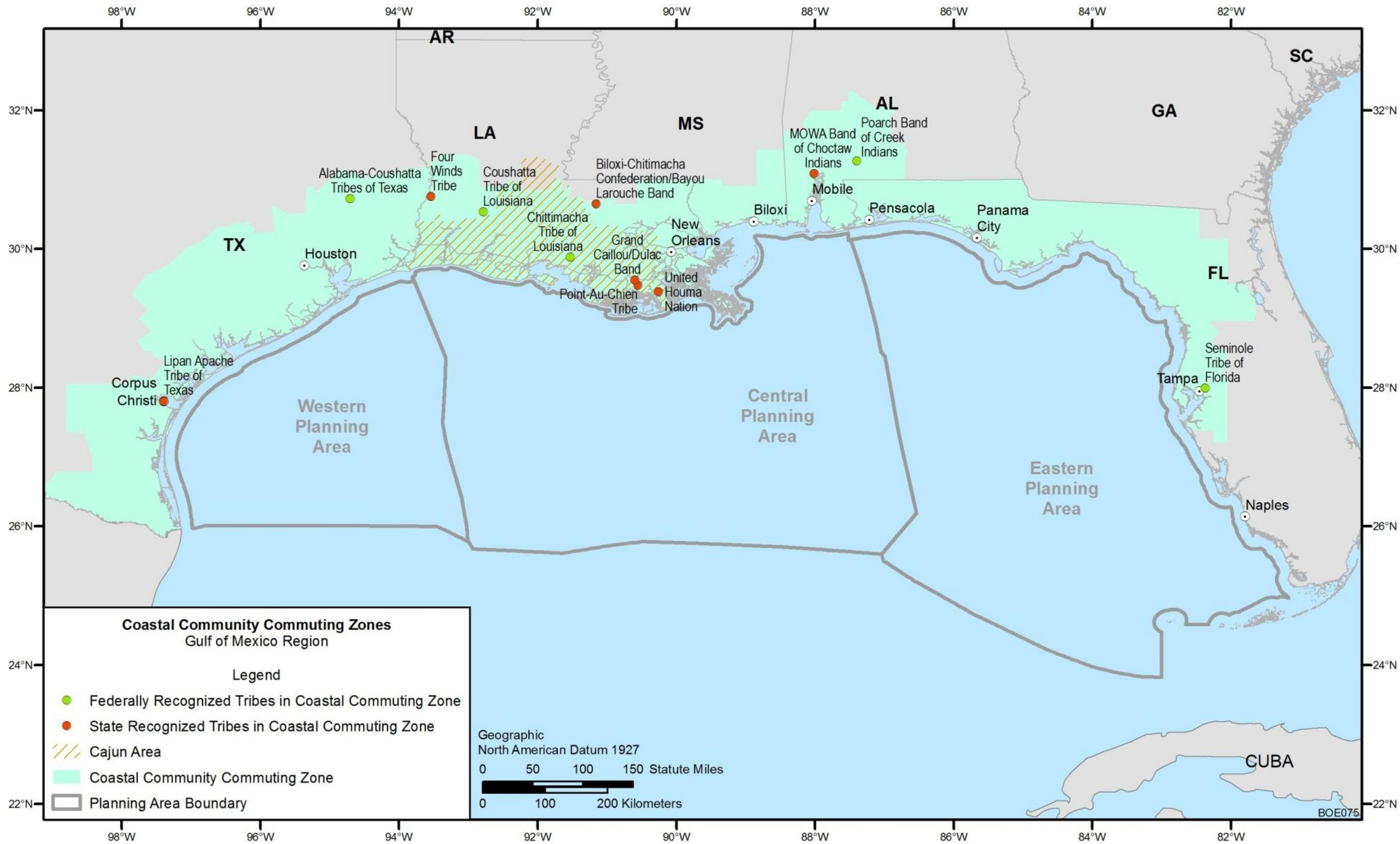

FIGURE 3.14.1-1 GOM Coastal Community Commuting Zone

TABLE 3.14.1-1 Federally Recognized Tribes in the Coastal Community Commuting Zone

State	County/Parish	Tribe
Alabama	Escambia	Poarch Band of Creek Indians
Florida	Escambia	Poarch Band of Creek Indians
Florida	Hillsborough	Seminole Tribe of Florida
Louisiana	Allen	Coushatta Tribe of Louisiana
Louisiana	St. Mary	Chittimacha Tribe of Louisiana
Texas	Polk	Alabama-Coushatta Tribes of Texas

Source: NPS 2010.

TABLE 3.14.1-2 State-Recognized Tribes in the Coastal Community Commuting Zone

State	County/Parish	Tribe
Alabama	Mobile	MOWA Band of Choctaw Indians
Louisiana	East Baton Rouge	Biloxi-Chitimacha Confederation/ Bayou Larouche Band
Louisiana	Vernon	Four Winds Tribe
Louisiana	Terrebonne	Point-Au-Chien Tribe
Louisiana	Lafourche	United Houma Nation
Louisiana	Terrebonne	Grand Caillou/Dulac Band
Texas	Nueces	Lipan Apache Tribe of Texas

Sources: AIAC 2011; FGCIA 2011; LATT 2009; LGOIA 2011.

characteristically Cajun, including festivals and the preparation of certain foods such as crawfish (Esman 1982).

3.14.1.2 Subsistence and Renewable Resource Harvesting

The coastal estuaries along the GOM have long provided a wealth of wild resources suitable for harvesting. While the bulk of the harvest currently comes in the form of commercial shrimping, fishing, and oystering, traditional subsistence harvesting including fishing and hunting continues among some ethnic groups and low-income minorities (Hemmerling and Colton 2004). In the words of Tim Melancon, a Cajun shrimper, "We're the last of the Mohicans. We still live off the land. Everything we need is right here" (Tidwell 2003). Although most Cajuns are now urban dwellers with blue collar jobs, the cultural ideal of harvesting the bounty of the bayous remains and is practiced recreationally (Henry and Bankston 2002). Native American groups such as the State-recognized United Houma Nation and the federally recognized Chittimacha Tribe in southern Louisiana depend on fishing, hunting, and gathering for at least part of their domestic subsistence (Brightman 2004; Campisi 2004). Despite being primarily commercial fishers, Vietnamese fishers normally retain up to 25% of their catch for family use and for barter (Alexander-Bloch 2010).

3.14.2 Alaska – Cook Inlet

3.14.2.1 Sociocultural Systems

The region surrounding the Cook Inlet Planning Area, referred to as south central Alaska, including both the southern portions of Cook Inlet and the Shelikof Strait, is quite diverse (Figure 3.14.2-1). It includes economically complex cities such as Anchorage and its suburbs, the largest urban community in the State; towns such as Kenai, Soldotna, and Nikiski that are centers of the oil and gas industry, on the Kenai Peninsula, as well as commercial fishing; smaller towns such as Port Lions that are dependent on commercial fishing; and small, predominantly Alaska Native communities. The northern Knik Arm of Cook Inlet extends into the Borough of Matanuska-Susitna (Mat-Su), which includes both urban communities tied to Anchorage and remote rural settlements. Subsistence harvesting plays some role in communities of all types.

Anchorage is the major service center for the area. It is located between the Knik and Turnagain Arms of upper Cook Inlet northeast of the Cook Inlet Planning Area. Oil and Gas activities in the Cook Inlet Planning Area would affect Anchorage to the extent that they affect the waters of the upper inlet and the oil and gas companies located there. It is the center of the local road network and serves as a hub for scheduled and charter air traffic. Although majority Caucasian, it is home to significant Alaska Native, Asian, Black, and Hispanic populations. It is the center of commerce for the State, serving as the headquarters for the oil and gas industry, finance and real estate, communications, government offices, and military facilities, as well as much of the tourist industry (DCRA 2011). In spite of its urban character, the Anchorage community partakes in Alaskan values of independence and accessibility to the wild and remote. The ADF&G estimates that 34 Anchorage households currently participate in subsistence harvesting (ADFG 2011e).

Lying north of Anchorage, the Mat-Su Borough, although including the northern reach of Knik Arm, is farther from the Cook Inlet Planning Area. Activities in the planning area would affect Mat-Su communities in much the same way as they would the Anchorage area. Palmer and Wasilla are major Mat-Su communities. Connected to Anchorage by the road network, they serve partly as bedroom communities for Anchorage, but also are home to a variety of retail, service, and light manufacturing enterprises. Seventy-seven Palmer residents have commercial fishing permits and would be affected by oil and gas activities in Cook Inlet (DCRA 2011). The ADF&G has tracked subsistence use in four Mat-Su communities. Subsistence harvest includes marine resources (ADFG 2011e), indicating that subsistence users are harvesting in areas beyond the upper inlet, very likely within the planning area.

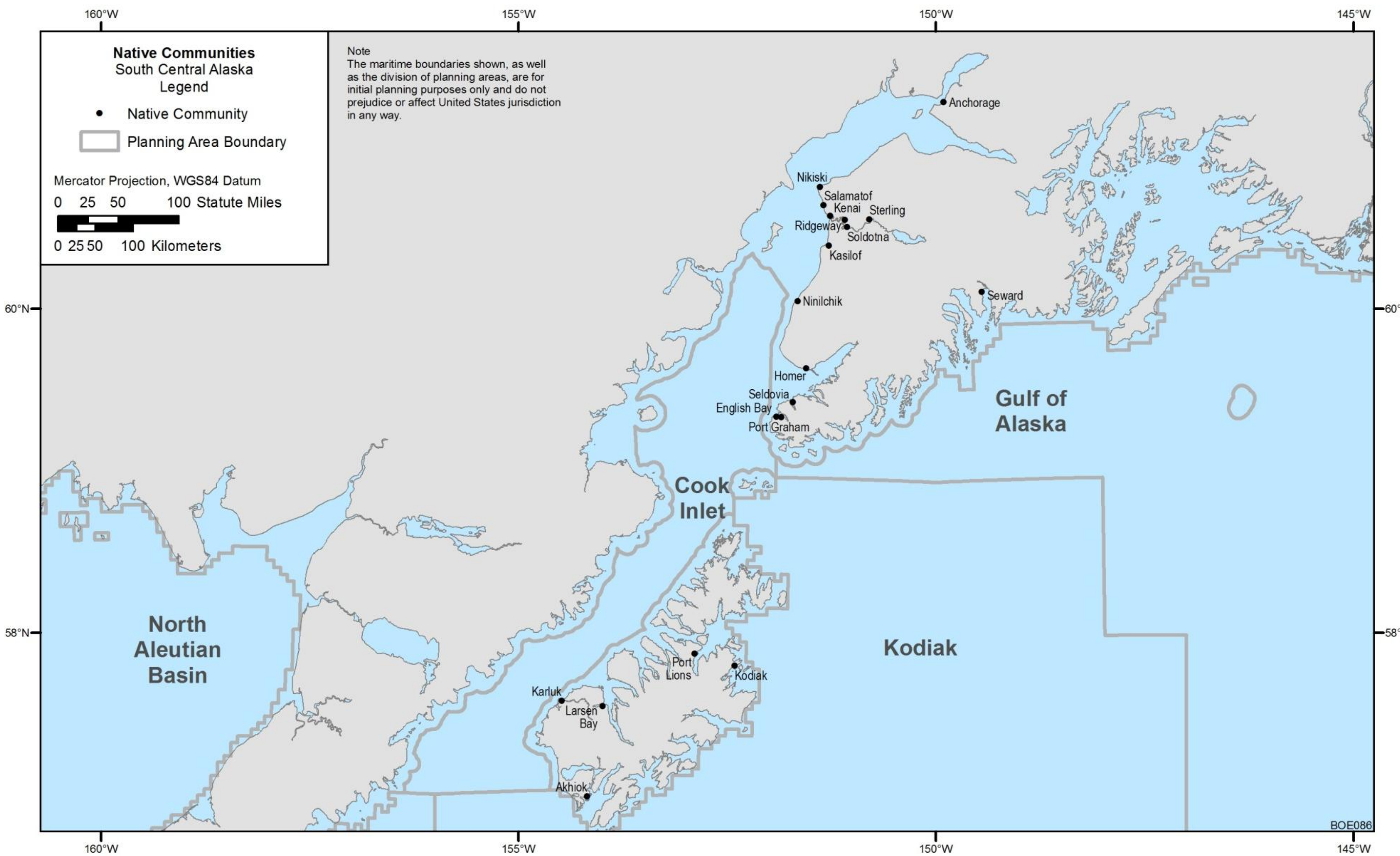

FIGURE 3.14.2-1 Native Communities around Cook Inlet

The Kenai Peninsula forms the southeastern coast of Cook Inlet with direct access to the Cook Inlet Planning Area from its southern end. The Kenai-Soldota area (Kenai, Soldotna, Nikiski, Sterling, Ridgeway, and Kasilof) serves as a diversified center for the central Kenai Peninsula. Homer serves as a smaller-scale hub for the southern part of the peninsula. All communities on the peninsula except those lying south of Katchemak Bay are connected to Anchorage by a road network. Most communities are of mixed ethnicity or predominantly non-Native. Small communities that are not connected to the road network include Tyonek, Nanwalek, Port Graham, and Seldovia. These four communities share many of the same characteristics as communities in the less economically developed areas of the State. All but Seldovia are predominantly Alaska Native with limited commercial economic activities primarily related to fishing and fish processing. Tyonek is a Dena'ina village, while Nanwalek and Port Graham are Chugachmuit. In these communities, subsistence activities retain significant importance and reinforce their fundamental kin-based social organization.

The Cook Inlet Planning Area extends southwest beyond Cook Inlet proper and includes the heart of the Shelikof Strait. The Shelikof Strait lies between Kodiak Island and the Alaska Peninsula. The small communities along the northwestern coast of Kodiak Island, Ahiok, Karluk, Larsen Bay, and Port Lions are reachable only by sea and by air. Similar to the small isolated communities on the Kenai Peninsula, they have a high proportion of Alaska Native inhabitants and rely mostly on commercial fishing and subsistence harvesting (DCRA 2011). Given their reliance on marine resources, these communities have the potential to be directly affected by oil and gas development in the Cook Inlet Planning Area.

At the time of European contact, the area around Cook Inlet was inhabited by Dena'ina Athabascans. The southern end of the Kenai Peninsula was inhabited by the Chugachmuit, while Kodiak Island and the southwestern shores of the inlet were inhabited by Koniagmiut. The area covered by Cook Inlet Region, Inc. (CIRI), a regional Alaska Native corporation established under the ANCSA, closely follows traditional Dena'ina lands, but draws its membership from a cross section of Native cultures whose descendants now live in the Anchorage metropolitan area. Native lands on the southern end of the Kenai Peninsula are now part of the Chugachmuit Alaska regional Alaska Native corporation, while the Native communities along the Shelikof Strait are part of the Koniag, Inc. or Bristol Bay regional Native corporations. Table 3.14.2-1 lists south central Alaska communities with Alaska Native populations (Davis 1984).

3.14.2.2 Subsistence

Alaskans generally place a high value on being able to hunt, fish, and to live off the land, if desired. The Alaska Constitution guarantees equal access to fish, wildlife, and waters for all State residents. Traditionally Alaska Natives hunted, fished, and lived off the land of necessity. They view subsistence hunting and gathering as a core value of their traditional cultures. For them, most subsistence activities are group activities that further core values of community, kinship, cooperation, and reciprocity. In Alaska, State and Federal definitions of subsistence and who is permitted to participate in the subsistence harvest differ. The ADF&G defines subsistence fishing as "the taking of, fishing for, or possession of fish, shellfish or other fisheries resources by a resident of the State for subsistence uses [customary and traditional uses of fish]"

TABLE 3.14.2-1 Alaska Natives in Communities around the Cook Inlet

Community	Population (2010)	Percent Native	Local Native Corporation	Federally Recognized Tribal Government	Incorporated?
Cook Inlet Region Inc.					
Anchorage	291,826	8	None	None	1920
Big Lake	529	23	None	None	No
Chickaloon	272	6	Chickaloon-Moose Creek Native Association	Chickalonn Native Village	
Eklutna	384	13	Eklutna, Inc.	Native Village of Eklutna	No
Fishhook	4,679	4	None	None	No
Glacier View	234	1	None	None	No
Houston	1,912	7	None	None	1966
Kenai	7,100	9	Kenai Natives Association, Inc.	Kenaitze Indian Tribe	1960
Knik Fairview	14,923	5	Knikatnu, Inc.	Knik Tribal Council	No
Knik River	744	4	None	None	No
Lake Louise	48	2	None	None	No
Ninilchik	883	5	Ninilchik Native Association, Inc.	Ninilchik Traditional Council	No
Palmer	5,937	9	Montana Creek Native Association		
Point Mackenzie	529	23	None	None	No
Salamatof	980	18	Salamatof Native Association, Inc.	Native Village of Salamatof	No
Seldovia	255	14	Seldovia Native Association, Inc.	Seldovia Village Tribe	1945
Trapper Creek	481	6	None	None	No
Tyonek	171	88	Tyonek Native Corp.	Native Village of Tyonek	No
Wasilla	7,831	5			1951
Chugach Alaska Corp.					
Nanwalek	254	80	English Bay Corporation	Native Village of Nanwalek	No
Port Graham	177	71	Port Graham Corp.	Native Village of Port Graham	No
Koniag Inc.					
Akhiok	71	51	Ayakulik Inc.	Native Village of Ahiok	
Karluk	37	95	None	Native Village of Karluk	
Larsen Bay	87	71	None	Native Village of Larsen Bay	
Port Lions	194	59	Afognak Native Corp.	Native Village of Port Lion	

Source: DCRA 2011.

(ADFG 2011f). Current Federal regulations define subsistence use as "the customary and traditional use by rural Alaska residents of wild, renewable resources for direct personal or family consumption as food, shelter, fuel, clothing, tools of transportation; for making and selling handicraft articles out of nonedible byproducts of fish and wildlife resources taken for personal or family consumption; for barter, or sharing for personal or family consumption; and for customary trade" (FSMP 2010). The State definition makes subsistence harvesting available to all Alaska residents, while Federal land managers restrict the harvest to those whose primary residence is rural, and may restrict a particular harvest area to a specified community or group of communities. The entire State is defined as rural except for designated non-rural areas (FSMP 2011). Priority for subsistence harvesting in land management is expressed in the ANILCA, passed by Congress in 1980. Similar State legislation was struck down as violating the State Constitution. ANILCA now applies only to Federal lands. Both approaches to subsistence are represented in south central Alaska.

Subsistence resources on Federal lands and waters are managed by the Federal Subsistence Board (FSB). For some resources in certain areas, the FSB has determined that all rural Alaskans are qualified subsistence users. For other areas, the FSB has made more restrictive "customary and traditional" determinations of eligibility. For example, only the communities of Copper Landing, Hope, and Ninilchik may harvest salmon with dipnets in the Kenai River drainage. *Customary and traditional use* means "a long-established, consistent pattern of use, incorporating beliefs and customs transmitted from generation to generation. This use plays an important role in the economy of the community" (FSMP 2011)

Some marine resources are subject to Federal regulation. Subsistence hunting of marine mammals is governed by the MMPA, and is restricted to Alaska Natives who reside on the coast of the North Pacific Ocean or the Arctic Ocean. Halibut may be harvested by residents of rural communities through the Federal subsistence halibut program (ADFG 2011f).

While the State of Alaska makes regulated subsistence harvesting available to all residents of at least a year, it also designates some areas as nonsubsistence use areas. Alaska statutes define nonsubsistence use areas as "areas where dependence upon subsistence (customary and traditional uses of fish and wildlife) is not a principal characteristic of economy culture and way of life" (AS 16.05.258(c)). In south central Alaska, the Anchorage-Mat-Su-Kenai Nonsubsistence Use Area includes FSB-designated non-rural areas in Anchorage, the Mat-Su Borough, and on the Kenai Peninsula. The State does allow "personal use" fisheries within nonsubsistence use areas. Alaska defines "personal use" fishing as "the taking, fishing for, or possession of finfish, shellfish, or other fishery resources, by Alaska residents for personal use and not for sale or barter, with gill or dip net, seine, fish wheel, long line, or other means defined by the Board of Fisheries" (ADFG 2011f). Personal use harvest is for food rather than sport. It is illegal to buy, sell, trade or barter personal use finfish, shellfish, or aquatic plants.

A discussion of subsistence in and around the Cook Inlet Planning Area must take into account, both Native and non-Native populations, urban and rural communities, Federal and State jurisdiction; and the Anchorage-Mat-Su-Kanai Nonsubsistence Use Area, and personal use fisheries. The Anchorage-Mat-Su-Kanai Nonsubsistence Use Area includes all but the southern tip of the Kenai Peninsula, State waters within Cook Inlet, and Anchorage and its suburbs and extends northward into Mat-Su Borough as far as Chickaloon, Talkeetna, and Petersville. Although subsistence harvesting is excluded from this area, personal use fishing does provide opportunities for harvesting fish with gear other than rod and reel within nonsubsistence areas at designated locations and seasons. These include a salmon fishery off the mouth of the Kenai River, a razor clam fishery on the beaches between Homer and Kenai, and a hooligan and herring fishery in Cook Inlet (ADFG 2011f). The urban Anchorage area is home to 42% of the State's population. Its residents hunt and fish under personal use, sport, and subsistence regulations in other parts of the area, especially the Kenai Peninsula.

These hunting and fishing options are available to Alaska residents living in Mat-Su as well. The small Caucasian community of Chase, located just outside the nonsubsistence area, relies almost entirely on subsistence harvesting and gardening, and Trappers Creek with a small Native population, relies substantially on subsistence harvesting as well (DCRA 2011) (see Table 3.14.2-1). The most recent subsistence harvest data for Mat-Su communities dates to the 1980s (Table 3.14.2-2). While the bulk of the harvested species reported are terrestrial species or anadromous fish, subsistence harvesters were taking marine finfish and shellfish as well, suggesting that the effects of gas and oil activities in the Cook Inlet Planning Area would not be confined to communities directly on the coast.

In the predominantly Alaska Native communities (Table 3.14.2-1) adjacent to the planning area — Port Graham, Nanwelek, Tyonek, Akhiok, Karluk, Larsen Bay, and Port Lions — subsistence resources are an important part of household economy in terms of variety, amount, and sharing (see Table 3.14.2-3). The communities connected to the road network are of mixed ethnicity or predominantly non-Native and display somewhat different patterns of subsistence resource use.

Many species, often migratory species, play an important role in the annual cycle of subsistence-resource harvests. Thus, specific effects on subsistence can be serious, depending on the season in which they occur, seasonally specific effects on subsistence can be serious, even if the annual net quantity of available food does not decline. Subsistence use patterns vary considerably in and adjacent to the the Cook Inlet Planning Area. Smaller, more traditional villages harvest salt and freshwater fishes and small sea mammals in summer and fall, hunt moose in the fall, and harvest invertebrates and some sea mammals all year. Residents in the more urban-based communities tend to fish in the summer and hunt in the fall.

Where Alaska Natives are located in urban areas, such as the Kenaitze Indian Tribe, located in Kenai, a yearly Educational Fishery Permit has been issued so that they can instruct the younger generation in traditional food harvesting and preparation skills. In 2008, a quota of 8,000 salmon was allotted to the Kenaitze Tribe during a season lasting from May 1 to November 30 (Kenaitze Indian Tribe 2011). In 2010, due to low escapement numbers in the Ninilchik River, the Ninilchik Village Tribe was allotted 100 king salmon and 200 coho salmon during an educational fishery season lasting from May 1 through May 20 (NTC 2010).

TABLE 3.14.2-2 Reported Subsistence Use at Mat-Su Borough Communities

Resource	Scientific Name	Chase 1986	Chickaloon 1982	Lake Louise 1987	Trapper Creek 1985
Marine Mammals		–	–	–	–
Terrestrial Mammals					
Deer	Species not reported	X	–	X	–
Bison	*Bison bison*	–	X		X
Dall Sheep	*Ovis dalli*	X	–	–	–
Moose	*Alces alces*	X	X	X	X
Brown Bear	*Ursus arctos*	X	–	X	–
Black bear	*Ursus americanus*	X	X	X	X
Fox	Species not reported	X	X	X	X
Wolf	*Canis lupus*	X	–	X	–
Coyote	*Canis latrans*	X	X	–	–
Wolverine	*Gulo gulo*	X	–	–	–
Porcupine	*Erethizon dorsatum*	X	X	–	X
Beaver	*Castor Canadensis*	X	X	–	X
Marten	*Martes* spp.	X	X	X	X
Mink	Species not reported	X	–	X	X
Weasel	Species not reported	X	–	X	–
Hare	Species not reported	X	X	–	X
Land otter	*Lutra canadensis*	X	–	–	–
Muskrat	*Ondatra zibethicus*	–	X	–	–
Fish					
Salmon	Species not reported	X	X	X	X
Chum	*Oncorhynchus keta*	X	–	–	X
Pink (humpback)	*O. gorbuscha*	X	X	–	X
Silver (coho)	*O. kisutch*	X	X	X	X
Chinook	*O. tshawytscha*	X	X	X	X
Sockeye	*O. nerka*	X	X	X	X
Herring	*Clupea* spp.	X	–	–	–
Halibut	*Hippoglosus* spp.	X	–	X	X
Dolly varden	*Salverlinus mallma miyabei*	X	X	–	–
Char	Species not reported	X	–	X	–
Rock fish	Species not reported	–	–	X	–
Trout	Species not reported	X	X	–	X
Lake trout	*Salvelinus namaycush*	X	X	X	–
Smelt	Species not reported	X	X	–	–
Pacific cod	*Gadus macrocephalus*	–	–	–	X
Burbot	*Lota lota*	X	X	X	–
Pike	Species not reported	–	–	X	–
Grayling	*Thymallus arcticus*	X	X	X	X
Greenling	Species not reported	–	X	–	–
White fish	*Coregonus* spp.	X	–	X	X
Eulachon	*Thaleichthys pacificus*	X	X	–	–

TABLE 3.14.2-2 (Cont.)

Resource	Scientific Name	Chase 1986	Chickaloon 1982	Lake Louise 1987	Trapper Creek 1985
Marine Invertebrates					
Mussels	Species not reported	–	–	–	X
Clams	Species not reported	X	–	–	X
Crab	Species not reported	X	–	–	–
Shrimp	Species not reported	X	–	–	–
Birds		X	X	X	X
Ducks	Species not reported	X	X	X	X
Mallard	*Anas platyrhynchos*	–	X	–	–
Geese	Species not reported	X	–	–	–
Ptarmigan	*Lagopus* spp.	X	X	X	X
Grouse	Species not reported	X	X	X	X
Other Resources					
Berries	Species not reported	X	X	X	X
Greens/roots/mushrooms	Species not reported	X	X	X	X
Wood	Species not reported	X	–	X	–

Source: ADFG 2011e.

Residents of Seldovia, Port Graham, and Nanwalek are the primary subsistence harvesters of the lower Kenai Peninsula, and, since the *Exxon Valdez* oil spill fouled local traditional clamming areas, residents of Nanwalek and Port Graham have used the area around Ninilchik for the harvest of clams. Subsistence harvesting of fish, wildlife, and vegetation also occurs at the head and along the southern shore of Kachemak Bay. Area residents harvest seals, sea lions, and sea otters around Yukon Island and Tutka Bay. Primary waterfowl harvest areas are in the vicinity of Seldovia, Tutka, and China Poot Bays and McKeon and Fox River flats. Seabirds and their eggs also are harvested. Moose, black bear, and mountain goats are hunted along local shorelines. Port Graham and Nanwalek residents harvest salmon in Nanwalek and Koyuktolik (“Dogfish”) Bays. Seldovians gather berries in larger quantities than any of the other Kenai Peninsula subsistence communities (ADNR 1999).

Resources preferred by Nanwalek and Port Graham residents include clams, chitons, bear, and especially salmon. These provide large quantities of food during a short period of the year and also are preserved for use throughout the remainder of the year. A combination of commercial, subsistence, personal use, and rod-and-reel fisheries provide salmon for domestic use. Residents of Nanwalek and Port Graham participate in permitted general subsistence and personal-use fisheries that have existed in upper Cook Inlet since 1991 and are open to Natives and non-Natives. Dipnet fisheries take place on the Kenai and Kasilof Rivers and on Fish Creek. A set gillnet fishery takes place on the Kasilof River beginning June 21. In addition, a general

1 **TABLE 3.14.2-3 Reported Subsistence Use at Selected Alaska Native Villages Adjacent to the**
2 **Cook Inlet Planning Area**

Resource	Scientific Name	Nanwalek 2003	Port Graham 2003	Tyonek 2006	Akhiok 2003	Larsen Bay 2003	Poort Lions 2003
Marine Mammals							
Harbor seal	*Phoca vitulina*	X[a]	X	X	X	X	X
Steller sea lion	*Eumetopias jubatus*	X	X	X	X	—	—
Beluga whale	*Delphinapterus leucas*	—[a]	—	X	—	—	—
Bowhead whale	*Balaena mysticetus*	—	—	X	—	—	—
Sea otter	*Enhydra lutris*	X	X	—	—	—	X
Terrestrial Mammals							
Deer	Species not reported	—	X	X	X	X	X
Moose	*Alces alces*	—	X	X	—	—	X
Elk	*Cervus canadensis*	—	—	—	—	—	X
Black bear	*Ursus americanus*	X	X	X	—	—	—
Fox	Species not reported	—	—	X	—	—	X
Porcupine	*Erethizon dorsatum*	X	X	X	—	—	—
Beaver	*Castor Canadensis*	—	—	X	—	—	X
Coyote	*Canis latrans*	—	—	X	—	—	—
Snowshoe hare	*Lepus americanus*	—	—	—	—	X	X
Fish							
Salmon	Species not reported	X	X	X	X	X	X
Chum	*Oncorhynchus keta*	X	X	X	X	X	X
Pink (humpback)	*O. gorbuscha*	X	X	X	X	X	X
Silver (coho)	*O. kisutch*	X	X	X	X	X	X
Chinook	*O. tshawytscha*	X	X	X	—	—	—
Sockeye	*O. nerka*	X	X	X	X	X	X
Steelhead	*O. mykiss*	—	—	—	—	X	X
Herring	*Clupea* spp.	—	X	X	—	X	X
Halibut	*Hippoglosus* spp.	X	X	X	X	X	X
Dolly varden	*Salverlinus mallma miyabei*	X	X	X	X	X	X
Char	Species not reported	X	X	X	X	X	X
Rock fish	Species not reported	X	X	—	X	X	X
Sculpin	Species not reported	X	—	—	—	—	—
Trout	Species not reported	X	—	X	—	X	X
Smelt	Species not reported	X	X	X	—	—	—
Pacific cod	*Gadus macrocephalus*	X	X	—	X	X	X
Tomcod	*Eleginus gracilis*	X	X	X	—	—	—
Flounder	*Liopsetta glacialis*	X	X	—	—	—	X
Eel	Species not reported	X	X	—	—	—	—
Walleye Pollock	*Theragra chalcogramma*	—	—	—	—	—	X
Greenling	Species not reported	—	—	—	—	—	X
Shark	Species not reported	—	—	—	—	—	X
Sole	*Hippoglossoides elassodon*	—	—	—	—	—	X

TABLE 3.14.2-3 (Cont.)

Resource	Scientific Name	Nanwalek 2003	Port Graham 2003	Tyonek 2006	Akhiok 2003	Larsen Bay 2003	Poort Lions 2003
Marine Invertebrates							
Chitons	Species not reported	X	X	—	X	—	—
Limpets	Species not reported	X	—	—	—	—	—
Mussels	Species not reported	X	X	—	—	—	X
Clams	Species not reported	X	X	X	X	X	X
Oysters	Species not reported	—	X	—	—	—	—
Snails	Species not reported	X	X	—	—	X	—
Crab	Species not reported	X	—	—	X	X	X
Shrimp	Species not reported	X	—	—	—	—	—
Cockles	Species not reported	—	—	—	X	—	—
Sea urchins	Species not reported	—	—	—	X	—	X
Octopus	Species not reported	X	X	—	—	—	—
Birds							
Ducks	Species not reported	X	X	X	X	X	X
Mallard	*Anas platyrhynchos*	X	X	X	X	X	X
Pintail	*Anas acuta*	—	—	X	—	—	—
Canvasback	*Aythya valisineria*	—	—	X	—	—	—
Eider	*Somerteria* spp.	—	—	—	—	—	X
Bufflehead	*Bucephala albeola*	—	—	—	—	—	X
Gadwall	*Anas strepera*	—	—	—	—	—	X
Harlequin	*Histrionicus histrionicus*	—	—	—	—	—	X
Green-winged teal	*Anas carolinensis*	—	—	X	X	—	X
Scoter	Species not reported	X	X	—	—	—	X
Merganser	*Mergus merganser*	—	X	—	—	—	X
Goldeneye	*Bucephala* spp.	—	X	—	X	X	X
Snow goose	*Chen caerulescens*	—	—	X	—	—	—
Canada goose	*Branta canadensis*	—	—	X	—	—	X
Emperor goose	*Chen canagica*	—	—	—	X	—	—
Sandhill crane	*Grus canadensis*	—	—	X	—	—	—
Ptarmigan	*Lagopus* spp.	—	—	X	X	—	X
Grouse	Species not reported	X	X	X	—	—	—
Gulls	Species not reported	X	—	—	—	—	—
Other Resources							
Kelp	Species not reported	X	X	—	—	—	X
Berries	Species not reported	X	X	X	X	X	X
Bird eggs	Species not reported	X	X	X	X	X	X
Gull eggs	Species not reported	X	X	X	X	X	X
Greens/roots/mushrooms	Species not reported	X	X	X	X	X	X
Wood	Species not reported	X	X	X	X	X	X

[a] X = Reported; — = Not reported.

Source: ADFG 2011e.

Kachemak Bay subsistence and personal-use salmon fishery has taken place since before statehood. This fishery uses Fox River drainage salmon runs and hatchery stocks returning to the fishing lagoon on Homer Spit and to Fox Creek (ADNR 1999).

Other resources such as trout, cod, halibut, chitons, snails, whelks, and crabs are used fresh in season. Harbor seals and sea lions are highly valued marine mammals, are harvested by local Alaska Native residents year-round, and are extensively shared by the Alaska Natives in any community. A variety of plants also are harvested in Kachemak Bay and Cook Inlet. Bull kelp, rockweed, and brown seaweeds are collected from intertidal areas, and shoreline areas provide seaside plantain, rye grass, beach pea, wild parsley, and cow parsnip. Seldovia, Kasitsna, and Jakolof Bays are important areas for the harvest of marine invertebrates.

The Native villages on Kodiak Island rely on a varying mix of commercial fishing, fish processing, tourism, and subsistence harvesting. While the extent to which they rely on subsistence varies, all of these villages rely on subsistence harvesting to a greater or lesser degree. Salmon and halibut are subsistence mainstays, as are seals and migrating birds along with invertebrates such as clams and crabs (Table 3.14.2-3) (DCRA 2011).

Often overlooked, gardening has been part of village subsistence life since Russian times. Potatoes, cabbage, and turnips were brought to the Kenai Peninsula by Russian settlers who planted gardens due to the need for fresh vegetables (Fall 1981). A variety of local wild berries are picked, particularly low- and high-bush cranberries, rosehips, blueberries, moss berries, and wild raspberries. Locally harvested subsistence foods are distributed widely among community households.

Tyonek, on the west side of Cook Inlet, has a subsistence harvest area that extends from the Susitna River south to Tuxedni Bay; harvests concentrate in areas west and south of Tyonek. Moose and salmon are the most important subsistence resources, although important components of the harvest include non-salmon fishes such as smelt, waterfowl, and clams (ADNR 1999). In the past, the subsistence use of beluga in Cook Inlet was traditionally important to the village of Tyonek. Declines in the beluga population have led Cook Inlet beluga stock to be classified as depleted under the MMPA and endangered under the ESA (see Section 3.8.1.2.1) In 1999 and 2000, Federal laws established a moratorium on beluga whale harvests except for subsistence hunts under cooperative agreements between the NMFS and affected Alaska Native organizations. Co-management agreements between NMFS and the Cook Inlet Marine Mammal Council representing Native subsistence hunters were signed for 2000–2003 and 2005–2006. Two belugas were harvested from Cook Inlet as recently as 2005. Currently, harvest limits are determined in 5-yr increments based on the average beluga population over the preceding 5 yr and the population growth rate over the previous 10 yr. When that average falls below 350, no harvest is allowed. Since the 2003–2007 average abundance was below 350, there is no allowable beluga harvest for the years 2008–2012 (Allen and Angliss 2011). In April of 2011, the NMFS designated upper Cook Inlet, Katchemak Bay, and the eastern coastal waters of lower Cook Inlet as critical habitat for beluga whales. The taking of belugas in these waters is prohibited (76 FR 69:20180–20194).

3.14.3 Alaska – Arctic

3.14.3.1 Sociocultural Systems

Since the planning areas under consideration here are for the most part located adjacent to sparsely populated rural areas that are largely inhabited by indigenous Alaskans, this section focuses on Alaska Native sociocultural systems, although non-Native populations are considered as well. Unlike many of the indigenous populations in the lower 48 States, Alaskan Natives continue to occupy and use their traditional lands. They maintain many traditions with respect to social organization and cultural values. Among the most prized values retained are those placed on social cohesion and group activities expressed in subsistence harvesting of wildlife and plant resources. Alaska Natives have been able to maintain these values partly because of the interaction between ecological possibilities, history of contact with non-Natives, and a commitment to retaining their culture and identity. The sociocultural systems of modern Alaska Natives have been modified to some extent from those existing prior to Euro-American contact; however, much of the earlier systems survive, resulting in modern sociocultural systems that to various degrees blend traditional and Euro-American characteristics.

Native populations in Alaska are involved in a complex network of institutions, unique to Native populations in the United States, that have allowed them to retain or regain control over much of their traditional homelands and modify western institutions of government and business to further traditional values. These include municipal governments, tribal councils, and regional and local ANSCA Native village and regional corporations, as well as non-governmental organizations (NGOs) such as the Alaska Federation of Natives (AFN) and the Alaska Eskimo Whaling Commission (AEWC). Under the terms of the Alaska Statehood Act (P.L. 85-508), the State of Alaska and Alaska Natives were allowed to select Federal lands as their own. In most cases, lands selected by the State were also claimed by Natives. The ANCSA, passed by Congress in 1971, authorized Alaska Natives to select 18 million ha (44 million ac) of their traditional lands in fee title and in exchange for extinguishing claims to the remainder of the State in return for compensation. Under ANCSA, titles to the lands were given to 12 regional for-profit corporations and more than 200 village corporations that could be organized on either a non-profit or for-profit basis. Corporation shares were divided among Alaska Natives. In most cases, village corporations hold title to the surface estate while the regional corporations hold title to the subsurface estate. Despite initial concerns that Native cultural values would be enveloped by American corporate culture and that they could eventually lose control of their corporations and corporation lands, Alaska Natives have modified corporate culture to support traditional cultural values including sharing and subsistence (ASRC 2011). To make it more likely that Natives will maintain control of their corporations in the future, ANSCA was modified in 1987 to allow corporations to allocate shares to the younger generation not covered under the original Act and to restrict share ownership to Alaska Natives.

Given these multiple layers of jurisdiction and control, a Native community might be governed by a local municipal government, a wider borough government, and a local and regional tribal council. The land surface might be owned and administered by a village corporation while subsurface resources would be under the control of a regional corporation.

The multiple concerned institutions do not always see eye to eye, and there is some tension between successful and less profitable corporations (Zellen 2008).

This section discusses the regional and community systems found on Alaska's North Slope and Northwest Arctic Borough (NWAB) (Figure 3.14.3-1) that could be affected by future oil and gas activities on the Arctic OCS. Most directly affected would be the communities lying along the shore of the Beaufort and Chukchi Sea Planning Areas are part of the North Slope Borough (NSB). These include the predominantly Alaska Native communities of Kaktovik, Nuiqsut, Barrow, Wainwright, Point Lay, and Point Hope, as well as the unincorporated community of Deadhorse that serves primarily to house as many as 5,000 transient workers in the nearby Prudhoe Bay oil fields. NWAB communities along the Bering Sea, (Kivalina, those near Kotzebue, Buckland, and Deering) would be less directly affected.

North Slope

Barrow is the largest permanent community on the North Slope and serves as the administrative and commercial hub of the region. At the 2010 Census, the population of the NSB was 9,430, almost 54% of which are Alaska Natives (USCB 2011c). These Alaska Natives living in the communities lying along the shore of the Chukchi and Beaufort Sea Planning Areas are primarily Iñupiaq Eskimo whose traditional culture is based on cooperation, kinship ties, and subsistence hunting and gathering. In particular, traditional coastal North Slope cultures are specially adapted to whaling (Spencer 1984).

Traditionally, the Iñupiat occupied small, independent, kin-based communities or camps dispersed across the North Slope. Communities were situated to take seasonal advantage of subsistence resources. Not all Iñupiat communities practiced whaling, but most were tied to whaling through ties of kinship and trade. For the most part, Iñupiat subsistence activities and whaling in particular were and continue to be group activities requiring cooperative efforts (SRBA 2010). Whaling crews, comprised of those pursuing whales on the water and their support teams on shore or ice, bound the society together (Spencer 1984; Burch 2006).

The presence of Yankee commercial whalers in the in the mid- to late nineteenth century (Bockstoce 1995) prompted Iñupiat settlement patterns to begin to change. The desire for Western trade goods drew an increasing number of Alaska Natives to the coast, where permanent communities remain today. In spite of significant population loss resulting from exposure to European disease, the Iñupiat were slowly drawn into the world economy (Chance 1984; Spencer 1984). Even after Alaska was organized as a U.S. territory, Alaska Natives outnumbered immigrants from the south until the military buildup during World War II. Communities on the arctic coast remained relatively isolated from Western culture. Western influence increased when many Alaska Natives served in the Alaskan Territorial Guard, and as a result of the military buildup on the North Slope during the Cold War, the construction of the Distant Early Warning (DEW) Line and the White Alice communication network, and the establishment of the Naval Arctic Research Laboratory (NARL) at Barrow in 1947. This military presence on the North Slope increased the exposure of the Iñupiat to industrialized Euro-American culture. Exposure to industrialization was significantly increased by the discovery of the Prudhoe Bay oil fields in 1967 and the construction of the TAPS along with the construction

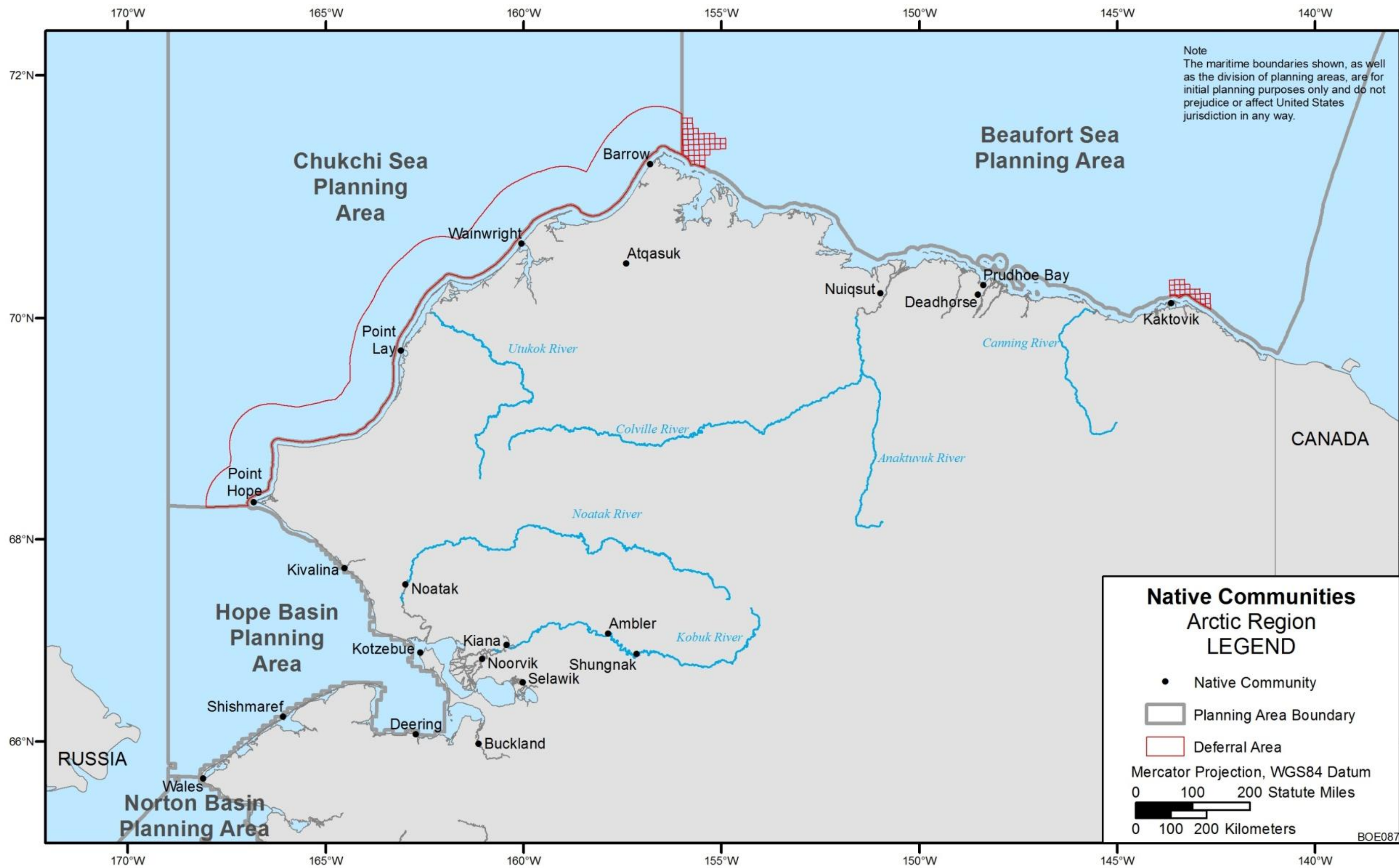

FIGURE 3.14.3-1 Native Communities around the Arctic Region

of the Dalton Highway connecting the North Slope to the south. The increasing presence of modern American culture has stressed traditional Native culture, yet the Iñupiat have managed to remain in and retain control over much of their traditional homeland. They have successfully incorporated modern technology into their subsistence way of life. Rifles and whale bombs have replaced spears and harpoons, aluminum skiffs are employed along with seal-skin boats (*umiat*) in the whale hunt, whaling crews use electronic global positioning and communication devices in the hunt, and snow machines and all-terrain vehicles (ATVs) have replaced dog teams and sleds (Roderick 2010; SRBA 2010). With increasing local control of land and resources has come a resurgence of traditional culture, as local and regional corporations and governments have supported the preservation of traditional languages and culture, and teaching of traditional values to the rising generation (Zellen 2008).

Local control has been increased through adaptation of Western business and governmental institutions to local values and needs. The municipal government of the NSB, established in 1972, is dominated by Alaska Natives. With ample resources from the taxation of the developing energy industry in the region, the NSB has been able to make marked improvements in municipal services and education. The Arctic Slope Regional Corporation (ASRC) is the regional corporation covering the arctic coast. It is one of the more profitable regional corporations. It receives and distributes royalties from the development of mineral resources on Native lands. Half of the Alpine Oil Field lies on ASRC lands. ASRC has extended membership to Iñupiat born after 1971 and encourages the preservation and transmission of traditional Iñupiat values including the maintenance of subsistence resources (ASRC 2011). As shown in Table 3.14.3-1, each Iñupiat village is subject to multiple jurisdictions. Village corporations own the surface lands and further Iñupiat business interests.

TABLE 3.14.3-1 Coastal North Slope Alaska Native Communities

Community	Population (2010)	Percent Alaska Native	Native Corporation	Federally Recognized Tribal Government	State Incorporated Municipality?
Atqasuk	233	92	Atqasuk Village Corp.	Native Village of Atqasuk	Yes 1982
Barrow	4,212	61	Ukpeagvik Iñupiat Corp.	Native Village of Barrow	Yes 1959
Kaktovik	239	89	Kaktovik Iñupiat Corp.	Native Village of Kaktovik	Yes 1971
Nuiqsut	402	87	Kuupik Village Corp.	Native Village of Nuiqsut	Yes 1975
Point Hope	674	90	Tikigaq (Tigara) Corp.	Native Village of Point Hope	Yes 1966
Point Lay	189	88	Cully Corp.	Native Village of Point Lay	No
Wainwright	556	90	Olgoonik Corp.	Native Village of Wainwright	Yes 1962

Sources: ASRC 2011; DCRA 2011; NSB 2011; BIA 2010.

Local and regional municipal governments provide social services, public safety, education, and utilities. Tribal government councils, both village councils and the regional Iñupiat Community of Arctic Slope, are recognized by the Federal Government and have jurisdiction in the domestic affairs of tribal members and serve to transmit traditional culture to the next generation (Roderick 2010; Zellen 2008). The corporations tend to support tribal values, traditional culture, and subsistence activities. Through the NSB, Alaska Natives exert some measure of control over their traditional homeland beyond the lands retained by the Native corporations (Zellen 2008).

Based on past experience, many Alaska Natives approach their relationship with the Federal Government with some degree of mistrust. For much of the last century, the government either neglected or sought to acculturate Alaska Natives. Even today, Alaska Natives express skepticism that Native input at public hearings will have much, if any, effect on project decisions and the overall direction of the leasing program. In the past, Alaska Natives have expressed fear of losing or diluting their traditional culture as industrial development of oil fields results in an influx of outsiders (MMS 2007b). Native communities are small (see Table 3.14.2-3) and relatively poor.

Northwest Arctic Borough

The Northwest Arctic Borough (NWAB) lies south of the western portion of the NSB. Its 2010 population was 7,523, 81% of which were Alaska Natives (USCB 2011b). NWAB includes eleven communities, most of which are predominantly Alaska Native. Seven of these are on the coast or are regularly involved is subsistence harvesting of marine resources (Table 3.14.3-2). Of these, Kotzebue is the administrative and communications hub. As is the

TABLE 3.14.3-2 Coastal Northwest Arctic Borough Native Communities

Community	Population (2010)	Percent Alaska Native	Native Corporation	Federally Recognized Tribal Government	State Incorporated Municipality?
Buckland	416	95	Merged with NANA	Native Village of Buckland	Yes 1966
Deering	122	87	Merged with NANA	Native Village of Deering	Yes 1970
Kiana	361	90	Merged with NANA	Native Village of Kiana	Yes 1964
Kivalina	374	96	Merged with NANA	Native Village of Kivalina	Yes 1969
Kotzebue	3,201	74	Kikiktagruk Iñupiat Corporation	Native Village of Kotzebue	Yes 1958
Noatak	514	95	Merged with NANA	Native Village of Noatak	No
Noorvik	668	88	Merged with NANA	Noorvik Native Community	Yes 1964

Sources: ASRC 2011; Burch 1984.

case with the NSB, Native Alaskans strongly influence local municipal government; however, unlike the NSB, most villages have no Native village corporations. These small communities found it difficult to support village corporations. All local corporations except the Kikiktagruk Iñupiat Corporation in Kotzebue merged with the Northwest Alaska Native Association (NANA) Regional Corporation in 1976 (Burch 1984).

The traditional lifeway of the Alaska Natives living along and upstream from the Bering Sea and Kotzebue Sound was similar to that found on the North Slope. Mobile kin-based groups dispersed across the landscape taking seasonal advantage of a variety of wild food sources. Kin groups came together for a regional summer fair at Sheshalik, or combined in smaller groups in messenger feasts (Burch 1984). Even after first European contact in 1816, they maintained their traditional lifestyle until mid-century. The latter half of the nineteenth century was a time of stress. Increased contacts with American and European traders lead to the introduction of disease, alcohol and firearms. This, combined with a rapid decline in the caribou herd led to out-migration and depopulation of much of the NWAB in the 1880s. A period of consolidation began in 1897 followed by a gold rush along the Noatak and Kobuk Rivers and Seward Peninsula. Missions and schools established and domesticated reindeer introduced in the first decades of the twentieth century became the foci for the Natives who continued for the most part to live in dispersed camps hunting and herding reindeer. The decline of the reindeer herds and the collapse of the fur market during the 1930s resulted in sedentarization in mission-school villages that have mostly persisted to the present day. An increase in caribou population and the arrival of a moose population in the 1940s and 50s, in combination with the maintenance of marine resources allowed a subsistence lifeway to continue. By the 1960s, each community had a school, a store, a National Guard armory, and an all weather airstrip and Natives lived on a combined, the subsistence harvest, with welfare, and wage labor (Burch 1984). NANA was formed in 1966, and Natives in the area began to have increased control of the development of the area. The NWAB was established in 1986. NANA worked to develop resources, such as the Red Dog Mine. Currently, the economy of the NWAB relies on a combination, of subsistence harvesting, employment in the government sector, mining, other commercial ventures, and commercial fishing. Each of the villages along the coast has at least one inhabitant with a commercial fishing permit, while Kotzebue is home to 115 permitees (DCRA 2011).

The Russian Chukchi Coast

Oil and gas activities on the OCS could also affect communities to the east of the Chukchi and Bering Seas located in Russia. The indigenous Chukotan peoples on the eastern shore of the Chukchi Sea are citizens of the Chukotsky Autonomous Okrug. Important coastal lagoons and near-shore subsistence harvest areas for beluga, gray, and bowhead whales; as well as other marine mammals and seabirds could be affected by a large oil spill. The concept of subsistence harvesting as known in Alaska does not exist on the Russian side of the sea, however local native leaders and activists are in support of indigenous concerns and initiatives. The NSB has cooperated with the Eskimo Society of Chukotka to aid in reestablishing whaling traditions and to help facilitate the gray whale harvest (MMS 2008b).

On the Russian side, the arctic tundra region starting at East Cape and extending 200 mi west includes the coastal indigenous communities of Naukan (population 350); Uelen (population 678); Inchoun (population 362); Chegitun (a seasonal subsistence camp); Enurmino (population 304); Neshkan (population 628); Alyatki (a seasonal subsistence camp); Nutpel'men (population 155); and Vankarem (population 186). The former seasonal hunting and fishing sites of Naukan, Chegitun, and Alyatki may have been reoccupied. Uelen, Inchoun, Enurmino, Neshkan, Nutpel'men, and Vankarem are permanent indigenous settlements where subsistence hunting and fishing occur year-round. Both Naukan and Uelen are important areas for hunting polar bears. The area west of Inchoun, including the communities of Enurmino and Neshkan, was particularly hard hit by socioeconomic disintegration during the collapse of the Soviet Union in the 1990s (MMS 2008b)

Historically, there were a number of indigenous settlements in the region from Vankarem west and north to Cape Billings. In general, there has been a trend toward repopulating settlements (and reoccupying seasonal hunting and fishing camps) abandoned earlier due to forced relocation by the Soviet government into larger urban and centralized communities. Repopulation also has occurred to exploit natural food sources, as subsidies from Moscow to support employment and infrastructure have disappeared. The coastal settlements westward from Vankarem are Rigol (population unknown); Mys Shmidta (Cape Shmidt; population 717); Rypkarpyy (population 915); Polyarnyy (population unknown); Pil'gyn (population unknown); Leningradskii (population 835); Billings (Cape Billings; population 272); and Ushakovskoe (population 8) on Wrangel Island. Of all these named settlements, only Ushakovskoe is known to still have functioning subsistence-harvest practices. Many names that still appear on maps of the region are historical villages that no longer exist and, in some cases, they may be small family camps where a few Native inhabitants live on a seasonal basis (MMS 2008b).

3.14.3.2 Subsistence

The majority of permanent residents of the arctic and Bering Sea coasts are Alaska Natives. For them, many subsistence activities are group activities that further core values of community, kinship, cooperation, and reciprocity. Current regulations define subsistence use as "the customary and traditional use by rural Alaska residents of wild renewable resources for direct personal or family consumption as food, shelter, fuel, clothing, tools of transportation; for making and selling handicraft articles out of nonedible byproducts of fish and wildlife resources taken for personal or family consumption; for barter, or sharing for personal or family consumption; and for customary trade" (FSMP 2010). Section 109 of the MMPA applies the same definition explicitly to the subsistence harvesting of marine mammals.

Priority for subsistence harvesting in land management is expressed in ANILCA, passed by Congress in 1980. Similar State legislation was struck down as violating the Alaska constitution, which guarantees equal access to fish, wildlife, and waters for all State residents. ANILCA applies only to Federal lands (excluding the OCS).

Management of subsistence resources on Federal lands and navigable waters along the coast are managed by the FSB. For some areas, the FSB has determined that all rural Alaskans are qualified subsistence users. For other areas, the FSB has made more restrictive "customary and traditional" determinations of eligibility. *Customary and traditional use* means "a long-established, consistent pattern of use, incorporating beliefs and customs transmitted from generation to generation. This use plays an important role in the economy of the community" (FSMP 2010).

While a subsistence lifestyle is a rural preference and not confined to Native Alaskans in rural communities, subsistence is inextricably intertwined with Alaska Native culture and is key to cultural identity. The harvest and consumption of wild resources are only the most visible aspects of a complex set of behaviors and values that extend far beyond the food quest. Kinship, sharing, and subsistence resource use behaviors (such as preparation, harvest, processing, consumption, and celebration) are inseparable. Beyond dietary benefits, subsistence resources provide materials for personal and family use, and the sharing of resources helps maintain traditional family organization.

Subsistence is a central focus of North Slope and NWAB personal and group cultural identity (MMS 2007b, 2008b). Subsistence on the North Slope provides cultural identity, social integration and solidarity, and diet that Alaska Natives view as more healthy (BOEMRE 2001c–f). Many of the most important subsistence resources are found in or near the sea and are thus potentially subject to the effects of oil and gas exploration, production, and any spills on the continental shelf. The cultural value placed on subsistence harvesting and whaling in particular is found throughout the North Slope and in northwestern Alaska. For example, the CEO of the ASRC describes himself as a part-time subsistence hunter (ASRC 2011). Subsistence has been described as the "organizing concept for the NSB." The NSB has been described as "the most organized, strongest, and best-funded subsistence economy in Alaska" (MMS 2007b). Within the NSB and NWAB, both subsistence activities and wage economic opportunities are highly developed and highly interdependent. Since money is needed to purchase resources, such as rifles, ammunition, fuel, snow machines, ATVs, boats, and motors, to most effectively harvest resources, Native communities most active in subsistence activities tend to also be very involved in the wage economy (MMS 2007b).

In general, subsistence foods consist of a wide range of fish and game products that have substantial nutritional benefits. They tend to be rich in nutrients and low in fats. In addition to health benefits, there are social and cultural benefits to subsistence food harvesting and sharing (MMS 2007b). Marine mammals are culturally most important even in villages where caribou or fish supply more meat. Bowhead whale meat is most preferred, and seal oil is a necessary adjunct to meals based on the sea harvest (MMS 2008b). Subsistence species supply more than meat. Skins and furs go into the production of clothing and *umiat*. Bone, baleen, and ivory provide raw materials for handicrafts.

The subsistence harvest plays an important role in all Native communities of the North Slope and northwest Alaska. However, each community has its unique harvest pattern and preferences. Table 3.14.3-3 provides information on the subsistence harvest by hunters and fishers from the villages of Barrow, Nuiqsut, and Kaktovik (SRBA 2010). Table 3.14.3-4 provides a fuller listing of species reported as harvested by communities along the Beaufort and Chukchi Seas. Table 3.14.3-5 provides a listing of species reported harvested by coastal NWAB communities (MMS 2008b). Subsistence harvesting follows a seasonal pattern constrained by changes in climate and by the migration patterns of whales, fishes, and birds. Subsistence

TABLE 3.14.3-3 Important Subsistence Species Harvested from Kaktovik, Nuiqsut, and Barrow[a]

Marine Mammals	
Bowhead whale	Taken in spring and fall migrations; mostly within 32–40 km (20–25 mi) of the coast, but as far as 80 km (50 mi). Primarily for food.
Bearded seal	Taken in summer on ice mostly within 40 km (25 mi) of the coast, but as far out as 80 km (50 mi). Skins used for *umiat* construction by Barrow whalers. Seal oil is an important part of the diet.
Ringed seal	Taken year-round. Formerly used to feed sled dogs.
Walrus	As opportunity arises. Mostly in summer and fall on ice within 40 km (25 mi), as far out as 120 km (75 mi).
Terrestrial Mammals	
Caribou	A major meat source taken year-round, but primarily in summer, mostly inland but in summer hunted by boat along the coast.
Wolves and wolverines	Inland during winter.
Fish	
Broad white fish	Mostly summer and fall; major fish source along coast and in rivers.
Arctic cisco	Mostly summer and fall; along coast and in rivers.
Arctic char/Dolly varden	Mostly late summer/early fall along coast and in rivers.
Waterfowl	
Geese	In spring and fall, mostly inland but as far as 80 km (50 mi) offshore.
Eider	On ice in spring and fall mostly within 40 km (25 mi) of shore, but as far as 64 km (40 mi).

Source: SRBA 2010.

[a] The species listed here were the objects of mapped subsistence harvesting from three villages near the Beaufort Seas. It is not a complete inventory of species harvested from those villages.

marine harvesting can occur anywhere along the coast, but tends to be concentrated in areas directly offshore from the villages and Cross Island where the village of Nuiqsut stages its fall bowhead hunt. Most seaward harvesting occurs within 40 km (25 mi) of shore but may extend to as much as three times that distance depending on the conditions of ice and sea. Preference is given to locations where returning harvesters do not have to fight against the currents to bring their harvest home (SRBA 2010).

Bowhead whales are harvested during both their spring and fall migrations. Barrow and Wainwright crews hunt in both the spring and fall. Point Hope whale only in the spring. In the NWAB, Kivalina and Kiana take occasional bowhead in the spring if they follow nearshore leads, areas of open water resulting from the breaking up of ice flows, but more frequently hunt belugas, as do Buckland and Deering (MMS 2008b; ADFG 2011e). Nuiqsut and Kaktovik hunt only in the fall. Point Lay has traditionally hunted only beluga whales, but now hunts bowheads in the spring. In the spring, when whales are migrating toward the pole, Barrow and Point Hope crews bring light seal-skin *umiat* to leads in the ice. Aluminum skiffs are used in open water for the fall harvest, which targets younger, smaller whales (MMS 2008b). In addition to boat crews,

TABLE 3.14.3-4 Reported Subsistence Use at Arctic Coast Alaska Native Villages[a]

			Native Villages						
Resource	Iñupiaq Name	Scientific Name	Point Lay	Point Hope	Wainwright	Barrow	Atqasuk	Nuisqut	Kaktovik
Marine Mammals									
Bearded seal	Ugruk	*Erignathus barbatus*	X[b]	X	X	X	X	X	X
Ringed seal	Natchiq	*Phoca hispida*	X	X	X	X	X	X	X
Spotted seal	Qasigiaq	*Phoca largha*	X	—[b]	X	X	X	X	X
Ribbon seal	Qaigulik	*Phoca fasciata*	X	—	X	X	X	—	—
Beluga whale	Quilalugaq	*Delphinapterus leucas*	X	X	X	X	X	—	X
Bowhead whale	Agviq	*Balaena mysticetus*	X	X	X	X	X	X	X
Polar bear	Nanuq	*Ursus maritimus*	X	X	X	X	X	X	X
Walrus	Aiviq	*Odobenus rosmarus*	X	X	X	X	X	—	X
Terrestrial Mammals									
Caribou	Tuttu	*Rangifer tarandus*	X	X	X	X	X	X	X
Moose	Tuttuvak	*Alces alces*	—	X	X	X	X	X	—
Brown bear	Aklaq	*Ursus arctos*	X	—	X	X	X	X	—
Dall sheep	Imnaiq	*Ovis dalli*	—	X	X	X	X	X	X
Muskox	Uminmaq	*Ovibus moschatus*	—	—	X	—	X	X	X
Arctic fox (blue)	Tigiganniaq	*Alopex lagopus*	X	—	X	X	X	X	X
Red fox	Kayuqtuq	*Vulpes fulva*	X	—	X	X	X	X	—
Porcupine	Qinagluk	*Erethizon dorsatum*	—	—	X	X	—	—	—
Ground squirrel	Siksrik	*Spermophilus parryii*	X	—	X	X	X	X	X
Wolverine	Qavvik	*Gulo gulo*	X	—	X	X	X	X	X
Weasel	Itigiaq	*Mustela erminea*	—	—	X	—	X	X	—
Wolf	Amaguk	*Canis lupus*	X	—	X	X	X	X	X
Marmot	Siksrikpak	*Marmota broweri*	X	—	X	—	X	X	X
Fish									
Salmon	Species not reported	Species not reported	X	X	X	X	X	X	—
Chum	Iqalugruaq	*Oncorhynchus keta*	X	X	X	X	X	X	—
Pink (humpback)	Amaqtuuq	*O. gorbuscha*	—	X	X	X	X	X	—
Silver (coho)	Iqalugruaq	*O. kisutch*	—	X	—	—	—	—	—
Whitefish	Aanaakliq	*Coregonus* spp.	—	X	X	X	X	—	—
Round whitefish	Aanaakliq	*Prosopium cylindraceum*	—	—	X	X	—	—	—
Broad whitefish	Aanaakliq	*Coregonus nasus*	—	—	X	X	X	X	X
Humpback whitefish	Pikuktuuq	*C. clupeaformis*	—	—	X	X	X	X	—
Least cisco	Iqalusaaq	*C. sardinella*	—	—	X	X	X	X	X
Bering and Arctic cisco	Qaaktaq	*C. autumnalis*	X	—	X	X	X	X	X

TABLE 3.14.3-4 (Cont.)

			Native Villages						
Resource	Iñupiaq Name	Scientific Name	Point Lay	Point Hope	Wainwright	Barrow	Atqasuk	Nuisqut	Kaktovik
Other Freshwater Fish									
Arctic grayling	Sulukpaugaq	*Thymallus arcticus*	X	X	X	X	X	X	X
Arctic char	Iqalukpik	*Salvelinus alpinus*	X	X	X	X	X	X	X
Burbot (ling cod)	Tittaaliq	*Lota lota*	—	—	X	X	X	X	—
Lake trout	Iqaluaqpak	*Salvelinus namaycush*	—	—	X	X	X	X	—
Northern pike	Siulik	*Esoxlucius*	—	—	X	X	—	—	—
Other coastal fish									
Rainbow smelt	Ilhuagniq	*Osmerus morda*	X	—	X	X	—	X	—
Arctic cod	Iqalugaq	*Boreogadus saida*	—	—	X	X	X	X	X
Tomcod	Uugaq	*Eleginus gracilis*	X	X	X	X	X	—	X
Flounder	Nataagnaq	*Liopsetta glacialis*	—	X	—	—	—	—	X
Birds									
Snowy owl	Ukpik	*Nyctea scandiaca*	—	X	X	—	—	X	—
Red-throated loon	Qaqsraupiagruk	*Gavia stellata*	*X*	—	X	X	—	—	—
Tundra swan	Qugruk	*Cygnus columbianus*	—	—	X	—	X	X	X
Eider	Species not reported	Species not reported	—	X	—	—	—	—	X
Common eider	Amauligruaq	*Somateria mollissima*	X	—	X	X	X	X	—
King eider	Qinalik	*Somateria spectabilis*	X	—	X	X	X	X	—
Spectacled eider	Tuutalluk	*Somateria fischeri*	X	—	X	X	—	—	—
Steller's eider	Igniqauqtuq	*Polysticta stelleri*	X	—	X	X	—	—	—
Other ducks	Qaugak	Species not reported	—	X	X	X	X	—	—
Pintail	Kurugaq	*Anas acuta*	X	—	X	—	X	—	X
Long-tailed duck	Aaqhaaliq	*Clangula hyemalis*	*X*	—	X	X	X	—	X
Surf scoter	Aviluktuk	*Melanitta perspicillata*	—	—	X	X	—	—	—
Geese	Species not reported	Species not reported	—	X	—	—	—	—	X
Brant	Niglingaq	*Branta bernicla* n.	X	X	X	X	X	X	X
White-fronted goose	Niglivialuk	*Anser albifrons*	X	—	X	X	X	X	X
Snow goose	Kanuq	*Chen caerulescens*	X	—	X	X	X	X	X
Canada goose	Iqsragutilik	*Branta canadensis*	X	—	X	X	X	X	X
Ptarmigan	Aqargiq	*Lagopus* spp.	—	—	X	X	X	X	X
Willow ptarmigan	Nasaullik	*L. lagopus*	X	—	X	X	—	—	—
Other Resources									
Berries	Species not reported	Species not reported	X	X	X	X	X	X	
Cranberry	Kimminnaq	*V. vitisidaea*	—	—	X	X	—	—	—
Salmonberry	Aqpik	*Rubus spectabilis*	—	—	X	X	—	—	—
Bird eggs	Mannik	Species not reported	X	X	X	X	X	—	—
Gull eggs	Species not reported	Species not reported	—	—	X	—	X	—	—
Goose eggs	Species not reported	Species not reported	—	—	X	—	X	—	—
Eider eggs	Species not reported	Species not reported	—	—	X	X	X	—	—
Greens/roots	Species not reported	Species not reported	—	—	X	X	X	X	—

TABLE 3.14.3-4 (Cont.)

			Native Villages						
Resource	Iñupiaq Name	Scientific Name	Point Lay	Point Hope	Wainwright	Barrow	Atqasuk	Nuisqut	Kaktovik
Wild rhubarb	Qunulliq	*Oxyric digyna*	—	—	X	X	—	—	—
Wild chives	Quagaq	*Allium schoenoprasum*	—	—	X	X	—	—	—
Clams	Imaniq	Species not reported	X	—	X	X	—	—	—
Crab	Puyyugiaq	Species not reported	X	X	X	—	X	X	—

Source: MMS 2008b.

[a] This table is based on a variety of surveys conducted at different times between 1987 and 2006. The underlying data were not uniformly collected. The range of resources used in some communities, particularly Point Hope, may be underreported.

[b] X = Reported; — = Not reported.

there are camp crews on ice or shore that provide food and other support to the whalers. They may hunt ringed seals to provide camp food. Crews help one another in hauling and butchering their take. Whale meat and blubber are distributed according to cultural norms relating to the roles played in the hunt and support, kin and other social ties, and the values placed on generosity and the social responsibility to provide for widows and others unable to hunt. With the *Nalukataq* festival, an important Iñupiat ceremony, the community the marks the end of the whale hunt (SRBA 2010).

In recent public meetings, Alaska Natives on the North Slope have voiced concerns regarding the effects of oil and gas exploration on subsistence resources and are concerned that traditional knowledge of subsistence resources is not regularly taken into account. They express concerns that noise, particularly from seismic testing, disturbs whales and other sea mammals, causing them to avoid the noise source and stay farther out to sea, making the whale hunt in small craft more difficult and more dangerous, and exposing the whalers to rougher seas, more shifting ice, and stronger offshore currents. They are concerned that any oil spill, even if rare, could result in harm to subsistence species and could cause others to avoid the area. They also feel that existing pipelines on land had altered caribou migration patterns (BOEMRE 2011c–f).

3.15 ENVIRONMENTAL JUSTICE

Executive Order 12898, “Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations” (59 FR 7629), formally requires Federal agencies to incorporate environmental justice as part of their missions. Environmental justice is defined by the Executive Order as “the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development,

TABLE 3.14.3-5 Reported Subsistence Harvest by Coastal NWAB Communities

		Native Villages						
Resource	Scientific Name	Kivalina 2007	Noatak 2007	Kiana 2006	Kotzebue 1991	Noorvik 1996	Buckland 1996	Deering 1997
Marine Mammals						X		
Seal	Species not reported	–	–	–	–	–	X	X
Bearded seal	*Erignathus barbatus*	X	X	X	–	–	–	–
Ringed seal	*Phoca hispida*	X	X	X	–	–	–	–
Spotted seal	*Phoca largha*	X	X	X	–	–	–	–
Ribbon seal	*Phoca fasciata*	X	–	–	–	–	–	–
Beluga whale	*Delphinapterus leucas*	X	X	X	X	–	X	X
Bowhead whale	*Balaena mysticetus*	X	–	X	–	–	–	–
Polar bear	*Ursus maritimus*	X	–	X	–	–	–	–
Walrus	*Odobenus rosmarus*	X	X	X	X	–	–	–
Terrestrial Mammals								
Caribou	*Rangifer tarandus*	X	X	X	–	X	–	–
Moose	*Alces alces*	X	X	X	–	X	–	X
Brown bear	*Ursus arctos*	X	X	–	–	–	–	–
Black Bear	*Ursus americanus*	–	X	X	–	–	–	–
Dall sheep	*Ovis dalli*	X	X	–	–	–	–	–
Muskox	*Ovibus moschatus*	–	–	–	–	–	–	–
Arctic fox (blue)	*Alopex lagopus*	X	–	–	–	–	–	–
Red fox	*Vulpes fulva*	–	X	X	–	–	–	–
Porcupine	*Erethizon dorsatum*	X	–	X	–	–	–	–
Ground squirrel	*Spermophilus parryii*	X	–	–	–	–	–	–
Wolverine	*Gulo gulo*	X	X	X	–	–	–	
Wolf	*Canis lupus*	X	X	X	–	–	–	–
Beaver	*Castor Canadensis*	–	X	X	–	–	–	–
Land otter	*Lutra canadensis*	–	X	–	–	–	–	–
Marten	*Martes* sp.	–	X	–	–	–	–	–
Muskrat	*Ondatra zibethicus*	–	X	X	–	–	–	–
Fish								
Salmon	Species not reported	X	–	–	X	–	–	–
Chum	*Oncorhynchus keta*	–	X	X	–	–	–	–
Pink (humpback)	*O. gorbuscha*	X	X	X	–	–	–	X
Silver (coho)	*O. kisutch*	X	X	X	–	–	–	–
Chinook	*O. tshawytscha*	X	X	X	–	–	–	–
Sockeye	*O. nerka*	–	X	X	–	–	–	–
Whitefish	*Coregonus sp.*	X	X	–	X	–	–	–
Broad whitefish	*Coregonus nasus*	–	–	–	X	–	–	–
Humpback whitefish	*C. clupeaformis*	–	–	–	X	–	–	–
Least cisco	*C. sardinella*	–	–	X	X	–	–	–
Bering and Arctic cisco	*C. autumnalis*	–	–	–	X	–	–	–

TABLE 3.14.3-5 (Cont.)

		Native Villages						
Resource	Scientific Name	Kivalina	Noatak	Kiana	Kotzebue	Noorvik	Buckland	Deering
Other Freshwater Fish						X		
Arctic grayling	*Thymallus arcticus*	X	X	X	X	–	–	–
Arctic char	*Salvelinus alpinus*	X	X	X	X	–	–	–
Burbot (ling cod)	*Lota lota*	X	X	X	X	–	–	–
Dolly Varden Trout	*Salvelinus malma malma*	X	X	X	X	–	–	–
Lake trout	*Salvelinus namaycush*	–	X	X	–	–	–	–
Northern pike	*Esoxlucius*	–	X	X	X	–	–	–
Sheefish	*Stenodus leucicthyes*	X	X	–	X	–	–	–
Other coastal fish								
Rainbow smelt	*Osmerus morda*	X	–	–	X	–	–	–
Arctic cod	*Boreogadus saida*	X	–	–	–	–	–	–
Tomcod (Saffron cod)	*Eleginus gracilis*	X	–	–	X	–	–	X
Herring	*Clupea* sp	–	–	–	X	–	–	X
Halibut	*Hippoglosus* sp	–	–	X	X	–	–	–
Flounder	*Liopsetta glacialis*	–	–	–	X	–	–	–
Birds								
Snowy owl	*Nyctea scandiaca*	X	X	–	–	–	–	–
Ptarmigan	*Lagopus* sp.	X	X	X	X	X	–	X
Grouse	Species not reported	–	X	X	X	X	–	–
Murres	Mutiple species	X	–	–	–	–	–	X
Waterfowl	Species not reported	–	X	X	X	X	–	X
Red-throated loon	*Gavia stellata*	–	–	–	X	–	–	–
Tundra swan	*Cygnus columbianus*	X	X	X	X	X	X	–
Eider	Species not reported	–	–	–	X	X	X	X
Common eider	*Somateria mollissima*	X	–	–	–	–	–	X
King eider	*Somateria spectabilis*	X	–	–	–	X	–	–
Spectacled eider	*Somateria fischeri*	–	–	–	–	X	–	–
Pintail	*Anas acuta*	–	–	–	X	X	X	X
Long-tailed duck	*Clangula hyemalis*	–	–	–	–	X	X	–
Scoters	Multiple species	–	–	–	–	X	X	X
Other ducks	Species not reported	X	X	X	X	X	X	X
Geese	Species not reported	X	–	–	–	–	–	–
Brant	*Branta bernicla* n.	X	X	X	X	X	X	X
White-fronted goose	*Anser albifrons*	X	X	X	X	–	X	X
Snow goose	*Chen caerulescens*	X	X	X	–	–	X	X
Canada goose	*Branta canadensis*	X	X	X	X	X	X	X
Sandhill crane	*Grus canadensis*	–	–	–	–	X	X	X
Bird eggs	Species not reported	X	X	–	–	X	–	–
Gull eggs	Species not reported	X	X	–	–	–	–	–
Goose eggs	Species not reported	X	X	–	–	–	–	–
Eider eggs	Species not reported	X	–	–	–	–	–	X

TABLE 3.14.3-5 (Cont.)

		Native Villages						
Resource	Scientific Name	Kivalina	Noatak	Kiana	Kotzebue	Noorvik	Buckland	Deering
Other Resources								
Berries	Species not reported	–	–	X	X	–	–	–
Cranberry	*V. vitisidaea*	X	X	X	–	–	–	–
Salmonberry	*Rubus spectabilis*	X	X	X	–	–	–	–
Blueberry	*Vsccinium* sp.	X	X	X	–	–	–	–
Blackberry	*Rubus* sp.	X	X	–	–	–	–	–
Crowberry	*Empetrum* sp.	–	–	X	–	–	–	–
Greens/roots	Species not reported	–	–	–	X	–	–	–
Wild rhubarb	*Oxyric digyna*	–	–	–	–	–	–	–
Wild celery	*Vallisneria americana*	X	X	–	–	–	–	–
Eskimo potato	Species not reported	X	X	X	–	–	–	–
Stinkweed	Species not reported	–	X	X	–	–	–	–
Sourdock	*Rumex crispus*	–	X	X	–	–	–	–
Willow leaves	Species not reported	X	X	X	–	–	–	–
Clams	Species not reported	–	–	–	X	–	–	–
Crab	Species not reported	X	X	–	X	–	–	–
Shrimp	Species not reported	–	–	–	X	–	–	–

This table is based primarily on data from the Alaska Department of Fish and Game. Subsistence harvest data are not uniformly reported. Data for Noorvik, Buckland, and Deering are mostly confined to migrating bird species. The date next to the community name is the date of the subsistence harvest data designated as "most representative" on the ADF&G subsistence website.

Sources: ADFG 2011; ASRC 2011; MMS 2008b.

implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no group of people, including racial, ethnic, or socioeconomic group should bear a disproportionate share of the negative environmental consequences resulting from industrial, municipal, and commercial operations or the execution of Federal, State, local, and tribal programs and policies." Specifically, it directs them to address, as appropriate, any disproportionately high and adverse human health or environmental effects of their actions, programs, or policies on minority and low-income populations.

The analysis of the impacts of offshore oil and gas development projects on environmental justice issues follows guidelines described in the Council on Environmental Quality's (CEQ's) *Environmental Justice Guidance under the National Environmental Policy Act* (CEQ 1997). The analysis method has three parts: (1) a description of the geographic distribution of low-income and minority populations in the affected area is undertaken; (2) an assessment is conducted to determine whether oil and gas activities would produce impacts that are high and adverse; and (3) if impacts are high and adverse, a determination is made as to whether these impacts would disproportionately affect minority and low-income populations.

Construction and operation of offshore oil and gas development projects could affect environmental justice if any adverse health and environmental impacts resulting from either phase of development are significantly high and if these impacts disproportionately affect minority and low-income populations. If the analysis determines that health and environmental impacts are not significant, there can be no disproportionate impacts on minority and low-income populations. In the event impacts are significant, disproportionality would be determined by comparing the proximity of any high and adverse impacts with the location of low-income and minority populations.

A description of the geographic distribution of minority and low-income groups in the affected area was based on demographic data from the 2000 Census (USCB 2011g,h). The following definitions were used to define minority and low-income population groups:

- **Minority.** Persons are included in the minority category if they identify themselves as belonging to any of the following racial groups: (1) Hispanic, (2) Black (not of Hispanic origin) or African American, (3) American Indian or Alaska Native, (4) Asian, or (5) Native Hawaiian or Other Pacific Islander.

  Beginning with the 2000 Census, where appropriate, the census form allows individuals to designate multiple population group categories to reflect their ethnic or racial origins. In addition, persons who classify themselves as being of multiple racial origin may choose up to six racial groups as the basis of their racial origins. The term minority includes all persons, including those classifying themselves in multiple racial categories, except those who classify themselves as not of Hispanic origin and as White or "Other Race" (USCB 2009d).

- **Low-Income.** Individuals who fall below the poverty line. The poverty line takes into account family size and age of individuals in the family. In 1999, for example, the poverty line for a family of five with three children below the age of 18 was $19,882. For any given family below the poverty line, all family members are considered as being below the poverty line for the purposes of analysis (USCB 2009e).

The CEQ guidance proposed that minority and low-income populations be identified where either (1) the minority or low-income population of the affected area exceeds 50% or (2) the minority or low-income population percentage of the affected area is greater than the minority population percentage in the general population or other appropriate unit of geographic analysis.

This PEIS applies both criteria in using the U.S. Census Bureau data, wherein consideration is given to the minority and population that is both greater than 50% and 20 percentage points higher than in the State as a whole (the reference geographic unit).

3.15.1 Gulf of Mexico

The analysis of environmental justice issues associated with the development of offshore oil and gas development facilities considered impacts within the 129 counties that constitute the 23 Labor Market Areas (LMAs) located along the GOM coast, defined on the basis of inter-county commuting patterns using a method suggested by Tolbert and Sizer (1996). Analysis at the county level for each LMA allows the inclusion of impacts that would potentially occur at the various facilities and infrastructure directly and indirectly associated with the construction and operation of offshore oil and gas developments.

The data in Table 3.15.1-1 show the minority and low-income composition of the total population located within the LMA counties along the GOM coast based on 2000 Census data and CEQ guidelines. Individuals identifying themselves as Hispanic or Latino are included in the table as a separate entry. However, because Hispanics can be of any race, this number also includes individuals identifying themselves as being part of one or more of the population groups listed in the table.

A large number of minority and low-income individuals are located in the LMA counties along the GOM coast. Within the combined LMA counties in each State along the GOM coast, the percentage of the total population classified as minority varies between 23.6% in Mississippi and 55.8% in Texas. The number of minority individuals in the LMAs combined exceeds 50% of the total population in Texas, but the number of minority individuals does not exceed the State average by 20 percentage points or more in any of the combined LMA counties in each State; thus, there is a minority population only in the LMA counties in Texas, based on 2000 Census data and CEQ guidelines. The number of low-income individuals in the combined LMA counties in each State does not exceed the State average by 20 percentage points or more and does not exceed 50% of the total population in any of the LMA counties; thus, there are no low-income populations in any of the combined LMA counties in any of the five States.

In the Alabama portion of the GOM coast, more than 50% of the population is classified as minority in Wilcox County, northeast of Mobile, where the low-income population is more than 20 percentage points higher than the State average. In Florida, more than 50% of the population is classified as minority in Gadsden County, west of Tallahassee, and in Miami-Dade County. In Louisiana, Iberville Parish, to the southwest of Baton Rouge; St. Helena Parish, to the northeast of Baton Rouge; and West Feliciana Parish, to the north of Baton Rouge, have populations in which more than 50% is classified as minority. The case is similar in Orleans Parish, in central New Orleans, and St. James Parish, to the west of New Orleans.

In Texas, more than 50% of the population in Brooks County, southwest of Corpus Christi, is classified as minority, where the low-income population is more than 20 percentage points higher than the State average. Elsewhere in the Corpus Christi area, in Duval County, Jim Wells County, Kenedy County, Kleburg County, Nueces County, and Refugio County, more than 50% of the population is classified as minority. In the Brownsville area, Harris and Starr Counties have more than 50% of the population classified as minority, and have a low-income population that is more than 20 percentage points higher than the State average. The low-income population in Starr County also exceeds 50% of the total population. In Cameron and Willacy

TABLE 3.15.1-1 Gulf Coastal Region Minority and Low-Income Populations, 2000

Population Segment	Alabama	Florida	Louisiana	Mississippi	Texas	Total
Total Population	599,405	8,955,931	3,382,809	458,674	6,939,834	20,336,653
White, Non-Hispanic	401,434	5,297,536	2,116,976	350,300	3,068,665	11,234,911
Hispanic or Latino	7,790	2,002,650	91,720	9,761	2,584,430	4,696,351
Non-Hispanic or Latino minorities	190,181	1,655,745	1,174,113	98,613	1,286,739	4,405,391
One Race	184,863	1,520,754	1,143,483	93,437	1,215,951	4,158,488
Black or African American	173,361	1,341,280	1,073,021	83,554	942,898	3,614,114
American Indian or Alaskan Native	4,751	23,724	17,988	1,778	16,203	64,444
Asian	6,193	135,194	47,637	7,470	247,451	443,945
Native Hawaiian or Other Pacific Islander	124	3,574	793	234	2,254	6,979
Some Other Race	434	16,982	4,044	401	7,145	29,006
Two or More Races	5,318	134,991	30,630	5,176	70,788	246,903
Total Minority	197,971	3,658,395	1,265,833	108,374	3,871,169	9,101,742
Percent Minority	33.0%	40.8%	37.4%	23.6%	55.8%	44.8%
Low-Income	101,236	1,200,105	611,737	65,629	1,194,653	3,173,360
Percent Low-Income	16.9%	13.4%	18.1%	14.3%	17.2%	15.6%

Source: USCB 2011g, h.

Counties, more than 50% of the population is classified as minority. In the Houston area, in Fort Bend County, Harris County, and Waller County, more than 50% of the population is classified as minority.

There are 81 counties and parishes in the GOM coast region that contain oil-related infrastructure, including platform fabrication yards, port facilities, shipyards, shipbuilding yards, support facilities, transport facilities, waste management facilities, pipelines, pipe coating yards, natural gas processing facilities, natural gas storage facilities, refineries, and petrochemical facilities (MMS 2006b). Thirty-nine counties contain more than five facilities. Ten counties (or parishes in Louisiana) have a high concentration of oil-related infrastructure (50 or more facilities). Of these 10 counties, 5 have higher minority percentages than their respective State average. These counties include Mobile, Alabama; St. Mary, Louisiana; and Galveston, Harris, and Jefferson, Texas. Two of the 10 high infrastructure concentration counties also have higher poverty rates than their respective State rate. St. Mary Parish, Louisiana, and Jefferson, Texas, have higher poverty rates than the average poverty rate in their States. Fifteen counties (or parishes in Louisiana) are considered to have a medium concentration of oil-related infrastructure (15–49 facilities). Five of these counties have a higher poverty rate than the mean rate in their States: Iberia, Orleans, and Vermillion, Louisiana; and Nueces and San Patricio, Texas. Eight of the 15 medium concentration counties also have higher minority populations than their State average. These counties include Hillsborough, Florida; East Baton Rouge, Iberia, Orleans, and St. James, Louisiana; and Calhoun, Nueces, and San Patricio, Texas.

3.15.1.1 Oil Spills and Human Health Effects

The potential health effects of oil spills include effects related to worker safety, toxicological effects in workers and community members, and mental health effects emanating from social and economic disruption (Goldstein et al. 2011). Toxicological effects include chemical effects such as respiratory and dermal irritation, headaches, eye irritation, nausea, and dizziness. The short-term and long-term natures of these impacts are dependent on the contaminants involved and the characteristics of the exposed populations.

Crude oil contains many different hydrocarbons, and the relative amounts of trace metal and sulfur content can vary significantly (Goldstein et al. 2011). Some crude oil components can cause respiratory, hepatic, renal, endocrine, neurologic, hematologic effects at high doses after a threshold concentration has been exceeded. Mutagenic effects, on the other hand, can result from a single molecular DNA alternation (Goldstein et al. 2011). Carcinogens in crude oil include benzene, which is present at a concentration of between 1 and 6%, and PAHs, which are present at lower, variable concentrations. Benzene and PAHs are also present from the offshore controlled burning of crude oil (Goldstein et al. 2011). Benzene is a known hematotoxicant and hematocarcinogen (Goldstein and Witz 2009). Benzene affects the circulating blood cells in workers exposed to concentrations below current occupational health standards (Lan et al. 2004), and has reproductive and developmental effects (Xing et al. 2010). Benzene is only a risk close to an oil source; it appears to evaporate, with other VOCs, before reaching shore, meaning that community exposures are relatively minimal (Morita et al. 1999). PAHs are more persistent, and can cause skin and lung cancer, in addition to reproductive and neurological effects (Department of Health and Human Services 2010). All organic components of crude oil may contribute to acute short-term effects, but are unlikely to be present in sufficient concentrations to cause long-term health effects (Goldstein et al. 2011). During summer months VOCs are converted to ozone, which can cause respiratory irritation, including asthma (Eggleston 2007; Leikauf 2002).

Surfactants used as dispersants during the DWH spill contained petroleum distillate, propylene glycol, and sulfonic acid salt, which contained dioctyl sodium sulfosuccinate, or stool softener (Goldstein et al. 2011). Another surfactant used was 2-butoxyethnol, known to cause hepatic angiosarcoma and hemolytic anemia in rodents (Gualtieri et al. 2003). Exposure to trace quantities of metals such as arsenic, chromium, lead, and nickel could be a toxicological concern, and statistical evidence of association with endocrine and genotoxic effects after spills has been established (Perez-Cadahia et al. 2008). Water monitoring by the USEPA did not find positive evidence of benzene or PAHs in water samples, and air monitoring did not find evidence of VOCs except for trace levels of naphthalene (USEPA 2011f).

Approximately 52,000 workers responded to the DWH spill (NIOSH 2011), and a number of symptoms were reported in evaluations undertaken by NIOSH, including chemically induced upper respiratory illnesses, throat and eye irritation, headaches, dizziness, nausea, and vomiting (Goldstein et al. 2011). Longer-term health effects in workers include pulmonary abnormalities (Meo et al. 2009), bronchial hyperresponsiveness, acute and persistent genotoxic effects, and endocrine effects (Aguilera et al. 2010).

The DWH spill affected many communities that had health disparities compared to others in the United States, and that were also still suffering from the impacts of Hurricane Katrina (Goldstein et al. 2011). Louisiana, for example, is currently ranked among the most severely affected states in the nation in terms of rates of infant death, death from cancer, premature death, death from cardiovascular disease, children in poverty, and violent crime (United Health Foundation 2009). Children are particularly at risk for effects of environmental exposure; they breathe more air per unit of body mass, detoxify chemicals less effectively, and may suffer from accidental exposure more readily than adults (Goldstein et al. 2011). No evidence has been found regarding the risk of asthma or impaired respiratory function in children (Crum 1993), although indoor exposure may pose additional risk for children with asthma (Barbeau et al. 2010). The effects of crude oil components, such as higher-weight molecular compounds, are unknown (Xu et al. 2005).

Although symptoms of deterioration in mental health following an oil spill are reflected in increases in calls to mental health and violence hotlines (Yun et al. 2010), assessments of factors leading to deterioration in mental health, lack of adequate baseline data, study design, and delay in study initiation have limited the validity of studies on mental health impacts (Savitz et al. 2008). In addition, in the case of the DWH spill, many communities were still recovering from Hurricane Katrina, complicating the response by community members to the spill (Goldstein et al. 2011). After Katrina, the severity and frequency of mental health symptoms seems to have increased, but there has also been a decline in the use of mental health services and the use of prescribed medication (Kessler et al. 2008). The Centers for Disease Control reported that 50% of adults in New Orleans had psychological stress, while post-traumatic stress disorder was prevalent among first responders, leading to alcohol and domestic abuse (Goldstein et al. 2011). Another survey found that in 2005–2006, 48% of returning students in the main parishes affected by Katrina had mental health symptoms, a rate that had only dropped to 30% by 2009–2010, indicating that repeated trauma increases vulnerability to deterioration in mental health (Kronenberg et al. 2010).

Minority communities may have specific concerns related to their psychosocial welfare. Working-age Vietnamese residents in New Orleans had numerous unresolved problems in the aftermath of Katrina, and then 1 yr later, including inadequate access to healthcare (Vu et al. 2009). Suspension of free health services led to the reemergence of disparities between racial and ethnic groups (Do et al. 2009). Symptoms of post-traumatic stress disorder were found in this population group, especially among members with a low degree of acculturation and high exposure to floods, together with long stays in emigration transit camps (Norris et al. 2009). As was the case for small, isolated Alaskan native communities with the *Exxon Valdez* spill (Goldstein et al. 2011), it is likely that the DWH spill could lead to higher levels of depression, generalized anxiety disorder, post-traumatic stress disorder, violence, and other psychological problems among minority communities.

3.15.2 Alaska – Cook Inlet

The analysis of environmental justice issues associated with the development of offshore oil and gas development facilities considered impacts for the south central Alaska region, which includes Anchorage Municipality, Kenai Peninsula Borough, Kodiak Island Borough, and Matanuska-Susitna Borough.

The data in Table 3.15.2-1 show the minority and low-income composition of the total population located within the south Alaska region based on 2000 Census data and CEQ guidelines. Individuals identifying themselves as Hispanic or Latino are included in the table as a separate entry. However, because Hispanics can be of any race, this number also includes individuals identifying themselves as being part of one or more of the population groups listed in the table.

A large number of minority and low-income individuals are located in the south central Alaska region. However, the number of minority individuals in each of the boroughs does not exceed 50% of the total population, and the number of minority individuals does not exceed the State average by 20 percentage points or more in any of the boroughs; thus, there is no minority population in the south central Alaska region, based on 2000 Census data and CEQ guidelines. The number of low-income individuals in the three boroughs does not exceed the State average by 20 percentage points or more and does not exceed 50% of the total population; thus, there are no low-income populations in any of the boroughs.

3.15.2.1 Consumption of Fish and Game

Subsistence is “an activity performed in support of the basic beliefs and nutritional need of the residents of the borough and includes hunting, whaling, fishing, trapping, camping, food gathering, and other traditional and cultural activities” (ADNR 1997). Subsistence fishing is for direct personal or family consumption. Many thousands of Alaskans participate in subsistence fishing and processing, and it is an important element of Alaska’s social and cultural heritage. For a more complete discussion of subsistence and its cultural and nutritional importance, see Section 3.5.5.6. In rural Alaska, subsistence fisheries harvest produces about 230 lb per person per year (MMS 2006b). Although important as a source of food, subsistence fisheries are only about 2% of the fisheries harvest. Commercial fisheries account for about 97% of the wild harvest, and sport fisheries the remaining 1% (MMS 2006b).

Subsistence fishing and hunting are an important part of the economies of rural Alaskan communities, providing sources of food, clothing, and employment. While the harvest of animals, birds, shellfish, and plants only represents 2% of the fish and game harvested annually (MMS 2006b), the subsistence harvest contains about 35% of the caloric requirements of the rural population. In some areas of Alaska, notably the interior and western areas, subsistence products provide up to 50% of the daily requirement (MMS 2006b; Bersamin et al. 2007). Approximately 2% of the daily requirement of the urban population is met through subsistence activities.

Although it is difficult to establish the economic importance of subsistence harvests because the consumption and exchange of subsistence products do not occur in the marketplace, estimates of their importance have been made based on the dollar value of replacing subsistence products in the market. Using a replacement value of \$3/lb, the replacement value of subsistence

TABLE 3.15.2-1 South Central Alaska Region Minority and Low-Income Populations, 2000

	Anchorage Municipality	Kenai Peninsula	Kodiak Island	Matanuska-Susitna	South Central Alaska Region Total
Total population	260,283	49,691	13,913	59,322	383,209
White, Non-Hispanic	181,982	42,263	8,001	51,175	283,421
Hispanic or Latino	14,799	1,087	848	1,485	18,219
Non-Hispanic or Latino Minorities	63,502	6,341	5,064	6,662	81,569
One Race	50,119	4,549	4,439	4,195	63,302
Black or African American	14,667	220	129	398	15,414
American Indian or Alaskan Native	18,326	3,644	1,997	3,168	27,135
Asian	14,208	471	2,193	401	17,273
Native Hawaiian or Other Pacific Islander	2,335	85	105	66	2,591
Some Other Race	583	129	15	162	889
Two or More Races	13,383	1,792	625	2,467	18,267
Total Minority	78,301	7,428	5,912	8,147	99,788
Percent Minority	30.1	14.9	42.5	13.7	26.0
Low-Income	18,682	4,861	901	6,419	30,863
Percent Low-Income	7.3	10.0	6.6	11.0	8.2

Source: USCB 2011g, h.

harvests in rural Alaska is estimated to be $131 million annually; at $5/lb, the replacement value of these products would be $219 million. In Alaska as a whole, the replacement value of subsistence products is estimated to be between $160 million and $267 million (MMS 2006b).

3.15.2.2 Oil Spills and Subsistence

Subsistence activities of Native communities could be affected by accidental oil spills, with the potential health effects of oil spill contamination of subsistence foods being the main concern. After the 1989 *Exxon Valdez* spill, testing of subsistence foods for hydrocarbon contamination between 1989 and 1994 revealed very low concentrations of petroleum hydrocarbons in most subsistence foods, and the U.S. Food and Drug Administration concluded that eating food with such low levels of hydrocarbons posed no significant risk to human health (Hom et al. 1999). Human health risks can be reduced through timely warnings about spills, forecasts about which areas may be affected, and even evacuations of people and avoidance of marine and terrestrial foods that may be affected. Avoidance of shellfish, which accumulates hydrocarbons, would be recommended, and Federal and State agencies with health care responsibilities would have to sample the food sources and test for possible contamination.

Whether subsistence users will use potentially tainted foods would depend on the cultural "confidence" in the purity of these foods. Based on surveys and findings in studies of the *Exxon Valdez* spill, Natives in affected communities largely avoided subsistence foods as long as the oil remained in the environment. Perceptions of food tainting and avoiding use lingered in Native communities after the *Exxon Valdez* spill, even when the testing agency maintained that consumption posed no risk to human health (MMS 2006b).

The assessment and communication of the contamination risks of consuming subsistence resources following an oil spill is a continuing challenge to health and natural resource managers. After the *Exxon Valdez* spill, analytical testing and rigorous reporting procedures failed to convince many subsistence consumers because test results were often inconsistent with Native perceptions about environmental health. According to MMS (2006b), a discussion of subsistence food issues must be cross-disciplinary, reflecting a spectrum of disciplines from toxicology, to marine biology, to cultural anthropology, to cross-cultural communication, to ultimately understanding disparate cultural definitions of risk perception itself. Any effective discussion of subsistence resource contamination must understand the conflicting scientific paradigms of Western science and traditional knowledge in addition to the vocabulary of the social sciences in reference to observations throughout the collection, evaluation, and reporting processes. True restoration of environmental damage "must include the re-establishment of a social equilibrium between the biophysical environment and the human community" (Picou and Gill 1996; Field et al. 1999; Nighswander and Peacock 1999; Fall et al. 1999). Since 1995, subsistence restoration resulting from the Exxon Valdez oil spill has improved by taking a more comprehensive approach by partnering with local communities and by linking scientific methodologies with traditional knowledge (Fall et al. 1999; Fall and Utermohle 1999).

3.15.3 Alaska – Arctic

The analysis of environmental justice issues associated with the development of offshore oil and gas development facilities considered impacts for the Arctic region, which consists of the NSB and the Northwest Arctic Borough.

The data in Table 3.15.3-1 show the minority and low-income composition of the total population located within the Arctic region, based on 2000 Census data and CEQ guidelines. Individuals identifying themselves as Hispanic or Latino are included in the table as a separate entry. However, because Hispanics can be of any race, this number also includes individuals identifying themselves as being part of one or more of the population groups listed in the table.

A large number of minority and low-income individuals are located in the Arctic region. The number of minority individuals in the region exceeds 50% of the total population, and the number of minority individuals exceeds the State average by 20 percentage points; thus, there is a minority population in the Arctic region, based on 2000 Census data and CEQ guidelines. The number of low-income individuals in the region does not exceed the State average by 20 percentage points or more and does not exceed 50% of the total population; thus, there are no low-income populations in the region.

TABLE 3.15.3-1 Arctic Region Minority and Low-Income Populations, 2000

	North Slope Borough	Northwest Arctic Borough	Arctic Region Total
Total Population	7,385	7,208	14,593
White, Non-Hispanic	1,228	878	2,106
Hispanic or Latino	175	57	232
Non-Hispanic or Latino Minorities	5,982	6,273	12,255
One Race	5,530	6,101	11,540
Black or African American	51	15	66
American Indian or Alaskan Native	4,982	5,919	10,901
Asian	435	64	499
Native Hawaiian or Other Pacific Islander	59	4	63
Some Other Race	3	8	11
Two or More Races	452	263	715
Total Minority	6,157	6,330	12,487
Percent Minority	83.4	87.8	85.6
Low-Income	663	1,243	1,906
Percent Low-Income	9.1	17.4	13.2

Source: USCB 2011g, h.

3.15.3.1 Health Status of Alaska Native Communities

The potential health effects of oil spills, including effects related to worker safety, toxicological effects in workers and community members, and mental health effects emanating from social and economic disruption, can disproportionately impact Alaska Native and other minority population groups and low-income communities (see Section 3.15.1.1). In addition to the impacts of oil spills, there are more general concerns regarding the possible health effects of oil and gas exploration and development on minority and low-income populations. Based on analysis undertaken for MMS, this section summarizes the current health status of the North Slope Iñupiat, the changes that have taken place over the past 50 yr, and the important determinants of public health in the North Slope communities, based on a series of meetings between the NSB and BOEMRE on this issue (MMS 2006b). Although specifically related to health issues in the North Slope Borough, many of the health issues identified in this section are also relevant to Alaskan Native populations in south central Alaska. "Health" is defined as "a state of complete physical, mental, and social well-being, and not merely the absence of disease or infirmity" (MMS 2006b). The disease and mortality figures discussed are age-adjusted unless otherwise specified.

Alaska Native health has undergone profound changes over the last 50 yr, and the changes in health status among the Iñupiat residents of the North Slope mirrors Statewide trends in Alaska Native health status in many respects. Since 1950, infant mortality, overall mortality, and life expectancy have improved significantly, as has been the case in American Indian tribes throughout the United States. However, over the same time period, cancer, chronic diseases (such as diabetes, hypertension, and asthma), and social pathology have increased (MMS 2006b).

Much of the overall improvement in mortality figures is attributable to decreased rates of infectious diseases such as tuberculosis. In 1950, tuberculosis was the leading cause of death, causing over 45% of deaths; by 2000, the proportion of deaths caused by infection had fallen to 1.3%; life expectancy at birth had increased from 46.6 to 69 yr, and infant mortality had decreased from 90/100,000 to 9.5/100,000. The most rapid improvement in general health indicators occurred in the 1950s and 1960s. However, since 1979, health status has continued to improve based on general indicators, with a decline of roughly 20% in all-cause mortality (MMS 2006b).

Health improvements have been facilitated by a combination of region-wide increases in general socioeconomic status (a powerful determinant of health); improved housing, sanitation, and health care; and specific infection-control efforts. Since 1979, much of the continued improvement in mortality figures can be accounted for by decreasing fatality from injuries. Mortality from unintentional injury, the second leading cause of death in Alaska Natives, accounts for much of the more recent improvement, with a decline of roughly 40% between 1979 and 1998. Much of this change can be attributed to local health departments' injury prevention programs and the efficacy of local alcohol control and local prohibition ordinances (MMS 2006b).

Despite these improvements in overall mortality figures, significant health disparities remain, and cancer, social pathology, and chronic diseases are rapidly increasing. Health disparities between Alaska Natives and American Indians and the general U.S. population constitute one of the top priorities in current public health efforts. Life expectancy at birth for Alaska Natives remains significantly lower than for the general population (69 compared with 76 yr). Since 1979, Alaska Native mortality rates remain roughly 30% higher than the U.S. population, and on the North Slope, overall mortality rates are 1.5 times higher than the U.S. population. Rates of assault, domestic violence, and unintentional and intentional (homicide and suicide) injury and death on the North Slope remain far higher than in the general U.S. population, despite the improvements noted above in unintentional injuries (MMS 2006b).

To understand the changes in Iñupiat health status and the reasons behind the current health disparities in general health indicators, it is useful to examine the prevalent health issues among the North Slope Iñupiat communities individually.

Cancer. Cancer has increased roughly 50% since 1969, and is now the leading cause of death on the North Slope. Three cancers — breast, colon, and lung — account for much of the overall increase. North Slope Alaska Natives have the highest incidence of cancer in Alaska, at 579/100,000. Cancer mortality rates for all Alaska Natives, including North Slope residents, at

303/100,000, are significantly higher than the U.S. rate of 163/100,000, a disparity of great concern to health care providers in the State (MMS 2006b).

A substantial percentage of the increase in cancer incidence, particularly for lung cancer, is attributable to smoking. There may be other, much less significant environmental factors at work as well, such as environmental contamination due to increases in industrialization, the use of locally generated electricity and of vehicles, and the adoption of highly insulated housing. Cancer mortality rates due to these factors are less well understood. The possible contribution of environmental factors such as contaminants in subsistence resources is of great concern to local residents, but does not likely constitute the sole or perhaps the most likely explanation. Current public health efforts focus on smoking cessation efforts, early detection, surveillance of carcinogens in subsistence foods, and curtailing exposure to known carcinogenic compounds as much as possible while discouraging their continued use (MMS 2006b).

Psychological and Social Problems. Alcohol and drug problems, accidental and intentional injury (a high percentage of which are associated with alcohol use), depression, anxiety, and assault and domestic violence are now highly prevalent in the North Slope Borough (as they are in many rural Alaska Native villages) and cause a disproportionate burden of suffering and mortality for these communities. Suicide rates among Alaska Natives have increased dramatically since 1960 (MMS 2006b). The prevalence of suicide on the North Slope in recent years has been estimated at roughly 45/100,000, more than four times the rate in the general U.S. population. Still more strikingly, the age distribution of suicide has shifted to become a phenomenon of youth; before 1960, it was exceedingly rare and generally occurred primarily among elderly individuals. The rate of suicide among young Iñupiat men in the Alaskan Arctic has been documented as high as 185/100,000, nearly 16 times the national rate (MMS 2006b).

Domestic violence and child abuse are also now generally acknowledged as epidemic problems in rural Alaska and, internationally, in other arctic indigenous communities as well. Unprocessed arrest data from the U.S. Department of Health and Social Services in 2000–2003, for example, show rates of rape and assault 8–15 times the national rate (MMS 2006b). Homicide rates have dropped more than 50% since 1979, but remain markedly higher than the U.S. population. Alcohol and substance abuse are thought to contribute substantially to the rates of these problems (MMS 2006b).

Research in circumpolar Inuit societies suggests that social pathology and related health problems, which are common across the Arctic, relate directly to the rapid sociocultural changes that have occurred over the same time period (MMS 2006b). In the North Slope Borough, suicide rates increased dramatically in the 1960s and 1970s, and since 1979 have remained relatively constant but dramatically higher than the overall U.S. rates.

Injury Rates. Injury — including unintentional (or accidental) injury, suicide, assault, and homicide — is the second leading cause of death on the North Slope. Accidental injury rates have declined 43% since 1979, but mortality from accidental injury remains 3.5 times more common for Alaska Natives than U.S. whites (MMS 2006b). Injury is the second leading reason for hospitalization, after childbirth. Figures from the Alaska Trauma Registry indicated that the hospitalization rate for injuries in the North Slope Borough was the highest in the State, at 141/10,000 residents, and over twice the State average. Alcohol has been estimated to be involved in up to 40% of injuries and traumatic deaths in Alaska Natives (MMS 2006b).

Unintentional injury rates are high in the North Slope, not only because of the challenges of life in Arctic Alaska, but also because of factors such as high rates of alcohol and substance abuse and risk-taking behavior in youth (MMS 2006b). Many public health officials in Alaska have speculated that many "accidental" injuries in younger people may actually reflect abnormal risk-taking or latent suicidal behaviors.

Diabetes and Metabolic Diseases. Diabetes, obesity, and related metabolic disorders were previously rare or nonexistent in the Iñupiat. Diabetes rates in the North Slope Borough are low compared with other Alaska Native groups — and extremely low compared with all American Indians — but have begun to climb quite rapidly (MMS 2006b). The prevalence of diabetes in the North Slope is estimated at only 2.4% compared with the U.S. rate of roughly 7%. However, between 1990 and 2001, the rate of diabetes climbed roughly 110%, nearly three times the rate of increase in the general U.S. population (MMS 2006b). Subsistence diets and the associated active lifestyle are known to be the main protective factors against diabetes. The increase in diabetes is felt to reflect increased use of store-bought food, and a more sedentary lifestyle, potentially against the backdrop of a baseline genetic susceptibility (MMS 2006b).

Cardiovascular Disease. Cardiovascular disease rates, the second leading cause of death in Alaska, are significantly lower in Alaska Natives than in U.S. non-Natives. In the North Slope Borough, recent mortality figures show death rates roughly 10% less than the U.S. population (MMS 2006b). However, as discussed above, many of the risk factors are increasing, and smoking rates are already extremely high (MMs 2006b). As in the case of diabetes, many public health researchers have explained the lower mortality from cardiovascular disease as stemming primarily from subsistence diets and the associated active lifestyle.

Chronic Pulmonary Disease. Chronic pulmonary disease mortality rates in Alaska Natives have climbed 192% since 1979. North Slope Borough residents have the highest mortality in the State from chronic lung diseases, at nearly three times the mortality rate for the United States (130/100,000 compared with 45/100,000) (MMS 2006b). As in the case of cancer, the primary reason for the disparate rates of increase and mortality in pulmonary disease is ascribed to the high smoking rates in the North Slope Borough. However, there may be environmental reasons for the rates of increase as well, such as air pollution generated by industrialization and changes in local energy use (see discussion on cancer above). Because there are no available data on local fine particulate concentrations, no data on hazardous air pollutants, and little data on intra-regional variation in other USEPA criteria pollutants, it is difficult to determine the possible contribution of these environmental factors.

In the United States in recent years, the field of public health has focused on efforts to explain and address health disparities between ethnic groups and social classes (MMS 2006b). That health disparities tend to accrue predominantly in minority and low-income populations is an indication of the vulnerability of these groups to outside societal-level influences on health status. An impressive body of data has demonstrated a direct association between measurable societal factors, which have been collectively termed the "social determinants of health" — including income inequity within a society, the "social gradient" (or disparities of social class), stress, social exclusion, decreasing social capital (the social support networks that provide for needs within a group or community), unemployment, cultural integrity, and environmental quality — and the incidence, prevalence, and mortality rates of many specific diseases. These disparities persist and can be dramatic, even after controlling for standard risk factors such as smoking rates, cholesterol and blood pressure levels, and overall poverty (MMS 2006b).

The determinants of health status in North Slope Iñupiat communities are complex and reflect a wide array of considerations, including genetic susceptibility, behavioral change, environmental factors, diet, and sociocultural inputs (MMS 2006b). Identifying the potential influences, or "determinants," of health status is an essential step for public health programs seeking to address health disparities. State, regional, and village-specific influences on health and health behavior can be directly or indirectly associated with past oil and gas development on the North Slope. For example, modernization and socioeconomic change are common to all of rural Alaska, and are one of the dominant influences on the evolution of health status. As noted above, North Slope petroleum development provided the economic tax base that funded many of the programs and activities that define these changes in rural Alaska. The associations between these influences and oil and gas development can be very complex and indeterminate (MMS 2006b). For example, regional differences exist between the NSB and other rural regions, such as the Northwest Arctic Borough, in terms of family income and employment status, largely related to oil and gas taxation and employment opportunities that came into being not because of the oil development alone, but because of the establishment and policymaking of the NSB. Similarly, residents of the North Slope village of Nuiqsut have experienced socioeconomic changes related not only to the State and regional-level influences discussed above, but also from local social and economic influences of the petroleum industry from the Alpine oilfield such as profits of the Kuukpik Corporation, shifts in income distribution, oilfield-related employment, the increased presence of oil workers in the village, a new road connection to the Alaska road system, and changes in hunting patterns and the availability of game due to oil-related infrastructure (MMS 2006b).

Public testimony on prior NEPA-based onshore and offshore actions in the region has indicated a persistent concern that regional industrialization may be at the root of some of the human health disparities described above. For example, testifying in 2001 on the MMS' Liberty draft EIS, Rosemary Ahtuangaruak, a former health aide who received advanced training as a physician's assistant, stated:

"Increased incidents of community social ills associated with rapid technological and social change cause problems with truancy, vandalism, burglary, child abuse, domestic violence, alcohol and drug abuse, suicide, and primarily the loss of self-esteem. This has materialized during transient employment cycles. The influx of construction workers brings their own problems to a village impacted by oil development activities already. Historically, from past experience, we know that the incidents of alcohol and drug use increase dramatically" (MMS 2006b).

Similarly, former North Slope Borough Mayor George Ahmaogak noted: "The benefits of oil development are clear — I don't deny that for a moment. The negative impacts are more subtle. They're also more widespread and more costly than most people realize. We know the human impacts of development are significant and long-term. So far, we've been left to deal with them on our own. They show up in our health statistics, alcohol treatment programs, emergency service needs, police responses — you name it" (MMS 2006b).

The health status of the North Slope Iñupiat people has improved significantly since the 1950s; however, significant new pathologies, most importantly cancer, cardiovascular and metabolic problems, and social pathology, have emerged during this period. The reasons for the improvements, the continuing disparities, and the new problems are very complex and originate in many different sources. However, while there is little definitive data linking degradation of environmental quality and local health impacts, and no data indicating specific health impacts of a particular oil and gas development project, a consideration of regional health data does allow for the recognition of risks associated with projects, and for the development of mitigation strategies. In general, the field of health impact assessment responds to concerns of environmental health impacts through efforts to control exposure to environmental contaminants rather than through attempts to identify specific increases in disease rates with specific exposures (MMS 2006b).

3.16 ARCHAEOLOGICAL AND HISTORIC RESOURCES

3.16.1 Gulf of Mexico

As defined in the ACHP regulations at 36 CFR 800.16, "historic property" means any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in, the *National Register of Historic Places* (NRHP). The term includes properties of traditional religious and cultural importance to an Indian tribe or Native Hawaiian organization and that meet the NRHP criteria. As used in this analysis, the more general term "cultural resources" also includes those historic resources not yet determined eligible for the NRHP.

Section 106 of the National Historic Preservation Act of 1966, as amended (NHPA; 16 USC 470(f)) requires that Federal agencies such as BOEMRE take into account the effect of an undertaking under their jurisdiction on significant cultural resources. A cultural resource is considered significant when it meets the eligibility criteria for listing on the NRHP (36 CFR 60.4). The Section 106 process requires the identification of cultural resources within the area of potential effect of a Federal project, consideration of a project's impact on cultural resources, and the mitigation of adverse effects on significant cultural resources. The process also requires consultation with State Historic Preservation Officers, the ACHP, Native American tribes, and interested parties. In the case of oil, gas, and sulfur leases, BOEMRE has established regulations (e.g., 30 CFR 250.194) and issues guidance to lessees (e.g., Notice to Lessees [NTL] No. 2005-G07 and G10, NTL No. 2006-G07, NTL No. 2005-A03, NTL No. 2006-PO3) to ensure compliance with Section 106 of the NHPA and its implementing regulations in 36 CFR

Part 800. The NTLs provide guidance on the regulations regarding archaeological discoveries and the conduct of archaeological surveys and identify specific OCS lease blocks with a high potential for containing cultural resources on the basis of previous studies.

BOEMRE can only consider the effects on cultural resources of projects over which it has permitting authority (Sansonetti 1987). BOEMRE does not have the legal authority to manage cultural resources on the OCS outside of its lease areas (Solicitor 1980). The only impacts that BOEMRE can consider off of the OCS are the visual impacts on historic properties on land. BOEMRE intends to develop additional guidance on the issue of indirect visual impacts through consultation with the Advisory Council on Historic Preservation and other interested parties. Once a project's footprint enters State waters, the project is no longer under BOEMRE control but is subject to the requirements identified by the State.

3.16.1.1 Offshore Prehistoric Resources

The GOM region consists of approximately 2,600 km (1,600 mi) of coastline. Onshore cultural resources are highly varied in coastal areas. Prehistoric cultural resources range from small, temporary use sites to substantial permanent settlements ranging in age from the earliest known human occupation of the area, approximately 12,000 yr ago, through the post-contact period (e.g., the last several hundred years). It is estimated that the current water levels of the GOM were reached approximately 3,000 yr ago (Stright et al. 1999). Therefore, sites predating this period could be located under water.

Approximately 19,000 yr ago, during the late Wisconsinan glacial advance, much of the OCS constituted dry land, as the sea level was approximately 120 m (390 ft) lower than present levels. During the earliest period of uncontested human prehistoric populations in the GOM coast region (approximately 12,000 yr ago), the sea level would have been approximately 45 to 60 m (150 to 200 ft) lower than present (CEI 1982). The submerged area between the paleoshoreline (vicinity of the 45- to 60-m [150- to 200-ft] bathymetric contour) to the present-day shoreline would, therefore, have the potential to contain prehistoric sites. Studies conducted in the 1980s and 1990s confirmed that inundated former terrestrial archaeological sites do exist in the GOM (Dunbar et al. 1989; Anuskiewicz and Dunbar 1993). A growing body of information suggests that North America may have been populated much earlier than 12,000 yr ago (e.g., Waters et al. 2011). If an earlier date can be established for the settling of North America, the depth and extent of areas with the potential for inundated terrestrial sites could expand.

3.16.1.2 Offshore Historic Resources

From the historic period (1492 to present), offshore cultural resources primarily consist of numerous shipwrecks dating from as early as the sixteenth century. However, other historic structures can also be found offshore, such as the Ship Shoal Lighthouse. Literature searches can be completed for reported ship losses and known shipwrecks, but they offer only a partial understanding of the resources that may be present. It can be assumed that some percentage of the reporting is inaccurate, some locations were imprecisely recorded, some of the ships were badly broken up and widely dispersed during drift, and additional ship losses may not have been documented (e.g., the losses of small coastal fishing boats were largely unreported, and the regular reporting of other larger boats did not occur until the nineteenth century). Often there is only a record that a ship was lost in the GOM region.

The preservation potential of shipwrecks varies throughout the GOM. The preservation of shipwrecks is dependent on several factors including the level of sedimentation at a wreck site, the depth the wreck, the strength and extent of water current activity near a site, and the temperature of the water. Shipwrecks in areas with high sediment loads are expected to be better preserved. The sediment protects the sites from the effects of severe storms and wood-eating shipworms. The coasts of Texas, Louisiana, Mississippi, and Alabama are likely to have sufficient sediment load to preserve shipwrecks. However, as a result of differences in sedimentation rates, it is anticipated that preservation would be slightly better off the Mississippi/Alabama coast than off the Louisiana coast due to the greater amount of sediment being discharged and deposited from the Mississippi River (CEI 1977). Deepwater shipwrecks are expected to have a moderate to high preservation potential. Studies conducted in 2004 and 2008 for BOEMRE suggest that the high level of preservation in deep water is partially attributable to these areas being low-energy environments (Church et al. 2004; Ford et al. 2008). In addition, the water is colder at deepwater sites; this slows the oxidation process. Finally, the cause of a shipwreck could also affect its preservation potential. Shipwrecks nearer to the shoreline have a greater potential to be broken up and scattered by subsequent storms.

Several studies have been conducted for the BOEMRE to model areas in the GOM where shipwrecks have the highest potential to exist. The first study, conducted in 1977, concluded that two-thirds of all shipwrecks in the northern GOM are located within 1.5 km (0.9 mi) of the shore (CEI 1977). A second study in 1989 (Garrison et al. 1989) concluded that the highest frequency of shipwrecks occurred in areas of the highest volume of marine traffic (e.g., approaches to seaports and mouths of navigable rivers and straits). This study also reported an increased frequency in shipwrecks in the open sea of the eastern GOM that was double that reported for the western or central GOM, attributed to changes in sailing routes in the late nineteenth and early twentieth centuries. In addition, the study looked at distribution patterns of shipwrecks relative to ocean currents, storm tracks, natural navigational hazards, and economic histories of ports. The final study, conducted in 2003 (Pearson et al. 2003), incorporated new data that had been compiled over 15 yr of high-resolution shallow hazard surveys for oil and gas development and sonar surveys. To date, shipwrecks have been discovered in water depths up to 1,981 m (6,500 ft). Many of the deepwater wrecks, at least their locations, were not previously known; several of the deepwater shipwrecks date to the World War II era. As a result of the findings in this study, BOEMRE updated its guidelines to include lease blocks in deepwater areas within the approach to the Mississippi River as high-potential areas requiring archaeological survey (NTL No. 2006-G07).

3.16.1.3 Onshore Archaeological and Historic Resources

Geographic features associated with onshore prehistoric archaeological sites in coastal areas in the western and central GOM include river channels and associated floodplains, terraces, levees and point bars, barrier islands, back barrier embayments, and salt domes. In the eastern GOM, off the coast of Florida, additional features include chert outcrops, solution caverns, and sinkholes. These same types of features are present on the OCS, are submerged and often buried by estuarine and marine sediments, and have the same potential for being associated with prehistoric site locations in this region. BOEMRE requires high-resolution remote sensing surveys prior to any bottom-disturbing activities associated with oil, gas, and sulfur leasing.

Historic resources located in coastal regions can include historic residences and communities, lighthouses, historic forts, and piers and docks. Onshore historic resources can also include shipwrecks that have been buried on beaches.

3.16.2 Alaska – Cook Inlet

3.16.2.1 Offshore Prehistoric Resources

Minimal research has been conducted in the Cook Inlet Planning Area concerning the potential for submerged landforms that could contain archaeological material. During the time that Alaska was first populated (c. 13,000 yr ago), sea levels were significantly lower than today (Dixon et al. 1986). Much of the shoreline, where the first peoples would have lived, is now inundated in water up to 60 m (197 ft) in depth. Most of the research concerning identification of these old shorelines has occurred in the Beaufort and Chukchi Seas (see Section 3.6.5.8.1). However, an archaeological baseline study completed by Dixon et al. (1986) compiled available geologic, bathymetric, geophysical, climatic, and archaeological data in an effort to outline those areas of the Alaska OCS that may have the highest potential for preserved prehistoric archaeological sites. The primary indicators used to evaluate offshore prehistoric site potential were coastal geomorphic features onshore, relict geomorphic features offshore, and ecological data. It was proposed in the baseline study that these lines of evidence, taken together, indicate areas where subsistence resources used by prehistoric human populations would have been concentrated for sustained periods of time. However, actual geophysical data would be required to reconstruct the offshore paleogeography and determine specific areas where prehistoric archaeological sites might occur. The results of the baseline study suggest that the area around the Aleutian Islands has potential for preserved prehistoric sites. While the information contained in the Dixon et al. (1986) report is useful for understanding Alaskan prehistory, the Alaska SHPO requires that baseline reports be updated regularly (personal comm. McMahan 2011). Since the report has not been updated, it can no longer be used as the primary resource for determining the likelihood of the presence of prehistoric resources.

Portions of Cook Inlet are subject to high-energy tidal movements. The seafloor of lower Cook Inlet contains seafloor characteristics such as lag gravels, sand ribbons, and sand wave fields (MMS 2003a). These features are only formed in areas of high energy. High-energy water movement may have removed the potential for archaeological resources to be present. Additional research is needed to determine the extent of the disturbance.

3.16.2.2 Offshore Historic Resources

A total of 108 shipwrecks were lost in Cook Inlet between 1799 and 1954 (Tornfelt and Burwell 1992). With some exceptions, the sites of most of these shipwrecks are within State waters. However, the best-preserved shipwrecks are likely to be found on the OCS, because wave action and ice are less likely to contribute to the breakup of ships in deeper waters. No shipwreck studies have been done in Cook Inlet since 1992.

3.16.2.3 Onshore Archaeological and Historic Resources

Records for known onshore archaeological and historic resources around Cook Inlet are maintained by the Alaska Office of History and Archaeology (Alaska OHA). Along the shoreline surrounding Cook Inlet, the predominant types of prehistoric resources are house pits containing the household and subsistence artifacts (stone lamps, sinkers, arrowheads, etc.) of prehistoric people. Historic sites found onshore consist of early Russian houses, churches, roadway inns, fish camps, and mining camps.

3.16.3 Alaska – Arctic

3.16.3.1 Offshore Prehistoric Resources

At the height of the late Wisconsinan glacial advance (approximately 19,000 yr ago), the global (eustatic) sea level was approximately 120 m (394 ft) lower than present. During this time, large expanses of what is now the OCS were exposed as dry land. Where the actual shorelines were located varied depending on the location and the amount of ice that was present. The lower sea levels created land bridges between the Asian continent and the North American continent. It is commonly thought that it was over these land bridges that the first people came to North America roughly 13,000 yr ago (Dariago et al. 2007). It is also commonly held that the first inhabitants of North America would have settled along the coasts. Therefore, if the relic coastlines or landforms (which are now completely inundated) can be found and identified, it is possible that archaeological evidence for the populating of North America could be found.

Studies using data collected during various explorations in the Beaufort Sea attempted to clarify if landforms dating to the early Holocene Period (between 13,000 and 11,000 yr ago) could be found and whether there was any potential for intact archaeological material to remain in these areas (Dariago et al. 2007). The studies found that the shoreline at 13,000 yr ago was approximately 60 m (197 ft) below sea level and that landforms do appear to exist from that time period. Similarly, in 1992, studies conducted in the Chukchi Sea also seem to indicate that landforms from the early Holocene may remain (Elias et al. 1992). However, major disturbances have occurred to these landforms. Ice gouging resulting from large pieces of ice dragging along the bottom of the ocean may have altered the landform sediments and removed all archaeological evidence of the first peoples. The full extent of the disturbance is not known. Some areas near barrier islands or areas that are protected by shorefast ice show less evidence of ice gouging (Dariago et al. 2007). The amount of disturbance also varies between the Beaufort and Chukchi Seas. Because more investigations have occurred in the Beaufort Sea, there is a better understanding of the situation in that area. Ultimately, sonar and seismic surveys are needed to determine the condition of the sediments and underlying strata.

3.16.3.2 Offshore Historic Resources

Numerous shipwrecks have been documented in the Beaufort and Chukchi Seas. Most of the shipwrecks off of Alaska's north coast were associated with commercial whaling, which occurred between 1849 and 1921 (Bockstoce and Burns 1993). Archival research has identified numerous reports of shipwrecks (Bockstoce 1977; Tornfelt and Burwell 1992; Rozell 2000). BOEMRE maintains an Alaska Shipwreck Database which includes information on all known shipwrecks. As a result of the studies conducted on shipwrecks, BOEMRE has identified some areas in the Chukchi and Beaufort Seas as having high probability for containing wrecks. Most of the wrecks off northern Alaska are likely in State waters and are not under the direct jurisdiction of BOEMRE. High resolution geophysical surveys are needed to determine shipwreck locations. The following contains some information on the types and locations of shipwrecks in the Beaufort and Chukchi Seas.

Based on archival research cited above, between 1849 and 1921, 34 shipwrecks occurred within a few miles of Barrow; another 13 wrecks occurred to the west and east of Barrow in the waters of the Chukchi and Beaufort Seas. No surveys of these shipwrecks have been made; therefore, no exact locations are known. These wrecks would be important finds, providing information on past cultural norms and practices, particularly with regard to the whaling industry (Tornfelt and Burwell 1992).

At Point Belcher near Wainwright, 30 ships were frozen in the ice in September 1871; 13 others were lost in other incidents off Icy Cape and Point Franklin. Another 7 wrecks occurred off Cape Lisburne and Point Hope. From 1865 to 1876, 76 whaling vessels — an average of more than 6 per year — were lost because of ice and also because of raids by the *Shenandoah*, which burned 21 whaling ships near the Bering Strait during the Civil War (Bockstoce 1977). The possibility exists that some of these shipwrecks have not been completely destroyed by ice and storms. The probabilities for preservation are particularly high around Point Franklin, Point Belcher, and Point Hope (Tornfelt and Burwell 1992).

A remote sensing survey in the Beaufort Sea recorded a large side-scan sonar target. The size and shape of this object and historical accounts suggest that it may be the crash site of the Sigismund Levanevsky, a Russian airplane that was lost during a transpolar flight in 1939 (Rozell 2000). Subsequent attempts at relocating the object and confirming its identity were unsuccessful.

3.16.3.3 Onshore Archaeological and Historic Resources

Archaeological and historic resources are found along the Chukchi and Beaufort Sea coasts. Onshore archaeological resources near the Chukchi Sea coast receive less damage from the eroding shoreline than those on the Beaufort Sea coast, which is subjected to more slumping because of water action and permafrost (Lewbel 1984). Therefore, known onshore archaeological resources exist in greater numbers in the Chukchi Sea area; additional unknown resources are also more likely to exist. Known historic and archaeological resources are cataloged in the Alaska Heritage Resources Files maintained by the Alaska OHA. The types of onshore archaeological and historic resources known to exist include prehistoric and historic villages, graves, whaling camps, fishing/hunting camps, and whaling ship remains (Tornfelt and Burwell 1992; Beebe and Jensen 2006, 2007). In addition, Cold War era historic sites including former Distant Early Warning line outposts, radar stations associated with the Aircraft Control and Warning System, missile sites, and others can be found along the Chukchi and Beaufort Sea coasts (Whorton and Hoffecker 1999).

Significant resources found along the Chukchi and Beaufort Seas include the Ipiutak Site National Historic Landmark at Point Hope, the Cape Krusenstern National Monument, the Bering Land Bridge National Preserve, and the Birnirk Site National Historic Landmark at Barrow. These areas are known to contain significant archaeological resources, occasionally in large numbers.

3.17 REFERENCES

Aarimitsu, M.L., J.F. Piatt, M.A. Litzow, A.A. Abookire, M.D. Romano, and M.D. Robards, 2008, “Distribution and Spawning Dynamics of Capelin (*Mallotus villosus*) in Glacier Bay, Alaska: A Cold Water Refugium,” *Fisheries Oceanography* 17:137–146.

ABC (American Bird Conservancy), 2011, *Globally Important Bird Areas of the United States. The Plains, Virginia*. Available at http://www.abcbirds.org/abcprograms/domestic/iba/index.html. Accessed April 20, 2011

ACIA (Arctic Climate Impact Assessment), 2005, *Arctic Climate Impact Assessment,* Cambridge University Press, New York, N.Y.

Ackerman, R.A., 1997, “The Nest Environment and the Embryonic Development of Sea Turtles,” in *The Biology of Sea Turtles*, P.L. Lutz and J.A. Musick (eds.), CRC Press, Boca Raton, Fla., p. 83–106.

ACRC (Alaska Climate Research Center), 2011, *Alaska Climatology*. Available at http://climate.gi.alaska.edu/Climate/index.html. Accessed May 30, 2011.

ADEC (Alaska Department of Environmental Conservation), 2010a, *Alaska’s Final 2010 Integrated Water Quality Monitoring and Assessment Report*, July 15.

ADEC, 2010b, *Alaska's 2011 Air Monitoring Network Plan, Chapter 1 – Monitoring Plan*, Anchorage, Alaska. Available at http://www.epa.gov/ttnamti1/files/networkplans/ AKPlan2010.pdf. Accessed May 29, 2011.

ADFG (Alaska Department of Fish and Game), 2011a, *Species Profiles: Mammals*, Juneau, Alaska. Available at http://www.adfg.alaska.gov/index.cfm?adfg=animals.listmammals. Accessed May 10, 2011.

ADFG, 2011b, *Sitka Black-tailed Deer Hunting in Alaska*, Juneau, Alaska. Available at http://www.adfg.alaska.gov/index.cfm?adfg=deerhunting.main. Accessed May 9, 2011.

ADFG, 2011c, *Porcupine Caribou Herd Shows Growth*, Press Release No. 11-14, Juneau, Alaska, March 2. Available at http://www.adfg.alaska.gov/index.cfm?adfg= pressreleases.pr03022011. Accessed April 8, 2011.

ADFG, 2011d, *Western Arctic Caribou Herd Count Revised*, Press Release No. 11-20, Juneau, Alaska, March 24. Available at http://www.adfg.alaska.gov/index.cfm?adfg=pressreleases. pr03242011. Accessed April 8, 2011.

ADFG, 2011e, *Subsistence in Alaska, Harvest Data and Reports Community Subsistence Information System.* Available at http://www.adfg.alaska.gov/index.cfm?adfg= subsistence.harvest. Accessed June 17, 2011.

ADFG 2011f, *Subsistence in Alaska,* Alaska Department of Fish and Game. Available at http://www.adfg.alaska.gov/index.cfm?adfg=subsistence.main. Accessed August 2011.

ADNR (Alaska Department of Natural Resources), 1997, *Oil and Gas Lease Sale 86, Central Beaufort Sea: Final Finding of the Director*, ADNR, Division of Oil and Gas Anchorage, Alaska.

ADNR, 1999, *Best Interest Finding, Cook Inlet Areawide 1999 Oil and Gas Lease Sale: Final Finding of the Director,* Division of Oil and Gas, Anchorage, Alaska.

ADNR, 2008, *Best Interest Finding, North Slope Areawide Oil and Gas Lease Sale: Final Finding of the Director*. Anchorage, AK: State of Alaska/ADNR, Division of Oil and Gas.

ADNR, 2009, *Beaufort Sea Areawide Oil and Gas Lease Sale Final Finding of the Director*, Division of Oil and Gas, Anchorage, Alaska, Nov. 9.

AFN (Alaska Federation of Natives), 2006, *Subsistence History,* AFN Subsistence Forum, Anchorage, Oct. 25.

Agler, B.A., S.J. Kendall, and D.B. Irons, 1998, "Abundance and Distribution of Marbled and Kittlitz's Murrelets in Southcentral and Southeast Alaska." *The Condor* 100: 254–265.

Agrium, Inc., 2007, *Agrium Announces Closure of Kenai Nitrogen Facility*. Available at http://www.agrium.com/news/05784_8346.jsp. Accessed July 2011.

Aguilera, F., J. Méndez, E. Pásaro, and B. Laffon, 2010, "Review on the Effects of Exposure to Spilled Oils on Human Health," *Journal of Applied Toxicology* 30: 291–301.

Aharon, P., D. Van Gent, B. Fu, and L.M. Scott, 2001, *Fate and Effects of Barium and Radium-Rich Fluid Emissions from Hydrocarbon Seeps on the Benthic Habitats of the Gulf of Mexico Offshore Louisiana*, prepared by Louisiana State University, Coastal Marine Institute, OCS Study MMS 2001-004, MMS, Gulf of Mexico OCS Region, New Orleans, La.

AIAC (Alabama Indian Affairs Commission), 2011, *Tribes Recognized by the State of Alabama*, State of Alabama Indian Affairs Commission, Montgomery, Ala. Available at http://aiac.alabama.gov/tribes.aspx. Accessed 28 February 2011.

Ainley, D.G., D.N. Nettleship, H.R.C. Storey, and A.E. Storey, 2002, *Common Murre* (Uria aalge), Issue 666, The Birds of North America Online (A. Poole, ed.), Cornell Lab of Ornithology, Ithaca, New York. Available at http://bna.birds.cornell.edu/bna/species/666. Accessed August 18, 2011.

Alabama Department of Environmental Management, 2005, *Coastal Alabama Beach Monitoring Program*.

Alabama Ornithological Society, 2006, *Field Checklist of Alabama Birds*. Alabama Ornithological Society, Dauphin Island, Ala.

Alabama Ornithological Society, 2011, *Annotated Alabama Record Pelagic List*. Available at http://www.aosbirds.org/pelagicrecords.php. Accessed April 11, 2011.

Alaska Department of Administration, 2004, *2004 Final Gas Disposition Report*. Available at http://doa.alaska.gov/ogc/annual/2004/2004_Gas_Disposition_Final.pdf. Accessed August 31, 2011.

Alaska Department of Labor and Workforce Development, 2007, *Alaska Population Projections, 2007-2030*. Available at http://laborstats.alaska.gov/pop/projected/pub/popproj0730.pdf. Accessed July 29, 2011.

Alaska Oil and Gas Association (AOGA), 2008, *The Role of Oil and Gas in Alaska's Economy*, June. Available at http://www.aoga.org/wp-content/uploads/2010/06/report2008.pdf. Accessed September 9, 2011.

Alaska Regional Assessment Group, 1999, *The Potential Consequences of Climate Variability and Change: Alaska*, report prepared for U.S. Global Change Research Program, Center for Global Change and Arctic System Research, Fairbanks, Alaska.

Alaska Shorebird Group, 2008, *Alaska Shorebird Conservation Plan, Version II*, Alaska Shorebird Group, Anchorage, Alaska. Available at http://alaska.fws.gov/mbsp/mbm/shorebirds/plans.htm. Accessed August 18, 2011.

Alaska Visitors Statistics Program, 1990a, *Alaska Visitor Expenditures, Summer 1989*, prepared for the State of Alaska Department of Commerce and Economic Development, Division of Tourism, by The McDowell Group, August.

Alaska Visitor Statistics Program, 1990b, *Visitor Patterns, Opinions, Planning, Summer 1989*, prepared for the State of Alaska, Department of Commerce and Economic Development, Division of Tourism, by The McDowell Group, October.

Alaska Visitors Association, 1990, *Oil Spill Impact on Tourism*, May.

Alexander-Bloch, B., 2010, "Vietnamese-American Fishers Fight for Oil Spill Claim Approval," *nola.com.* Available at http://www.nola.com/news/gulf-oil-spill/index.ssf/2010/12/vietnamese-american_fishermen.html. Accessed June 17, 2011.

Alkire, M.B., and J.H. Trefry, 2006, "Transport of Spring Floodwater from Rivers under Ice to the Alaskan Beaufort Sea," *Journal of Geophysical Research* 111:C12008.

Allen, B.N., and R.P. Angliss, 2010a, *Alaska Marine Mammal Stock Assessments, 2009*, NOAA Technical Memorandum NMFS-AFSC-206, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, Wash., Feb.

Allen, B.N., and R.P. Angliss, 2010b, *Draft Alaska Marine Mammal Stock Assessments, 2010*, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, Wash., April.

Allen, B.N., and R.P. Angliss, 2011, *Alaska Marine Mammal Stock Assessments, 2010*, NOAA, Technical Memorandum NMFS-AFSC-223, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, Wash., May.

Alter, S.E., M.P. Simmonds, and J.R. Brandon, 2010, "Forecasting the Consequences of Climate-driven Shifts in Human Behavior on Cetaceans," *Marine Policy* 34(5):943–954.

AMAP (Arctic Monitoring and Assessment Programme), 1997, *Arctic Pollution Issues: A State of the Arctic Environment Report*, Oslo, Norway, 188 p.

AMAP, 2002, *Arctic Pollution 2002*, Arctic Monitoring and Assessment Programme, Oslo, Norway.

AMAP, 2004, *AMAP Assessment 2002: Persistent Organic Pollutants in the Arctic*, Oslo, Norway: Arctic Monitoring and Assessment Programme.

American Cetacean Society, 2006, *Harbor Porpoise Phocoena phocoena*, ACS Cetacean Fact Packs, Sept. 18.

American Gaming Association, 2010, *State of the States: The AGA Survey of Casino Entertainment*, 2010, Washington, D.C. Available at http://www.americangaming.org/files/aga/uploads/docs/sos/aga-sos-2010.pdf. Accessed July 15, 2011.

Amstrup, S.C., 2003, "Polar Bear *Ursus maritimus*," pp. 587–610 in *Wild Mammals of North America: Biology, Management, and Conservation*, 2nd edition, G.A. Feldhamer, B.C. Thompson, and J.A. Chapman (eds.), John Hopkins University Press, Baltimore, Md.

Amstrup, S.C., and C.L. Gardner, 1994, "Polar Bear Maternity Denning in the Beaufort Sea," *Journal of Wildlife Management* 58:1–10.

Amstrup, S.C., G.M. Durner, I. Stirling, N.J. Lunn, and F. Messier, 2000, "Movements and Distribution of Polar Bears in the Beaufort Sea," *Canadian Journal of Zoology* 78(6):948–966.

Anderson, P.J., and J.F. Piatt, 1999, "Community Reorganization in the Gulf of Alaska Following Ocean Climate Regime Shift," *Marine Ecology Progress Series* 189:117–123.

Andrews, R.K., B.M. Howe, J.A. Mercer, and M.A. Dzieciuch, 2002, "Ocean Ambient Sound: Comparing the 1960s with the 1990s for a Receiver Off the California Coast," *Acoustics Research Letters Online* 3(2):65–70.

Angerbjorn, A., B. Arvidson, E. Noren, and L. Stromgren, 1991, "The Effect of Winter Food on Reproduction in the Arctic Fox, *Alopex lagopus*: A Field Experiment," *Journal of Animal Ecology* 60:705–714.

Anisimov, O.A., D.G. Vaughan, T.V. Callaghan, C. Furgal, H. Marchant, T.D. Prowse, H. Vilhjálmsson and J.E. Walsh, 2007, "Polar Regions (Arctic and Antarctic)," in *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson (eds.), Cambridge University Press, Cambridge, United Kingdom, pp. 653–685.

Anuskiewicz, R.J., and J.S. Dunbar, 1993, "Evidence of Prehistoric Man at Ray Hole Springs: A Drowned Sinkhole Located 32 km Offshore on the Continental Shelf in 12 m of Seawater," *Proceedings of the American Academy of Underwater Sciences Thirteenth Annual Scientific Diving Symposium*, September 19–22, 1993, Pacific Grove, Calif.

Anthony, R.M., N.M. Barten, and P.E. Seiser, 2000, "Foods of Arctic Foxes (*Alopex lagopus)* during Winter and Spring in Western Alaska," *Journal of Mammalogy* 81(3):820–828.

Aquarone, M.C., and S. Adams, 2009, "XIV-46 Gulf of Alaska: LME #2," LME Briefs. Available at http://www.lme.noaa.gov/index.php?option=com_content&view=article&id=48:lme2&catid=41:briefs&Itemid=72. Accessed January 28, 2011.

Archer, F.I., and W.F. Perrin, 1999, "*Stenella coeruleoalba*," *Mammalian Species* 603:1–9.

Arctic Council, 2005, *Arctic Climate Impacts Assessment*, Cambridge University Press, Cambridge, U.K.

Armstrong, R.H., 2003, *Guide to the Birds of Alaska*, Alaska Northwest Books, Portland, Oregon.

Arp, C.D., B.M. Jones, J.A. Schmutz, F.E. Urban, M.T. Jorgenson, 2010, "Two Mechanisms of Aquatic and Terrestrial Habitat Change along an Alaskan Arctic Coastline," *Polar Biology* 33:1629–1640.

ASRC (Arctic Slope Regional Corporation), 2011, *Communities.* Available at http://www.asrc.com/Communities/Pages/Communities.aspx. Accessed June 17, 2011.

Associated Press, 2010, *Gulf Spill Cleanup Winners and Losers*. Available at http://www.huffingtonpost.com/2010/08/26/gulf-oil-spill-cleanup-winners-and-losers_n_696416.html. Accessed July 15, 2011.

A.T. Kearney, Inc., 1991, *Impacts of Oil and Gas Development on the Recreation and Tourism Activity in the Florida Straits*, OCS Study MMS 91-039, Minerals Management Service. Available at http://www.gomr.mms.gov/PI/PDFImages/ESPIS/1/1980.pdf. Accessed July 15, 2011.

Attrill, M.J., 2002, "A Testable Linear Model for Diversity Trends in Estuaries," *Journal of Animal Ecology* 71(2):262–269, March.

Au, W.W.L., 1993, *The Sonar of Dolphins*, Springer-Verlag, New York, N.Y.

Au, W.W.L., D.A. Carder, R.H. Penner, and B.L. Scronce, 1985, "Demonstration of Adaptation in Beluga Whale Echolocation Signals," *J. Acoust. Soc. Am.* 77(2):726–730.

Au, W.W.L., R.H. Penner, and C.W. Turl, 1987, "Propagation of Beluga Whale Echolocation Signals," *J. Acoust. Soc. Am.* 82(3): 807–813.

Audet, A.M., C.B. Robbins, and S. Lariviere, 2002, "*Alopex lagopus*," *Mammalian Species No. 713*:1–10.

Audubon Alaska, 2011, *Important Bird Areas*. Audubon Alaska, Anchorage. Available at http://ak.audubon.org/birds-science-education/important-bird-areas-0. Accessed July 12, 2011.

Audubon Society, 2011a, *Important Bird Areas Along the Gulf Coast: Priority Sites*. Available at http://web4.audubon.org/bird/iba/gulfIBAs_list.html. Accessed April 27, 2011.

Audubon Society, 2011b, *Dauphin Island Site Report*. Available at http://iba.audubon.org/iba/siteSearch.do. Accessed April 25, 2011.

Augerot, X., 2005, *Atlas of Pacific Salmon*, University of California Press, Berkeley, Calif.

Aumack, C.F., K.H. Dunton, A.B. Burd, D.W. Funk, and R.A. Maffione, 2007, "Linking Light Attenuation and Suspended Sediment Loading to Benthic Productivity within an Arctic Kelp-Bed Community," *Journal of Phycology* 43:853–863.

Bacheler, N.M., K.M. Bailey, L. Ciannelli, V. Bartolino, and K.-S. Chan, 2009, "Density-Dependent, Landscape, and Climate Effects on Spawning Distribution of Walleye Pollock *Theragra chalcogramma*," *Marine Ecology Progress Series* 391:1–12.

Bailey, R.G., 2005, "Identifying Ecoregion Boundaries," *Environmental Management* 34 (Supplement 1):S14–S26.

Bailey, H., and P. Thompson, 2010, "Effect of Oceanographic Features on Fine-Scale Foraging Movements of Bottlenose Dolphins," *Marine Ecology Progress Series* 418:223–233.

Baird, P.H., 2009a, *Black-legged Kittiwake* (Rissa tridactyla), Issue 092, The Birds of North America Online (A. Poole, ed.), Cornell Lab of Ornithology, Ithaca, New York. Available at http://bna.birds.cornell.edu/bna/species/092. Accessed August 18, 2011.

Baird, R.W., 2009b, *A Review of False Killer Whales in Hawaiian Waters: Biology, Status, and Risk Factors*, prepared by Cascadia Research Collective, Olympia, Washington for U.S. Marine Mammal Commission, Dec. 23. Available at http://www.mmc.gov/reports/workshop/pdf/killerwhale_review_mmc09.pdf. Accessed September 9, 2011.

Baker, J.D., C.L. Littnan, and D.W. Johnston, 2006, "Potential Effects of Sea Level Rise on the Terrestrial Habitats of Endangered and Endemic Megafauna in the Northwestern Hawaiian Islands," *Endangered Species Research* 4:1–10.

Baker, C.S., S.R. Palumbi, R.H. Lambertsen, M.T. Weinrich, J. Calambokidis, and S.J. O'Brien, 1990, "Influence of Seasonal Migration on Geographic Distribution of Mitochondrial DNA Haplotypes in Humpback Whales," *Nature* 344:238–240.

Bakun, A., 1990, "Global Climate Change and Intensification of Coastal Ocean Upwelling," *Science* 247:198–201.

Balcomb, K.C., J.R. Boran, R.W. Osborne, and N.J. Haenel, 1980, *Observations of Killer Whales (Orcinus orca) in Greater Puget Sound, State of Washington*, Report No. 78/13, Marine Mammal Commission, Washington, D.C.

Barbeau, D.N., L.F. Grimsley, L.E. White, J.M. El-Dahr, and M. Lichtveld, 2010, "Mold Exposure and Health Effects Following Hurricanes Katrina and Rita," *Annual Review of Public Health* 31: 165–178.

Barras, J.A., J.C. Bernier, and R.A. Morton, 2008, *Land Area Change in Coastal Louisiana: A Multidecadal Perspective (from 1956 to 2006)*, U.S. Geological Survey Scientific Investigations Map 3019, scale 1:250,000, 14 p. pamphlet.

Barber, W.E., R.L. Smith, M. Vallarino, and R.M. Meyer, 1997, "Demersal Fish Assemblages of the Northeastern Chukchi Sea, Alaska," *Fishery Bulletin* 95:195–209.

Barnes, V.G., Jr., 1990, "The Influence of Salmon Availability on Movements and Range of Brown Bears on Southwest Kodiak Island," *International Association for Bear Research and Management* 8:305–313.

Barr, N., and L. Barr, 1972, "An Observation of Killer Whale Predation on a Dall Porpoise," *Canadian Field-Naturalist* 86:170–171.

Barras, J., S. Beville, D. Britsch, S. Hartley, S. Hawes, J. Johnston, P. Kemp, Q. Kinler, A. Martucci, J. Porthouse, D. Reed, K. Roy, S. Sapkota, and J. Suhayda, 2004, *Historical and Projected Coastal Louisiana Land Changes: 1978-2050*, USGS Open File Report, OFR 03-334, U.S. Geological Survey, Revised January 2004.

Barry A. Vittor & Associates, Inc., 1985, *Tuscaloosa Trend Regional Data Search and Synthesis Study, Synthesis Report, Volume I*, OCS Study MMS 85-0056, MMS, Gulf of Mexico OCS Regional Office, New Orleans, La.

Bates, N.R., and J.T. Mathis, 2009, "The Arctic Ocean Marine Carbon Cycle: Evaluation of Air-Sea CO_2 Exchanges, Ocean Acidification Impacts and Potential Feedbacks," *Biogeosciences* 6:2433–2459.

Bates, N.R., B. Moran, D.A. Hansell, L.A. Codispoti, and J.R. Swift, 2005, "Seasonal and Spatial Distribution of Suspended and Large Aggregate Particulate Organic Matter (POM) in the Chukchi Sea," *Deep-Sea Research II* 52:3324–3323.

Baumgartner, M.F., 1997, "The Distribution of Risso's Dolphin (*Grampus griseus*) with Respect to the Physiography of the Northern Gulf of Mexico," *Marine Mammal Science* 13(4):614–638.

Baustian, M.M., and N.N. Rabalais, 2009, "Seasonal Composition of Benthic Macroinfauna Exposed to Hypoxia in the Northern Gulf of Mexico," *Estuaries Coasts* 32:975–982.

Becker, P.R., and C.A. Manen, 1988, *Natural Oil Seeps in the Alaskan Marine Environment*, Final Report, Outer Continental Shelf Environmental Assessment Program Research Unit 703, May.

Beebe, R.G., and A.M. Jensen, 2006, *Searching for the Wrecks of the 1871 Whaling Disaster in the Chukchi Sea: A Minimalist Approach to Remote Sensing in Remote Areas*, unpublished report, Barrow Arctic Science Consortium, Barrow, Alaska.

Beebe, R.G., and A.M. Jensen, 2007, Searching for the Wrecks of the 1871 Whaling Disaster in the Chukchi Sea: Final Report, unpublished report, Barrow Arctic Science Consortium, Barrow, Alaska.

Belkin, I.M., 2009, "Rapid Warming of Large Marine Ecosystems," *Progress in Oceanography* 81:207–213.

Belkin, I., M.C. Aquarone, and S. Adams, 2009, "XI-30 Beaufort Sea: LME #55," LME Briefs. Available at http://www.lme.noaa.gov/index.php?option=com_content&view=article&id=101:lme55&catid=41:briefs&Itemid=72. Accessed January 28, 2011.

Bentzen, R.L., A.N. Powell, and R.S. Suydam, 2009, "Strategies for Nest-Site Selection by King Eiders," *Journal of Wildlife Management* 73(6):932–938.

Bergerud, A.T., 1987, "An Assessment of Petroleum on the Status of the Porcupine Caribou Herd," pp. 4–19 in *Arctic National Wildlife Refuge, Alaska Coastal Plain Resource Assessment*, Report and Recommendation to the Congress of the U.S., and Final Legislative Environmental Impact Statement, Vol. 2, Appendix, Public Comments and Responses, U.S. Department of the Interior, U.S. Fish and Wildlife Service, Washington, D.C.

Bergerud, A.T., and J.P. Elliot, 1986, "Dynamics of Caribou and Wolves in Northern British Columbia," *Canadian Journal Zoology* 64:1515–1529.

Berkes, F., and D. Jolly, 2001, "Adapting to Climate Change: Social-Ecological Resilience in a Canadian Western Arctic Community," *Conservation Ecology* 5(2):18.

Bersamin, A., S. Zidenberg-Cherr, J. Stern, and B. Luick, 2007, "Nutrient Intakes Are Associated with Adherence to a Traditional Diet Among Yupi'ik Eskimos Living in Remote Alaska Native Communities: The Canhr Study," *International Journal of Circumpolar Health* 66(1):62–70. Available at http://ijch.fi/issues/661/Bersamin%20vol%2066%20no%201.pdf. Accessed September 9, 2011.

Berzin, A.A., and A.A. Rovnin, 1966, "The Distribution and Migrations of Whales in the Northeastern Part of the Pacific, Chukchi, and Bering Seas," pp. 103–136 in *Soviet Research on Marine Mammals of the Far East*, K.I. Panin (ed.), U.S. Department of the Interior, Bureau of Commercial Fisheries, Washington, D.C. (translation).

BIA (Bureau of Indian Affairs), 2010, *Tribal Leaders Directory: Summer 2010*, Washington, D.C.

Bianchi, T.S., M.A. Allison, E.A. Canuel, D.R. Corbett, B.A. McKee, T.P. Sampere, S.G. Wakeham, and E. Waterson, 2006, "Rapid Export of Organic Matter to the Mississippi Canyon," *Eos Trans. AGU* 87(50):565.

Bigg, M.A., 1969, "The Harbour Seal in British Columbia," *Fisheries Research Board of Canada Bulletin 172.*

Bigg, M.A., 1981, "Harbour Seal, *Phoca vitulina*, Linnaeus, 1758 and *Phoca largha*, Pallas, 1811," pp. 1–77 in *Handbook of Marine Mammals, Vol. 2: Seals*, S.H. Ridgeway and R.J. Harrison (eds.), Academic Press, New York.

Bindoff, N.L., J. Willebrand, V. Artale, A, Cazenave, J. Gregory, S. Gulev, K. Hanawa, C. Le Quéré, S. Levitus, Y. Nojiri, C.K. Shum, L.D. Talley, and A. Unnikrishnan, 2007, "Observations: Oceanic Climate Change and Sea Level," in *Climate Change 2007: The Physical Science Basis*, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.), Cambridge University Press, Cambridge, United Kingdom, and New York, N.Y.

Bird, B.L., L.C. Branch, and M.E. Hostetler, 2009, *Beach Mice*, Publication WEC 165, University of Florida IFAS Extension. Available at http://edis.ifas.ufl.edu/uw173. Accessed March 16, 2011.

Blackwell, S.B., C.R. Greene, Jr., and W.J. Richardson, 2004, "Drilling and Operational Sounds from an Oil Production Island in the Ice-Covered Beaufort Sea," *J. Acoust. Soc. Am.* 116(5):3199–3211.

Blackwell, S.B., and C.R. Greene, Jr., 2002, *Acoustic Measurements in Cook Inlet, Alaska, during August 2001*, Greeneridge Report 271-1, prepared by Greeneridge Sciences, Inc., Aptos and Santa Barbara, Calif., for NMFS, Protected Resources Division, Anchorage, Alaska.

Blackwell, S.B., and C.R. Greene, Jr., 2005, "Underwater and In-Air sounds from a Small Hovercraft," *J. Acoust. Soc. Am.* 118(6):3646–3652.

BLM (Bureau of Land Management), 2002, *Renewal of the Federal Grant for the Trans-Alaska Pipeline System Right-of-Way, Final Environmental Impact Statement*, BLM/AK/PT-03/005+2880+990, BLM, Anchorage, Alaska.

BLM, 2003, *Northwest National Petroleum Reserve-Alaska, Final Integrated Activity Plan/Environmental Impact Statement*, November.

BLM, 2008, *Northeast National Petroleum Reserve-Alaska Supplemental Integrated Activity Plan Record of Decision*, BLM/AK/PL-08/021+1610+930, July.

BLM and MMS (Bureau of Land Management and Minerals Management Service), 2003, *Northeast National Petroleum Reserve-Alaska, Final Integrated Activity Plan/Environmental Impact Statement*, BLM/AK/PL-04/002+3130+930, BLM, Anchorage, Alaska.

Bluhm, B.A, and R. Gradinger, 2008, "Regional Variability in Food Availability for Arctic Marine Mammals," *Ecological Applications* 18:2 Supplement, pp. S77–S96.

Blum, M.D., and H.H. Roberts, 2009, "Drowning of the Mississippi Delta Due to Insufficient Sediment Supply and Global Sea-Level Rise," *Nature Geoscience*, Vol. 2, July.

Blunden J., D.S. Arndt, and M.O. Baringer, 2011, "State of the Climate in 2010," *Bulletin of the American Meteorological Society* 92(6):S1–S266.

Bockstoce, J., 1977, *Steam Whaling in the Western Arctic*, New Bedford Whaling Museum, New Bedford, Mass.

Bockstoce, J.R., 1995, Whales, Ice, and Men The History of Waling in the Western Arctic, University of Washington Press.

Bodkin, J., D. Mulcahy, and C. Lensink, 1993, "Age-Specific Reproduction in Female Sea Otters (*Enhydra lutris*) from South-Central Alaska: Analysis of Reproductive Tracts," *Canadian Journal of Zoology* 71(9):1811–1815.

Boehm, P.D., 2001, *Sediment Quality in Depositional Areas of Shelikof Strait and Outermost Cook Inlet*, Final Report, OCS Study MMS 2000-024, prepared by Arthur D. Little, Inc., Cambridge, Mass., for Minerals Management Service, Anchorage, Alaska.

Boehm, P.D., J. Brown, C. Howell, H. Tsomides, S.E. Graham, J. Trefry, S. Metz, J. Gold, L. Cook, C.F. Newton, W. Smith, and R. Spies, 2001a, *Sediment Quality in Depositional Areas of Shelikof Strait and Outermost Cook Inlet*, OCS Study, MMS 2000-024, MMS, Alaska OCS Region, Anchorage, Alaska.

Boehm, P.D., J. Brown, H. Camp, L. Cook, J. Trefry, R.P. Trocine, R.D. Rember, and G. Shepard, 2001b, *ANIMIDA Phase I: Arctic Nearshore Characterization and Monitoring of the Physical Environment in the Northstar and Liberty Development Areas*, Final Report, OCS Study, MMS Study 2001-104, MMS, Anchorage, Alaska.

BOEMRE (Bureau of Ocean Energy Management, Regulation, and Enforcement), 2008, *Beaufort Sea and Chukchi Sea Planning Area Oil and Gas Lease Sales 209, 212, 217 and 221*, Draft Environmental Impact Statement. OCS EIS/EA BOEMRE 2008-0055.

BOEMRE, 2010a, *Revised Offshore Environmental Cost Model (OECM): Guide to Cost Benefit Calculations*, prepared by Industrial Economics, December.

BOEMRE, 2010b, "Federal and Academic Scientists Return from Deep-Sea Research Cruise in Gulf of Mexico: Scientists Observe Damage to Deep-Sea Corals, press release, November 4. Available at http://www.boemre.gov/ooc/press/2010/press1104a.htm. Accessed April 24, 2011.

BOEMRE (Bureau of Ocean Energy Management, Regulation and Enforcement), 2011a, *Platform Structures Online Query*. Available at http://www.gomr.boemre.gov/homepg/fastfacts/platform/master.asp. Accessed February 2011.

BOEMRE, 2011b, *Commercial Wind Lease Issuance and Site Characterization Activities on the Atlantic Outer Continental Shelf Offshore New Jersey, Delaware, Maryland, and Virginia, Draft Environmental Assessment*, OCS EIS/EA BOEMRE 2011-037, USDOI/BOEMRE, Office of Offshore Alternative Energy Programs, July.

BOEMRE, 2011c, *2012-2017 Five-Year Scoping Meeting for Programmatic Environmental Impact Statement Bureau of Ocean Energy Management, Regulation and Enforcement, U.S. Department of the Interior, Kaktovik, Alaska*, transcript reported by Mary A. Vavrik, Midnight Sun Court Reporters, February 23.

BOEMRE, 2011d, *2012-2017 Five-Year Scoping Meeting for Programmatic Environmental Impact Statement Bureau of Ocean Energy Management, Regulation and Enforcement, U.S. Department of the Interior, Nuiqsut, Alaska*, transcript reported by Mary A. Vavrik, Midnight Sun Court Reporters, February 22.

BOEMRE, 2011e, *2012-2017 Five-Year Scoping Meeting for Programmatic Environmental Impact Statement Bureau of Ocean Energy Management, Regulation and Enforcement, U.S. Department of the Interior, Wainwright, Alaska*, transcript reported by Mary A. Vavrik, Midnight Sun Court Reporters, February 15.

BOEMRE, 2011f, *2012-2017 Five-Year Scoping Meeting for Programmatic Environmental Impact Statement Bureau of Ocean Energy Management, Regulation and Enforcement, U.S. Department of the Interior, Barrow, Alaska*, transcript reported by Mary A. Vavrik, Midnight Sun Court Reporters, February 21.

Boesch, D.F., J.C. Field, and D. Scavia (eds.), 2000, *The Potential Consequences of Climate Variability and Change on Coastal Areas and Marine Resources: Report of the Coastal Areas and Marine Resources Sector Team*, U.S. National Assessment of the Potential Consequences of Climate Variability and Change, U.S. Global Change Research Program, Decision Analysis Series No. 21, National Oceanic and Atmospheric Administration Coastal Ocean Program, Silver Spring, Md.

Bond, C.E., 1996, *Biology of Fishes*, 2nd Edition, Saunders College Publishing, Harcourt Brace and Company, Orlando, Fla.

Born, E.W., J. Teilmann, M. Acquarone, and F.F. Riget, 2004, "Habitat Use of Ringed Seals (*Phoca hispida*) in the North Water Area (North Baffin Bay)," *Arctic* 57(2):129–142.

Boudreaux, P., 2011, personal communication, August 30.

Boveng, P.L., J.L. Bengtson, T.W. Buckley, M.F. Cameron, S.P. Dahle, B.A. Megrey, J.E. Overland, and N.J. Williamson, 2008, *Status Review of the Ribbon Seal* (Histriophoca fasciata), NOAA Technical Memorandum NMFS-AFSC-191, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, Wash., Dec. Available at http://www.fakr.noaa.gov/protectedresources/seals/ice/ribbon/statusreview08.pdf. Accessed May 24, 2011.

Boveng, P.L., J.L. Bengtson, T.W. Buckley, M.F. Cameron, S.P. Dahle, B.P. Kelly, B.A. Megrey, J.E. Overland, and N.J. Williamson, 2009, *Status Review of the Spotted Seal* (Phoca largha), NOAA Technical Memorandum NMFS-AFSC-200, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, Wash., Oct. Available at http://www.afsc.noaa.gov/publications/AFSC-TM/NOAA-TM-AFSC-200.pdf. Accessed May 24, 2011.

Bowen, W.W., 1968, "Variation and Evolution of Gulf Coast Populations of Beach Mice, *Peromyscus polionotus*," *Bulletin of the Florida State Museum* 12(1):1–91.

Bowyer, R.T., V.V. Ballenberghe, and J.G. Kie, 1998, "Timing and Synchrony of Parturition in Alaskan Moose: Long-term Versus Proximal Effects of Climate," *Journal of Mammalogy* 79(4):1332–1344.

Bradley, M.J., S.J. Kutz, E. Jenkins, and T.M. O'Hara, 2005, "The Potential Impact of Climate Change on Infectious Diseases of Arctic Fauna," *International Journal of Circumpolar Health* 64(5):468–477.

Bradstreet, M.S.W., and W.E. Cross, 1982, "Tropic Relationships at High Arctic Ice Edges," *Arctic* 35:1–12.

Braham, H.W., and M.E. Dahlheim, 1982, "Killer Whales in Alaska Documented in the Platforms of Opportunity Program," *Report of the International Whaling Commission* 32:643–646, International Whaling Commission, Cambridge, U.K.

Braham, H.W., and D.W. Rice, 1984, "The Right Whale, *Balaena glacialis*," *Marine Fisheries Review* 46(4):38–47.

Braham, H.W., M.A. Fraker, and B.D. Krogman, 1980, "Spring Migration of the Western Arctic Population of Bowhead Whales," *Marine Fisheries Review* 42:36–46.

Brashier, J., 1988, Coexistence of Fishing and Oil and Gas Industries in the Gulf of Mexico. Available at http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=00794841. Accessed July 15, 2011.

Braund, S.R., and J. Kruse, 2009, *Synthesis: Three Decades of Research on Socioeconomic Effects Related to Offshore Petroleum Development in Coastal Alaska*, MMS 2009-006, Minerals Management Service, Outer Continental Shelf Study.

Brickhill, M.J., S.Y. Lee, and R.M. Connolly, 2005, "Fishes Associated with Artificial Reefs: Attributing Changes to Attraction or Production Using Novel Approaches," *Journal of Fish Biology* 67:53–71.

Bright, T.J., G.P. Kraemer, G.A. Minnery, and S.T. Viada, 1984, "Hermatypes of the Flower Garden Banks, Northwestern Gulf of Mexico: A Comparison to Other Western Atlantic Reefs," *Bull. Mar. Sci.* 34:461–476.

Bright, M., C. Plum, L.A. Riavitz, N. Nikolov, P. Martinez Arbizu, E.E. Cordes, and S. Gollnera, 2010, "Epizooic Metazoan Meiobenthos Associated with Tubeworm and Mussel Aggregations from Cold Seeps of the Northern Gulf of Mexico," *Deep Sea Research, Part 2, Top. Stud. Oceangr*. 57(21-23):1982–1989.

Brigham, L., and B. Ellis (eds.), 2004, *Arctic Marine Transport Workshop*, funded by Circumpolar Infrastructure Task Force, Secretariat at the Institute of the North; United States Arctic Research Commission; and International Arctic Science Committee, held at Scott Polar Research Institute, Cambridge University, U.K., Sept. 28–30.

Brightman, R.A, 2004, "Chitimacha," pp. 642–652 in *Handbook of North American Indians, Vol. 14 Southeast*, R.A. Fogelson (ed.) Smithsonian Institution, Washington, D.C.

Brook, R.K., and E.S. Richardson, 2002, "Observations of Polar Bear Predatory Behaviour toward Caribou," *Arctic* 55(2): 193–196.

Brooks, J.M. (ed.), 1991, *Mississippi-Alabama Continental Shelf Ecosystem Study: Data Summary and Synthesis, Volume I: Executive Summary, Volume II: Technical Narrative, Volume III: Appendices, Part 1 (Appendices A–D), Part 2 (Appendix E),* OCS Study MMS 91-0062 (I), 91-0063 (II), 91-0064 (III), Minerals Management Service, Gulf of Mexico OCS Regional Office, New Orleans, La.

Brooks, J.M., and C.P. Giammona (eds.), 1991, *Mississippi-Alabama Continental Shelf Ecosystem Study: Data Summary and Synthesis*, OCS Study MMS 91-0062 (I), 91-0063 (II), 91-0064 (III), MMS, Gulf of Mexico OCS Regional Office, New Orleans, La.

Brooks, J.M., C. Fisher, H. Roberts, B. Bernard, I. McDonald, R. Carney, S. Joye, E. Cordes, G. Wolff, and E. Goehring, 2008, *Investigations of Chemosynthetic Communities on the Lower Continental Slope of the Gulf of Mexico: Interim Report 1,* OCS Study MMS 2008-009, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La.

Brown, J., 2003, *ANIMIDA Task 2 Hydrocarbon and Metal Characterization of Sediment Cores in the ANIMIDA Study Area*, Special Report, MMS OCS Study 2004-024, MMS, Alaska OCS Region, Anchorage, Alaska.

Brown, L.F., Jr., et al., 1977, *Environmental Geological Atlas of the Texas Coastal Zone: Kingsville Area*, University of Texas, Bureau of Economic Geology, Austin, TX.

Brownell, R.L., Jr., P.J. Clapham, T. Miyashita, and T. Kasuya, 2001, "Conservation Status of North Pacific Right Whales," *Journal of Cetacean Research and Management* 2 (Special Issue):269–286.

Brueggeman, J.J., R.A. Grotefendt, and A.W. Erickson, 1984, *Endangered Whale Surveys of the Navarin Basin, Alaska*, Final Report, Outer Continental Shelf Environmental Assessment Program Research Unit 625, prepared by Envirosphere Company, Bellevue, Wash., for Minerals Management Service.

Brueggeman, J.J., G.A. Green, R.W. Tressler, and D.G. Chapman, 1988, *Shipboard Surveys of Endangered Cetaceans in the Northwest Gulf of Alaska*, Final Report, Outer Continental Shelf Environmental Assessment Program Research Unit 673, prepared by Envirosphere Company, Bellevue, Wash., for Minerals Management Service, Alaska Outer Continental Shelf Region, and National Oceanic and Atmospheric Administration, Anchorage, Alaska.

Brueggeman, J.J., G.A. Green, R.A. Grotefendt, and R.W. Tressler, 1989, "Marine Mammal Habitat Use on the North Aleutian Basin, St. George Basin, and Gulf of Alaska," pp. 97–108 in *Proceedings of the Gulf of Alaska, Cook Inlet, and North Aleutian Basin Information Update Meeting*, L.E. Jarvela and L.K. Thorsteinson (eds.), National Oceanic and Atmospheric Administration, Anchorage, Alaska.

Brueggeman, J., 2009, *90-Day Report of the Marine Mammal Monitoring Program for the ConocoPhillips Alaska Shallow Hazards Survey Operations during the 2008 Open Water Season in the Chukchi Sea*, prepared by Canyon Creek Consulting LLC, Seattle, Wash., for ConocoPhillips Alaska, Inc., revised March. Available at http://www.nmfs.noaa.gov/pr/pdfs/permits/cpai_90day_report.pdf. Accessed May 3, 2011.

Brueggeman, J.J., R.A. Grotefendt, and A.W. Erickson, 1984, *Endangered Whale Survey of the Navarin Basin, Alaska*, Envirosphere Company, prepared for MMS, Bellevue, Wash.

Brunner, R.D., A.H. Lynch, J.C. Pardikes, E.N. Cassano, L.R. Lestak, and J.M. Vogel, 2004, "An Arctic Disaster and Its Policy Implications," *Arctic* 57(4):336–346.

Bryant, M.D., 2009, "Global Climate Change and Potential Effects on Pacific Salmonids in Freshwater Ecosystems of Southeast Alaska," *Climatic Change* 95:169–193.

Bryden, H.L., E.L. McDonagh, and B.A. King, 2003, "Changes in Ocean Water Mass Properties: Oscillations or Trends?" *Science* 300:2086–2088.

Burch, E.S., 1984, "Kotzebue Sound Eskimo," pp. 303-219 in D. Dams, ed. *Handbook of North American Indians, Vol. 5, Arctic*, Smithsonian Institution, Washington, D.C.

Burch, Ernest S., Jr., 2006, *Social Life in Northwest Alaska: The Structure of Iñupiaq Eskimo Nations*, University of Alaska Press.

Buesseler, K.O., 1998, "The Decoupling of Production and Particulate Export in the Surface Ocean," *Glob. Biogeochem. Cycles* 12:297–310.

Burgess, M., 2000, "Arctic Fox," Chapter 8 in *The Natural History of an Arctic Oil Field Development and the Biota*, J.C. Truett and S.R. Johnson (eds.), Academic Press, San Diego, Calif.

Burgess, R.M., J.R. Rose, P.W. Banyas, and B.E. Lawhead, 1993, *Arctic Fox Studies in the Prudhoe Bay Unit and Adjacent Undeveloped Areas, 1992*, report prepared for British Petroleum Exploration (Alaska), Inc., Alaska Biological Research, Inc., Fairbanks, Alaska.

Burgess, W.C., and C.R. Greene, Jr., 1999, "Physical Acoustic Measurements," in *Marine Mammal and Acoustical Monitoring of Western Geophysical's Open-Water Seismic Program in the Alaskan Beaufort Sea, 1998*, W.J. Richardson (ed.), LGL Report TA2230-3, prepared by LGL Ltd., King City, Ontario, Canada, and Greeneridge Sciences, Inc., Santa Barbara, Calif., for Western Geophysical, Houston, Texas, and NMFS, Anchorage, Alaska, and Silver Spring, Md.

Burns, J.J., 1967, *The Pacific Bearded Seal,* Pittman-Robertson Project Reports W-6-R and W-14-R, Alaska Department of Fish and Game.

Burns, J.J., 1981, "Bearded Seal — *Erignathus barbatus* Erxleben, 1777," pp. 145–170 in *Handbook of Marine Mammals, Vol. 2, Seals,* S.H. Ridgeway and R.J. Harrison (eds.), Academic Press, New York, N.Y.

Butler, R.G., and D.E. Buckley, 2002, "Black Guillemot (*Cepphus grylle*)," Issue 675, *The Birds of North America Online* (A. Poole, ed.), Cornell Lab of Ornithology, Ithaca, New York. Available at http://bna.birds.cornell.edu/bna/species/675. Accessed August 18, 2011.

Cai, W., X. Hu, W. Huang, M.C. Murrell, J.C. Lehrter, S.E. Lohrenz, Y. Wang, X. Guo, F. Chen, and K. Gundersen, 2010, "Enhanced Ocean Acidification in the Northern Gulf of Mexico Hypoxic Bottom Waters," Abstract #OS22A-07, presented at American Geophysical Union 2010 Fall Meeting.

Caikoski, J.R., 2009, "Units 25A, 25B, 25D, and 26C Caribou," pp. 240–258 in *Caribou Management, Report of Survey and Inventory Activities 1 July 2006–30 June 2008, Project 3.0,* P. Harper (ed.), Alaska Department of Fish and Game, Juneau, Alaska.

Calambokidis, J., B.L. Taylor, S.D. Carter, G.H. Steiger, P.K. Dawson, and L.D. Antrim, 1987, "Distribution and Haul-out Behavior of Harbor Seals in Glacier Bay, Alaska," *Canadian Journal of Zoology* 65:1391–1396.

Caldeira, K., and M.E. Wickett, 2005, "Ocean Model Predictions of Chemistry Changes from Carbon Dioxide Emissions to the Atmosphere and Ocean," *Journal of Geophysical Research* 110:C09S04.

Calvert, W., and I. Stirling, 1990, "Interactions between Polar Bears and Overwintering Walruses in the Central Canadian High Arctic," *International Conference on Bear Research and Management* 8:351–356.

Cameron, M., and P. Boveng, 2009, *Habitat Use and Seasonal Movements of Adult and Sub-Adult Bearded Seals*, Alaska Fisheries Science Center Quarterly Report, Oct., Nov., Dec. Available at http://www.afsc.noaa.gov/Quarterly/ond2009/OND09feature.pdf. Accessed March 17, 2011.

Camilli, R., C.M. Reddy, D.R. Yoerger, B.A. S. Van Mooy, M.V. Jakuba, J.C. Kinsey, C.P. McIntyre, S.P. Sylva, and J.V. Maloney, 2010, "Tracking Hydrocarbon Plume Transport and Biodegradation at Deepwater Horizon," *Science* 330:201–204.

Campisi, J., 2004, "Houma," pp. 632–641 in *Handbook of North American Indians, Vol. 14 Southeast*, R.A. Fogelson (ed.), Washington, D.C.

Carmack, E., D. Barber, J. Christensen, R. Macdonald, B. Rudels, and E. Sakshaug, 2006, "Climate Variability and Physical Forcing of the Food Webs and the Carbon Budget on Panarctic Shelves," *Progress in Oceanography* 71:145–181.

Carr, A., and A.B. Meylan, 1980, "Evidence of Passive Migration of Green Turtle Hatchlings in *Sargassum*," *Copeia* 2:366–368.

Carretta, J.V., K.A. Forney, M.S. Lowry, J. Barlow, J. Baker, D. Johnston, B. Hanson, R.L. Brownell, Jr., J. Robbins, D.K. Matilla, K. Ralls, M.M. Muto, D. Lynch, and L. Carswell, 2009, *U.S. Pacific Marine Mammal Stock Assessments: 2009*, NOAA-TM-NMFS-SWFSC-453, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center. Available at http://www.nmfs.noaa.gov/pr/pdfs/sars/po2009.pdf. Accessed March 15, 2009.

Carroll, G.M., 1991, "Game Management Unit 26A Western North Slope," in *Brown Bear, Federal Aid in Wildlife Restoration, Annual Performance Report of Survey-Inventory Activities, 1 July 1990–30 June 1991, XXII, Part V, Project W-23-4, Study 4.0*, S.M. Abbott (ed.), Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau, Alaska.

Carroll, G.M., 1992, "Caribou Survey-Inventory Progress Report, Unit 26A," pp. 177–186 in *Caribou, Federal Aid in Wildlife Restoration, Survey-Inventory Management Report, 1 July 1989–30 June 1991, Project W-23-3, Study 3.0,* S.M. Abbott (ed.), Alaska Department of Fish and Game, Juneau, Alaska.

Carroll, G., 2007, "Unit 26A Furbearer," pp. 335–343 in *Furbearer Management, Report of Survey and Inventory Activities, 1 July 2003–30 June 2006, Project 7.0*, P. Harper (ed.), Alaska Department of Fish and Game, Juneau, Alaska.

Carroll, G.M., J.C. George, L.F. Lowry, and K.O. Coyle, 1987, "Bowhead Whale (*Balaena mysticetus*) Feeding near Point Barrow, Alaska, during the 1985 Spring Migration," *Arctic* 40:105–110.

CCSP (Climate Change Science Program), 2009, "Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region," in *A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research*, J.G. Titus (Coordinating lead author), K.E. Anderson, D.R. Cahoon, D.B. Gesch, S.K. Gill, B.T. Gutierrez, E.R. Thieler, and S.J. Williams (lead authors), U.S. Environmental Protection Agency, Washington D.C.

CEC (Commission for Environmental Cooperation), 2008, *North American Environmental Atlas – Marine Ecoregions Level III*, 2008.

CEI (Coastal Environments, Inc.), 1977, *Cultural Resources Evaluation of the Northern Gulf of Mexico Continental Shelf,* prepared by CEI, Baton Rouge, La., for the National Park Service, Interagency Archaeological Service, Office of Archaeology and Historic Preservation, Washington, D.C.

CEI, 1982, *Sedimentary Studies of Prehistoric Archaeological Sites,* prepared by CEI, Baton Rouge, La., for National Park Service, Division of State Plans and Grants.

CEQ (Council on Environmental Quality), 1997, *Environmental Justice: Guidance Under the National Environmental Policy Act,* Executive Office of the President.

Chance, N.A., 1984, "Alaska Eskimo Modernization," pp. 646–656 in *Handbook of North American Indians, Vol. 5 Arctic,* D. Damas (ed.), Smithsonian Institution, Washington, D.C.

Chapin, F.S., III, E.S. Zavaleta, V.T. Eviner, R.L. Naylor, P.M. Vitousek, H.L. Reynolds, D.U. Hooper, S. Lavorel, O.E. Sala, S.E. Hobbie, M.C. Mack, and S. Diaz, 2000, "Consequences of Changing Biodiversity," *Nature* 405:234–242.

Chesemore, D.L., 1967, *Ecology of the Arctic Fox in Northern and Western Alaska,* M.S. thesis, University of Alaska, Fairbanks, Alaska.

Chittenden, M.E., Jr., and J.D. McEachran, 1976, *Composition, Ecology, and Dynamics of Demersal Fish Communities on the Northwestern Gulf of Mexico Continental Shelf, with a Similar Synopsis for the Entire Gulf*, Texas A&M University, Sea Grant Publication TAMU-SG76-208.

Childs, J., 2004, *Background Information on the Fish Resources of the Alaskan-Beaufort Sea Region. Administrative File for the Lease Sale 195 Environmental Assessment*, MMS, Alaska OCS Region, Anchorage, Alaska.

Christensen, J.H., B. Hewitson, A. Busuioc, A. Chen, X. Gao, I. Held, R. Jones, R.K. Kolli, W.-T. Kwon, R. Laprise, V. Magaña Rueda, L. Mearns, C.G. Menéndez, J. Räisänen, A. Rinke, A. Sarr, and P. Whetton, 2007, "Regional Climate Projections," in *Climate Change 2007: The Physical Science Basis,* Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.), Cambridge University Press, Cambridge, U.K., and New York, N.Y.

Church, J.A., 2007, "A Change in Circulation?" *Science* 317:908–909.

Church, J., J.M. Gregory, P. Huybrechts, M. Kuhn, K. Lambeck, M.T. Nhuan, D. Qin, and P.L. Woodworth, 2001, *Changes in Sea Level, in Climate Change 2001: The Scientific Basis, Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change*, J.T. Houghton et al. (eds.), pp. 639–693, Cambridge University Press, New York.

Church, R.A., D.J. Warren, J.B. Weirich, and D.A. Ball, 2004, *Return to the U-166: Working Together to Meet the Challenge of Deepwater Archaeology*.

Citizens Advisory Committee, 2002, *Kodiak Archipelago Bear Conservation and Management Plan.* , Feb. Available at http:www.adfg.alaska.gov/static/home/about/management/wildlife planning/pdfs/kabcmp.pdf. Accessed April 7, 2011.

Citta, J., 2008, *Alaska Wildlife Notebook Series: Ringed Seal*, Alaska Department of Fish and Game, Juneau, Alaska. Available at http://www.adfg.alaska.gov/static/education/wns/ringed_seal.pdf. Accessed April 11, 2011.

Citta, J., and L. Lowry, 2008, *Alaska Wildlife Notebook Series: Beluga Whale*, Alaska Department of Fish and Game, Juneau, Alaska. Available at http://www.adfg.alaska.gov/static/education/wns/beluga_whale.pdf. Accessed April 11, 2011.

City of Barrow, 2011, *About Barrow*. Available at http://www.cityofbarrow.org/content/view/5/5/. Accessed June 2011.

Clapham, P.J., and J.G. Mead, 1999, "*Megaptera novaeangliae*," *Mammalian Species No. 604*:1–9.

Clapp, R.B., D. Morgan-Jacobs, and R. Banks,1983, *Marine Birds of the Southeastern United States and Gulf of Mexico*. Contract No. 14-16-0009-78-917. Washington, D.C.: USDOI/FWS, Division of Biological Services; USDOI/BLM. Vols. I–III.

Clark, C.W., W.T. Ellison, and K. Beeman, 1986, *An Acoustic Study of Bowhead Whales,* Balaena mysticetus, *Off Point Barrow, Alaska during the 1984 Spring Migration*, prepared by Marine Acoustics, Clinton, Mass., for Department of Wildlife Management, North Slope Borough, Barrow, Alaska.

Clark, R., A. Ott, M. Rabe, D. Vincent-Lang, and D. Woodby, 2010, *The Effects of a Changing Climate on Key Habitats in Alaska*, Special Publication No. 10-14, Alaska Department of Fish and Game, Anchorage, Alaska, September.

Cleator, H.J., and I. Stirling, 1990, "Winter Distribution of Bearded Seals (*Erignathus barbatus*) in the Penny Strait Area, Northwest Territories, as Determined by Underwater Vocalizations," *Canadian Journal of Fisheries and Aquatic Sciences* 47:1071–1076.

Cleator, H.J., I. Stirling, and T.G. Smith, 1989, "Underwater Vocalizations of the Bearded Seal (*Erignathus barbatus*)," *Can. J. Zool.* 67(8):1900–1910.

Coles, R.R.A., G.R. Garinther, D.C. Hodge, and C.G. Rice, 1968, "Hazardous Exposure to Impulse Noise," *J. Acoust. Soc. Am.* 43(2):336–343.

Comiso, J.C., 2002, "A Rapidly Declining Perennial Sea Ice Cover in the Arctic," *Geophysical Research Letters* 29:17-1 through 17-4.

Congressional Research Service, 2005, *The Impact of Hurricane Katrina on Biological Resources*, CRS Report for Congress, October 18, 2005, Library of Congress, Washington, D.C.

Consiglieri, L.D., H.W. Braham, M.E. Dahlheim, C. Fiscus, P.D. McGuire, C.E. Peterson, and D.A. Pippenger, 1982, *Seasonal Distribution and Relative Abundance of Marine Mammals in the Gulf of Alaska*, pp. 189–343, Outer Continental Shelf Environmental Assessment Program (OCSEAP) Final Reports of Principal Investigators, Vol. 61, National Oceanic and Atmospheric Administration, OCSEAP, Anchorage, Alaska.

Continental Shelf Associates, Inc., 1987, *Southwest Florida Shelf Regional Biological Communities Survey, Year 3, Final Report*, prepared for Minerals Management Service.

Continental Shelf Associates, Inc., 1992, *Mississippi-Alabama Shelf Pinnacle Trend Habitat Mapping Study,* OCS Study MMS 92-0026, Minerals Management Service, Gulf of Mexico OCS Regional Office, New Orleans, La.

Continental Shelf Associates, Inc., 1996, *Baseline Environmental Surveys for the Destin Dome Unit,* Final Report to Chevron U.S.A., Inc., New Orleans, La.

Continental Shelf Associates, Inc., and Texas A&M University, Geochemical and Environmental Research Group, 1999, *Northeastern Gulf of Mexico Coastal and Marine Ecosystem Program: Ecosystem Monitoring, Mississippi/Alabama Shelf,* Third Annual Interim Report, OCS Study MMS 99-0055, USGS/BRD/CR-1999-0005, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La., and U.S. Geological Survey, Biological Resources Division.

Cook Inlet Regional Citizens Advisory Council, 2011, *Cook Inlet Oil and Gas Platforms and Related Facilities Map*. Available at http://www.circac.org/CI_interactivemap.html. Accessed June 2011.

Cooper, L.W., J.M Grebmeier, I.L. Larsen, V.G. Egorov, C. Theodorakis, H.P. Kelly, and J.R. Lovvorn, 2002, “Seasonal Variation in Sedimentation of Organic Materials in the St. Lawrence Island Polynya Region, Bering Sea,” *Marine Ecology Progress Series* 226:13–26.

Cordes, E.E., E.L. Becker, S. Hourdez, and C.R. Fisher, 2010, “Influence of Foundation Species, Depth, and Location on Diversity and Community Composition at Gulf of Mexico Lower Slope Cold Seeps,” *Deep Sea Research* II 57:1870–1881.

Core and Technical Working Groups, 2010, *MC 252 Stage III SCAT — Shoreline Treatment Implementation Framework for Louisiana*, September 9.

Courbis, S.S., and G.A.J. Worthy, 2003, “Opportunistic Carnivory by Florida Manatees (*Trichechus manatus latirostris*),” *Aquatic Mammals* 22.1:104–107.

Couturier, S., S.D. Côté, R.D. Otto, R.B. Weladji, and J. Huot, 2009, “Variation in Calf Body Mass in Migratory Caribou: The Role of Habitat, Climate, and Movements,” *Journal of Mammalogy* 90(2):442-452.

Craig, P.C., 1984, "Fish Use of Coastal Waters of the Alaskan Beaufort Sea: A Review." *Transaciton of the American Fisheries Society* 113:265–282.

Craig, P.C., 1989, "An Introduction to Anadromous Fishes in the Alaskan Arctic," pp. 27–54 in *Research Advances on Anadromous Fish in Arctic Alaska and Canada, Nine Papers Contributing to an Ecological Synthesis*, D.W. Norton (ed.), Biological Papers of the University of Alaska No. 24, Institute of Arctic Biology, Fairbanks, Alaska.

Craig, P.C., and L. Haldorson, 1986, "Pacific Salmon in the North American Arctic," *Arctic* 39(1):2–7.

Craig, P.C., R.R. Emerson, R.G. Fechhelm, C. George, J.D. Hall, J.P. Houghton, C. Johnson, T.K. Newbury, and D.R. Schmidt, 1984, "Fish Resources," pp. 117–131 in *The Barrow Arch Environment and Possible Consequences of Planned Offshore Oil and Gas Development*, J.C. Truett (ed.), NOAA and MMS, Anchorage, Alaska.

Cronin, M.A., B.J. Pierson, S.R. Johnson, L. Noel, and W.B. Ballard, 1997, "Caribou Population Density in the Prudhoe Bay Region of Alaska," *Wildlife Resources* 2(1):59–68.

Cronin, M.A., H.A. Whitlaw, and W.B. Ballard, 2000, "Northern Alaska Oil Fields and Caribou," *Wildlife Society Bulletin* 28(4):919–922.

Crouse, J., S. Crouse, R.A. Rausch, B. Gasaway, and C. Schwartz, 2008, *Alaska Wildlife Notebook Series: Moose*, Alaska Department of Fish and Game, Juneau, Alaska. Available at http://www.adfg.alaska.gov/static/education/wns/moose.pdf. Accessed August 30, 2011.

CRS (Congressional Research Service), 2010, *Deepwater Horizon Oil Spill: Selected Issues for Congress*, July 30. Available at http://www.fas.org/sgp/crs/misc/R41262.pdf. Accessed July 15, 2011.

Crum, J.E., 1993, "Peak Expiratory Flow Rate in Schoolchildren Living Close to Braer Oil Spill," *British Medical Journal* 307: 23–4.

CSA (Continental Shelf Associates), 2006, *Effects of Oil and Gas Exploration and Development at Selected Slope Sites in the Gulf of Mexico, Volume I*, OCS Study MMS 2006-004, MMS, Gulf of Mexico OCS Region, New Orleans, La.

CSA International, Inc., 2007, *Characterization of Northern Gulf of Mexico Deepwater Hard Bottom Communities with Emphasis on Lophelia Coral*, OCS Study MMS 2007-044, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La.

Culik, B.M., 2010, *Odontocetes: The Toothed Whales: Distribution, Behaviour, Migration and Threats*, compiled for the Convention of Migratory Species (CMS/UNEP) Secretariat, Bonn, Germany, Feb. 4. Available at http://www.cms.int/reports/small_cetaceans/index.htm. Accessed March 25, 2011.

Cummings, W.C., and D.V. Holliday, 1985, "Passive Acoustic Location of Bowhead Whales in a Population Census Off Point Barrow, Alaska," *J. Acoust. Soc. Am.* 78(4):1163–1169.

Cummings, W.C., and P.O. Thompson, 1971, "Underwater Sounds from the Blue Whale, *Balaenoptera musculus*," *J. Acoust. Soc. Am.* 50(4B): 1193–1198.

Cummings, W.C., and P.O. Thompson, 1994, "Characteristics and Seasons of Blue and Finback Whale Sounds along the U.S. West Coast as Recorded at SOSUS Stations," *J. Acoust. Soc. Am.* 95(5, Part 2): 2853–2853.

Cummings, W.C., D.V. Holliday, W.T. Ellison, and B.J. Graham, 1983, Technical Feasibility of Passive Acoustic Location of Bowhead Whales in Population Studies Off Point Barrow, Alaska, T-83-06-002, prepared by Tracor Applied Sciences, Inc., San Diego, Calif., for North Slope Borough, Barrow, Alaska.

Cummings, W.C., D.V. Holliday, and B.J. Lee, 1984, *Potential Impacts of Man-Made Noise on Ringed Seals: Vocalizations and Reactions*, Final Report, Outer Continental Shelf Environmental Assessment Program, Research Unit 636, Dec. Available at http://www.gomr.boemre.gov/PI/PDFImages/ESPIS/0/390.pdf. Accessed July 4, 2011.

Dagg, M.J., J.W. Ammerman, R.M.W. Amon, and W.S. Gardner, 2007, "A Review of Water Column Processes Influencing Hypoxia in the Northern Gulf of Mexico," *Estuaries and Coasts* 30:735–752.

Dahlheim, M., A. York, R. Towell, J. Waite, and J. Breiwick, 2000, "Harbor Porpoise (*Phocoena phocoena*) Abundance in Alaska: Bristol Bay to Southeast Alaska, 1991–1993," *Marine Mammal Science* 16:28–45.

Dai, A., T. Qian, K.E. Trenberth, and J.D. Milliman, 2009, "Changes in Continental Freshwater Discharge from 1948 to 2004," *Journal of Climate* 22:2773–2792.

Dames & Moore, Inc., 1979, *Mississippi, Alabama, Florida Outer Continental Shelf Baseline Environmental Survey, MAFLA, 1977/78, Vol. II: Compendium of Work Element Reports*, Final Report for USDOI/BLM, Contract No. AA550-CT7-34.

Darigo, N., O. Mason, and P. Bowers, 2007, *Review of Geological/Geophysical Data and Core Analysis to Determine Archaeological Potential of Buried Landforms, Beaufort Sea Shelf, Alaska*, OCS Study MMS 2007-004, prepared by Northern Land Use Research, Inc., URS Corporation, and GeoArch Alaska for MMS, Alaska OCS Region.

Dau, J., 2009, "Units 21D, 22A, 22B, 22C, 22D, 22E, 23, 24 and 26A Caribou Management Report," pp. 176–239 in *Caribou Management, Report of Survey and Inventory Activities 1 July 2006 –30 June 2008, Project 3.0,* P. Harper (ed.), Alaska Department of Fish and Game, Juneau, Alaska.

David M. Dornbusch and Company, 1987, *Impacts of Outer Continental Shelf (OCS) Development on Recreation and Tourism*, OCS Study MMS 87-0064, prepared for the Minerals Management Service, April. Available at http://www.gomr.mms.gov/PI/PDFImages/ESPIS/1/1928.pdf. Accessed July 15, 2011.

Davis, N.Y., 1984, "Contemporary Pacific Eskimo," pp. 198–204 in *Handbook of North American Indians, Vol. 5 Arctic,* D. Damas (ed.), Smithsonian Institution, Washington, D.C.

Davis, R.A., C.R Greene, Jr., and P.L. McLaren, 1985, Studies of the Potential for Drilling Activities on Seal Island to Influence Fall Migration of Bowhead Whales through Alaskan Nearshore Waters, prepared by LGL Ltd., King City, Ontario, Canada, for Shell Western E&P Inc., Anchorage, Alaska.

Davis, R.W., and G.S. Fargion (eds.), 1996, *Distribution and Abundance of Cetaceans in the North-Central and Western Gulf of Mexico: Final Report, Volume II: Technical Report,* OCS Study MMS 96-0027, prepared by Texas Institute of Oceanography and National Marine Fisheries Service, New Orleans, La., for Minerals Management Service, Gulf of Mexico Outer Continental Shelf Region.

Davis, R.W., G.S. Fargion, N. May, T.D. Leming, M. Baumgartner, W.E. Evans, L.J. Hansen, and K. Mullin, 1998, "Physical Habitat of Cetaceans along the Continental Slope in the North-central and Western Gulf of Mexico," *Marine Mammal Science* 14:490–507.

Davis, R.W., W.E. Evans, and B. Würsig (eds.), 2000, *Cetaceans, Sea Turtles and Seabirds in the Northern Gulf of Mexico: Distribution, Abundance and Habitat Associations, Volume II: Technical Report,* USGS/BRD/CR-1999-005, OCS Study MMS 2000-003, prepared by Texas A&M University at Galveston and the National Marine Fisheries Service for U.S. Geological Survey, BRD, and Minerals Management Service, Gulf of Mexico Outer Continental Shelf Region, New Orleans, La.

Davis, J.L., P. Valkenburg, and R. Boertje, 1982, *Home Range Use, Social Structure, and Habitat Selection of the Western Arctic Caribou Herd,* Final Research Report, prepared by Alaska Department of Fish and Game, Fairbanks, Alaska, for National Park Service.

Davis, W.B., and D.J. Schmidly, 1997, *The Mammals of Texas, Online Edition*, Texas Tech University, Lubbock, Texas. Available at http://www.nsrl.ttu.edu/tmot1/Default.htm. Accessed May 19, 2011.

Day, R.H., K.J. Kuletz, and D.A. Nigro. 1999, "Kittlitz's Murrelet (*Brachyramphus brevistris*)." Issue 435, *Birds of North America Online*, A. Poole (ed.), Cornell Lab of Ornithology, Imaca, New York. Available at http://bna.birds.Cornell.edu/bna/species/435. Accessed August 18, 2011.

DCRA (Alaska Division of Community and Regional Affairs), 2011, *Alaska Community Database Community Information Summaries*. Available at http://www.commerce.state.ak.us/dca/commdb/CF_CIS.htm. Accessed February 2011.

Defenbaugh, R.E., 1976, *A Study of the Benthic Macro-Invertebrates of the Continental Shelf of the Northern Gulf of Mexico*, Ph.D. dissertation, Texas A&M University, College Station, Texas.

DeGange, A.R., and L. Thorsteinson, 2011, "Chapter 3: Exological and Subsistence Context," pp. 13–40 in *An Evaluation of the Science Needs to Inform Decisions on Outer Continental Shelf Energy Development in the Chukchi and Beaufort Seas*, L. Holland-Bartels and B. Pierce (eds.), U.S. Geological Survey Circular 1370, Alaska.

Delgado, J.P. (ed.), 1998, *Encyclopedia of Underwater and Maritime Archaeology*, Yale University Press, New Haven, Conn., and London.

Dennis, G.D., and T.J. Bright, 1988, "Reef Fish Assemblages on Hard Banks in the Northwestern Gulf of Mexico," *Bull. Mar. Sci.* 43:280–307.

Department of Health and Human Services, Public Health Service, 2010, *Toxicological Profile for Polycyclic Aromatic Hydrocarbons (PAHs)*, Atlanta: Agency for Toxic Substances and Disease Registry. Available at http://www.atsdr.cdc.gov/toxprofiles /tp69.pdf.

Department of Labor and Workforce Development, 2011, *Research and Analysis, Historical Data: Boroughs/Census Areas*. Available at http://laborstats.alaska.gov/pop/popest.htm. Accessed September 9, 2011.

Derocher, A.E., and O. Wiig, 1999, "Infanticide and Cannibalism of Juvenile Polar Bears (*Ursus maritimus*) in Svalbard," *Arctic* 52:307–310.

Derocher, A.E., O. Wiig, and G. Bangjord, 2000, "Predation of Svalbard Reindeer by Polar Bears," *Polar Biology* 23:675–678.

DFO, 2008, *Total Allowable Harvest Recommendations for Nunavut Narwhal and Beluga Populations*, DFO Canadian Science Advisory Secretariat Science Advisory Report 2008/035. Available at http://www.dfo-mpo.gc.ca/CSAS/Csas/Publications/SAR-AS/2008/SAR-AS2008_035_E.pdf. Accessed September 9, 2011.

Dickson, D.L., and H.G. Gilchrist, 2002, "Status of Marine Birds of the Southeastern Beaufort Sea," *Arctic* 55(Supplement 1):46–58.

Dickson, D.L., R.S. Suydam, and G. Balogh, 2000, Tracking the Movement of King Eiders from Nesting Grounds at Prudhoe Bay, Alaska, to their Molting and Wintering Areas Using Satellite Telemetry, 1999/2000 Progress Report, Canadian Wildlife Service, Edmonton, Alberta, Canada.

Diercks, A.R., V.L. Asper, R.C. Highsmith, D.J. Joung, Z. Zhau, L. Guo, S.E. Lohrenz, A.M. Shiller, S.B. Joye, A.P. Teske, N. Guiasso, and T.L. Wade, 2010, "Characterization of Subsurface Polycyclic Aromatic Hydrocarbons at the Deepwater Horizon Site," *Geophys. Res. Lett.*, 37:L20602.

Di Silvestro., R., 2006, *Natural Acts: When Hurricanes Hit Habitat*. National Wildlife Federation, National Wildlife, August/September 2006, 44:5. Available at http://www.nwf.org/nationalwildlife/article.cfm?issueID=109%articleId=1378.

Ditton, R., and J. Auyong, 1984, *1983 An Analysis of the Recreational and Commercial Fishing Use of 164 Major Offshore Petroleum Structures in the Central Gulf of Mexico*, prepared by the Texas Agricultural Experiment Station for Minerals Management Service, August.

Ditton, R., and A. Graefe, 1978, *Recreational Fishing Use of Artificial Reefs on the Texas Coast*, prepared for the Texas Coast and Marine Council.

Ditty, J.G., 1986, "Ichthyoplankton in Neretic Waters of the Northern Gulf of Mexico off Louisiana: Composition, Relative Abundance, and Seasonality," *Fishery Bulletin* 84(4):935–946.

Ditty, J.G., G.G. Zieske, and R.F. Shaw, 1988, "Seasonality and Depth Distribution of Larval Fishes in the Northern Gulf of Mexico above 26°00' N," *Fishery Bulletin* 86:811–823.

Divoky, G.J., G.A. Sanger, S.A. Hatch, and J.C. Haney, 1988, *Fall Migration of Ross' Gull* (Rhodostethia rosea) *in Alaskan Chukchi and Beaufort Seas*, Final Report OCS Study MMS 88-0023, U.S. Fish and Wildlife Service, Alaska Fish and Wildlife Research Center, Anchorage.

Dixon, E.J., G. Sharma, and S. Stoker, 1986, *Alaskan Outer Continental Shelf Cultural Resource Compendium*, Technical Report No. 119, OCS Study MMS 86-0018, MMS, Alaska Outer Continental Shelf Office, Anchorage, Alaska.

Do, M.P., P.L. Hutchinson, K.V. Mai, and M.J. Vanlandingham, 2009, "Disparities in Health Care among Vietnamese New Orleanians and the Impacts of Hurricane Katrina," *Research in the Sociology of Health Care* 27: 301–319.

Dodd, C.K., Jr., 1988, *Synopsis of the Biological Data on the Loggerhead Turtle*, Caretta caretta (*Linnaeus, 1758*), USDOI/FWS Biol. Rep. 88. 100 p.

Dokken, Q.R., I.R. MacDonald, J.W. Tunnell, Jr., C.R. Beaver, G.S. Boland, and D.K. Hagman, 1999, *Long-Term Monitoring of the East and West Flower Garden Banks, 1996–1997*, OCS Study MMS 99-0005, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La.

Doney S.C., V.J. Fabry, R.A. Feely, and J.A. Kleypas, 2009, "Ocean Acidification: The Other CO_2 Problem," *Annual Review of Marine Science* 1:169–192.

Doty, S.R., B.L. Wallace, and G.C. Holzworth, 1976, *A Climatological Analysis of Pasquill Stability Categories Based on 'STAR' Summaries*, National Oceanic and Atmospheric Administration, Environmental Data Service, National Climatic Center, April.

Dow, W., K. Eckert, M. Palmer, and P. Kramer, 2007, *An Atlas of Sea Turtle Nesting Habitat for the Wider Caribbean Region*, WIDECAST Technical Report No. 6, the Wider Caribbean Sea Turtle Conservation Network and the Nature Conservancy, Beaufort, N.C.

Dunbar, J.S., S.D. Webb, M. Faught, R.J. Anuskiewicz, and M.I. Stright, 1989, "Archaeological Sites in the Drowned Tertiary Karst Region of the Eastern Gulf of Mexico," pp. 25–31 in *Underwater Archaeology Proceedings from the Society for Historical Archaeology Conference*, J.B. Arnold, III (ed.), Society for Historical Archaeology, Baltimore, Md.

Dunton, K.H., and S.V. Schonberg, 2000, "The Benthic Faunal Assemblage of the Boulder Patch Community," in *The Natural History of an Arctic Oil Field, Development of the Biota*, J.C. Truett and S.R. Johnson (eds.), Academic Press, San Diego, Calif.

Dunton, K.H., E. Reimnitz, and S. Schonberg, 1982, "An Arctic Kelp Community in the Alaskan Beaufort Sea," *Arctic* 35:465–484.

Dunton, K.H., A. Burd, D. Funk, and R. Maffione, 2004, *Linking Water Turbidity and Total Suspended Solids Loading to Kelp Productivity within the Stefansson Sound Boulder Patch*, ANIMIDA Task 6 (Boulder Patch) Final Report, OCS Study MMS 2005-0011, MMS, Alaska OCS Region, Anchorage, Alaska.

Dunton, K.H., J.L. Goodall, S.V. Schonberg, J.M Grebmeier, and D.R. Maidment, 2005, "Multi-decadal Synthesis of Benthic-Pelagic Coupling in the Western Arctic: Role of Cross-Shelf Advective Processes," *Deep Sea Research II* 52:3462–3477.

Dunton, K.H., T. Weingartner, and E.C. Carmack, 2006, "The Nearshore Western Beaufort Sea Ecosystem: Circulation and Importance of Terrestrial Carbon in Arctic Coastal Food Webs," *Progress in Oceanography* 71:362–378.

Durner, G.M., S.C. Amstrup, and A.S. Fischbach, 2003, "Habitat Characteristics of Polar Bear Terrestrial Maternal Den Sites in Northern Alaska," *Arctic* 56(1):55–62.

Durner, G.M., S.C. Amstrup, R. Neilson, and T. McDonald, 2004, *The Use of Sea Ice Habitat by Female Polar Bears in the Beaufort Sea*, MMS 2004-014, U.S. Geological Survey Outer Continental Shelf Study, Alaska Science Center, Anchorage, Alaska.

Dushaw, B.D., et al., 2009, "A Decade of Acoustic Thermometry in the North Pacific Ocean," *J. Geophys. Res.* 114:C07021, doi:10.1029/2008JC005124.

Dyck, M.G., and K.J. Daley, 2002, "Cannibalism of a Yearling Polar Bear (*Ursus maritimus*) at Churchill, Canada," *Arctic* 55:190–192.

Eales, J.G., 1968, *The Eel Fisheries of Eastern Canada*, Fisheries Research Board of Canada Bulletin 166.

Eastland, W.G., R.T. Bowyer, and S.G. Fancy, 1989, "Effects of Snow Cover on Selection of Calving Sites by Caribou," *Journal of Mammalogy* 70:824–828.

Eberhardt, L.E., W.C. Hanson, J.L. Bengtson, R.A. Garrott, and E.E. Hanson, 1982, "Arctic Fox Home Range Characteristics in an Oil-Development Area," *Journal of Wildlife Management* 46(1):183–190.

Eggleston, P.A., 2007, "The Environment and Asthma in U.S. Inner Cities," *Chest* 132, Suppl: 782S–788S.

EIA (U.S. Energy Information Administration), 2006, *Natural Gas Processing: The Crucial Link between Natural Gas Production and Its Transportation to Market*, Office of Oil and Gas, Washington, D.C., Jan.

EIA, 2010a, *Ranking of U.S. Refineries, U.S. Refineries Operable Capacity*. Available at http://www.eia.gov/neic/rankings/refineries.htm. Accessed June 2011.

EIA, 2010b, *Short-Term Energy Outlook*, Washington, D.C, July 7. Available at http://www.eia.doe.gov/emeu/steo/pub/contents.html. Accessed July 15, 2011.

Eide, S., S. Miller, and L. Van Daele, 2008, *Alaska Wildlife Notebook Series: Brown Bear*, Alaska Department of Fish and Game, Juneau, Alaska. Available at http://www.adfg.alaska.gov/static/education/wns/brown_bear.pdf. Accessed April 11, 2011.

Elias, S., S. Short, and R.L. Phillips, 1992, "Paleoecology of Late-Glacial Peats from the Bering Land Bridge, Chukchi Sea Shelf Region, Northwestern Alaska," *Quaternary Research* 38(3):371–378.

Ellis, G., N. Johnson, and D. Chapman, 1991, *Inventory and Evaluation of Washington and Oregon Coastal Recreational Resources: Assessing Economic Impacts to Coastal Recreation and Tourism from Oil and Gas Development in the Oregon and Washington Outer Continental Shelf*, OCS Study MMS 91-0046. Available at http://www.gomr.mms.gov/PI/PDFImages/ESPIS/1/1894.pdf. Accessed July 15, 2011.

Ely, C.R., and A.X. Dzubin, 1994, *Greater White-Fronted Goose* (Anser albifrons), Issue 131, The Birds of North America Online (A. Poole, ed.), Cornell Lab of Ornithology, Ithaca, New York. Available at http://bna.birds.cornell.edu/bna/species/131. Accessed August 18, 2011.

ENSR Consulting and Engineering, 1996, *Prudhoe Bay Air Quality Monitoring Program, Annual Data Report, January through December 1995*, prepared for BP Exploration (Alaska) Inc., Fort Collins, Colo.

Environmental Science and Engineering, Inc., 1987, *Kuparuk Aerometric Monitoring Program, Annual Data Summary*, prepared by ARCO Alaska, Inc., Anchorage, Alaska.

ERS (Economic Research Service), 2011, *Data Sets, County Typology Codes,* U.S. Department of Agriculture. Available at http://www.ers.usda.gov/Data/TypologyCodes/. Accessed February 2011.

ERT Company, 1987, *Prudhoe Bay Air Quality Monitoring Program Quarterly and Annual Data Report*, Report No. D816, Standard Alaska Production Co., Anchorage, Alaska.

Eschmeyer, W.N., E.S. Herald, H. Hammann, and K.P. Smith, 1984, *A Field Guide to Pacific Coast Fishes of North America from the Gulf of Alaska to Baja California*, Houghton-Mifflin, Boston, Mass.

Eslinger, D.L., R.T. Cooney, C.P. McRoy, A. Ward, T.C. Kline, E.P. Simpson, J. Wang, and J. Allen, 2001, "Plankton Dynamics: Observed and Modeled Responses to Physical Conditions in Prince William Sound, Alaska," *Fisheries Oceanography* 10:81–96.

Esman, M.R., 1982, "Festivals, Change, and Unity: The Celebration of Ethnic Identity among Louisiana Cajuns," *Anthropological Quarterly* 55(4):199–210.

Estes, J.A., R.J. Jameson, and A.M. Johnson, 1981, "Food Selection and Some Foraging Tactics of Sea Otters," in *Worldwide Furbearer Conference Proceedings*, D.A. Chapman and D. Pursley (eds.), Frostburg, Md., Aug. 3–11.

Exxon Valdez Oil Spill Trustee Council, 2009, Exxon Valdez *Oil Spill Trustee Council 2009 Status Report*. Available at http://www.evostc.state.ak.us/Universal/Documents/Publications/AnnualStatus/2009AnnualReport.pdf. Accessed May 10, 2011.

Ezoe, M., T. Ishita, M. Kinugasa, X. Lai, K. Norisue and Y. Sohrin, 2004, "Distributions of Dissolved and Acid-dissolvable Bioactive Trace Metals in the North Pacific Ocean," *Geochem. J.* 38:535–550.

Fabry, V.J., B.A. Seibel, R.A. Feely, and J.C. Orr, 2008, "Impacts of Ocean Acidification on Marine Fauna and Ecosystem Processes," *ICES Journal of Marine Sciences* 65:414–432.

Fabry, V.J., J.B. McClintock, J.T. Mathis, and J.M. Grebmeier, 2009, "Ocean Acidification at High Latitudes: The Bellwether," *Oceanography* 22:160–171.

Fall, J.A., 1981, *Traditional Resource Use in the Knik Arm Area: Historical and Contemporary Patterns*, State of Alaska/ADF&G, Division of Subsistence, Juneau, Alaska.

Fall, J.A., and C.J. Utermohle, 1999, *Subsistence Harvests and Uses in Eight Communities Ten Years after the Exxon Valdez Oil Spill*, Technical Paper No. 252, ADF&G, Division of Subsistence, Juneau, Alaska.

Fall, J.A., L.J. Field, T.S. Nighswander, N. Peacock, and U. Varansi (eds.), 1999, "Overview of Lessons Learned from the Exxon Valdez Oil Spill: A 10-Year Retrospective," in *Evaluating and Communicating Subsistence Seafood Safety in a Cross-Cultural Context*, SETAC Press, Pensacola, Fla.

Fay, F.H., 1982, "Ecology and Biology of the Pacific Walrus, *Odobenus rosmarus divergens* Illiger," *North American Fauna* 74.

Fay, F.H., 1985, "*Odobenus rosmarus*," *Mammalian Species* 238:1–7.

Fechhelm, R.G., and W.B. Griffiths, 2001, *Status of Pacific Salmon in the Beaufort Sea*, LGL Alaska Research Assocs., Inc., Anchorage, Alaska.

Feder, H.M., and S.C. Jewett, 1986, *The Subtidal Benthos, The Gulf of Alaska, Physical Environment and Biological Resources,* OCS Study MMS 86-0095, D.W. Hood and S.T. Zimmerman (eds.), National Oceanic and Atmospheric Administration, Washington, D.C., and Minerals Management Service, Washington, D.C., pp. 347–396.

Feely, R.A., and G.J. Massoth, 1982, *Sources, Composition, and Transport of Suspended Particulate Matter in Lower Cook Inlet and Northwestern Shelikof Strait*, NOAA Technical Report ERL 415—PMEL 34, USDOC/NOAA/ERL/PMEL, Seattle, Wash.

Feely, R.A., S.R. Alin, J. Newton, C.L. Sabine, M. Warner, A. Devol, C. Krembs, and C. Maloy, 2010, "The Combined Effects of Ocean Acidification, Mixing, and Respiration on pH and Carbonate Saturation in an Urbanized Estuary," *Estuarine, Coastal and Shelf Science* 88:442–449.

Ferguson, S.H., I. Stirling, and P. McLoughlin, 2005, "Climate Change and Ringed Seal (*Phoca hispida*) Recruitment in Western Hudson Bay," *Marine Mammals Science* 21(1):121–135.

Ferrero, R.C., and W.A. Walker, 1996, "Age, Growth, and Reproductive Patterns of Pacific White-Sided Dolphin (*Lagenorhynchus obliquidens*) Taken in High Seas Driftnets in the Central North Pacific Ocean," *Canadian Journal of Mammalogy* 74:1673–1687.

Fertl, D., T.A. Jefferson, I.B. Moreno, A.N. Zerbini, and K.D. Mullin, 2003, "Distribution of the Clymene Dolphin *Stenella clymene*," *Mammal Review* 33(3):253–271.

FGCIA (Florida Governor's Council on Indian Affairs), 2011, *Florida's American Indian and Alaska Native Population,* Florida Governor's Council on Indian Affairs, Inc., Tallahassee, Fla. Available at http://www.fgcia.com/FLORIDA_NDNs_07.pdf. Accessed 1 March 2011.

Field, C.B., L.D. Mortsch,, M. Brklacich, D.L. Forbes, P. Kovacs, J.A. Patz, S.W. Running, and M.J. Scott, 2007, *North America, Climate Change 2007: Impacts, Adaptation, and Vulnerability, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson (eds.), Cambridge University Press, Cambridge, U.K., pp. 617–652.

Field, L.J., J.A. Fall, T.J. Nighswander, N. Peacock, and U. Varanasi (eds.), 1999, *Evaluating and Communicating Subsistence Seafood Safety in a Cross-Cultural Context*, SETAC Press, Pensacola, Fla.

Finney, B., I. Gregory-Eaves, J. Sweetman, M. Douglas, and J. Smol, 2000, "Impacts of Climatic Change and Fishing on Pacific Salmon Abundance over the Past 300 Years," *Science* 290:795–799.

Fischbach, A.S., S.C. Amstrup, and D.C. Douglas, 2007, "Landward and Eastward Shift of Alaskan Polar Bear Denning Associated with Recent Sea Ice Changes," *Polar Biology* 30:1395–1405.

Fischer, J.B., and W.W. Larned, 2004, "Summer Distribution of Marine Birds in the Western Beaufort Sea," *Arctic* 57(2):143–159.

Fisher, H.D., 1952, "The Status of the Harbour Seal in British Columbia, with Particular Reference to the Skeena River," *Fisheries Research Board Canada Bulletin* 93.

Fisher, W.L., et al., 1973, *Environmental Geologic Atlas of the Texas Coastal Zone: Beaumont–Port Arthur Area*, University of Texas, Bureau of Economic Geology, Austin, TX.

Fisher, C.R., I. Urcuyo, M.A. Simpkins, and E. Nix, 1997, "Life in the Slow Lane: Growth and Longevity of Cold-Seep Vestimentiferans," *Marine Ecology* 18:83–94.

Florida Ornithological Society, 2010, *Official Florida State Bird List*. Records Committee, Florida Ornithological Society, Florida Museum of Natural History, Gainesville, Fla. December 31, 2010.

Florida Sea Grant, 2005, Economics of Florida's Beaches: The Impact of Beach Restoration.

FNAI (Florida Natural Areas Inventory), 2001, "Field Guide to the Rare Animals of Florida Online," Tallahassee, Fla. Available at http://www.fnai.org/FieldGuide/index.cfm. Accessed March 4, 2010.

Fodrie, F.J., and K.L. Heck, Jr., 2011, "Response of Coastal Fishes to the Gulf of Mexico Oil Disaster," PLoS One. 6: e21609.

Ford, B., A. Borgens, W. Bryant, D. Marshall, P. Hitchcock, C. Arias, and D. Hamilton, 2008, *Archaeological Excavation of the Mardi Gras Shipwreck (16GM01), Gulf of Mexico Continental Slope*, OCS Report MMS 2008-037, prepared by Texas A&M University for Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La.

Fox, D.A., J.E. Hightower, and F.M. Paruka, 2000, "Gulf Sturgeon Spawning Migration and Habitat in the Choctawhatchee River System, Alabama-Florida," *Transactions of the American Fisheries Society* 129:811–826.

Frame, G.W., 1974, "Black Bear Predation on Salmon at Olsen Creek, Alaska," *Zeitschrift für Tierpsychologie* 35(1):23–38.

Fredrickson, L.O.H, 2001, "Steller's Eider (*Polysticta stelleri*)," Issue 571, *The Birds of North America Online* (A. Poole, ed.), Cornell Lab of Ornithology, Ithaca, New York. Available at http://bna.birds.cornell.edu/bna/species/571. Accessed August 18, 2011.

Freeman, M.M.M., 1973, "Polar Bear Predation on Beluga in the Canadian Arctic," *Arctic* 26(2):162–163.

Frost, K., and S. Karpovich, 2008, *Alaska Wildlife Notebook Series: Gray Whale*, Alaska Department of Fish and Game, Juneau, Alaska. Available at http://www.adfg.alaska.gov/static/education/wns/gray_whale.pdf. Accessed April 11, 2011.

FSMP (Federal Subsistence Management Program), 2010, *Subsistence Management Regulations for the Harvest of Wildlife on Federal Public Lands in Alaska, Effective July 1, 2010–June 30, 2012*, Office of Subsistence Management, Anchorage, Alaska.

Fu, B., and P. Aharon, 1998, "Sources of Hydrocarbon-Rich Fluids Advecting on the Seafloor in the Northern Gulf of Mexico," *Gulf Coast Association of Geological Societies Transactions* 48:73–81.

Funk, D.W., L.E. Noel, and A.H. Freedman, 2004, "Environmental Gradients, Plant Distribution, and Species Richness in Arctic Salt Marsh near Prudhoe Bay, Alaska," *Wetlands Ecology and Management* 12: 215–233.

Galbraith, H., R. Jones, R. Park, J. Clough, S. Herrod-Julius, B. Harrington, and G. Page, 2002, "Global Climate Change and Sea Level Rise: Potential Losses of Intertidal Habitat for Shorebirds," *Waterbirds* 25(2):173–183.

Gales, R.S., 1982, *Effects of Noise of Offshore Oil and Gas Operations on Marine Mammals, An Introductory Assessment*, NOSC TR 844, 2 vols., U.S. Naval Ocean Systems Center, San Diego, Calif., Sept.

Gallant, A.L., E.F. Binnian, J.M. Omernik, and M.B. Shasby, 1995, *Ecoregions of Alaska*, USGS Professional Paper 1567, USGS, Washington, D.C.

Gallaway, B.J., and G.S. Lewbel, 1982, *The Ecology of Petroleum Platforms in the Northwestern Gulf of Mexico: A Community Profile*, U.S. Fish and Wildlife Service (FWS/OBS 82/27), Washington, D.C., and Bureau of Land Management, Gulf of Mexico Regional Office (Open File Report 82-03), New Orleans, La.

Gallaway, B.J., and M.C. Kennicutt II, 1988, "Characterization of Benthic Habitats of the Northern Gulf of Mexico," Chapter 2 in *Northern Gulf of Mexico Continental Slope Study, Final Report, Year 4, Volume II: Synthesis Report*, B.J. Gallaway (ed.), OCS Study MMS 88-0053, MMS, Gulf of Mexico OCS Region, New Orleans, La.

Gardner, J.V., L.A. Mayer, J.E. Hughes Clarke, and A. Kleiner, 1998, "High-Resolution Multibeam Bathymetry of East and West Flower Gardens and Stetson Banks, Gulf of Mexico," *Gulf of Mexico Science* 16:131–143.

Garrison, E.G., et al., 1989, *Historic Shipwrecks and Magnetic Anomalies of the Northern Gulf of Mexico: Reevaluation of Archaeological Resource Management Zone*, OCS Study MMS 89-0023, 89-0024, and 89-0025, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La.

Garshelis, D.L., and J.A. Garshelis, 1984, "Movements and Management of Sea Otters in Alaska," *Journal of Wildlife Management* 48(3):665–678.

Garshelis, D.L., J.A. Garshelis, and A.T. Kimker, 1986, "Sea Otter Time Budgets and Prey Relationships in Alaska," *Journal of Wildlife Management* 50(4):637–647.

Gaskin, D.E., 1984, "The Harbor Porpoise *Phocoena phocoena* (L.): Regional Populations, Status, and Information on Direct and Indirect Catches," *Rep. Int. Whal. Comm*. 34:569–586.

Gaston, A.J., and J.M. Hipfner, 2000, "Thick-billed Murre (*Uria lomvia*)," Issue 497, *The Birds of North America Online* (A. Poole, ed.), Cornell Lab of Ornithology, Ithaca, New York. Available at http://bna.birds.cornell.edu/bna/species/497. Accessed August 18, 2011.

Gatto, L.W., 1976, *Baseline Data on the Oceanography of Cook Inlet, Alaska*, CRREL Report 76-25, U.S. Army Corps of Engineers, CRREL, Hanover, N.H.

Geoplatform, 2011a, *SCAT Latest Ground Observations 01-12-11, Louisiana Sector*. Available at http://www.geoplatform.gov/gulfresponse. Accessed January 13, 2011.

Geoplatform, 2011b, *SCAT Latest Ground Observations 01-12-11, Mobile Sector*. Available at http://www.geoplatform.gov/gulfresponse. Accessed January 13, 2011.

Gilbert, C.R. (ed.), 1992, *Rare and Endangered Biota of Florida, Vol. II, Fishes*, University Press of Florida, Gainesville, Fla.

Gilchrist, H.G., 2001, "Glaucous Gull (*Larus hyperboreus*)," Issue 573, *The Birds of North America Online* (A. Poole, ed.), Cornell Lab of Ornithology, Ithaca, New York. Available at http://bna.birds.cornell.edu/bna/species/573. Accessed August 18, 2011.

Gill, R.E., Jr., and T.L. Tibbitts, 1999, *Seasonal Shorebird Use of Intertidal Habitats in Cook Inlet, Alaska*. Final Report. U.S. Department of the Interior, U.S. Geological Survey, Biological Resources Division and OCS Study, MMS 99–0012.

Gill, S., J. Sprenke, J. Kent, and M. Zieserl, 2011, "Tides under the Ice: Measuring Water Levels at Barrow, Alaska 2008-2010, in *Proceedings of U.S. Hydro 2011*, April 25–28, meeting of the Hydrographic Society of America, Tampa Fla.

Gittings, S.R., 1998, "Monitoring at the Flower Gardens: History and Status," in *Proceedings of the 17th Information Transfer Meeting*, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La.

GMFMC (Gulf of Mexico Fishery Management Council), 1998, *Generic Amendment for Addressing Essential Fish Habitat Requirements in the Following Fishery Management Plans of the Gulf of Mexico: Shrimp Fishery of the Gulf of Mexico United States Waters; Red Drum Fishery of the Gulf of Mexico; Reef Fish Fishery of the Gulf of Mexico; Coastal Migratory Pelagic Resources (Mackerels) in the Gulf of Mexico and South Atlantic; Stone Crab Fishery in the Gulf of Mexico; Spiny Lobster in the Gulf of Mexico and South Atlantic; Coral and Coral Reefs of the Gulf of Mexico*, Tampa, Fla.

GMFMC (Gulf of Mexico Fishery Management Council), 2004, *Final Environmental Impact Statement for the Generic Essential Fish Habitat Amendment to the Following Fishery Management Plans of the Gulf of Mexico (GOM): Shrimp Fishery of the Gulf of Mexico, Red Drum Fishery of the Gulf of Mexico, Reef Fish Fishery of the Gulf of Mexico, Stone Crab Fishery of the Gulf of Mexico, Coral and Coral Reef Fishery of the Gulf of Mexico, and South Atlantic Coastal Migratory Pelagic Resources of the Gulf of Mexico and the South Atlantic,* Vol. 1, Tampa, Fla.

Goddard, P.D., and D.J. Rugh, 1998, "A Group of Right Whales Seen in the Bering Sea in July 1996, *Marine Mammal Science* 1(2):344–349.

Goldstein, B., M. Howard, J. Osofsky, and M. Lichtveld, 2011, "The Gulf Oil Spill," *The New England Journal of Medicine*, 364: 1334–1348.

Goldstein, B.D., and G. Witz, 2009, "Benzene," in *Environmental Toxicants: Human Exposures and Their Health Hffects*, 3rd ed., M. Lippmann (editor), John Wiley, Hoboken, NJ.

Goolsby, D.A., W.A. Battaglin, G.B. Lawrence, R.S Artz, B.T. Aulenbach, R.P Hooper, D.R. Keeney, and G.J. Stensland, 1999, "Flux and Sources of Nutrients in the Mississippi-Atchafalaya River Basin," in *Topic 3 Report for the Integrated Assessment of Hypoxia in the Gulf of Mexico*, NOAA Coastal Ocean Program Decision Analysis Series No. 17, NOAA Coastal Ocean Program, Silver Spring, Md.

Gorbics, C.S., and J.L. Bodkin, 2001, "Stock Structure and Sea Otters (*Enhydra lutris kenyoni*) in Alaska," *Marine Mammal Science* 17(3):632–647.

Gordon, W., 1993, "Travel Characteristics of Marine Anglers Using Oil and Gas Platforms in the Central Gulf of New Mexico," *Marine Fisheries Review* 55:25–31. Available at http://spo.nmfs.noaa.gov/mfr551/mfr5514.pdf. Accessed July 15, 2011.

Gosho, M.E., D.W. Rice, and J.M. Breiwick, 1984, "The Sperm Whale, *Physeter macrocephalus*," *Marine Fisheries Review* 46(4):54–64.

Goudie, R.I., G.J. Robertson, and A. Reed, 2000, "Common Eider (*Somateria mollissima*)," Issue 546, *The Birds of North America Online* (A. Poole, ed.), Cornell Lab of Ornithology, Ithaca, New York. Available at http://bna.birds.cornell.edu/bna/species/546. Accessed August 18, 2011.

Gower, J., and S. King, 2008, "Satellite Images Show the Movement of Floating *Sargassum* in the Gulf of Mexico and Atlantic Ocean," posted on precedings.nature.com, May 15. Available at http://precedings.nature.com/documents/1894/version/1/files/npre20081894-1.pdf. Accessed June 29, 2011.

Gradinger, R., 2009, "Sea-Ice Algae: Major Contributors to Primary Production and Algal Biomass in the Chukchi and Beaufort Seas during May/June 2002," *Deep Sea Research Part II: Topical Studies in Oceanography* 56:1201–1212.

Gradinger, R.R., and B.A. Bluhm, 2004, "In-situ Observations on the Distribution and Behavior of Amphipods and Arctic Cod (*Boreogadus saida*) under the Sea Ice of the High Arctic Canada Basin," *Polar Biology* 27:595–603.

Gradinger R.R., and B.A. Bluhm, 2005, *Susceptibility of Sea Ice Biota to Disturbances in the Shallow Beaufort Sea: Phase 1: Biological Coupling of Sea Ice with the Pelagic and Benthic Realms, Final Report*, OCS Study MMS 2005-062, Minerals Management Service, Alaska OCS Region, Anchorage, Alaska.

Graham, W.M., 2001, "Numerical Increases and Distributional Shifts of *Chrysaora quinquecirrha* (Desor) and *Aurelia aurita* (Linné) (*Cnidaria: Scyphozoa*) in the Northern Gulf of Mexico," *Hydrobiologia* 451:97–111.

Graham, W.M, R.H. Condon, R.H. Carmichael, I. D'Ambra, H.K. Patterson, L.J. Linn, and F.J. Hernandez, Jr., 2010, "Oil Carbon Entered the Coastal Planktonic Food Web during the Deepwater Horizon Oil Spill," *Environmental Research Letters* 5(4):045301.

Grebmeier, J.M., and K.H. Dunton, 2000, "Benthic Processes in the Northern Bering/Chukchi Seas: Status and Global Change," pp. 61–71 in *Impacts of Changes in the Sea Ice and Other Environmental Parameters in the Arctic,* H.P. Huntington (ed.), Report of the Marine Mammal Commission Workshop, Girdwood, Alaska., Feb. 15–17, Marine Mammal Commission, Bethesda, Md.

Grebmeier, J.M., J.E. Overland, S.E. Moore, E.V. Farley, E.C. Carmack, L.W. Cooper, K.E. Frey, J.H. Helle, F.A. McLaughlin, and S.L. McNutt, 2006, "A Major Ecosystem Shift in the Northern Bering Sea," *Science* 311: 14611464.

Green, G.A., and J.J. Brueggeman, 1991, "Sea Otter Diets in a Declining Population in Alaska," *Marine Mammal Science* 7(4):395–401.

Greene, C.R., 1981, "Underwater Acoustic Transmission Loss and Ambient Noise in Arctic Regions," in *The Question of Sound from Icebreaker Operations: The Proceedings of a Workshop*, N.M. Peterson (ed.), Arctic Pilot Project, Petro-Canada, Calgary, Alberta, Canada.

Greene, C.R., 1985a, "Characteristics of Waterborne Industrial Noise, 1980-1984," in *Behavior, Disturbance Responses and Distribution of Bowhead Whales* Balaena mysticetus *in the Eastern Beaufort Sea, 1980-84,* OCS Study MMS 85-0034, prepared by W.J. Richardson (ed.), LGL Ecological Research Associates Inc., Bryan, Texas, for MMS, Reston, Va.

Greene, C.R., Jr., 1985b, *A Pilot Study of Possible Effects of Marine Seismic Airgun Array Operation on Rockfish Plumes*, prepared by Greeneridge Sciences Inc., Santa Barbara, Calif., for Seismic Steering Committee.

Greene, C.R., Jr., 1987, "Characteristics of Oil Industry Dredge and Drilling Sounds in the Beaufort Sea," *J. Acoust. Soc. Am.* 82(4):1315–1324.

Greene, C.R., Jr., 1995, "Ambient Noise," Chapter 5 in *Marine Mammals and Noise,* Richardson et al., Academic Press, San Diego, Calif.

Greene, C.R., Jr., and S.E. Moore, 1995, "Man-Made Noise," Chapter 6 in *Marine Mammals and Noise*, Richardson et al., Academic Press, San Diego, Calif.

Greene, C.R., Jr., and W.J. Richardson, 1988, "Characteristics of Marine Seismic Survey Sounds in the Beaufort Sea," *J. Acoust. Soc. Am.* 83(6):2246–2254.

Gregor, D.J., and W.D. Gummer, 1989, "Evidence of Atmospheric Transport and Deposition of Organochlorine Pesticides and Polychlorinated Biphenyls in Canadian Arctic Snow," *Environmental Science and Technology* 23(5):561–565.

Groot, C., and L. Margolis, 1991, *Pacific Salmon Life Histories,* UBC Press, Vancouver, B.C.

GSMFC, 2006, *The Striped Bass Fishery of the Gulf of Mexico, United States: A Regional Management Plan*, Gulf States Marine Fisheries Commission, Ocean Springs, Miss.

Gualtieri, J.F., L. DeBoer, C.R. Harris, and R. Corley, 2003, "Repeated Ingestion of 2-Butoxyethanol: Case Report and Literature Review," *Journal of Toxicology, Clinical Toxicology* 41: 57–62.

Hagemoen, R.I.M., and E. Reimers, 2002, "Reindeer Summer Activity Pattern in Relation to Weather and Insect Harassment," *Journal of Animal Ecology* 71:883–892.

Hagstrom, A., F. Azam, A. Andersson, J. Wikner, and F. Rassoulzadegan, 1988, "Microbial Loop in an Oligotrophic Pelagic Marine Ecosystem: Possible Roles of Cyanobacteria and Nanoflagellates in the Organic Fluxes," *Marine Ecology Progress Series* 49:171–178.

Hall, J.D., M.L. Gallagher, K.D. Brewer, P.R. Regos, and P.E. Isert, 1994, *1993* Kuvlum *Exploration Area Site Specific Monitoring Program*, final report, prepared by Coastal & Offshore Pacific Corp., Walnut Creek, Calif., for ARCO Alaska Inc., Anchorage, Alaska.

Hammarstrom, L.F., and E.G. Ford, 2010, *2009 Lower Cook Inlet Annual Finfish Management Report*, Fishery Management Report No. 10-17, Alaska Department of Fish and Game, Anchorage.

Hammill, M.O., and T.G. Smith, 1991, "The Role of Predation in the Ecology of the Ringed Seal in Barrow Strait, Northwest Territories, Canada," *Marine Mammal Science* 7:123–135.

Hancock, D., 1965, "Killer Whales Kill and Eat a Minke Whale," *Journal of Mammalogy* 46:341–342.

Harding, L.E., 1976, "Den-Site Characteristics of Arctic Coastal Grizzly Bears (*Ursus arctos*) on Richards Island, Northwest Territories, Canada," *Canadian Journal of Zoology* 54:1357–1363.

Harington, C.R., 1968, *Denning Habits of the Polar Bear* (Ursus maritimus) *Phipps,* Canadian Wildlife Service Report, Series 5.

Harper, J., S. Saupe, and M. Morris, 2004, "A Shore Zone Mapping Protocol for Use in Mapping Regional Variations of Nearshore Habitat along the Gulf of Alaska Coast," in *2004 Symposium, Marine Science in Alaska (Abstracts),, Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.

Hashagen, K.A., G.A. Green, and B. Adams, 2009, "Observations of Humpback Whales, *Megaptera novaeangliae*, in the Beaufort Sea, Alaska," *Northwestern Naturalist* 90(2):160–162.

Hasselbach, L., J. Ver Hoef, J. Ford, P. Neitlich, E. Crecelius, S. Berryman, B. Wolk, and T. Bohle, 2005, *Spatial Patterns of Cadmium and Lead Deposition on and Adjacent to National Park Service Lands near Red Dog Mine, Alaska*, NPS Final Report. Available at http://digitalcommons.unl.edu/natlpark/12. Accessed January 20, 2011.

Hatch, L.T., and A.J. Wright, 2007, "A Brief Review of Anthropogenic Sound in the Oceans," *International Journal of Comparative Psychology* 20:121–133. Available at http://comparativepsychology.org/ijcp-vol20-2-3-2007/04.Hatch&Wright_PDF.pdf. Accessed April 19, 2011.

Hatch, S.A., and D.N. Nettleship, 1998, "Northern Fulmar (*Fulmaris glacialis*)," Issue 361, *The Birds of North America Online* (A. Poole, ed.), Cornell Lab of Ornithology, Ithaca, New York. Available at http://bna.birds.cornell.edu/bna/species/361. Accessed August 18, 2011.

Hatch, S.A., P.M. Meyers, D.M. Mulcahy, and D.C. Douglas, 2000, "Seasonal Movements and Pelagic Habitat Use of Murres and Puffins Determined by Satellite Telemetry," *Condor* 102:145–154.

Haubold, E.M., C. Deutsch, and C. Fonnesbeck, 2006, "Final Biological Status Review of the Florida Manatee (*Trichechus manatus latirostris*)," Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, St. Petersburg, Fla., April. Available at http://www.fwc.state.fl.us/media/201862/finalreport_3230.pdf. Accessed September 9, 2009.

Hawkes, L.A., A.C. Broderick, M.H. Godfrey, and B.J. Godley, 2009, "Climate Change and Marine Turtles," *Endangered Species Research* 7:137–154.

Hazard, K., 1988, "Beluga Whale, Delphinapterus leucas," in *Selected Marine Mammals of Alaska: Species Accounts with Research and Management Recommendations*, in J.W. Lentfer (ed.), Marine Mammal Commission, Washington, D.C.

Hazen, T.C., et al., 2010, "Deep-Sea Oil Plume Enriches Indigenous Oil-Degrading Bacteria," *Science* 330:204–208.

Heard, D.C., and T.M. Williams, 1992, "Distribution of Wolf Dens on Migratory Caribou Ranges in the Northwest Territories," *Canadian Journal of Zoology* 70(8):1504–1510.

Hecker, B., 1985, "Fauna from a Cold Sulfur-Seep in the Gulf of Mexico: Comparison with Hydrothermal Vent Communities and Evolutionary Implications," in *Hydrothermal Events of the Eastern Pacific: An Overview*, M.L. Jones (ed.), *Bulletin of the Biological Society of Washington* 6:465–473.

Heileman, S., and I. Bekin, 2009, "XI-31 Chukchi Sea: LME #54," LME Briefs. Available at http://www.lme.noaa.gov/index.php?option=com_content&view=article&id=100:lme54&catid=41:briefs&Itemid=72. Accessed January 28, 2011.

Heileman, S., and N. Rabalais, 2009, "XV-50 Gulf of Mexico: LME #5," LME Briefs. Available at http://www.lme.noaa.gov/index.php?option=com_content&view=article&id=51:lme5&catid=41:briefs&Itemid=72. Accessed January 28, 2011.

Heimlich-Boran, J.R., 1988, "Behavioral Ecology of the Killer Whales (*Orcinus orca*) in the Pacific Northwest," *Canadian Journal of Zoology* 66:565–578.

Hemmerling, S.A., and C.E. Colton, 2004, *Environmental Justice Considerations in Lafourche Parish, Louisiana,* OCS Study MMS 2003-038, prepared by Louisiana State University Coastal Studies Institute, Baton Rouge, La., for MMS, Gulf of Mexico OCS Region, New Orleans, La., Jan.

Hemming, J.E., 1971, *The Distribution and Movement Patterns of Caribou in Alaska, Federal Aid in Wildlife Restoration Project W-17-R,* Wildlife Technical Bulletin No. 1, Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau, Alaska.

Hennick, D.P., 1973, *Sea Scallop,* Patinopectin caurinus, *Investigations in Alaska,* Completion Report 5-23-R, Alaska Department of Fish and Game, Division of Commercial Fisheries, Juneau, Alaska.

Henry, J.M., and C.L. Bankston, III, 2002, *Blue Collar Bayou: Louisiana Cajuns in the New Economy of Ethnicity,* Praeger, Westport, Conn.

Henshaw, J., 1968, "The Activities of the Wintering Caribou in Northwestern Alaska in Relation to Weather and Snow Conditions," *International Journal of Biometeorology* 12:18–24.

Hersteinsson, P., and D.W. Macdonald, 1992, "Interspecific Competition and the Geographical Distribution of Red and Arctic Foxes *Vulpes vulpes* and *Alopex lagopus*," *Oikos* 64:505-515.

Hester, K.C., E.T. Peltzer, W.J. Kirkwood, and P.G. Brewer, 2008, "Unanticipated Consequences of Ocean Acidification: A Noisier Ocean at Lower pH," *Geophys. Res. Lett.* 35:L19601, doi:10.1029/2008GL034913. Available at http://iod.ucsd.edu/courses/sio278/documents/hester_et_al_08_ocean_noisier_pH_jrl.pdf. Accessed May 4, 2011.

Heyland, J.D., and K. Hay, 1976, "An Attack by a Polar Bear on a Juvenile Beluga," *Arctic* 29:56–57.

Heyning, J.E., 1989, "Cuvier's Beaked Whale — *Ziphius cavirostris* (G. Cuvier, 1823)," pp. 289–308 in *Handbook of Marine Mammals: River Dolphins and the Larger Toothed Whales,* S.H. Ridgway and R. Harrison (eds.), Academic Press, New York.

Hiatt, T., M. Dalton, R. Felthoven, B. Fissel, B. Garber-Yonts, A. Haynie, S. Kasperski, D. Lew, C. Package, J. Sepez and C. Seung, 2010, *Stock Assessment and Fishery Evaluation Report of the Groundfish Fisheries of the Gulf of Alaska and Bearing Sea/Aleutian Islands Area: Economic Status of the Groundfish Fisheries of Alaska, 2009*. Available at http://www.afsc.noaa.gov/refm/docs/2010/economic.pdf. Accessed July 15, 2011.

Hickerson, E.L., G.P. Schmahl, M. Robbart, W.F. Precht, and C. Caldow, 2008, "The State of Coral Reef Ecosystems of the Flower Garden Banks, Stetson Bank, and Other Banks in the Northwestern Gulf of Mexico," in *The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2008*, Technical Memorandum NOS NCCOS 73, J.E. Waddell and A.M. Clarke (eds.), National Oceanic and Atmospheric Administration, National Centers for Coastal Ocean Science, Center for Coastal Monitoring and Assessment, Silver Spring, Md.

Hiett, R.L., and J.W. Milon, 2001, *Economic Impact of Recreational Fishing and Diving Associated with Offshore Oil and Gas Structures in the Gulf of Mexico, Final Report*, OCS Study MMS 2002-010, prepared by QuanTech, Inc. for the Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La. Available at http://www.gomr.mms.gov/PI/PDFImages/ESPIS/2/3058.pdf. Accessed July 15, 2011.

Highsmith, R.C., S.M. Saupe, and A.L. Blanchard, 2001, *Kachemak Bay Experimental and Monitoring Studies: Recruitment, Succession, and Recovery in Seasonally Disturbed Rocky-Intertidal Habitat*, OCS Study MMS 2001-053, MMS, Alaska OCS Region, Anchorage, Alaska.

Hildebrand, J.A., 2009, "Anthropogenic and natural sources of ambient noise in the ocean," *Marine Ecology Progress Series* 395:5-20.

Hinzman, L.D., N.D. Bettez, W.R. Bolton, F.S. Chapin, M.B. Dyurgerov, C.L. Fastie, B. Griffith, R.D. Hollister, A. Hope, H.P. Huntington, A.M. Jensen, G.J. Jia, R. Jorgenson, D.L. Kane, D.R. Klein, G. Kofinas, A.H. Lynch, A.H. Lloyd, A.D. McGuire, F.E. Nelson, W.C. Oechel, T.E. Osterkamp, C.H. Racine, V.E. Romanovsky, R.S. Stone, D.A. Stow, M. Sturm, C.E. Tweedie, G.L. Vourlitis, M.D. Walker, D.A. Walker, P.J. Webber, J.M. Welker, K.S. Winker, and K. Yoshikawa, 2005, "Evidence and Implications of Recent Climate Change in Northern Alaska and Other Arctic Regions, *Climatic Change* 72:251–298

Hirth, H.H., 1997, *Synopsis of Biological Data on the Green Turtle*, Chelonia mydas (*Linnaeus, 1758*), Report to the USFWS, Washington, D.C., Biological Report 97(1). 120 p.

Hoegh-Guldberg, O., P.J. Mumby, R.S. Hooten, A.J. Steneck, P. Greenfield, E. Gomez, C.D. Harvell, P.F. Sale, A.J. Edwards, K. Caldeira, N. Knowlton, C.M. Eakin, R. Iglesias-Prieto, N. Muthiga, R.H. Bradbury, A. Dubi, and M.E. Hatziolos, 2007, "Coral Reefs under Rapid Climate Change and Ocean Acidification," *Science* 318:1737.

Holler, N.R., D.W. Mason, R.M. Dawson, T. Simons, and M.C. Wooten, 1989, "Reestablishment of the Perdido Key Beach Mouse (*Peromyscus polionotus trissyllepsis*) on Gulf Islands National Seashore," *Conservation Biology* 3:397–403.

Holliday, D.V., W.C. Cummings, and B.J. Lee, 1984, *Acoustic and Vibration Measurements Related to Possible Disturbance of Ringed Seals*, Phoca hispida, T-84-06-001-U. Rep. from Tracor Applied Sciences, San Diego, Calif., for Outer Continental Shelf Environmental Assessment Program, NOAA, Juneau, Alaska.

Holzworth, G.C., 1972, *Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution throughout the Contiguous United States*, Publication No. AP-101, U.S. Environmental Protection Agency, Office of Air Programs, Research Triangle Park, N.C., Jan.

Hom, W., et al., 1999, "Measuring the Exposure of Subsistence Fish and Marine Mammal Species to Aromatic Compounds following the *Exxon Valdez* Oil Spill," in *Evaluating and Communicating Subsistence Seafood Safety in a Cross-Cultural Context*, L.J. Field, J.A. Fall, T.S. Nighswander, N. Peacock, and U. Varanasi (eds), SETAC Press, Pensacola, Fla.

Hopcroft, R., B. Bluhm, and R. Gradinger, 2008, *Arctic Ocean Synthesis: Analysis of Climate Change Impacts in the Chukhi and Beaufort Seas with Strategies for Future Research*, Institute of Marine Sciences, University of Alaska, Fairbanks, Alaska.

Hopkins, T.L., T.T. Sutton, and T.M. Lancraft, 1997, “The Trophic Structure and Predation Impact of a Low Latitude Midwater Fish Assemblage,” *Prog. Oceanogr.* 38:205–239.

Houck, W.J., and T.A. Jefferson, 1999, “Dall’s Porpoise (*Phocoenoides dalli*),” pp. 443–472 in *Handbook of Marine Mammals, Vol. 6: The Second Book of Dolphins and Porpoises*, S.H. Ridgeway and R. Harrison (eds.), Academic Press, San Diego, Calif.

Houghton, J.P., D.A. Segar, and J.E. Zeh, 1984, *Beaufort Sea Monitoring Program: Proceedings of a Workshop (September 1983) and Sampling Design Recommendations*, prepared for the Outer Continental Shelf Environmental Assessment Program, Juneau, Alaska, by USDOC, Anchorage, Alaska.

Howard, Z., 2011, “Climate Change Raising Tick Threat for Northern Moose: Officials,” *Reuters* June 18, 2011. Available at http://www.reuters.com/article/2011/06/18/us-moose-ticks-idUSTRE75H1UJ20110618. Accessed September 7, 2011.

Hubbard, H.H. (ed.), 1995, *Aeroacoustics of Flight Vehicles, Theory and Practice, Vol. 1, Noise Sources*, Acoustical Society of America, Woodbury, N.Y.

Huff, J.A., 1975, “Life History of Gulf of Mexico Sturgeon, *Acipenser oxyrhynchus desotoi*, in Suwannee River, Florida,” *Florida Marine Research Publications* 16:1–32.

Hulbert, E.M., and N. Corwin, 1972, “A Note on the Phytoplankton Distribution in the Offshore Water of the Eastern and Central Gulf of Mexico,” *Caribbean Journal of Science* 12:29–38.

Hummell, R.L., 1990, *Main Pass and the Ebb-Tidal Delta of Mobile Bay, Alabama*. Circular 146. Geological Survey of Alabama, Energy and Coastal Geology Division.

Hung, C.-C., C. Xu, P.H. Santschi, S.-J. Zhang, K. A. Schwehr, A. Quigg, L. Guo, G.-C. Gong, J.L. Pinckney, R.A. Long, and C.-L. Wei, 2010, “Comparative Evaluation of Sediment Trap and ^{234}Th-derived POC Fluxes from the Upper Oligotrophic Waters of the Gulf of Mexico and the Subtropical Northwestern Pacific Ocean,” *Mar. Chem*. 121:132–144.

Iken, K., 2009, “Monitoring the Boulder Patch: Biodiversity Assessments,” in Long-Term Monitoring of the Kelp Community in the Stefansson Sound Boulder Patch: *Detection of Change Related to Oil and Gas Development*, OCS Study MMS 2009-040, cANIMIDA Final Report: Summers 2004–2007.

Impact Assessment, Inc., 2001, Exxon Valdez *Oil Spill, Cleanup and Litigation: A Collection of Social-Impact Information and Analysis*, OCS Study MMS 2001-058, MMS, Alaska OCS Region, Anchorage, Alaska.

Incze, L.S., D.W. Siefert, and J.M. Napp, 1997, "Mesozooplankton of Shelikof Strait, Alaska: Abundance and Community Composition," *Continental Shelf Research* 17:287–305.

Intergovernmental Panel on Climate Change (IPCC), 2002, *Climate Change and Biodiversity*, IPCC Technical Paper V, H.Gitay, A. Suarez, D.J. Dokken, and R.T. Watson (eds).

IPCC (International Panel on Climate Change), 2007a, *Climate Change 2007: Synthesis Report,* Contribution of Working Groups I, II, and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Core Writing Team, R.K. Pachauri and A. Reisinger (eds.), Geneva, Switzerland.

IPCC (Intergovernmental Panel on Climate Change), 2007b, *Climate Change 2007: The Physical Science Basis*, contribution of Working Group I to the Fourth Assessment Report of the IPCC, S. Solomon et al. (eds.), Cambridge University Press, Cambridge, U.K.

Irvine, J.R., R.W. Macdonald, R.J. Brown, L. Godbout, J.D. Reist, and E.C. Carmack, 2009, "Salmon in the Arctic and How They Avoid Lethal Low Temperatures," *North Pacific Anadromous Fish Commission Bulletin* No. 5:39–50.

Jacob, D.J., and D.A. Winner, 2009, "Effect of climate change on air quality," *Atmospheric Environment* 43(2009):51–63.

Jameson, R.J., and A.M. Johnson, 1993, "Reproductive Characteristics of Female Sea Otters," *Marine Mammal Science* 9:156–167.

Janetos, A., L. Hansen, D. Inouye, B.P. Kelly, L. Meyerson, B. Peterson, and R. Shaw, 2008, "Biodiversity," in *The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity, A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research*, Washington, D.C.

Jefferson, T.A., 1988, "*Phocoenoides dalli*," *Mammalian Species* 319:1–7.

Jefferson, T.A., and N.B. Barros, 1997, "*Peponocephala electra*," *Mammalian Species* 553:1–6.

Jefferson, T.A., and B.E. Curry, 2003, "*Stenella clymene*," *Mammalian Species* 726:1–5.

Jefferson, T.A., and A.J. Schiro, 1997, "Distributions of Cetaceans in the Offshore Gulf of Mexico," *Mammal Review* 27(1):27–50.

Jefferson, T.A., D.K. Odell, and K.T. Prunier, 1995, "Notes on the Biology of the Clymene Dolphin (*Stenella clymene*) in the Northern Gulf of Mexico," *Marine Mammal Science* 11(4):564–573.

Jefferson, T.A., S. Leatherwood, and M.A. Webber, 2006, *Marine Mammals of the World*, ETI — Projects in the World Biodiversity Database. Available at http://nlbif.eti.uva.nl/bis/marine_mammals.php?menuentry=inleiding. Accessed March 15, 2011.

Jochens, A.E., S.F. DiMarco, W.D. Nowlin, Jr., R.O. Reid, and M.C. Kennicutt II, 2002, *Northeastern Gulf of Mexico Chemical Oceanography and Hydrography Study: Synthesis Report*, OCS Study MMS 2002-005, MMS, Gulf of Mexico OCS Region, New Orleans, La.

Jochens, A.E., L.C. Bender, S.F. DiMarco, J.W. Morse, M.C. Kennicutt II, M.K. Howard, and W.D. Nowlin, Jr., 2005, *Understanding the Processes that Maintain the Oxygen Levels in the Deep Gulf of Mexico: Synthesis Report*, OCS Study MMS 2005-032, MMS, Gulf of Mexico OCS Region, New Orleans, La.

Jochens, A., D. Biggs, K. Benoit-Bird, D. Engelhaupt, J. Gordon, C. Hu, N. Jaquet, M. Johnson, R. Leben, B. Mate, P. Miller, J. Ortega-Ortiz, A. Thode, P. Tyack, and B. Würsig, 2008, *Sperm Whale Seismic Study in the Gulf of Mexico: Synthesis Report*, OCS Study MMS 2008-006, Minerals Management Service, Gulf of Mexico Outer Continental Shelf Region, New Orleans, La.

Johnson, J.H., and A.A. Wolman, 1984, "The Humpback Whale, *Megaptera novaeangliae*," *Marine Fisheries Review* 46(4):300–337.

Johnson, L., 2008, *Alaska Wildlife Notebook Series: Black Bear*, Alaska Department of Fish and Game, Juneau, Alaska. Available at http://www.adfg.alaska.gov/static/education/wns/black_bear.pdf. Accessed April 11, 2011.

Johnson, S.R., 1979, "Fall Observations of Westward Migrating White Whales (*Delphinapterus leucas*) along the Central Alaskan Beaufort Sea Coast," *Arctic* 32(3):275–276.

Johnson, S.R., 1993, "An Important Early-Autumn Staging Area for Pacific Flyway Brant: Kasegaluk Lagoon, Chukchi Sea, Alaska," *Journal of Field Ornithology* 64(4):539–548.

Johnson, S.R., and D.R. Herter, 1989, *The Birds of the Beaufort Sea*, BP Exploration (Alaska) Inc., Anchorage, Alaska.

Johnston, J., 2003, *100+ Years of Land Change for Coastal Louisiana*. Presentation by J. Johnston, U.S. Geological Survey, Society of Environmental Journalists Annual Meeting, New Orleans, Louisiana, September 11, 2003.

Johnston, K.M., and O.J. Schmitz, 1997, "Wildlife and Climate Change: Assessing the Sensitivity of Selected Species to Simulated Doubling of Atmospheric CO_2," *Global Change Biology* 3:531-544.

Johnston, R.C., and B. Cain, 1981, "Marine Seismic Energy Sources: Acoustic Performance Comparison," presented at 102nd Meet. Acoust. Soc. Am., Miami Beach, Fla., Dec.

Jones, I.L., 1993a, "Least Auklet (*Aethia pusilla*)," Issue 069, *The Birds of North America Online* (A. Poole, ed.), Cornell Lab of Ornithology, Ithaca, New York. Available at http://bna.birds.cornell.edu/bna/species/069/articles/introduction. Accessed August 18, 2011.

Jones, I.L., 1993b, "Crested Auklet (*Aethia cristatella*), Issue 070, *The Birds of North America Online* (A. Poole, ed.), Cornell Lab of Ornithology, Ithaca, New York. Available at http://bna.birds.cornell.edu/bna/species/070. Accessed August 18, 2011.

Jones, I.L., N.B. Konyukhov, J.C. Williams, and G.V. Byrd, 2001, "Parakeet Auklet (*Aethia psittacula*)," Issue 594, *The Birds of North America Online* (A. Poole, ed.), Cornell Lab of Ornithology, Ithaca, New York. Available at http://bna.birds.cornell.edu/bna/species/594. Accessed August 18, 2011.

Jorgenson, M.T., and J. Brown, 2005, "Classification of the Alaskan Beaufort Sea Coast and Estimation of Carbon and Sediment Inputs from Coastal Erosion," *Geo-Marine Letters* 25:69–80.

Joyce, C., 2009, "When Rain Falls on Snow, Arctic Animals May Starve," NPR News July 28, 2009. Available at http://www.npr.org/templates/story/story.php?storyId=111109436. Accessed September 7, 2011.

Justic, D., N.N. Rabalais, and R.E. Turner, 1996, "Effects of Climate Change on Hypoxia in Coastal Waters: A Doubled CO_2 Scenario for the Northern Gulf of Mexico," *Limnology and Oceanography* 41:992–1003.

Kajimura, H., and T.R. Loughlin, 1988, "Marine Mammals in the Oceanic Food Web of the Eastern Subarctic Pacific," *Bull. of the Ocean Res. Inst. Univ. of Tokyo* 26(II):187–223.

Karl, T.R., J.M. Melilo, and T.C. Peterson (eds.), 2009, *Global Climate Change Impacts in the United States*, U.S. Global Change Research Program, Cambridge University Press, New York, N.Y.

Kavalok, T., 2007, "Unit 16 Brown Bear Management Report," in *Brown Bear Management Report of Survey and Inventory Activities 1 July 2004–30 June 2006*, P. Harper (ed.), Alaska Department of Fish and Game, Juneau, Alaska.

Kawamura, A., 1980, "A Review of Food of Balaenopterid Whales," pp. 155–197 in *Scientific Reports of the Whale Research Institute 32*, Whales Research Institute, Tokyo, Japan.

Kellett, D.K., and R.T. Alisauskas, 1997, "Breeding Biology of King Eiders Nesting on Karrak Lake, Northwest Territories," *Arctic* 50(1):47–54.

Kelly, B.P., 1988a, "Ribbon Seal, *Phoca fasciata*," pp. 96–106 in *Selected Marine Mammals of Alaska: Species Accounts with Research and Management Recommendations*, J.W. Lentfer (ed.), Marine Mammal Commission, Washington, D.C.

Kelly, B.P., 1988b, "Ringed Seal, *Phoca hispida*," pp. 57–77 in *Selected Marine Mammals of Alaska: Species Accounts with Research and Management Recommendations*, J.W. Lentfer (ed.), Marine Mammal Commission, Washington, D.C.

Kelly, B.P., 2001, "Climate Change and Ice Breeding Pinnipeds," *In:* Walther, G.-R., C.A. Burga, and P.J. Edwards (eds.), *"Fingerprints" of Climate Change – Adapted Behaviour and Shifting Species Ranges*, Kluwer Academic/Plenum Publishers, New York, pp. 43–55.

Kelly, B.P., O.H. Badajos, M. Kunnasranta, J.R. Moran, M. Martinez-Bakker, D. Wartzok, and P. Boveng, 2010a, "Seasonal Home Ranges and Fidelity to Breeding Sites among Ringed Seals," *Polar Biology* 33(8):1095–1109.

Kelly, B.P., J.L. Bengtson, P.L. Boveng, M.F. Cameron, S.P. Dahle, J.K. Jansen, E.A. Logerwell, J.E. Overland, C.L. Sabine, G.T. Waring, and J.M. Wilder, 2010b, *Status Review of the Ringed Seal (Phoca hispida)*, NOAA Technical Memorandum NMFS-AFSC-212, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Center, Seattle, Wash., Dec. Available at http://www.afsc.noaa.gov/publications/AFSC-TM/NOAA-TM-AFSC-212.pdf. Accessed April 17, 2011.

Kenaitze Indian Tribe, 2011, *Introduction to Kenaitze Indian Tribe's Cultural & Educational Fishery*, Sovereign Nation of the Kenaitze, Kenai, Alaska. Available at http://www.kenaitze.org/tribal/fishery/index.html. Accessed June 17, 2011.

Kendall, A.W., J.D. Schumacher, and S. Kim, 1996, "Walleye Pollock Recruitment in Shelikof Strait: Applied Fisheries Oceanography," *Fisheries Oceanography* 5:4–18.

Kessler, R.C., S. Galea, M.J. Gruber, N.A. Sampson, R.J. Ursano, and S. Wessely, 2008, "Trends in Mental Illness and Suicidality after Hurricane Katrina," *Molecular Psychiatry* 13: 374–384.

Kessler, J.D., D.L. Valentine, M.C. Redmond, M. Du, E.W. Chan, S.D. Mendes, E.W. Quiroz, C.J. Villanueva, S.S. Shusta, L.M. Werra, S.A. Yvon-Lewis, and T.C. Weber, 2011, "A Persistent Oxygen Anomaly Reveals the Fate of Spilled Methane in the Deep Gulf of Mexico," *Science* 331(6015):312–315.

Kinkhart, E., K. Pitcher, and G. Blundell, 2008, *Alaska Wildlife Notebook Series: Harbor Seal*, Alaska Department of Fish and Game, Juneau, Alaska. Available at http://www.adfg.alaska.gov/static/education/wns/harbor_seal.pdf. Accessed April 11, 2011.

Kinney, P.J., J. Groves, and D.K. Button, 1970, *Cook Inlet Environmental Data*, R/V Acona Cruise 065, May 21–28, 1968, Report No. R-70-2, University of Alaska Fairbanks, Fairbanks, Alaska.

Kollewe, J., 2010, *BP Oil Spill Cost Hits Nearly $10bn*. Available at http://www.guardian.co.uk/environment/2010/sep/20/bp-oil-spill-deepwater-horizon-costs-10bn. Accessed July 15, 2011.

Konar, B., 2007, "Recolonization of a High Latitude Hard Bottom Nearshore Community," *Polar Biology* 30:663–667.

Kondzela, C., M. Garvin, R. Riley, J. Murphy, J. Moss, S. A. Fuller, and A. Gharrett, 2009, Preliminary Genetic Analysis of Juvenile Chum Salmon from the Chukchi Sea and Bering Strait, North Pacific Anadromous Fish Commission Bulletin No. 5: 25-27.

Koski, W.R., R.A. Davis, G.W. Miller, and D.E. Withrow, 1993, "Reproduction," pp. 239–274 in *The Bowhead Whale*, Special Publication, J.J. Burns et al. (eds.), The Society for Marine Mammalogy, Lawrence, Kansas.

Kovacs, K.M., C. Lydersen, and I. Gjertz, 1996, "Birth-Site Characteristics and Prenatal Molting of Bearded Seals (*Erignathus barbatus*)," *Journal of Mammalogy* 77(4):1085–1091.

Kovacs, K.M., C. Lydersen, J.E. Overland, and S.E. Moore, 2011, "Impacts of Changing Sea-ice Conditions on Arctic Marine Mammals," *Marine Biodiversity* 28:181–194.

Krishnamurti, T.N., C.M. Kishtawal, Z. Zhang, T. LaRow, D. Bachiochi, E. Williford, S. Gadgil, and S. Surendran, 2000, "Multimodel Ensemble Forecasts for Weather and Seasonal Climate," *Journal of Climate* 13:4196–4216.

Kronenberg, M.E., T.C. Hansel, A.M. Brennan, H.J. Osofsky, J.D. Osofsky, and B. Lawrason, 2010, "Children of Katrina: Lessons Learned about Postdisaster Symptoms and Recovery Patterns," *Child Development* 81: 1241–1259.

Kujawinski, E.B., M.C. Kido Soule, D.L. Valentine, A.K. Boysen, K. Longnecker, and M.C. Redmond, 2011, "Fate of Dispersants Associated with the Deepwater Horizon Oil Spill," *Environmental Science and Technology* 45:1298–1306.

Kvenvolden, K.A., and C.K. Cooper, 2003, "Natural Seepage of Crude Oil into the Marine Environment," *Geo-Marine Letters* 23:140–146.

Kvitek, R.G., C.E. Bowlby, and M. Staedler, 1993, "Diet and Foraging Behavior of Sea Otters in Southeast Alaska," *Marine Mammal Science* 9(2):168–181.

Kwok, R., and G.F. Cunningham, 2010, "Contribution of Melt in the Beaufort Sea to the Decline in Arctic Multiyear Sea Ice Coverage: 1993-2009," *Geophysical Research Letters* 37(20):L20501.

Kwok, R., and G.F. Cunningham, 2011, "Deformation of the Arctic Ocean Ice Cover after the 2007 Record Minimum in Summer Ice Extent," in *Cold Regions Science and Technology*, in press, doi: 10.1016/j.coldregions.2011.04.003.

Kwok, R., G. F. Cunningham, M. Wensnahan, I. Rigor, H. J. Zwally, and D. Yi, 2009, "Thinning and Volume Loss of Arctic Sea Ice: 2003-2008," *Journal of Geophysical Research*.

LA 1 Coalition, 2011, "Studies Show Existing LA 1 under Water by 2050," In *One to One: An Update on the Efforts of the LA 1 Coalition*, Spring/Summer 2011.

Lackmann, G.M., 1988, "Evaluation of the Rossby Radius for Offshore-Directed Flow Near a Mountainous Coast," in *Proceedings of the Fourth Conference on Meteorology and Oceanography of the Coastal Zone*, Anaheim, Calif., Jan. 3–5.

Laidre, K.L., K.E.W. Shelden, D.J. Rugh, and B.A. Mahoney, 2000, "Beluga, *Delphinapterus leucas*, Distribution and Survey Effort in the Gulf of Alaska," *Marine Fisheries Review* 62(3):27–36.

Laidre, K.L., I. Stirling, L.F. Lowry, Ø. Wiig, M.P. Heide-Jørgensen, and S.H. Ferguson, 2008, "Quantifying the Sensitivity of Arctic Marine Mammals to Climate-induced Habitat Change," *Ecological Applications* 18(2):S97–S125.

Laist, D.W., and J.E. Reynolds, III, 2005, "Florida Manatees, Warm-Water Refuges, and an Uncertain Future," *Coastal Management* 33:279–295.

Lan, Q., et al., 2004, "Hematotoxicity in Workers Exposed to Low Levels of Benzene," *Science* 306: 1774–1776.

Larned, W.W., 2006, *Winter Distribution and Abundance of Steller's Eiders (*Polysticta stelleri*) in Cook Inlet, Alaska 2004–2005*, OCS Study MMS 2006-066. U.S. Department of the Interior, Minerals Management Service, Alaska Outer Continental Shelf Region, Anchorage, AK.

Larned, W.W., R. Stehn, and R. Platte, 2006, *Eider Breeding Population Survey Arctic Coast Plain, Alaska 2006*, U.S. Fish and Wildlife Service, Anchorage, Alaska. Available at http://alaska.fws.gov/mbsp/mbm/waterfowl/surveys/pdf/nse2006rpt.pdf. Accessed August 18, 2011.

Larsen, D.N., 1984, "Feeding Habits of River Otters in Coastal Southeastern Alaska," *Journal Wildlife Management* 48:1446–1452.

LATT (Lipan Apache Tribe of Texas), 2009, *State Recognition of the Lipan Apache Tribe of Texas*, Lipan Apache Tribe of Texas, Corpus Christi, Texas. Available at http://www.lipanapache.org/StateRecognition/StateRecognitionEvent.html. Accessed March 2, 2011.

Law, K.S., and A. Stohl, 2007, "Arctic Air Pollution: Origins and Impacts," *Science* 315:1537–1540.

Lawhead, B.E., 1997, "Caribou and Oil Development in Northern Alaska: Lessons from the Central Arctic Herd," in *NPR — A Symposium Proceedings, Science, Traditional Knowledge, and the Resources of the Northeast Planning Area of the National Petroleum Reserve–Alaska, Anchorage, Alaska, April 16–18, 1997*, OCS Study MMS 97-0013, D. Yokel (ed), Minerals Management Service, and Bureau of Land Management, Anchorage, Alaska.

LCWCRTF (Louisiana Coastal Wetlands Conservation and Restoration Task Force), 1998, *Coast 2050: Toward a Sustainable Coastal Louisiana*. Louisiana Department of Natural Resources, Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority, Baton Rouge, LA.

LCWCRTF, 2001, *The 2000 Evaluation Report to the U.S. Congress on the Effectiveness of Louisiana Coastal Wetland Restoration Projects*. Louisiana Department of Natural Resources, Baton Rouge, Louisiana.

LCWCRTF, 2003, *The 2003 Evaluation Report to the U.S. Congress on the Effectiveness of Coastal Wetland Planning, Protection, and Restoration Act Projects*. Louisiana Department of Natural Resources, Baton Rouge, Louisiana.

Learmonth, J.A., C.D. MacLeod, M.B. Santos, G.J. Pierce, H.Q.P. Crick, and R.A. Robinson, 2006, "Potential Effects of Climate Change on Marine Mammals," *Oceanography and Marine Biology: An Annual Review* 44:431–464.

Leatherwood, S., and R.R. Reeves, 1987, *The Sea World Book of Dolphins,* Harcourt Brace Jovanovich, San Diego, Calif.

Leatherwood, S., R.R. Reeves, W.F. Perrin, and W.E. Evans, 1982, *Whales, Dolphins and Porpoises of the Eastern North Pacific and Adjacent Arctic Waters: Guide to Their Identification,* NOAA Technical Report, NMFS Circular 444, National Marine Fisheries Service, Juneau, Alaska.

LeDuc, R., W.L. Perryman, J.W. Gilpatrick, Jr., J. Hyde, C. Stinchcomb, J.V. Carretta, and R.L. Brownell, Jr., 2001, "A Note on Recent Surveys for Right Whales in the Southeastern Bering Sea," *Journal of Cetacean Research and Management*, Special Issue 2:287–289.

Leikauf, G.D., 2002, "Hazardous Air Pollutants and Asthma," *Environmental Health Perspectives* 110, Suppl: 505–526.

Lemke, P., J. Ren, R.B. Alley, I. Allison, J. Carrasco, G. Flato, Y. Fujii, G. Kaser, P. Mote, R.H. Thomas, and T. Zhang, 2007, "Observations: Changes in Snow, Ice and Frozen Ground," in *Climate Change 2007: The Physical Science Basis,* Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, S. Solomon et al. (eds.), Cambridge University Press, New York, N.Y.

LeMone, M.A., 1978, "The Marine Boundary Layer," pp.182–234 in *Proceedings of Workshop on the Planetary Boundary Layer,* American Meteorological Society.

Lenart, E.A., 2009a, "Units 26B and 26C Caribou," pp. 299–325 in *Caribou Management, Report of Survey and Inventory Activities, 1 July 2006–30 June 2008, Project 3.0,* P. Harper (ed.), Alaska Department of Fish and Game, Juneau, Alaska.

Lenart, E.A., R.T. Bowyer, J. Ver Hoef, and R.W. Ruess, 2002, "Climate Change and Caribou: Effects of Summer Weather on Forage," *Canadian Journal of Zoology* 80:664–678.

Lenart, E.A., 2009b, "Units 26B and 26C Muskox," pp. 48–69 in *Muskox Management, Report of Survey and Inventory Activities, 1 July 2006–30 June 2008, Project 16.0,* P. Harper (ed.), Alaska Department of Fish and Game, Juneau, Alaska.

Lent, P.C., 1966, "Chapter 19: The Caribou of Northwestern Alaska," pp. 481–516, in *Environment of the Cape Thompson Region, Alaska,* N.J. Wilimovsky and J. Wolfe (eds.), Atomic Energy Commission, Division of Technical Information, Oak Ridge, Tenn.

Lent, P.C., 1980, "Synoptic Snowmelt Patterns in Arctic Alaska in Relation to Caribou Habitat Use," in *Proceedings of the Second International Reindeer/Caribou Symposium, Roros, Norway, Sept. 17–21, 1979,* E. Reimers et al. (eds.), Direktoratet for Vilt og Ferskvannsfisk, Trondheim, Norway.

Lent, P.C., 1988, "*Ovibos moschatus*," *Mammalian Species* 302:1–9.

Lentfer, J.W., and R.J. Hensel, 1980, "Alaskan Polar Bear Denning," *International Conference on Bear Research and Management* 4:101–108.

Lentfer, J., and B. Small, 2008, *Alaska Wildlife Notebook Series: Polar Bear,* Alaska Department of Fish and Game, Juneau, Alaska. Available at http://www.adfg.alaska.gov/static/education/wns/polar_bear.pdf. Accessed April 11, 2011.

Leschine, T., 2002, "Oil Spills and the Social Amplification and Attenuation of Risk," *Spill Science & Technology Bulletin* 7:63–73.

Levinsky, I., F. Skov, J.C. Svenning, and C. Rahbek, 2007, "Potential Impacts of Climate Change on the Distributions and Diversity Patterns of European Mammals," *Biodiversity and Conservation* 16:3803–3816.

Lewbel, G.S., 1984, "Environmental Hazards to Petroleum Industry Development," pp. 31–46 in *Proceedings of a Synthesis Meeting: The Barrow Arch Environment and Possible Consequences of Planned Offshore Oil and Gas Development (Sale 85),* J.C. Truett (ed.), Girdwood, Alaska, Oct. 30–Nov. 1, 1983, USDOC, NOAA, OCSEAP, and MMS, Anchorage, Alaska.

LGL and Greeneridge, 1987, *Responses of Bowhead Whales to an Offshore Drilling Operation in the Alaskan Beaufort Sea, Autumn 1986*, prepared by LGL Ltd., King City, Ontario, Canada, and Greeneridge Sciences, Inc., Santa Barbara, Calif., for Shell Western E & P Inc., Anchorage, Alaska.

LGL Ltd., 2005, *Environmental Assessment of a Marine Geophysical Survey by the Coast Guard Cutter Healy across the Atlantic Ocean*, LGL Report 4122-1, King City, Ontario, Canada.

LGOIA (Louisiana Governor's Office of Indian Affairs), 2011, *State Recognized Tribes,* Louisiana Governor's Office of Indian Affairs, Baton Rouge, La.

Lincoln, F.C., S.R. Peterson, and J.L. Zimmerman, 1998, *Migration of Birds*. U.S. Department of the Interior, U.S. Fish and Wildlife Service, Washington, D.C. Circular 16. Jamestown, N.D.

Lindstedt, D., and E. Swenson, 2006, *The Case of the Dying Marsh Grass*. Prepared for Coastal Restoration Division, Louisiana Department of Natural Resources.

Lipkin, R., 1997, "Known Rare or Sensitive Plant Species Within the Planning Area," in *The NPR-A Symposium: Science, Traditional Knowledge, and the Resources of the Northeast Planning Area of the National Petroleum Reserve in Alaska, April 16-18, 1997, Anchorage, AK*, OCS Study Report MMS 97-0013, BLM and MMS, Anchorage, Alaska.

Little, J., 2001, "Authorities Investigate Death of Western Cook Inlet's Resident Walrus," *Peninsula Clarion* October 4, 2001. Available at http://peninsulaclarion.com/stories/100401/ala_100401alapm0010001.shtml. Accessed September 5, 2011.

Litzow, M.A., 2006, "Climate Regime Shifts and Community Reorganization in the Gulf of Alaska: How Do Recent Shifts Compare with 1976/1977?" *ICES Journal of Marine Science* 63:1386–1396.

Liu, Z., and M. Alexander, 2007, "Atmospheric Bridge, Oceanic Tunnel, and Global Climatic Teleconnections," *Review of Geophysics* 45:RG2005.

LMEW (Large Marine Ecosystems of the World), 2009, "Large Marine Ecosystems of the World," United Nations Environment Programme. Available at http://www.lme.noaa.gov. Accessed February 1, 2011.

LNG World News, 2011, *ConocoPhillips, Marathon to Shut Kenai LNG Plant (USA)*. Available at http://www.lngworldnews.com/conocophillips-marathon-to-shut-kenai-lng-plant-usa/. Accessed June 2011.

Loeng, H., 2005, "Marine Systems," *Arctic Climate Impact Assessment: Scientific Report, ACIA*, Cambridge University Press, Cambridge, U.K., pp. 454–538.

Logerwell, E., and R. Kimberly, 2008, *Beaufort Sea Marine Fish Monitoring 2008: Pilot Survey and Test of Hypotheses, Final Report*, Alaska Fisheries Science Center, NOAA National Marine Fisheries Service.

Logerwell, E., and K. Rand, 2008, *Beaufort Sea Marine Fish Monitoring 2008: Pilot Survey and Test of Hypotheses, Final Report*, Alaska Fisheries Science Center, NOAA National Marine Fisheries Service.

Lohr, K., 2010, *Louisiana Gulf Coast Businesses Lament Losses,* National Public Radio, Oct. 13. Available at http://www.npr.org/templates/story/story.php?storyId=130537922. Accessed June 2011.

Loughlin, T.R., 1993, *Status and Pelagic Distribution of Otariid Pinnipeds in the Bering Sea during Winter,* OCS Study MMS 93-0026, prepared by National Marine Fisheries Service, National Marine Mammal Laboratory, Seattle, Wash., funded by Minerals Management Service, Alaska Outer Continental Shelf Region, Anchorage, Alaska.

Loughlin, T.R., 1997, "Using the Phylogeographic Method to Identify Steller Sea Lion Stocks," pp. 159–171 in *Molecular Genetics of Marine Mammals,* Special Publication No. 3, A. Dizon, S.J. Chivers, and W.F. Perrin (eds.), Society for Marine Mammalogy, San Francisco, Calif.

Loughlin, T.R., G. Antonelis, J. Baker, R. Everitt, S. Jeffries, R. Ferraro, L. Fritz, B. Kelly, J. Lewis, R. Ream, J. Sease, and R. Towell, 1994, *Abundance and Distribution of Harbor Seals* Phoca vitulina richardsi *in Southeast Alaska during 1993,* annual report under Marine Mammal Protection Act Population Assessment Program, National Marine Fisheries Service, National Marine Mammal Laboratory, Seattle, Wash.

Louis Berger Group, Inc., 2004, *OCS-Related Infrastructure in the Gulf of Mexico Fact Book,* AOCS Study MMS 2004-027, Minerals Management Service, Gulf of Mexico Outer Continental Shelf Region. Available at http://www.gomr.boemre.gov/PI/PDFImages/ESPIS/2/2984.pdf. Accessed June 2011.

Louisiana Bird Records Committee, 2010, *Official Louisiana Field Check-list*. Louisiana Ornithological Society, Museum of Natural Science, Louisiana State University, Baton Rouge, La.

Louisiana Department of Health and Hospitals, Office of Public Health, 2005, *Beach Monitoring Program*.

Lovvorn, J.R., J.M. Grebmeier, L.W. Cooper, J.K. Bump, and S.E. Richman, 2009, "Modeling Marine Protected Areas for Threatened Eiders in a Climatically Changing Bering Sea," *Ecological Applications* 19(6):1596–1613.

Lowry, L.F., and K.J. Frost, 1984, "Foods and Feeding of Bowhead Whales in Western and Northern Alaska," *Scientific Reports of Cetacean Research* 35:1–16.

Lowry, L.F., J.J. Burns, and R.R. Nelson, 1987, "Polar Bear, *Ursus maritimus*, Predation on Belugas, *Delphinapterus leucas*, in the Bering and Chukchi Seas," *Canadian Field-Naturalist* 101:141–146.

Lowry, L.F., V.N. Burkanov, K.J. Frost, M.A. Simpkins, R. Davis, D.P. DeMaster, R. Suydam, and A. Springer, 2000, "Habitat Use and Habitat Selection by Spotted Seals (*Phoca largha*) in the Bering Sea," *Canadian Journal of Zoology* 78:1959–1971.

Lubard, S.C., and P.M. Hurdle, 1976, "Experimental Investigation of Acoustic Transmission from Air into a Rough Ocean," *J. Acoust. Soc. Am.* 60(5):1048–1055.

Lubchenco, J., M. McNutt, B. Lehr, M. Sogge, M. Miller, S. Hammond, and W. Conner, 2010, *BP Deepwater Horizon Oil Budget: What Happened to the Oil?* Available at http://www.restorethegulf.gov/sites/default/files/imported_pdfs/posted/2931/Oil_Budget_description_8_3_FINAL.844091.pdf. Accessed February 22, 2011.

Lucas, K.L., and G.A. Carter, 2010, "Decadal Changes in Habitat-Type Coverage on Horn Island, Mississippi, USA," *Journal of Coastal Research* 26:1142–1148.

LUMCON, 2011, *Hypoxia in Northern Gulf of Mexico, Research, Shelfwide Cruises*. Available at http://www.gulfhypoxia.net/Research/Shelfwide%20Cruises. Accessed September 8, 2011.

Lunn, N.J., and G.B. Stenhouse, 1985, "An Observation of Possible Cannibalism by Polar Bears (*Ursus maritimus*)," *Canadian Journal of Zoology* 63:1516–1517.

Lynch, A., M. Rothstein, L. Cassano, M. Koslow, and J. Maslanki, 2001, "Climate Change in Barrow: Average Conditions and Big Storms," poster presented at Barrow, Alaska, Aug. 21, University of Colorado, Boulder, Colo.

Lynn, W.J., 2000, *Social Organization and Burrow-Site Selection of the Alabama Beach Mouse* (Peromyscus polionotus ammobates), Master's Thesis, Auburn University, Auburn, Ala.

Lysne, L.A., E.J. Mallek, and C.P. Dau, 2004, "*Near Shore Surveys of Alaska's Arctic Coast, 1999-2003*," U.S. Fish and Wildlife Service, Migratory Bird Management Waterfowl Branch. Available at http://alaska.fws.gov/mbsp/mbm/waterfowl/surveys/pdf/NSSANC.pdf. Accessed September 6, 2011.

MacDonald, I.R., 1998, "Natural Oil Spills," *Scientific American* 279:56–61.

MacDonald, I.R., 2000, "Seep Communities," Chapter 8, in *Narrative Report*, Vol. I of *Deepwater Gulf of Mexico Environmental and Socioeconomic Data Search and Literature Synthesis*, OCS Study MMS 2000-049, prepared by Continental Shelf Associates, Inc. for Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La., pp. 209–230.

MacDonald, K.B., 1977, "Plant and Animal Communities of Pacific North American Salt Marshes," pp. 167–192 in *Wet Coastal Ecosystems, Ecosystems of the World*, V.J. Chapman (ed.), Elsevier, Amsterdam, The Netherlands.

MacDonald, I.R., N.L. Guinasso, Jr., S.G. Ackleson, J.F. Amos, R. Duckworth, R. Sassen, and J.M. Brooks, 1993, "Natural Oil Slicks in the Gulf of Mexico Visible From Space," *J. Geophysical Res.* 98:16351–16364.

MacDonald, I.R., B. Bluhm, K. Iken, S. Gagaev, and S. Robinson, 2005, "Benthic Community Composition and Seabed Characteristics of a Chukchi Sea Pockmark," presented at the American Geophysical Union, Fall Meeting 2005.

Mackum, P., and S. Wilson, 2011, *Population Distribution and Change: 2000 to 2010, 2010 Census Briefs*. Available at http://www.census.gov/prod/cen2010/briefs/c2010br-01.pdf. Accessed September 8, 2011.

MacLeod, C.D., S.M. Bannon, G.J. Pierce, C. Schweder, J.A. Learmonth, J.S. Herman, and R.J. Reid, 2005, "Climate Change and the Cetacean Community of North-West Scotland," *Biological Conservation* 124:477–483.

MacLeod, C.D., W.F. Perrin, R. Pitman, J. Barlow, L. Balance, A. D'Amico, T. Gerrodette, G. Joyce, K.D. Mullin, D.L. Palka, and G.T. Waring, 2006, "Known and Inferred Distributions of Beaked Whale Species *(Cetacea: Ziphidae)*," *Journal of Cetacean Research and Management* 7(3):271–286.

Madsen, P.T., M. Wahlberg, J. Tougaard, K. Lucke, and P. Tyack, 2006, "Wind turbine underwater noise and marine mammals: Implications of current knowledge and data needs," *Marine Ecology Progress Series* 309: 279-295.

Mallory, M.L., I.J. Stenhouse, G. Gilchrist, and G. Robertson, 2008, "Ivory Gull (*Pagophila eburnea*)," Issue 175, *The Birds of North America Online* (A. Poole, ed.), Cornell Lab of Ornithology, Ithaca, New York. Available at http://bna.birds.cornell.edu/bna/species/175. Accessed August 18, 2011.

Malme, C.I., 1995, "Sound Propagation," Chapter 4 in *Marine Mammals and Noise*, Richardson et al., Academic Press, San Diego.

Marcus, N.H., 2001, "Zooplankton: Responses to and Consequences of Hypoxia," Chapter 3 in *Coastal Hypoxia: Consequences for Living Resources and Ecosystems*, N.N. Rabalais and R.E. Turner (eds.), American Geophysical Union, Washington, D.C.

MarineLog, 2011, *Directory of U.S. and Canadian Shipyards*, updated August 26, 2011. Available at http://shipbuildinghistory.com/today/directory.htm. Accessed September 8, 2011.

Marquez, M.R., 1990, *FAO Species Catalogue, Vol 11: Sea Turtles of the World. An Annotated and Illustrated Catalogue of Sea Turtle Species Known to Date*, FAO Fisheries Synopsis No. 125, FAO, Rome.

Mars, J., and D. Houseknecht, 2007, "Quantitative Remote Sensing Study Indicates Doubling of Coastal Erosion Rate in Past 50 Years along a Segment of the Arctic Coast of Alaska," *Geology* 35(7):583–586, July.

MASGC (Mississippi-Alabama Sea Grant Consortium), 2011, *Peer Listeners Prepare to Lend an Ear*. Available at http://masgc.org/page.asp?id=593 Accessed March 8, 2011. Accessed June 30, 2011.

Mason, J.R., 2011, *The Economic Cost of a Moratorium on Offshore Oil and Gas Exploration to the Gulf Region*, Louisiana State University. Available at http://www.saveusenergyjobs.com/wp-content/uploads/2010/07/The_Economic_Cost_of_a_Moratorium_on_Offshort%20_Oil_and_Gas_Exploration_to_the_Gulf_Region.pdf. Accessed July 15, 2011.

McAllister, D.E., 1975, "Ecology of the Marine Fishes of Arctic Canada," in *Proceedings of the Circumpolar Conference on Northern Ecology, Ottawa, Sept. 15–18, 1975*, Ottawa, Ontario, Canada, National Research Council of Canada.

McCammon, M., P. Mundy, and B. Spies, 2002, *The Gulf of Alaska Ecosystem Monitoring and Research (GEM) Program Document*, *Exxon Valdez Oil* Spill Trustee Council, July 9.

McCauley, R.D., 1994, "Seismic Surveys," in *Environmental Implications of Offshore Oil and Gas Development in Australia: The Findings of an Independent Scientific Review*, J.M. Swan, J.M. Neff, and P.C. Young (eds.), Australian Petroleum Exploration Association, Sydney, N.S.W.

McDonough, T., 2007, "Units 7 & 15 Furbearer," pp. 91–96 in *Furbearer Management Report of Survey and Inventory Activities 1 July 2003—30 June 2006, Project 7.0*, P. Harper (ed.), Alaska Department of Fish and Game, Juneau, Alaska.

McEachran, J.D., and J.D. Fechhelm, 1998, *Fishes of the Gulf of Mexico*, Vol. 1, University of Texas Press, Austin, Texas.

McIlroy, C.W., 1970, *Aspects of the Ecology and Hunter Harvest of the Black Bear in Prince William Sound*, M.S. thesis, University of Alaska, Fairbanks.

McMahan, D., 2011, personal communication from McMahan (Alaska Office of History and Archaeology) to D. O'Rourke (EVS, Argonne National Laboratory), Sept. 7.

McMahon, G., S.M. Gregonis, S.W. Waltman, J.M. Omernik, T.D. Thorson, J.A. Freeouf, A.H. Rorick, and J.E. Keys, 2001, "Developing a Spatial Framework of Common Ecological Regions for the Conterminous United States," *Environmental Management* 28(3):293–316.

McWilliams, J.C., 2007, "Irreducible Imprecision in Atmospheric and Oceanic Simulations," *PNAS* 104(21):8709–8713.

Mecklenburg, C.W., T.A. Mecklenburg, and L.K. Thorsteinson, 2002, *Fishes of Alaska*, American Fisheries Society, Bethesda, Md.

Mecklenburg, C.W., D.L. Stein, B.A. Shieko, N.V. Chernova, T.A. Mecklenburg, and B.A. Holladay, 2007, "Russian-American Long Term Census of the Arctic: Benthic Fishes Trawled in the Chukchi Sea and Bering Strait, August 2004," *Northwestern Naturalist* 88:168–187.

Mellinger, D.K, K.M. Stafford, S.E. Moore, L.M. Munger, and C.G. Fox, 2004, "Detection of North Pacific Right Whale (*Eubalaena japonica*) Calls in the Gulf of Alaska," *Marine Mammal Science* 20:872–879.

Meo, S.A., A.M. Al-Drees, and S. Rasheed, 2009, "Effect of Duration of Exposure to Polluted Air Environment on Lung Function in Subjects Exposed to Crude Oil Spill into Sea Water," *International Journal Occupational Medicine and Environmental Health* 22: 35–41.

Merriam, H., J. Schoen, and D. Hardy, 2008, *Alaska Wildlife Notebook Series: Sitka Black-Tailed Deer*, Alaska Department of Fish and Game, Juneau, Alaska. Available at http://www.adfg.alaska.gov/static/education/wns/sitka_blacktailed_deer.pdf. Accessed April 11, 2011.

Meyers, C.R., 1985, *Vegetation of the Beaufort Sea Coast Alaska: Community Composition, Distribution, and Tidal Influences*, M.S. thesis, University of Alaska-Fairbanks.

Michener, W.K., E.R. Blood, K.L. Bildstein, M.K. Brinson, and L.R. Gardner, 1997, "Climate Change, Hurricanes and Tropical Storms, and Rising Sea Level in Coastal Wetlands," *Ecological Applications* 7(3):770–801.

Miles, P.R., C.I. Malme, and W.J. Richardson, 1987, *Prediction of Drilling Site-Specific Interaction of Industrial Acoustic Stimuli and Endangered Whales in the Alaskan Beaufort Sea*, BBN Report No. 6509 and OCS Study MMS 87-0084, prepared by BBN Laboratories Inc., Cambridge, Mass., and LGL Ltd., King City, Ontario, Canada, for MMS, Anchorage, Alaska, Nov.

Miller, C.B., 2004, Chapter 11 in *Biological Oceanography*, Blackwell Publishing, Malden Mass.

Miller, D.R., 1971, "Seasonal Changes in the Feeding Behavior of Barren-Ground Caribou on the Taiga Winter Range," pp. 744–755 in *The Behavior of Ungulates and Its Relation to Management 24*, V. Geist and F. Walther (eds.).

Miller, F.L., and A. Gunn, 2003, "Catastrophic Die-off of Peary Caribou on the Western Queen Elizabeth Islands, Canadian High Arctic," *Arctic* 56(4):381–390.

Miller, F.L., A. Gunn, and E. Broughton, 1985, "Surplus Killing as Exemplified by Wolf Predation on Newborn Caribou," *Canadian Journal of Zoology* 63(2):295–300.

Milne, A.R., and J.H. Ganton, 1964, "Ambient Noise under Arctic Sea Ice," *J. Acoust. Soc. Am.* 36(5):855–863.

Mississippi Coast Audubon Society, 2010, *Birds of the Mississippi Coastal Counties*. Mississippi Coast Audubon Society. Available at www.mscoastaudubon.org.

Mississippi Ornithological Society, 2007, *Checklist of Birds of Mississippi*. Records Committee, Mississippi Ornithological Society, Mississippi State University, Oxford, Miss.

Mississippi Gulf Coast Alliance for Economic Development, 2007, *Mississippi Gulf Coast Shipbuilding 2007*. Available at http://www.mscoastshipbuilding.com/files/shipbuilding_corridor_guts_031207.pdf. Accessed June 2011.

Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, 2009, *Moving Forward on Gulf Hypoxia: Annual Report 2009*, Office of Wetlands, Oceans, and Watersheds, Washington, D.C.

Mizroch, S.A., D.W. Rice, and J.M. Breiwick, 1984, "The Fin Whale, *Balaenoptera physalus*," *Marine Fisheries Review* 46(4):20–24.

MMS (Minerals Management Service), 1995, *Cook Inlet Planning Area Oil and Gas Lease Sale 149, Final Environmental Impact Statement*, OCS EIS/EA MMS 95-0066, MMS, Alaska OCS Region, Anchorage, Alaska.

MMS, 1996a, *Outer Continental Shelf Oil & Gas Leasing Program: 1997-2002, Final Environmental Impact Statement*. OCS EIS/EA MMS 96-0043. USDOI/MMS, Environmental Projects Coordination Branch, Herndon, VA.

MMS, 1996b, *Cook Inlet Planning Area Oil and Gas Lease Sale 149, Final Environmental Impact Statement*, Volume 1, OCS EIS/EA MMS 95-0066, Minerals Management Service, Alaska OCS Region. Available at http://alaska.boemre.gov/ref/eis_ea.htm. Accessed May 10, 2011.

MMS, 1999, *Destin Dome 56 Unit Development and Production Plan and Right-of-Way Pipeline Application, Draft Environmental Impact Statement*, OCS EIS/EA MMS 99-0040, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La.

MMS, 2002a, *Outer Continental Shelf Oil & Gas Leasing Program: 2002-2007, Final Environmental Impact Statement, April 2002*, OCS EIS/EA MMS 2002-006, Minerals Management Service, Herndon, Va. 2 vols.

MMS, 2002b, *Liberty Development and Production Plan, Final Environmental Impact Statement*, OCS Report 2002-019, Minerals Management Service, Alaska OCS Region, Anchorage, Alaska, May.

MMS, 2002c, *Outer Continental Shelf Oil & Gas Leasing Program: 2002-2007, Final Environmental Impact Statement*, OCS EIS/EA MMS 2002-006, MMS Herndon, Va., April.

MMS, 2003a, *Alaska Outer Continental Shelf, Cook Inlet Planning Area: Oil and Gas Lease Sales 191 and 199, Final Environmental Impact Statement*, Volume I, OCS EIS/EA MMS 2003-055, MMS, Alaska OCS Region, November.

MMS, 2003b, *Alaska Outer Continental Shelf, Beaufort Sea Planning Area, Oil and Gas Lease Sales 186, 195, and 202, Final Environmental Impact Statement*, OCS EIS/EA MMS 2003-001, Minerals Management Service, Alaska Region, Anchorage, Alaska.

MMS, 2004, *Geological and Geophysical Exploration for Mineral Resources on the Gulf of Mexico Outer Continental Shelf, Final Programmatic Environmental Assessment*, OCS EIS/EA MMS 2004-054, MMS, Gulf of Mexico OCS Region, New Orleans, La.

MMS, 2005a, *Structure-Removal Operations on the Gulf of Mexico Outer Continental Shelf, Programmatic Environmental Assessment*, OCS EIS/EA MMS 2005-013, MMS, Gulf of Mexico OCS Region, New Orleans, La., Feb. Available at http://www.nmfs.noaa.gov/pr/pdfs/permits/mms2005_013.pdf. Accessed August 31, 2011.

MMS, 2005b, *Gulf of Mexico OCS Oil and Gas Lease Sales: 2007-2012 Western Planning Area Sales 204, 207, 210, 215 and 218, Central Planning Area Sales 205, 206, 208, 213, 216, and 222, Draft Environmental Impact Statement*.

MMS, 2006a, *Impact Assessment of Offshore Facilities from Hurricanes Katrina and Rita*, news release, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La., January 19.

MMS, 2006b, *Outer Continental Shelf Oil and Gas Leasing Program: 2007-2012, Draft Environmental Impact Statement*, July.

MMS, 2006c, *Final Programmatic Environmental Assessment*, *Arctic Ocean Outer Continental Shelf Seismic Surveys – 2006*, OCS EIS/EA 2006-038, MMS, Alaska OCS Region, June. Available at http://www.alaska.boemre.gov/ref/EIS%20EA/Final_PEA/Final_PEA.pdf. Accessed September 1, 2011.

MMS, 2007a, *Outer Continental Shelf Oil & Gas Leasing Program: 2007-2012, Final Environmental Impact Statement*, OCS EIS/EA MMS 2007-003, Minerals Management Service, April.

MMS 2007b, *Chukchi Sea Planning Area Oil and Gas Lease Sale 193 and Seismic Surveying Activities in the Chukchi Sea Final Environmental Impact Statement*, OCS EIS/EA MMS 2007-026, Minerals Management Service, Alaska OCS Region, May.

MMS, 2007c, *Liberty Development and Production Plan Ultra Extended Reach Drilling from Endicott – Satellite Drilling Island (SDI), Environmental Assessment*, OCS EIS/EA MMS 2007-054.

MMS, 2008a, *Gulf of Mexico OCS Gas Lease Sales: 2009-2012, Central Planning Area Sales 208, 213, 216, and 222, Western Planning Area Sales 210, 215, and 218, Final Supplemental Environmental Impact Statement*, OCS EIS/EA MMS 2008-041, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans.

MMS, 2008b, *Alaska Outer Continental Shelf, Beaufort Sea and Chukchi Sea Planning Areas Oil and Gas Lease Sales 209, 212, 217, and 221 Draft Environmental Impact Statement*, OCS EIS/EA MMS 2008-0055, Minerals Management Service, Alaska Outer Continental Shelf Region. Nov.

MMS, 2010, *Chukchi Sea Planning Area, Oil and Gas Lease Sale 193 in the Chukchi Sea, Alaska, Draft Supplemental EIS*, OCS EIS/EA BOEMRE 2010-034, Office of Leasing and Environment, Alaska OCS Region.

Moline, M.A., N.J. Karnovsky, Z. Brown, G.J. Divoky, T.K. Frazer, C.A. Jacoby, J.J. Torres, and W.R. Fraserf, 2008, "High Latitude Changes in Ice Dynamics and Their Impact on Polar Marine Ecosystems," *Annals of the New York Academy of Sciences* 1134:267–319.

Moller, A.P., D. Rubolini, and E. Lehikoinen, 2008, "Populations of Migratory Bird Species That Did Not Show a Phenological Response to Climate Change Are Declining," *Proceedings of the National Academy of Sciences* 105(42):16195–16200.

Monnett, C., and J.S. Gleason, 2006, "Observations of Mortality Associated with Extended Open-water Swimming by Polar Bears in the Alaskan Beaufort Sea," *Polar Biology* 29:681–687.

Montgomery, R.A., J.M. Ver Hoei, and P.L. Boveng, 2007, "Spatial Modeling of Haul-out Site Use by Harbor Seals in Cook Inlet, Alaska," *Marine Ecology Progress Series* 341:257–264.

Moore, J.C., 1963, "The Goose-Beaked Whale Where in the World?" *Chicago Natural History Museum Bulletin* 34(2):2–3, 8.

Moore, S.E., 2008, "Marine Mammals as Ecosystem Sentinels." *Journal of Mammalogy* 89(3):534–540.

Moore, S.E., and H.P. Huntington, 2008, "Arctic Marine Mammals and Climate Change: Impacts and Resilience, *Ecological Applications* 18(2):S157–S165.

Moore, S.E., and K.L. Laidre, 2006, "Trends in Sea Ice Cover within Habitats Used by Bowhead Whales in the Western Arctic," *Ecological Applications* 16(3):932–944.

Moore, S.E., and R.R. Reeves, 1993, "Distribution and Movement," pp. 313–386 in *The Bowhead Whale*, J.J. Burns, J.J. Montague, and C.J. Cowles (eds.), Special Publication, Society for Marine Mammalogy, Lawrence, Kansas.

Moore, S.E., D.P. DeMaster, and P.K. Dayton, 2000a, "Cetacean Habitat Selection in the Alaskan Arctic during Summer and Autumn," *Arctic* 53(4):432–447.

Moore, S.E., J.M. Waite, L.L. Mazzuca, and R.C. Hobbs, 2000b, "Mysticete Whale Abundance and Observations of Prey Associations on the Central Bering Sea Shelf," *Journal of Cetacean Research and Management* 2:227–234.

Moore, S.E., K.E.W. Shelden, L.K. Litzky, B.A. Mahoney, and D.J. Rugh, 2000c, "Beluga, *Delphinapterus leucas*, Habitat Associations in Cook Inlet, Alaska," *Marine Fisheries Review* 62(3): 60-80.

Morel, F.M.M., D. Archer, J.P. Barry, G.D. Brewer, J.E. Corredor, S.C. Doney, V.J. Fabry, G.E. Hofmann, D.S. Holland, J.A. Kleypas, F.J. Millero, U. Riebesell, S. Park, S. Roberts, and K. Hughs, 2010, *Ocean Acidification: A National Strategy to Meet the Challenges of a Changing Ocean*, Committee on the Development of an Integrated Science Strategy for Ocean Acidification Monitoring, Research, and Impacts Assessment, National Research Council, National Academy of Sciences, Washington, D.C.

Morgan, S.G., C.S. Manooch III, D.L. Mason, and J.W. Goy, 1985, "Pelagic Fish Population on Cerataspis, A Rare Larval Genus of Oceanic Penaeoid," *Bull. Mar. Sci.* 36(2):249–259.

Morita, A., Y. Kusaka, and Y. Deguchi, 1999, "Acute Health Problems among the People Engaged in the Cleanup of the Nakhodka Oil Spill," *Environment Research* 81: 185–194.

Morrison, M.L., 2006, *Bird Movements and Behaviors in the Gulf Coast Region: Relation to Potential Wind Energy Developments*," National Renewable Energy Laboratory. Available at http://www.nrel.gov/wind/pdfs/39572.pdf. Accessed September 6, 2011.

Morton, R., N. Buster, and M. Krohn, 2002, "Subsurface Controls, on Historical Subsidence Rates and Associated Wetland Loss in Southcentral Louisiana," T*ransactions Gulf Coast Association of Geological Societies* 52:767–778.

Morton, R., G. Tiling, and N. Ferina, 2003, "Causes of Hot-Spot Wetland Loss in the Mississippi Delta Plain," *Environmental Geosciences* 10(2):71–80.

Moss, J.H., J.M. Murphy, E.V. Farley, Jr., L.B. Eisner, and A.G. Andrews, 2009, Juvenile Pink and Chum Salmon Distribution, Diet, and Growth in the Northern Bering and Chukchi Seas. North Pacific Anadromous Fish Commission Bulletin No. 5: 191-196.

Moulton, L.L., and J.C. George, 2000, "Freshwater Fishes in the Arctic Oil-Field Region and Coastal Plain of Alaska," in *The Natural History of an Arctic Oil Field: Development and the Biota*, J.C. Truett and S.R. Johnson (eds.), Academic Press, New York.

Mowry, T., 2009, "2 Alaska Caribou Herds See Big Growth," *Fairbanks Daily News-Miner*, April 15.

Muench, R.D., H.O. Mofjeld, and R.L. Charnell, 1978, "Oceanographic Conditions in Lower Cook Inlet, Spring and Summer 1973," *Journal of Geophysical Research* 83(10):5090–5098.

Mueter, F.J., C. Broms, K.F. Drinkwater, K.D. Friedland, J.A. Hare, G.L. Hunt Jr., W. Melle, and M. Taylor, 2009, "Ecosystem Responses to Recent Oceanographic Variability in High-Latitude Northern Hemisphere Ecosystems," *Progress In Oceanography* 81:93–110.

Mulholland, P.J., G.R. Best, C.C. Coutant, G.M. Hornberger, J.L. Meyer, P.J. Robinson, J.R. Stenberg, E. Turner, F. Vera-Herrera, and R.G. Wetzel, 1997, "Effects of Climate Change on Freshwater Ecosystems of the South-Eastern United States and the Gulf of Mexico," *Hydrological Processes* 11:949–970.

Mullin, K.D., and G.L. Fulling, 2004, "Abundance of Cetaceans in the Oceanic Northern Gulf of Mexico, 1996–2001," *Marine Mammal Science* 20:787–807.

Mullin, K., W. Hoggard, C. Roden, R. Lohoefener, C. Rogers, and B. Taggart, 1991, *Cetaceans on the Upper Continental Slope in the North-Central Gulf of Mexico*, OCS Study MMS 91-0027, Minerals Management Service, Gulf of Mexico Regional Office, New Orleans, La.

Mullin, K.D., T.A. Jefferson, L.J. Hansen, and W. Hoggard, 1994, "First Sightings of Melon-Headed Whales (*Peponocephala electra*) in the Gulf of Mexico," *Marine Mammal Science* 10:342–348.

Munk, W.H., R.C. Spindel, A. Baggeroer, and T.G. Birdsall, 1994, "The Heard Island Feasibility Test," *J. Acoust. Soc. Am.* 96(4):2330–2342.

Murray, S.P., 1997, *An Observational Study of the Mississippi-Atchafalaya Coastal Plume: Final Report*, OCS Study MMS 98-0040, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La.

Musick, J.A., and C.J. Limpus, 1997, "Habitat Utilization and Migration in Juvenile Sea Turtles," pp. 137-164 in *The Biology of Sea Turtles*, P.L. Lutz and J.A. Musick (eds.), CRC Press, Boca Raton, Fla.

Myatt, D.O., and R.B. Ditton, 1986, *Exclusion Mapping for Artificial Reef Site Selection to Maximize Recreational Fishing Benefits in the Gulf of Mexico*, Sport Fish. Institute, Artificial Reef Development Center.

NABCI, 2010, *State of the Birds Report*. Available at http://www.stateofthebirds.org/2010/pdf_files/State%20of%20the%20Birds_FINAL.pdf. Accessed September 7, 2011.

Nagorski, S., G. Eckert, E. Hood, and S. Pyare, 2007, *Assessment of Coastal Water Resources and Watershed Conditions at Katmai National Park and Preserve, Alaska*, Natural Resource Technical Report NPS/NRWRD/NRTR—2007/372, National Park Service, Fort Collins, Colo.

Naidu, A.S., J.J. Kelley, J.J. Goering, and M.I. Venkatesan, 2001, *Historical Changes in Trace Metals and Hydrocarbons in the Inner Shelf Sediments, Beaufort Sea: Prior and Subsequent to Petroleum-Related Industrial Developments*, OCS Study, MMS 2001-061, Minerals Management Service, Anchorage, Alaska.

Naidu, A.S., J.J. Kelley, D. Misra, and M.I. Venkatesan, 2005, *Trace Metals and Hydrocarbons in Sediments of the Beaufort Lagoon, Northeast Arctic Alaska, Exposed to Long-term Natural Oil Seepage, Recent Anthropogenic Activities and Pristine Conditions*, OCS Study MMS 2005-041, University of Alaska Fairbanks, Coastal Marin Institute, Fairbanks, Alaska.

Napp, J.M., L.S. Incze, and P.B. Ortner, 1996, "The Plankton of Shelikof Strait, Alaska: Standing Stock, Production, Mesoscale Variability and Their Relevance to Larval Fish Survival," *Fisheries Oceanography* 5:19–38.

NAST (National Assessment Synthesis Team), 2001, *Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change,* Cambridge University Press, Cambridge, U.K.

Nasu, K., 1963, "Oceanography and the Whaling Grounds in the Subarctic Regions of the Pacific Ocean," *Scientific Reports of the Whales Research Institute* 17:105–156.

National Commission, 2011, *Deep Water, The Gulf Oil Disaster and the Future of Offshore Drilling, Report to the President*, prepared by the National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, January.

National Marine Protected Areas Center, 2008, *State of the Nation's de Facto Marine Protected Areas,* R. Grober-Dunsmore and L. Wooninck (eds.), Silver Spring, Md.

Nature Conservancy, 2003, *Cook Inlet Basin Ecoregional Assessment*, The Nature Conservancy of Alaska, Anchorage, AK.

NatureServe, 2010a, *NatureServe Explorer: An Online Encyclopedia of Life,* Version 7.1, Arlington, Va. Available at http://www.natureserve.org/explorer. Accessed March 21, 2011.

NatureServe, 2010b, *Comprehensive Species Report* — Polysticta stelleri. Available at http://www.natureserve.org/explorer/servlet/NatureServe?init=Species. Accessed July 11, 2011.

NatureServe, 2010c, *Comprehensive Species Report* — Brachyramphus brevisostris. Availalble at http://www.natureserve.org/explorer/servlet/NatureServe?init=Species. Accessed July 11, 2011.

NatureServe 2010d. "Comprehensive Species Report – *Gavia adamsii*." Available at http://www.natureserve.org/explorer/servlet/NatureServe?searchName=Gavia+adamsii. Accessed September 6 11, 2011.

NatureServe, 2011a, *An Online Encyclopedia of Life*. Available at http://www.natureserve.org/ explorer/index.htm.

NatureServe, 2011b, *Comprehensive Species Report—Ursus arcos*, NatureServe Explorer: An Online Encyclopedia of Life, Version 7.1, NatureServe, Arlington, Va. Available at http://www.natureserve.org/explorer. Accessed September 8, 2011.

NCCOS (National Centers for Coastal Ocean Science), 2006, *Interagency Environmental Assessment of Hurricane Katrina: Preliminary Results from the NOAA National Status and Trends (NS&T) Mussel Watch Survey: Post-storm Assessment and 20 Year Retrospective Analysis.*

NCDC (National Climatic Data Center), 1995, *1994 Local Climatological Data, Annual Summary with Comparative Data, Galveston, Texas*, National Oceanic and Atmospheric Administration, Satellite and Information Service. Available at http://www7.ncdc.noaa.gov/IPS/lcd/lcd.html. Accessed March 28, 2011.

NCDC, 2011a, *2010 Local Climatological Data, Annual Summary with Comparative Data: Baton Rouge, Louisiana; Beaumont/Port Arthur, Texas; Brownsville, Texas; Corpus Christi, Texas; Houston, Texas; Lake Charles, Louisiana; Mobile, Alabama; New Orleans, Louisiana; Pensacola, Florida; Victoria, Texas*, National Oceanic and Atmospheric Administration, Satellite and Information Service. Available at http://www7.ncdc.noaa.gov/IPS/lcd/lcd.html. Accessed March 28, 2011.

NCDC (National Climatic Data Center), 2011b, *2010 Local Climatological Data, Annual Summary with Comparative Data: Homer, Alaska (PAHO) and Kodiak, Alaska (PADQ)*, National Oceanic and Atmospheric Administration. Available at http://www7.ncdc.noaa.gov/IPS/lcd/lcd.html. Accessed May 27, 2011.

NCDC, 2011c, *Storm Events*, National Oceanic and Atmospheric Administration, Satellite and Information Service. Available at http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~Storms. Accessed May 27, 2011.

NCDC, 2011d, *Climates of the States (CLIM60): Climate of Alaska*, National Oceanic and Atmospheric Administration, Satellite and Information Service. Available at http://hurricane.ncdc.noaa.gov/climatenormals/clim60/states/Clim_AK_01.pdf. Accessed May 27, 2011.

NCDC, 2011e, *Integrated Surface Data (ISD)*, DS3505 format, database, Asheville, N.C. Available at ftp://ftp3.ncdc.noaa.gov/pub/data/noaa. Accessed May 31, 2011.

NCDC, 2011x, *State of the Climate, National Overview, August 2011*. Available at http://www.ncdc.noaa.gov/sotc/national/. Accessed Sept. 15, 2011.

NDBC (National Data Buoy Center), 2011, *National Oceanic and Atmospheric Administration, National Data Buoy Center, Center of Excellence in Marine Technology*, U.S. Department of Commerce. Available at http://www.ndbc.noaa.gov/rmd.shtml. Accessed May 30, 2011.

Neff, J.M., 2005, *Composition, Environmental Fates, and Biological Effect of Water Based Drilling Muds and Cuttings Discharged to the Marine Environment: A Synthesis and Annotated Bibliography*, prepared by Battelle, Duxbury, Md., for the Petroleum Environmental Research Forum and American Petroleum Institute.

Nelson, M., 2008a, *Alaska Wildlife Notebook Series: Bearded Seal*, Alaska Department of Fish and Game, Juneau, Alaska. Available at http://www.adfg.alaska.gov/static/education/wns/bearded_seal.pdf. Accessed April 11, 2011.

Nelson, M., 2008b, *Alaska Wildlife Notebook Series: Ribbon Seal*, Alaska Department of Fish and Game, Juneau, Alaska. Available at http://www.adfg.alaska.gov/static/education/wns/ribbon_seal.pdf. Accessed April 11, 2011.

Nelson, M., 2008c, *Alaska Wildlife Notebook Series: Spotted Seal*, Alaska Department of Fish and Game, Juneau, Alaska. Available at http://www.adfg.alaska.gov/static/education/wns/spotted_seal.pdf. Accessed April 11, 2011.

NHC (National Hurricane Center), 2011a, *Tropical Cyclone Climatology*, National Oceanic and Atmospheric Administration, National Weather Service. Available at http://www.nhc.noaa.gov/pastprofile.shtml. Accessed March 28, 2011.

NHC (National Hurricane Center), 2011b, *Hurricane Basics*, National Oceanic and Atmospheric Administration, National Weather Service. Available at http://www.nhc.noaa.gov/HAW2/english/basics.shtml. Accessed March 28, 2011.

Nicholls, R.J., P.P. Wong, V.R. Burkett, J.O. Codignotto, J.E. Hay, R.F. McLean, S. Ragoonaden, and C.D. Woodroffe, 2007, "Coastal Systems and Low-Lying Areas," pp. 315–356 in *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson (eds.), Cambridge University Press, Cambridge, U.K.

Nieukirk, S.L., K.M. Stafford, D.K. Mellinger, R.P. Dziak, and C.G. Fox, 2004, "Low-Frequency Whale and Seismic Airgun Sounds Recorded in the Mid-Atlantic Ocean," *J. Acoust. Soc. Am.* 115(4):1832–1843.

Nighswander, T.S., and N. Peacock, 1999, "The Communication of Health Risk from Subsistence Food in a Cross Cultural Setting: Lessons Learned from the *Exxon Valdez* Oil Spill,' in *Evaluating and Communicating Subsistence Seafood Safety in a Cross-Cultural Context*, L.J. Field, J.A. Fall, T.S. Nighswander, N. Peacock, and U. Varanasi (eds.), SETAC Press, Pensacola, Fla.

Ning, Z.H., R.E. Turner, T. Doyle, and K.K. Abdollahi, 2003, *Preparing for a Changing Climate: Potential Consequences of Climate Variability and Change — Gulf Coast Region*, findings of the Gulf Coast Regional Assessment, prepared for the U.S. Environmental Protection Agency, GCRCC, Baton Rouge, La.

NIOSH (National Institute for Occupational Safety and Health), 2011, *NIOSH Voluntary Roster of Deepwater Horizon Response Workers*, Education and Information Division. Available at http://www.cdc.gov/niosh/topics/oilspill response/workerroster.html.

Nix, E.R., C.R. Fisher, J. Vodenichar, and K.M. Scott, 1995, "Physiological Ecology of a Mussel with Methanotrophic Endosymbionts at Three Hydrocarbon Seep Sites in the Gulf of Mexico," *Marine Biology* 122(4):605–617.

NMFS (National Marine Fisheries Service), 1991, *Final Recovery Plan for the Humpback Whale* Megaptera novaeangliae, prepared by Humpback Whale Recovery Team for National Oceanic and Atmospheric Administration, Office of Protected Resources, Silver Springs, Md., Nov. Available at http://www.nmfs.noaa.gov/pr/pdfs/recovery/whale_humpback.pdf. Accessed April 15, 2011.

NMFS, 1993, "Designated Critical Habitat; Steller Sea Lion," *Federal Register* 58(165):45269–45285.

NMFS, 1998, *Essential Fish Habitat Assessment Report for the Scallop Fisheries off the Coast of Alaska*, National Oceanic and Atmospheric Administration, Anchorage, Alaska.

NMFS, 2004, *Alaska Groundfish Fisheries Final Programmatic Supplemental Environmental Impact Statement*, NOAA/NMFS, Alaska Region, Juneau, Alaska.

NMFS, 2005, *Final Environmental Impact Statement for Essential Fish Habitat Identification and Conservation in Alaska*, National Oceanic and Atmospheric Administration/NMFS Alaska Regional Office. Available at http://www.fakr.noaa.gov/habitat/seis/efheis.htm. Accessed May 10, 2011.

NMFS, 2006, *Review of the Status of the Right Whales in the North Atlantic and North Pacific Oceans*, National Oceanic and Atmospheric Administration, Dec.

NMFS, 2008a, "Endangered and Threatened Species; Endangered Status for the Cook Inlet Beluga Whale," *Federal Register* 73(205):62919–62930.

NMFS, 2008b, *Recovery Plan for the Steller Sea Lion Eastern and Western Distinct Population Segments* (Eumetopias jubatus) *Revision*, National Oceanic and Atmospheric Administration, Office of Protected Resources, Silver Spring, Md., March.

NMFS, 2009, *Recovery Plan for Smalltooth Sawfish (*Pristis pectinata*)*, prepared by the Smalltooth Sawfish Recovery Team for the National Marine Fisheries Service, Silver Spring, Md.

NMFS, 2010a, *Essential Fish Habitat: A Marine Fish Habitat Conservation Mandate for Federal Agencies-Gulf of Mexico Region*. Available at http://sero.nmfs.noaa.gov/hcd/pdfs/efhdocs/gom_guide_2010.pdf. Accessed May 25, 2011.

NMFS, 2010b, *Final Recovery Plan for the Fin Whale* (Balaenoptera physalus), Silver Springs, Md., July 30.

NMFS, 2010c, "Endangered and Threatened Species; Proposed Threatened and Not Warranted Status for Subspecies and Distinct Population Segments of the Bearded Seal," *Federal Register* 75(237):77496–77515.

NMFS, 2010d, "Endangered and Threatened Species; Proposed Threatened Status for Subspecies of the Ringed Seal," *Federal Register* 75(237):77476–77495.

NMFS, 2010e, *Beaufort Sea Marine Fish Monitoring 2008: Pilot Survey and Test of Hypotheses*, Final Report, BOEMRE 2010-048, prepared by National Oceanic and Atmospheric Administration, NMFS Alaska Fisheries Science Center, Seattle, Wash., for Minerals Management Service, Anchorage, Alaska. Available at http://alaska.boemre.gov/reports/ 2010rpts/2010_048.pdf. Accessed May 10, 2011.

NMFS, 2010f, "BP Oil Spill: NOAA Modifies Commercial and Recreational Fishing Closure in the Oil-Affected Portions of the Gulf of Mexico," *Southeast Fishery Bulletin* FB10-050, June 2.

NMFS, 2010g, *Fisheries of the United States, 2009*, National Marine Fisheries Service, Office of Science and Technology, Silver Spring, Md.

NMFS, 2011a, *Marine Mammals*, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Md.

NMFS, 2011b, "Endangered and Threatened Species: Designation of Critical Habitat for Cook Inlet Beluga Whale," *Federal Register* 76(69):20180–20214.

NMFS, 2011c, "BP Oil Spill: NOAA Re-opens Federal Waters to Royal Red Shrimp Fishing," *Southeast Fishery Bulletin* FB11-010, February 1.

NMFS, 2011d, *Annual Commercial Landing Statistics*. Available at http://www.st.nmfs.noaa. gov/st1/commercial/landings/annual_landings.html. Accessed July 15, 2011.

NMFS, 2011e, *Recreational Fisheries Statistics Queries*. Available at http://www.st.nmfs.noaa. gov/st1/recreational/queries/index.html. Accessed July 15, 2011.

NMFS and USFWS (National Marine Fisheries Service and U.S. Fish and Wildlife Service), 1991, *Recovery Plan for U.S. Populations of Loggerhead Turtle*, USDOC/NOAA/NMFS, Washington, D.C.

NOAA (National Oceanic and Atmospheric Administration), 1991

NOAA, 1994, "Cook Inlet and Kenai Peninsula, Alaska: Environmentally Sensitive Areas: Summer (June-August)," 1-page chart, NOAA, Anchorage, Alaska.

NOAA, 1996, *South Florida Environmental Sensitivity Index*, Office of Response and Restoration, ESI data and maps, CD-ROM.

NOAA, 1999, *Coastal Assessment Framework – Coastal Estuarine Watersheds (EDA/CDA) – Land Only*, NOAA's Ocean Service, Special Projects, vector digital data, Silver Spring, Md.. Available at http://coastalgeospatial.noaa.gov/data_gis.html. Accessed September 9, 2011.

NOAA, 2004, "Regional Trends," in *Population Trends along the Coastal United States: 1980–2008*, U.S. Department of Commerce, National Ocean Service, Sept. Available at http://oceanservice.noaa.gov/programs/mb/pdfs/3_regional_trends.pdf. Accessed Feb. 2011.

NOAA, 2005, National Survey on Recreation and the Environment (NSRE).

NOAA, 2008, *Cruise Report for the 2008 Beaufort Sea Survey, July 27–August 30, 2008,* National Marine Fisheries Service, Alaska Fisheries Science Center. Available at http://www.afsc.noaa.gov/REFM/Stocks/fit/PDFS/Beaufort_sea_cruise_report.pdf. Accessed March 11, 2011.

NOAA, 2010a, *NRDA by the Numbers — December 1, 2010, Deepwater Horizon Oil Spill Natural Resources Damage Assessment (NRDA)*. Available at http://www.gulfspillrestoration.noaa.gov/wp-content/uploads/2010/12/FINAL-NRDA-by-the-Numbers-for-12-1-10.pdf. Accessed February 22, 2011.

NOAA, 2010b, *Deepwater BP Oil Spill, Natural Resource Damage Assessment (NRDA), NRDA By the Numbers – November 1, 2010*. Available at http://www.gulfspillrestoration.noaa.gov/wp-content/uploads/2010/11/FINAL-NRDA_by_the_Numbers_11.03.pdf.pdf. Accessed November 10, 2010.

NOAA, 2010c, *Sea Turtles, Dolphins, and Whales and the Gulf of Mexico Oil Spill. Turtles Documented by Species*. Available at http://www.nmfs.noaa.gov/pr/health/oilspill/turtles.htm. Accessed November 23, 2010.

NOAA, 2010d, *The Marine Protected Areas Inventory*, National Marine Protected Areas Center. Available at http://www.mpa.gov/dataanalysis/mpainventory/. Accessed December 1, 2010.

NOAA, 2010e, *Flower Garden Banks National Marine Sanctuary Draft Management Plan,* Office of National Marine Sanctuaries, Silver Spring, Md.

NOAA, 2011a, "Surface Washing Agents," in *Encyclopedia of Earth*, C.J. Cleveland (ed.), Environmental Information Coalition, National Council for Science and the Environment, Washington, D.C. [First published in the Encyclopedia of Earth September 30, 2010; last revised date October 7, 2010]. Available at http://www.eoearth.org/article/Surface_washing_agents. Accessed January 5, 2011.

NOAA, 2011b, *Vaisala's National Lightning Detection Network (NLDN), Cloud-to-Ground Lightning Incidence in the Continental U.S. (1997–2007),* U.S. Department of Commerce. Available at http://www.lightningsafety.noaa.gov/stats/08_Vaisala_NLDN_Poster.pdf. Accessed April 13, 2011.

NOAA, 2011c, *Loggerhead Turtle*, NOAA Fisheries Office of Protected Resources. Available at http://www.nmfs.noaa.gov/pr/species/turtles/loggerhead.htm#population. Accessed September 19, 2011.

NOAA, 2011d, *Green Turtle*, NOAA Fisheries Office of Protected Resources. Available at http://www.nmfs.noaa.gov/pr/species/turtles/green.htm#population. Accessed September 2, 2011.

NOAA, 2011e, *Hawksbill Turtle*, NOAA Fisheries Office of Protected Resources. Available at http://www.nmfs.noaa.gov/pr/species/turtles/hawksbill.htm#population. Accessed September 2, 2011.

NOAA, 2011f, *Kemp's Ridley Turtle*, NOAA Fisheries Office of Protected Resources. Available at http://www.nmfs.noaa.gov/pr/species/turtles/kempsridley.htm#population. Accessed September 2, 2011.

NOAA, 2011g, *NRDA by the Numbers — January 20, 2010, Deepwater Horizon Oil Spill Natural Resources Damage Assessment (NRDA)*. Available at http://www.gulfspillrestoration.noaa.gov/wp-content/uploads/2011/01/Final-NRDA-by-the-Numbers-Jan-20111.pdf. Accessed September 6, 2011.

NOAA and NMFS (National Oceanic and Atmospheric Administration and National Marine Fisheries Service), 2007, *Impact of Hurricanes Katrina, Rita, and Wilma on Commercial and Recreational Fishery Habitat of Oceanic and Atmospheric Administration and National Marine Fisheries Service*, July.

Noel, L.G., and J.D. McKendrick, 2000, "Land Cover Map for the Liberty Mine Site," BPXA, Anchorage, Alaska.

Norcross, B.L., B.A. Holladay, M.S. Busby, and K.L. Mier, 2009, "Demersal and Larval Fish Assemblages in the Chukchi Sea," *Deep-Sea Research II* 57:57–70.

Norris, F.H., M.J. Vanlandingham, and L. Vu, 2009, "PTSD in Vietnamese Americans Following Hurricane Katrina: Prevalence, Patterns, and Predictors," *Journal of Trauma and Stress* 22: 91–101.

North, M.R., 1994, "Yellow-billed Loon (*Gavia adamsii*)," Issue 121, *The Birds of North America Online*, A. Poole (ed.), Cornell Lab of Ornithology, Ithaca, New York. Available at http://bna.birds.cornell.edu/bna/species/121. Accessed September 8, 2011.

Northern Economics, 1990, *Economic Impacts of the S.S. Glacier Bay Spill*, OCS Study MMS 90-0081, November. Available at http://alaska.boemre.gov/reports/1990rpts/90_0081.pdf. Accessed July 15, 2011.

Northern Economics, 1993, *Commercial Fishing Industry of the Gulf of Alaska*, Technical Report No. 159, prepared for the MMS, Alaska OCS Office, Alaska OCS Socioeconomic Studies Program, Anchorage, Alaska.

Northrop, J., W.C. Cummings, and P.O. Thompson, 1968, "20-Hz Signals Observed in the Central Pacific," *J. Acoust. Soc. Am.* 43(2): 383–384.

Northrop, J., W.C. Cummings, and M.F. Morrison, 1971, "Underwater 20-Hz Signals Recorded near Midway Island," *J. Acoust. Soc. Am.* 49(6B): 1909–1910.

Nowlin, W.D., Jr., 1972, "Winter Circulation Patterns and Property Distributions," in *Contributions on the Physical Oceanography of the Gulf of Mexico*, L.R.A. Capurra and J.L. Reid (eds.), Gulf Publishing Company, Houston, Texas.

NPFMC (North Pacific Fishery Management Council), 2002, *Fishery Management Plan for Groundfish of the Gulf of Alaska*, Anchorage, Alaska.

NPFMC, 2004, *Fishery Management Plan for the Scallop Fishery off Alaska.* Available at http://www.fakr.noaa.gov/npfmc/fmp/scallop/ScallopFMP04.pdf. Accessed May 10, 2011.

NPFMC, 2009, *Fishery Management Plan for Fish Resources of the Arctic Management Area*. Available at http://www.fakr.noaa.gov/npfmc/fmp/arctic/ArcticFMP.pdf. Accessed May 10, 2011.

NPFMC, 2010, *Fishery Management Plan for Groundfish of the Gulf of Alaska.* Available at http://www.fakr.noaa.gov/npfmc/fmp/goa/GOA.pdf. Accessed May 10, 2011.

NPFMC and NMFS, 1990, Fishery Management Plan for the Salmon fisheries in the EEZ off the coast of Alaska. North Pacific Fisheries Management Council.

NPS (National Park Service), 2010, *Native American Consultation Database*, U.S. National Park Service, Washington, D.C., Sep. 23. Available at http://grants.cr.nps.gov/nacd/index.cfm. Accessed June 17, 2011.

NPS, 2011, *Reptiles of Padre Island National Seashore*, National Park Service, U.S. Department of the Interior. Available at http://www.nps.gov/pais/naturescience/reptiles.htm. Accessed January 17, 2011.

NRC (National Research Council), 1998, *Decade-to-Century-Scale Climate Variability and Change: A Science Strategy*, National Academies Press, Washington, D.C.

NRC, 2003a, *Ocean Noise and Marine Mammals*, The National Academies Press, Washington, D.C.

NRC, 2010, *America's Climate Choices: Advancing the Science of Climate Change*, Panel on Advancing the Science of Climate Change, Board on Atmospheric Sciences and Climate, Division on Earth and Life Studies, National Academies Press, Washington, D.C.

NSB (North Slope Borough), 2011, *North Slope Borough: Villages*, North Slope Borough, Barrow, Alaska. Available at http://www.co.north-slope.ak.us/. Accessed June 17, 2011.

NSIDC (National Snow and Ice Data Center), 2010, *Weather and Feedbacks Lead to Third-lowest Extent*, NSIDC press release, Cooperative Institute for Research in Environmental Sciences, Boulder, Colo., October 4. Available at http://nsidc.org/arcticseaicenews/2010/100410.html. Accessed September 2, 2011.

NSIDC, 2011, Ice Extent Low at Start of Melt Season; Ice Age Increases over Last Year, NSIDC press release, Cooperative Institute for Research in Environmental Sciences, Boulder, Colo., April 5. Available at http://nsidc.org/arcticseaicenews/2011/040511.html. Accessed September 6, 2011.

NSSL (National Severe Storms Laboratory), 2003, *Severe Thunderstorm Climatology*, National Oceanic and Atmospheric Administration, updated Aug. 29, 2003. Available at http://www.nssl.noaa.gov/hazard/totalthreat.html. Accessed April 5, 2011.

NTC (Ninilchik Traditional Council), 2010, *Ninilchik Traditional Council 2010 Educational Fishery Rules and Regulations,* Ninilchik Traditional Council, Ninilchik, Alaska.

O'Clair, C.E., and S.T. Zimmerman, 1986, "Biogeography and Ecology of Intertidal and Shallow Subtidal Communities," in *Gulf of Alaska, Physical Environment and Biological Resources*, D.W. Hood and S.T. Zimmerman (eds.), OCS Study MMS 86-0095, NOAA and MMS, Alaska OCS Region Anchorage, Alaska.

Ohsumi S., M. Nishiwaki, and T. Hibiya, 1958, "Growth of Fin Whale in the Northern Pacific," *The Scientific Reports of the Whales Research Institute* 13:97–133.

Oil Spill Commission (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling), 2011, *The Use of Surface and Subsea Dispersants during the BP Deepwater Horizon Oil Spill*, Staff Working Paper No. 4, January 11.

Oli, M.K., N.R. Holler, and M.C. Wooten, 2001, "Viability Analysis of Endangered Gulf Coast Beach Mice (*Peromyscus polionotus*) Populations," *Biological Conservation* 97:107–118.

Omernik, J.M., 1987, "Ecoregions of the Conterminous Unites States (map supplement)," *Annals of the Association of American Geographers* 77(1):118–125.

Omernik, J.M., 2004, "Perspectives on the Nature and Definition of Ecological Regions," *Environmental Management* 34 (Supplement 1):S27–S38.

OMP (Office of Marine Programs), 2010, *Discovery of Sound in the Sea*, University of Rhode Island. Available at http://www.dosits.org/. Accessed Aug. 2, 2010.

Omura, H., 1955, "Whales in the Northern Part of the North Pacific," *Nor. Hvalfangst-Tidende* 44(6):323–345.

Orr, J.C., V.J. Fabry, O. Aumont, L. Bopp, S.S. Doney, R.A. Feely, A. Gnanadesikan, N. Gruber, A. Ishida, F. Joos, R.M. Key, K. Lindsay, E. Maier-Reimer, R. Matear, P. Monfray, A. Mouchet, R.G. Najjar, G.K. Plattner, K.B. Rodgers, C.L. Sabine, J.L. Sarmiento, R. Schlitzer, R.D. Slater, I.J. Totterdell, M.F. Weirig, Y. Yamanaka, and A. Yool, 2005, "Anthropogenic Ocean Acidification over the Twenty-First Century and Its Impact on Calcifying Organisms," *Nature* 437:681–686.

OSAT (Operational Science and Advisory of the Unified Area Command), 2010, *Summary Report for Sub-Sea and Sub-Surface Oil and Dispersant Detection: Sampling and Monitoring*, Dec. 17.

OSAT, 2011, S*ummary Report for Fate and Effects of Remanant Oil Remaining in the Beach Environment*. Prepared for Lincoln D. Stroh, CAPT, U.S. Coast Guard Federal On-Scene Coordinator Deepwater Horizon MC252. Available at http://www.restorethegulf.gov/sites/default/files/u316/OSAT-2%20Report%20no%20ltr.pdf.

OSAT-2 (Operational Science Advisory Team), 2011, *Summary Report for Fate and Effects of Remnant Oil in the Beach Environment*, prepared by Operational Science Advisory Team Gulf Coast Incident Management Team for Lincoln D. Stroh, CAPT, U.S. Coast Guard, Federal On-Scene Coordinator, Deepwater Horizon MC252, Feb 10.

Otvos, E.G., 1980, "Barrier Island Formation through Nearshore Aggradation – Stratigraphic and Field Evidence." *Marine Geography* 43: 195–243.

Overland, J.E., and M. Wang, 2010, "Large-Scale Atmospheric Circulation Changes Are Associated With the Recent Loss of Arctic Sea Ice," Tellus. Series a: *Dynamic Meteorology and Oceanography* 62(1): 1–9.

Pacyna, J.M., 1995, "The Origin of Arctic Air Pollutants: Lessons Learned and Future Research," *The Science of the Total Environment* 160/161(1995):39–53.

Palinkas, L., J. Russell, M. Downs, and J. Petterson, 1992, "Ethnic Differences in Stress, Coping, and Depressive Symptoms after the *Exxon Valdez* Oil Spill," *Journal of Nerv. Mental Disease*180:287–295.

Pardue, J.H., W.M. Moe, D. McInnis, L.J. Thibodeaus, K.T. Valsaraj, E. Maciasz, I. Van Heerden, N. Korevec, and Q.Z. Yuan, 2005, "Chemical and Microbiological Parameters in New Orleans Floodwater Following Hurricane Katrina," *Environmental Science and Technology* 39:8591–8599.

Park, Y.H., and B.L. Edge, 2011, "Beach Erosion along Northeast Texas Coast," *Journal of Coastal Research* 27:502–514.

Parkinson, C.L., 2000, "Variability of Arctic Sea Ice: The View from Space, an 18-Year Record," *Arctic* 53:341–358.

Parrett, L.S., 2009, "Unit 26A, Teshekpuk Caribou Herd," pp. 271–298 in *Caribou Management, Report of Survey and Inventory Activities 1 July 2006—30 June 2008, Project 3.0,* P. Harper (ed.), Alaska Department of Fish and Game, Juneau, Alaska.

Parrott, R., 1991, *Seismic and Acoustic Systems for Marine Survey Used by the Geological Survey of Canada: Background Information for Environmental Screening,* Atlantic Geosciences Center, Geological Survey of Canada, Dartmouth, N.S.

Pasitschniak-Arts, M., 1993, "*Ursus arctos*," *Mammalian Species* 439:1–10.

Patterson, B., and G.R. Hamilton, 1964, "Repetitive 20 Cycle per Second Biological Hydroacoustic Signals at Bermuda," In*: Marine Bio-acoustics,* W.N. Tavolga (ed.), Pergamon, Oxford, U.K.

Paull, C.K., B. Hecker, R. Commeau, R.P. Freeman-Lynde, C. Neumann, W.P. Corso, S. Golubic, J.E. Hook, E. Sikes, and J. Curray, 1984, "Biological Communities at the Florida Escarpment Resemble Hydrothermal Vent Taxa," *Science* 226:965–967.

Pauly, D., A. Trites, E. Capuli, and V. Christensen, 1995, "Diet Composition and Trophic Levels of Marine Mammals," *ICES Journal of Marine Science* 55:467–481.

Pearson, C.E., et al., 2003, *Refining and Revising the Gulf of Mexico Outer Continental Shelf Region High-Probability Model for Historic Shipwrecks,* OCS Study MMS 2003-60, 61, and 62 prepared by Panamerican Consultants, Inc., Memphis, Tenn., and Coastal Environments, Inc., Baton Rouge, La., for Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La.

Peel, M.C., B.L. Finlayson, and T.A. McMahon, 2007, "Updated World Map of the Köppen-Geiger Climate Classification," *Hydrol. Earth Syst. Sci.* 11:1633–1644. Available at http://www.hydrol-earth-syst-sci.net/11/1633/2007/hess-11-1633-2007.pdf. Accessed April 5, 2011.

Peltier, T.C., 2007, "Unit 14 Furbearer," pp. 155–176 in *Furbearer Management Report of Survey and Inventory Activities 1 July 2003–30 June 2006, Project 7.0,* P. Harper (ed.), Alaska Department of Fish and Game, Juneau, Alaska.

Peltier, T., 2008, "Unit 16 Black bear Management Report," pp. 187–198 in *Black Bear Management Report of Survey and Inventory Activities 1 July 2004–30 June 2007, Project 17.0,* P. Harper (ed.), Alaska Department of Fish and Game, Juneau, Alaska.

Pendleton, E.A., J.A. Barras, S.J. Williams, and D.C. Twichell, 2010, *Coastal Vulnerability Assessment of the Northern Gulf of Mexico to Sea-Level Rise and Coastal Change*, Report Series 2010–1146, U.S. Geological Survey, Reston, Va.

Pequegnat, W.E. (ed.), 1983, *The Ecological Communities of the Continental Slope and Adjacent Regimes of the Northern Gulf of Mexico*, prepared for the Minerals Management Service, Gulf of Mexico OCS Office, Metairie, La., Contract No. AA851-CT1-12, TerEco Corporation.

Pérez-Cadahia, B., B. Laffon, and M. Porta, 2008, "Relationship Between Blood Concentrations of Heavy Metals and Cytogenetic and Endocrine Parameters Among Subjects Involved in Cleaning Coastal Areas Affected by the 'Prestige' Tanker Oil Spill," *Chemosphere* 71: 447–455.

Perovich, D.K., B. Light, H. Eicken, K.F. Jones, K. Runciman, and S.V. Nghiem, 2007, "Increasing Solar Heating of the Arctic Ocean and Adjacent Seas, 1979–2005: Attribution and Role in the Ice-Albedo Feedback," *Geophysical Research Letters* 34, L19505.

Perovich D., W. Meier, J. Maslanik, and J. Richter-Menge, 2010, "Sea Ice Cover" *in Arctic Report Card: Update for 2010*. Available at http://www.arctic.noaa.gov/reportcard/seaice.html. Accessed September 7, 2011.

Perrin, W.F., 1998, "*Stenella longirostris*," *Mammalian Species* 599:1–7.

Perrin, W.F., 2001, "*Stenella attenuata*," *Mammalian Species* 683:1–8.

Perrin, W.F., 2002, "*Stenella frontalis*," *Mammalian Species* 702:1–6.

Perry, A., C.S. Baker, and L.M. Herman, 1990, *Population Characteristics of Individually Identified Humpback Whales in the Central and Eastern North Pacific: A Summary and Critique*, Report of the International Whaling Commission, Special Issue 12:307–317.

Perry, S.L., D.P. DeMaster, and G. K. Silber, 1999, "The Great Whales: History and Status of Six Species Listed as Endangered under the U.S. Endangered Species Act of 1973," *Marine Fisheries Review* 61(1):7–58.

Perry, A.L., P.J.Low, J.R. Ellis, and J.D. Reynolds, 2005, "Climate Change and Distribution Shifts in Marine Fishes," *Science* 308:1912–1915.

Phillips, R.L., T.E. Reiss, E. Kempema, and E. Reimnitz, 1984, *Near Shore Marine Geologic Investigations, Wainwright to Skull Cliff, Northeast Chukchi Sea*, U.S. Geological Survey Open-File Report 84-108.

Philo, L.M., G.M. Carroll, and D.A. Yokel, 1993, *Movements of Caribou in the Teshekpuk Lake Herd as Determined by Satellite Tracking, 1990–1993,* North Slope Borough, Barrow, Alaska.

Piatt, J.F., and A.S. Kitaysky, 2002a, "Tufted Puffin (*Fratercula comiculata*)," Issue 603, *The Birds of North America Online* (A. Poole, ed.), Cornell Lab of Ornithology, Ithaca, New York. Available at http://bna.birds.cornell.edu/bna/species/708. Accessed August 18, 2011.

Piatt, J.F., and A.S. Kitaysky, 2002b, "Horned Puffin (*Fratercula cirrhata*)," Issue 708, *The Birds of North America Online* (A. Poole, ed.), Cornell Lab of Ornithology, Ithaca, New York. Available at http://bna.birds.cornell.edu/bna/species/603. Accessed August 18, 2011.

Piatt, J.F., J. Wetzel, K. Bell, A.R. DeGange, G.R. Balogh, G.S. Drew, T. Greernaert, C. Ladd, and G.V. Byrd, 2006, "Predictable Hotspots and Foraging Habitat of the Endangered Short-tailed Albatross (*Phoebastria albatrus*) in the North Pacific: Implications for Conservation," *Deep Sea Research II* 53:387–398.

Piatt, J.F., J. Wetzel, K. Bell, A.R. DeGange, G.R. Balogh, G.S. Drew, T. Greernaert, C. Ladd, and G.V. Byrd, 2006, "Predictable Hotspots and Foraging Habitat of the Endangered Short-tailed Albatross (*Phoebastria albatrus*) in the North Pacific: Implications for Conservation." *Deep Sea Research II* 53: 387–398.

Pickart, R.S., G.W.K. Moore, D.J. Torres, P.S. Fratantoni, R.A. Goldsmith, and J. Yang, 2009, "Upwelling on the Continental Slope of the Alaskan Beaufort Sea: Storms, Ice, and Oceanographic Response," *Journal of Geophysical Research* 114.

Picou, J.S., and C. Arata, 1997, "Chronic Psychological Impacts of the Exxon Valdez Oil Spill: Resource Loss and Commercial Fishers," Appendix J in *Coping with Technological Disasters: A User Friendly Guidebook*, Prince William Sound Regional Citizens' Advisory Council, Anchorage, Alaska.

Picou, J.S., and D.A. Gill, 1996, "The *Exxon Valdez* Oil Spill and Chronic Psychological Stress," pp. 879–893in *Proceedings of the* Exxon Valdez *Oil Spill Symposium*, Anchorage, Alaska, Feb. 2–5, 1993, American Fisheries Society, Bethesda, Md.

Picou, J.S., C. Formichella, B.K. Marshall, and C. Arata, 2009 "Community Impacts of the *Exxon Valdez* Oil Spill: A Synthesis and Elaboration," pp. 279–310 in *Synthesis: Three Decades of Research on Socioeconomic Effects Related to Offshore Petroleum Development in Coastal Alaska*, S.R. Braud and J. Kruse (eds.), MMS OCS Study No. 2009-006, Stephen R. Braud & Associates, Anchorage, Alaska.

Picou, J.S., G.D. Johnson, and D.A. Gill, 1999, "Mitigating the Chronic Community Impacts of Localized Environmental Degradation: A Case Study of the *Exxon Valdez* Oil Spill," Appendix K in *Coping with Technological Disasters: A User Friendly Guidebook*, Prince William Sound Regional Citizens' Advisory Council, Anchorage, Alaska.

Picou, S., 2010, *Helping Others: A Community Peer Listener Training Program*, training session presented at Louisiana State University, Baton Rouge, La., July 28. Available at http://130.39.4.49/mediasite/Viewer/?peid=594f72ab89f54d8285cbc7054145be2c. Accessed June 17, 2011.

Ping, C.-L., G.J. Michaelson, L. Guo, M.T. Jorgenson, M. Kanevskiy, Y. Shur, F. Dou, and J. Liang, 2011, "Soil Carbon and Material Fluxes across the Eroding Alaska Beaufort Sea Coastline," *Journal of Geophysical Research* 116, G02004.

Pitcher, K.W., 1989, *Studies of Southeastern Alaska Sea Otter Populations — Distribution, Abundance, Structure, Range Expansion, and Potential Conflicts with Shellfisheries,* Final Report Part 1, U.S. Fish and Wildlife Service Cooperative Agreement No. 14-16-0009-954, Alaska Department of Fish and Game, Juneau, Alaska.

Pitcher, K.W., and D.C. Calkins, 1979, "Biology of the Harbor Seal, *Phoca vitulina richardii*, pp. 231–310 in the Gulf of Alaska," *Environmental Assessment of the Alaskan Continental Shelf,* Final Reports of Principal Investigators, Vol. 19 (Dec. 1983), National Oceanic and Atmospheric Administration, Outer Continental Shelf Environmental Assessment Program, and Bureau of Land Management, Juneau and Anchorage, Alaska.

Pomeroy, L., P.L. Williams, F. Azam, and J.E. Hobbie, 2007, "The Microbial Loop," *Oceanography* 20:28–33.

Poole, F.W. and G.L. Hufford, 1982, "Meteorological and Oceanographic Factors Affecting Sea Ice in Cook Inlet," *Journal of Geophysical Research* 87C3:2061–2070.

Post, E., and M.C. Forchhammer, 2008, "Climate Change Reduces Reproductive Success of and Arctic Herbivore through Trophic Mismatch," *Philosophical Transactions of the Royal Society B* 3363:2369–2375.

Powell, A.N., A.R. Taylor, and R.B. Lanctot, 2010, *Pre-migratory Ecology and Physiology of Shorebirds Staging on Alaska's North Slope*, Coastal Marine Institute, University of Alaska, Fairbanks, Alaska.

Powell, J.A., and G.B. Rathbun, 1984, "Distribution and Abundance of Manatees along the Northern Coast of the Gulf of Mexico," *Northeast Gulf Science* 7:1–28.

Precht, W.F., R.B. Aronson, K.J.P. Deslarzes, M.L. Robbart, D.J. Evans, B. Zimmer, and L. Duncan, 2008, *Long-Term Monitoring at the East and West Flower Garden Banks, 2004–2005 – Interim Report, Vol. I: Technical Report,* OCS Study MMS 2008-027, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La.

Prince, R.C., E.H. Owens, and G.A. Sergy, 2002, "Weathering of an Arctic Oil Spill over 20 Years: The BIOS Experiment Revisited, Baffin Island Oil Spill," *Marine Pollution Bulletin* 44(11):1236–1242.

Pritchard, P.C.H., 1997, "Evolution, Phylogeny, and Current Status," pp. 1–28in *The Biology of Sea Turtles*, P.L. Lutz and J.A. Musick (eds.), CRC Press, Boca Raton, Fla.

Proshutinsky, A.Y., T. Proshutinsky, and T. Weingartner, 1999, *Environmental Conditions Affecting Commercial Shipping on the Northern Sea Ports*, International Northern Sea Route Programme, Working Paper No. 126-1999, I.5.8.

Proshutinsky, A., V. Pavlov, and R.H. Bourke, 2001, "Sea Level Rise in the Arctic Ocean," *Geophysical Research Letters* 28:2237–2240.

Pulsipher, A.G., D. Tootle, and R. Pincomb, 1999, *Economic and Social Consequences of the Oil Spill in Lake Barre, Louisiana*, OCS Report MMS 99-0028, prepared by the Louisiana State University, Center for Energy Studies for the Minerals Management Service, Gulf of Mexico OCS Region, Louisiana State University, Coastal Marine Institute, New Orleans, La.

Purcell, J.E., D.L. Breitburg, M.B. Decker, W.M. Graham, M.J. Younbluth, and K.A. Raskoff, 2001, "Pelagic Cnidarians and Ctenophores in Low Dissolved Oxygen Environments: A Review," Chapter 5 in *Coastal Hypoxia: Consequences for Living Resources and Ecosystems*, N.N. Rabalais and R.E. Turner (eds.), American Geophysical Union, Washington, D.C.

Purcell, J.E., S.-I. Uye, and W.-T. Lo, 2007, "Anthropogenic Causes of Jellyfish Blooms and Direct Consequences for Humans: A Review," *Marine Ecology Progress Series* 350:153–174.

Purdy, B.A. (ed.), 1988, *Wet Site Archaeology*, Telford Press, Caldwell, N.J.

Putkonen, J., and G. Roe, 2003, "Rain-on-Snow Events Impact Soil Temperatures and Affect Ungulate Survival." *Geophysical Research Letters* 30(4):37-1 – 37-4.

Quakenbush, L., 2008, *Alaska Wildlife Notebook Series: Bowhead Whale*, Alaska Department of Fish and Game, Juneau, Alaska. Available at http://www.adfg.alaska.gov/static/education/wns/bowhead_whale.pdf. Accessed April 11, 2011.

Qureshi, N.A., and N.N. Rabalais, 2001, "Distribution of Zooplankton on a Seasonally Hypoxi Continental Shelf," Chapter 4 in *Coastal Hypoxia: Consequences for Living Resources and Ecosystems,* N.N. Rabalais and R.E. Turner (eds.), American Geophysical Union, Washington, D.C.

Raabe, E.A., and L.C. Gauron, 2005, *Florida Salt Marsh Vole Habitat: Lower Suwannee National Wildlife Refuge*, Open-File Report 2005-1417, U.S. Geological Survey, St. Petersburg, Fla.

Rabalais, N.N, R.E. Turner, and D. Scavia, 2002, "Beyond Science into Policy: Gulf of Mexico Hypoxia and the Mississippi River," *BioScience* 52:129–142.

Rabalais, N.N., R.J. Díaz, L.A. Levin, R.E. Turner, D. Gilbert, and J. Zhang, 2010, "Dynamics and Distribution of Natural and Human-Caused Hypoxia," *Biogeosciences* 7:585–619.

Rabe, B., M. Karcher, U. Schauer, J.M. Toole, R.A. Krishfield, S. Pisarev, F. Kauker, R. Gerdes, and T. Kikuchi, 2011, "An Assessment of Arctic Ocean Freshwater Content Changes from the 1990s to the 2006-2008 Period," *Deep Sea Research Part 1: Oceanographic Research Papers* 58:173–185.

Ragen, T.J., H.P. Huntington, and G.K. Hovelsrud, 2008, "Conservation of Arctic Marine Mammals Faced with Climate Change," *Ecological Applications* 18(2):S166–S174.

Rahn, K.A., 1982, "On the Causes, Characteristics and Potential Environmental Effects of Aerosol in the Arctic Atmosphere," in *The Arctic Ocean: The Hydrographic Environment and the Fate of Pollutants*, L. Ray (ed.), John Wiley and Sons, New York, N.Y.

Rahn, K.A., R.D. Borys, and G.E. Shaw, 1977, "The Asian Source of Arctic Haze Bands," *Nature* 268:713–715.

Randall, D.A., R.A. Wood, S. Bony, R. Colman, T. Fichefet, J. Fyfe, V. Kattsov, A. Pitman, J. Shukla, J. Srinivasan, R.J. Stouffer, A. Sumi, and K.E. Taylor, 2007, "Climate Models and Their Evaluation," in *Climate Change 2007: The Physical Science Basis,* Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller (eds.), Cambridge University Press, Cambridge, U.K., and New York, N.Y.

Rathbun, G.B., J.P. Reid, and G. Carowan, 1990, "Distribution and Movement Patterns of Manatees (*Trichechus manatus*) in Northwestern Peninsular Florida," *Florida Marine Research Publication No. 48,* Florida Department of Natural Resources, Florida Marine Research Institute, St. Petersburg, Fla. Available at http://research.myfwc.com/publications/publication_info.asp?id=26075. Accessed June 3, 2010.

Ray, C.E., 1971, "Polar Bear and Mammoth on the Pribilof Islands," *Arctic* 24:9–19.

Raynolds, M.K., D.A. Walker, and H.A. Maier, 2006, "Alaska Arctic Tundra Vegetation Map, Scale 1:4,000,000, Conservation of Arctic Flora and Fauna (CAFF) Map No. 2," U.S. Fish and Wildlife Service, Anchorage, Alaska.

Read, A.J., P.N. Halpin, L.B. Crowder, B.D. Best, and E. Fujioka (eds.), 2011, *OBIS-SEAMAP: Mapping Marine Mammals, Birds, and Turtles,* Ocean Biogeographic Information System, Web electronic publication. Available at http://seamap.env.duke.edu. Accessed March 15, 2011.

Reese, C.S., J.A. Calvin, J.C. George, and R.A. Tarpley, 2001, "Estimation of Gestation in Bowhead Whales (with Discussion)," *Journal of the American Statistical Association* 96:915–938.

Reeves, R.R., B.S. Stewart, and S. Leatherwood, 1992, *The Sierra Club Handbook of Seals and Sirenians,* Sierra Club Books, San Francisco, Calif.

Reeves, R.R., G.K. Silber, and P.M. Payne, 1998, *Draft Recovery Plan for the Fin Whale* Balaenoptera physalus *and Sei Whale* Balaenoptera borealis, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Md.

Regehr, E.V., S.C. Amstrup, and I. Stirling, 2006, *Polar Bear Population Status in the Southern Beaufort Sea*, USGS Open-File Report 2006-1337, U.S. Geological Survey, Reston, Va. Available at http://pubs.usgs.gov/of/2006/1337/pdf/ofr20061337.pdf. Accessed May 5, 2011.

Regehr, E.V., C.M. Hunter, H. Caswell, S.A. Amstrup, and I. Stirling, 2010, "Survival and Breeding of Polar Bears in the Southern Beaufort Sea in Relation to Sea Ice," *Journal of Animal Ecology* 79:117–127.

Rehfisch, M.M., and H.Q.P. Crick, 2003, "Predicting the Impact of Climate Change on Arctic-Breeding Waders," *Wader Study Group Bulletin* 100:86–95.

Reist, J.D., F.J. Wrona, T.D. Prowse, M. Power, J.B. Dempson, R.J. Beamish, J.R. King, T.J. Carmichael, and C.D. Sawatzky, 2006, "General Effects of Climate Change on Arctic Fishes and Fish Populations," *Ambio* 35:370–380.

Renaud, M.L., J.A. Carpenter, and J.A. Williams, 1995, "Activities of Juvenile Green Turtles, *Chelonia mydas*, at a Jettied Pass in South Texas," *Fishery Bulletin* 93:586–593.

Restore the Gulf, 2010, *Deepwater Horizon Response Consolidated Fish and Wildlife Collection Report*, November 2, 2010. Available at http://www.restorethegulf.gov/sites/default/files/documents/pdf/Consolidated%20Wildlife%20Table%20110210.pdf. Accessed November 10, 2010.

Reynolds, P.E., 1992, "Seasonal Differences in the Distribution and Movements of Muskoxen (*Ovibos moschatus*) in Northeastern Alaska," *Rangifer* 13:171–172.

Rezak, R., T.J. Bright, and D.W. McGrail, 1983, *Reefs and Banks of the Northwestern Gulf of Mexico: Their Geological, Biological, and Physical Dynamics, Northern Gulf of Mexico Topographic Features Monitoring and Data Synthesis,* Executive Summary and Final Report prepared by Texas A&M University, Department of Oceanography, for Minerals Management Service, Gulf of Mexico OCS Office, Metairie, La.

Rezak, R., T.J. Bright, and D.W. McGrail, 1985, *Reefs and Banks of the Northern Gulf of Mexico: Their Geological, Biological, and Physical Dynamics*, John Wiley and Sons, New York, N.Y.

Rice, D.W., 1974, "Whales and Whale Research in the Eastern North Pacific," in *The Whale Problem: A Status Report,* W.E. Schevill (ed.), Harvard University Press, Cambridge, Mass.

Rice, D.W., 1986, "Beaked Whales," pp. 102–109 in *Marine Mammals of the Eastern North Pacific and Arctic Waters,* D. Haley (ed.), Pacific Search Press, Seattle, Wash.

Rice, D.W., 1988, "Sperm Whale *Physeter macrocephalus*, Linnaeus 1758," pp. 177–233 in *Handbook of Marine Mammals,* Vol. 4, S.H. Ridgway and R.J. Harrison (eds.), Academic Press, London, England.

Rice, D.W., 1989, "Sperm Whale, *Physeter macrocephalus*," pp. 177–233 in *Handbook of Marine Mammals, Vol. 4. River Dolphins and the Larger Toothed Whales,* S.H. Ridgway and R. Harrison (eds.), Academic Press, New York.

Rice, D.W., 1998, *Marine Mammals of the World: Systematics and Distribution,* Marine Mammal Science Special Publication 4, Society for Marine Mammals, Allen Press, St. Lawrence.

Rice, D.W., and A.A. Wolman, 1971, *The Life History and Ecology of the Gray Whale* (Eschrichtius robustus), Special Publication No. 3, The American Society of Mammalogists, Seattle, Wash.

Rice, D.W., and A.A. Wolman, 1982, "Whale Census in the Gulf of Alaska June to August 1980," *Report of the International Whaling Commission* 32:491–497.

Rice, D.W., A.A. Wolman, D.E. Withrow, and L.A. Fleischer, 1981, "Gray Whales on the Winter Grounds in Baja California," *Report of the International Whaling Commission* 31:477–493.

Richard, P.R., A.R. Martin, and J.R. Orr, 2001, "Summer and Autumn Movements of Belugas of the Eastern Beaufort Sea Stock," *Arctic* 54(3): 223–236.

Richards, W.J., and T. Potthoff, 1980, "Distribution and Seasonal Occurrence of Larval Pelagic Stages of Spiny Lobsters (*Palinuridae, Panulirus*) in the Western Tropical Atlantic," *Proceedings of the Gulf and Caribbean Fishery Institute* 33:244–252.

Richards, W.J., M.F. McGowan, T. Leming, J.T. Lampkin, and S. Kelley, 1993, "Larval Fish Assemblages at the Loop Current Boundary in the Gulf of Mexico," *Bulletin of Marine Science* 53(2):475–537.

Richardson, W.J. (ed.), 2011, *Monitoring of Industrial Sounds, Seals, and Bowhead Whales near BP's Northstar Oil Development, Alaskan Beaufort Sea, 2010: Annual Summary Report*, LGL Report P1182, prepared by LGL Alaska Research Associates Inc., Anchorage, Alaska, and LGL Ltd. environmental research associates, King City, Ontario, Canada, for BP Exploration (Alaska) Inc., Anchorage, Alaska, Feb. 22.

Richardson, W.J., C.R. Greene, Jr., C.I. Malme, and D.H. Thomson, 1995, *Marine Mammals and Noise,* Academic Press, San Diego.

Richardson, W.J., and D.H. Thomson (eds.), 2002, *Bowhead Whale Feeding in the Eastern Alaskan Beaufort Sea: Update of Scientific and Traditional Information*, Vols. 1 and 2, OCS Study MMS 2002-012, LGL Report TA2196-7, prepared by LGL Ltd., King City, Ontario, Canada, for Minerals Management Service, Anchorage, Alaska, and Herndon, Va.

Richter-Menge, J., and M. Jeffries, 2011, "The Arctic," in *State of the Climate in 2010, Bulletin of the American Meteorological Society* 92(6):S143–S160.

Riedman, M.L., and J.A. Estes, 1990, *The Sea Otter* (Enhydra lutris)*: Behavior, Ecology, and Natural History*, Biological Report 90(14), U.S. Fish and Wildlife Service, Washington, D.C., Sept.

Riedman, M.L., J.A. Estes, M.M. Staedler, A.A. Giles, and D.R. Carlson, 1994, "Breeding Patterns and Reproductive Success of California Sea Otters," *Journal of Wildlife Management* 58(3):391–399.

Roach, E.R., M.C. Watzin, J.D. Scurry, and J.B. Johnston, 1987, "Wetland Trends in Coastal Alabama." In: *Symposium on the Natural Resources of the Mobile Bay Estuary*, p. 92–101, T.A. Lowery (ed.). Auburn University. Alabama Sea Grant Extension Service, MASGP-87-007.

Robards, M.D., J.F. Piatt, A.B. Kettle and A.A. Abookire, 1999, "Temporal and Geographic Variation in Fish Communities of lower Cook Inlet, Alaska," *Fishery Bulletin* 97:962–977.

Robards, M.D., G.A. Rose, and J.F. Piatt, 2002, "Growth and Abundance of Pacific Sand Lance, *Ammodytes hexapterus*, under Differing Oceanographic Regimes," *Environmental Biology of Fishes* 64:429–441.

Robbart, M.L., R.B. Aronson, K.J.P. Deslarzes, W.F. Precht, L. Duncan, B. Zimmer, and T. DeMunda, 2009, *Post-Hurricane Assessment of Sensitive Habitats of the Flower Garden Banks Vicinity*, OCS Study MMS 2009-032, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La.

Robertson, G.J., and J.-P.L. Savard, 2002, "Long-tailed Duck (*Clangula hyemalis*)," Issue 651, *The Birds of North America Online* (A. Poole, ed.), Cornell Lab of Ornithology, Ithaca, New York. Available at http://bna.birds.cornell.edu/bna/species/651. Accessed August 18, 2011.

Roby, D.D., 1980, "Winter Activity of Caribou on Two Arctic Ranges," in *Proceedings of the Second International Reindeer/Caribou Symposium, Roros, Norway*, R. Reimers, E. Gaare, and S. Skjensberg (eds.), Direktorat for Vilt og Freskvannsfisk, Trondheim, Norway.

Roderick, L. (ed.), 2010, *Alaska Native Cultures and Issues: Responses to Frequently Asked Questions*, University of Alaska Press, Fairbanks, Alaska.

Rogner, H.-H., D. Zhou, R. Bradley, P. Crabbé, O. Edenhofer, B. Hare, L. Kuijpers, and M. Yamaguchi, 2007, "Introduction," in *Climate Change 2007: Mitigation,* Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, and L.A. Meyer (eds.), Cambridge University Press, Cambridge, U.K., and New York, N.Y.

Rosenberg, D.H., D.C. Burrell, K.V. Natarajan, and D.W. Hood, 1967, *Oceanography of Cook Inlet with Special Reference to the Effluent from the Collier Carbon and Chemical Plant*, Report No. IMS-67-5, University of Alaska, Institute of Marine Science, College, Alaska.

Rosenzweig, C., G. Casassa, D.J. Karoly, A. Imeson, C. Liu, A. Menzel, S. Rawlins, T.L. Root, B. Seguin, and P. Tryjanowski, 2007, "Assessment of Observed Changes and Responses in Natural and Managed Systems," pp. 79–131 in *Climate Change 2007: Impacts, Adaptation and Vulnerability,* Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson (eds.), Cambridge University Press, Cambridge, U.K.

Ross, D., 1976, *Mechanics of Underwater Noise*, Pergamon Press, New York.

Ross, S.T., W.T. Slack, R.J. Heise, M.A. Dugo, H. Rogillio, B.R. Bowen, P. Mickle, and R.W. Heard, 2009, "Estuarine and Coastal Habitat Use of Gulf Sturgeon (*Acipenser oxyrinchus desotoi*) in the North-Central Gulf of Mexico," *Estuaries and Coasts* 32:360–374.

Ross S.W., A.M. Quattrini, A.Y. Roa-Varón, and J.P. McClain, 2010, "Species Composition and Distributions of Mesopelagic Fishes over the Slope of the North-Central Gulf of Mexico," *Deep Sea Research Part II: Topical Studies in Oceanography* 57:1926–1956.

Rothrock, D.A., and J. Zhang, 2005, "Arctic Ocean Sea Ice Volume: What Explains Its Recent Depletion?" *Journal of Geophysical Research* 110(C1), C01002.

Rowe, G.T., and M.C. Kennicutt II (eds.), 2009, *Northern Gulf of Mexico Continental Slope Habitats and Benthic Ecology Study, Final Report*, OCS Study MMS 2009-039, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La., July. Available at http://www.gomr.boemre.gov/PI/PDFimages/ESPIS/4/4842.pdf. Accessed June 30, 2011.

Royal Society, 2005, *Ocean Acidification Due to Increasing Atmospheric Carbon Dioxide*, Policy Document 12/05, Science Policy Section, London, U.K. Available at http://royalsociety.org/Ocean-acidification-due-to-increasing-atmospheric-carbon-dioxide/. Accessed June 28, 2011.

Rozell, N., 2000, *The Search for Russia's Lindbergh*, Alaska Science Forum, September 10, 1999, Article #1456, University of Alaska, Fairbanks Geophysical Institute. Available at http://www.gi.alaska.edu/ScienceForum/ASF14/1456.html. Accessed July 5, 2011.

Rugh, D.J., and H. Braham, 1979, “California Gray Whale (*Eschrichtius robustus*) Fall Migration through Unimak Pass, Alaska, 1977: A Preliminary Report,” *Report of the International Whaling Commission* 29:315–320.

Rugh, D.J., M.M. Muto, S.E. Moore, and D.P. DeMaster, 1999, *Status Review of the Eastern North Pacific Stock of Gray Whales,* NOAA Technical Memorandum NMFS-AFSC-103, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Science Center, Seattle, Wash.

Rugh, D., D. Demaster, A. Rooney, J. Breiwick, K. Shelden, and S. Moore, 2003, “A Review of Bowhead Whale (*Balaena mysticetus*) Stock Identity,” *Journal of Cetacean Research and Management* 5(3):267–279.

Rugh, D.J., K.E.W. Shelden, and R.C. Hobbs, 2010, “Range Contraction in a Beluga Whale Population,” *Endangered Species Research* 12:69–75.

Russell, R.W., 2005, *Interactions between Migrating Birds and Offshore Oil and Gas Platforms in the Northern Gulf of Mexico: Final Report*. OCS Study MMS 2005 009. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La.

Sage, B., 1996, *Terrestrial Mammals of the Arctic*. Available at http://lynx.uio.no/jon/lynx/arctmam.html. Accessed August 30, 2011.

Sager, W.W., W.W. Schroeder, J.S. Laswell, K.S. Davis, R. Rezak, and S.R. Gittings, 1992, “Topographic Features of the Mississippi-Alabama Outer Continental Shelf and Their Implications for Sea Level Fluctuations during the Late Pleistocene-Holocene Transgression,” *Geo-Mar. Lett.* 12:41–48.

SAIC (Science Applications International Corporation), 1997, *Northeastern Gulf of Mexico Coastal and Marine Ecosystem Program: Data Search and Synthesis; Synthesis Report*, USGS/BRD/CR-1997-0005, prepared by SAIC for U.S. Geological Survey, Biological Resources Division; OCS Study MMS 96-0014 and MMS, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La.

Saliva, J.E., 1993, *Caribbean Roseate Tern Recovery Plan*. U.S. Fish and Wildlife Service, Southeast Region, Atlanta, Ga.

SAMHSA (Substance Abuse and Mental Health Services Administration), 2010, *Tips for Coping with the Oil Spill Disaster: Managing Your Stress*, U.S. Department of Health and Human Services, July.

Sammarco P.W., A.D., Atchison, and G.S. Boland, 2004, “Expansion of Coral Communities within the Northern Gulf of Mexico via Offshore Oil and Gas Platforms,” *Marine Ecology Progress Series* 280:129–143.

Sansonetti, T.L., 1987, "MMS Responsibility for Onshore Activities under the National Historic Preservation Act," memorandum from Sansonetti (Associate Solicitor, Energy and Resources, Office of the Solicitor, U.S. Department of the Interior, Washington, D.C.) to Director (Minerals Management Service), Aug.

Sassen, R., J.M. Brooks, M.C. Kennucutt II, I.R. MacDonald, and N.L. Guinasso, Jr., 1993a, "How Oil Seeps, Discoveries Relate in Deepwater Gulf of Mexico," *Oil & Gas Journal* 91(16):64–69.

Sassen, R., J. Brooks, I. MacDonald, M. Kennicutt II, and N. Guinasso, 1993b, "Association of Oil Seeps and Chemosynthetic Communities with Oil Discoveries, Upper Continental Slope, Gulf of Mexico," *Bull. Am. Assoc. Pet. Geol.* 77:1599.

Saupe, S.M., J. Gendron, and D. Dasher, 2005, *The Condition of Southcentral Alaska Coastal Bays and Estuaries*, a statistical summary for the National Coastal Assessment Program, Alaska Department of Environmental Conservation.

Savitz, D.A., R.T. Oxman, and K.B. Metzger, 2008, "Epidemiologic Research on Manmade Disasters: Strategies and Implications of Cohort Definition for World Trade Center Worker and Volunteer Surveillance Program," *Mt. Sinai Journal of Medicine* 75: 77–87.

Scarff, J.E., 1986, "Historic and Present Distribution of the Right Whale, *Eubalaena glacialis*, in the Eastern North Pacific South of 50 N and East of 180 W," *Report of the International Whaling Commission*, Special Issue 10, pp. 43–63.

Scavia, D., J.C. Field, D.F. Boesch, R.W. Buddemeier, V. Burkett, D.R. Cayan, M. Fogarty, M.A. Harwell, R.W. Howarth, C. Mason, D.J. Reed, T.C. Royer, A.H. Sallenger, and J.G. Titus, 2002, "Climate Change Impacts on U.S. Coastal and Marine Ecosystems," *Estuaries* 25(2):149–164.

Scavia, D., et al., 2003, "Predicting the Response of Gulf of Mexico Hypoxia to Variations in Mississippi River Nitrogen Load," *Limnology & Oceanography* 48:951–956.

Scheffer, V.B., and J.W. Slipp, 1944, "The Harbor Seal in Washington State," *American Midland Naturalist* 32:373–416.

Schliebe, S., T.J. Evans, S. Miller, C.J. Perham, J.M. Wilder, and L.J. Lierheimer, 2005, *Polar Bear Management in Alaska, 2000–2004*, Fish and Wildlife Service, Anchorage, Alaska.

Schneider, K., and B. Ballachey, 2008, *Alaska Wildlife Notebook Series: Sea Otter*, Alaska Department of Fish and Game, Juneau, Alaska. Available at http://www.adfg.alaska.gov/static/education/wns/sea_otter.pdf. Accessed April 11, 2011.

Schroeder, W.W., M.R. Dardeau, J.J. Dindo, P. Fleisher, K.L. Heck, Jr., and A.W. Shultz, 1989, "Geophysical and Biological Aspects of Hard Bottom Environments on the L'MAFLA Shelf, Northern Gulf of Mexico," pp. 17–21 in *Proceedings of Oceans '88 Conference*.

Schuur, E.A.G., J.G. Vogel, K.G. Crummer, H. Lee, J.O. Sickman, and T.E. Osterkamp, 2009, "The Effect of Permafrost Thaw on Old Carbon Release and Net Carbon Exchange from Tundra," *Nature* 459:556–559.

Schwartz, C.C., S.D. Miller, and A.W. Franzmann, 1987, "Denning Ecology of Three Black Bear Populations in Alaska," *International Conference Bear Research and Management* 7:281–291.

Schwing, F.B., R. Mendelssohn, S.J. Bograd, J.E. Overland, M. Wang, and S.-I. Ito, 2010, "Climate Change, Teleconnection Patterns and Regional Processes Forcing Marine Populations in the Pacific," *Journal of Marine Systems* 79:245–257.

Scott, R.L., D.C. Biggs, and S.F. DiMarco, 200l, *Spatial and Temporal Variability of Plankton Stocks on the Basis of Acoustic Backscatter Intensity and Direct Measurements in the Northeastern Gulf of Mexico*, OCS Study MMS 2001-063, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La.

Seaford, J., 2011, *The Impact of the Deepwater Horizon Oil Spill*. Available at http://jseaford.wordpress.com/2010/09/30/the-impact-of-the-deepwater-horizon-oil-spill/. Accessed July 15, 2011.

SEAMAP (Southeast Area Monitoring and Assessment Program), 2010, *Environmental and Biological Atlas of the Gulf of Mexico, 2006*, Gulf States Marine Fisheries Commission, No. 179.

Selinger, J., 2008, "Units 7 & 15 Black bear Management Report," pp. 143–148 in *Black Bear Management Report for Survey and Inventory Activities 1 July 2004–30 June 2007, Project 17.0,* P. Harper (ed.),Alaska Department of Fish and Game, Juneau, Alaska.

Semenov, V.N., 1965, "Quantitative Distribution of Bottom Fauna on Shelf and Upper Part of [Continental] Slope of the Alaska Gulf," *Proceed. All-Union Res. Inst. Mar. Fish. and Oceanogr*. (*VNIRO*) 58:49–77 (in Russian).

Sergeant, D.E., and P.F. Brodie, 1969, "Body Size in White Whales, *Delphinapterus leucas*," *Journal of the Fisheries Research Board of Canada* 26:2561–2580.

Serreze, M.C., and J.A. Francis, 2006, "The Arctic Amplification Debate," *Climatic Change* 76:241–264.

Servheen, C., and M. Cross, 2010, *Climate Change Impacts on Grizzly Bears and Wolverines in the Northern U.S. and Transboundary Rockies: Strategies for Conservation*, Report on a workshop held Sept. 13–15 in Fernie, British Columbia.

Sharma, G.D., 1979, *The Alaskan Shelf: Hydrographic, Sedimentary and Geochemical Environment*, Springer-Verlag, New York, N.Y.

Sharma, S., S. Couturier, and S.D. Côté, 2009, "Impacts of Climate Change on the Seasonal Distribution of Migratory Caribou," *Global Change Biology* 15:2549–2562.

Sheikh, P.A., 2006, *The Impact of Hurricane Katrina on Biological Resources*, Congressional Research Service Report for Congress, February 22. Available at http://www.nbii.gov/images/uploaded/156209_1216400089496_Impact_of_Hurricane_Katrina.pdf. Accessed September 8, 2011.

Shelden, K.E.W., and D.J. Rugh, 1995, "The Bowhead Whale, *Balaena mysticetus*: Its Historic and Current Status," *Marine Fisheries Review* 57(3–4):1–20.

Shelden, K.E.W., D.J. Rugh, B.A. Mahoney, and M.E. Dahlheim, 2003, "Killer Whale Predation on Belugas in Cook Inlet, Alaska: Implications for a Depleted Population," *Marine Mammal Science* 19(3):529–544.

Shelden, K.E.W., S.E. Moore, J.M. Waite, P.R. Wade, and D.J. Rugh, 2005, "Historic and Current Habitat Use by North Pacific Right Whales (*Eubalaena japonica*) in the Bering Sea and Gulf of Alaska," *Mammal Review* 35:129–155.

Shell Offshore, Inc., 2005, *Application for Incidental Harassment Authorization for the Non-lethal Taking of Whales and Seals in Conjunction with a Proposed Marine Geophysical (Seismic Acquisition) Program in the Northern Chukchi Sea, Alaska, during 2006*, Shell Exploration & Production Company, Robert, La. Available at http://www.nmfs.noaa.gov/pr/pdfs/permits/iha_Shell_chukchi.pdf. Accessed Jan. 22, 2007.

Sherman, K., 2003, *Physical, Biological and Human Forcing of Biomass Yields in Large Marine Ecosystems*, International Council for the Exploration of the Sea, Session P, Physical-Biological Interactions in Marginal and Shelf Seas. Available at http://www.ices.dk/products/CMdocs/2003/P/P1203.PDF. Accessed March 11, 2011.

Sherman, K., M. Aquarone, and S. Adams, 2007, *Global Applications of the Large Marine Ecosystem Concept 2007-2010*, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, NOAA Technical Memorandum NMFS-NE-208.

Shideler, R., and J. Hechtel, 1995, "Grizzly Bear Use of Oil Fields around Prudhoe Bay, Alaska," in *Tenth International Conference on Bears Resources and Management, Fairbanks, Alaska, July 16–20, 1995*.

Shideler, R., and J. Hechtel, 2000, "Grizzly Bear," pp. 105–132 in *The Natural History of an Arctic Oil Field: Development and the Biota*, J.C. Truett and S.R. Johnson (eds.), Academic Press, San Diego, Calif.

Shields, P., 2010a, *Upper Cook Inlet Commercial Fisheries Annual Management Report*, 2010, Fishery Management Report No. 10-54, Alaska Department of Fish & Game, Anchorage.

Shields, P., 2010b, *Upper Cook Inlet Commercial Fisheries Annual Management Report, 2009*, Fishery Management Report No. 10-27, Alaska Department of Fish and Game, Anchorage.

Short, J.W., 2004, "Exxon Valdez Oil in the Nearshore Environment of Prince William Sound: Persistence and Chemistry," in *2004 Symposium, Marine Science in Alaska (Abstracts), Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.

Sibley, D.A., 2000, *The Sibley Guide to Birds*. Alfred A Knopf, Inc., N.Y.

Sillero-Zubiri, C., and A. Angerbjorn, 2009, *Arctic Foxes and Climate Change*, Available at http://cmsdata.iucn.org/downloads/fact_sheet_red_list_arctic_foxes.pdf. Accessed September 12, 2011.

Simmonds, M.P., and S.J. Isaac, 2007, "The Impacts of Climate Change on Marine Mammals: Early Signs of Significant Problems," *Oryx* 41:19–26.

Simmonds, M.P., and W.J. Eliott, 2009, "Climate Change and Cetaceans: Concerns and Recent Developments," *Journal of Marine Biological Association of the United Kingdom* 89(1):203–210.

Smith, T., J. Coady, and R. Kacyon, 2008, *Alaska Wildlife Notebook Series: Muskox*, Alaska Department of Fish and Game, Juneau, Alaska. Available at http://www.adfg.alaska.gov/static/education/wns/muskox.pdf. Accessed April 11, 2011.

Sneckenberger, S., 2001, *Factors Influencing Habitat Use by the Alabama Beach Mouse* Peromyscus polionotus ammobates, Master's thesis, Auburn University, Auburn, Ala.

Solf, J.D., and H. Golden, 2008, *Alaska Wildlife Notebook Series: River Otter*, Alaska Department of Fish and Game, Juneau, Alaska. Available at http://www.adfg.alaska.gov/static/education/wns/river_otter.pdf. Accessed April 11, 2011.

Solicitor, 1980, "Clarification of Authorities and Responsibilities for Identifying and Protecting Cultural Resources on the Outer Continental Shelf," memorandum from Office of the Solicitor (U.S. Department of the Interior, Washington, D.C.) to Director (Bureau of Land Management) and Director (U.S. Geological Survey), Nov.

Solomon, S., et al., 2007, "Technical Summary," in *Climate Change 2007: The Physical Science Basis*, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller (eds.), Cambridge University Press, Cambridge, U.K., and New York, N.Y.

Speckman, S.G., J.F. Piattb, C.V. Minte-Veraa, and J.K. Parrisha, 2005, "Parallel Structure among Environmental Gradients and Three Trophic Levels in a Subarctic Estuary," *Progress In Oceanography* 66:25–65.

Spencer, R.F., 1984, "North Alaska Coast Eskimo," pp. 320–337 in *Handbook of North American Indians, Vol. 5 Arctic*, D. Damas (ed.), Smithsonian Institution, Washington, D.C.

SRBA (Stephen R. Braud and Associates), 2010, *Subsistence Mapping of Nuisquit, Kaktovik, and Barrow*, MMS OCS Study No. 2009-003, prepared for the Minerals Management Service, Alaska, by Stephen R. Braud and Associates, Anchorage, Alaska, April.

Staal, P.R., 1985, "Acoustic Effects of Underwater Explosive Discharges," in *Proceedings of Workshop on Effects of Explosives Use in the Marine Environment*, Halifax, Jan. 29–31, Canada Oil and Gas Lands Administration, Environmental Protection Branch, Technical Report No. 5.

Stabile, J., J.R. Waldman, F. Paruka, and I. Wirgin, 1996, "Stock Structure and Homing Fidelity in Gulf of Mexico Sturgeon (*Acipenser oxyrinchus desotoi*) Based on Restriction Fragment Length Polymorphism and Sequence Analysis of Mitochondrial DNA," *Genetics* 144:767–775.

Stacey, P.J., and R.W. Baird, 1991, "Status of the Pacific White-Sided Dolphin (*Lagenorhynchus obliquidens*) in Canada," *Canadian Field-Naturalist* 105(2):219–232.

Stacey, P.J., S. Leatherwood, and R.W. Baird, 1994, "*Pseudorca crassidens*," *Mammalian Species No. 456*:1–6.

Stanley, D.R., and C.A. Wilson, 1997, "Seasonal and Spatial Variation in Abundance and Size Distribution of Fishes Associated with a Petroleum Platform," International Council on the Exploration of the Sea, *Journal of Marine Science* 202:473–475.

Stanley, D.R., and C.A. Wilson, 2000, *Seasonal and Spatial Variation in the Biomass and Size Frequency Distribution of Fish Associated with Oil and Gas Platforms in the Northern Gulf of Mexico*, OCS Study MMS 2000-005, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La.

Stanley, D., and C. Wilson, 1989, "Utilization of Offshore Platforms by Recreational Fishermen and Scuba Divers off the Louisiana Coast," in *Petroleum Structures as Artificial Reefs: A Compendium*, comp. by V.C. Reggio, Jr., Minerals Management Service, Gulf of Mexico OCS Regional Office.

Stedman, S., and T.E. Dahl, 2008, *Status and Trends of Wetlands in the Coastal Watersheds of the Eastern United States 1998 to 2004*. National Oceanic and Atmospheric Administration, National Marine Fisheries Service and U.S. Department of the Interior, Fish and Wildlife Service.

Steinacher, M., F. Joos, T.L. Froelicher, G.K. Plattner, and S.C. Doney, 2009, "Imminent Ocean Acidification in the Arctic Projected with the NCAR Global Coupled Carbon Cycle-Climate Model," *Biogeosciences* 6:515–533.

Steinhauer, M.S., and P.D. Boehm, 1992, "Composition and Distribution of Saturated and Aromatic Hydrocarbons in Nearshore Sediments, River Sediments, and Coastal Peat of the Arctic Beaufort Sea: Implications for Detecting Anthropogenic Hydrocarbon Inputs," *Marine Environmental Research* 33(4):223–253.

Stephenson, S.A., 2005, "The Distribution of Pacific Salmon (*Oncorhynchus* spp.) in the Canadian Western Arctic," *Can. Manuscr. Rep. Fish. Aquat. Sci.* 2737:vi.

Stephenson, B., 2008, *Alaska Wildlife Notebook Series: Arctic Fox*, Alaska Department of Fish and Game, Juneau, Alaska. Available at http://www.adfg.alaska.gov/static/education/wns/arctic_fox.pdf. Accessed April 11, 2011.

Stewart, B.E., and R.E.A. Stewart, 1989, "*Delphinapterus leucas*," *Mammalian Species No. 336*:1–8.

Stirling, I., and W.R. Archibald, 1977, "Aspects of Predation of Seals by Polar Bears," *Journal of Fisheries Research Board of Canada* 34:1126–1129.

Stirling, I., and P.B. Latour, 1978, "Comparative Hunting Abilities of Polar Bear Cubs of Different Ages," *Canadian Journal of Zoology* 56(8):1768–1772.

Stirling, I., and N.J. Lunn, 1997, "Environmental Fluctuations in Arctic Marine Ecosystems as Reflected by Variability in Reproduction of Polar Bears and Ringed Seals," *In:* Woodin, S.J., and M. Marquiss (eds.), *Ecology of Arctic Environments*, Special Publication No. 13 of the British Ecology Society, Blackwell Science Ltd., Oxford, England, pp. 167–181.

Stirling, I., and E. McEwan, 1975, "The Caloric Value of Whole Ringed Seals (*Phoca hispida*) in Relation to Polar Bear (*Ursus maritimus*) Ecology and Hunting Behavior," *Canadian Journal of Zoology* 53:1021–1027.

Stirling, I., N.J. Lunn, and J. Iacozza, 1999, "Long-term Trends in the Population Ecology of Polar Bears in Western Hudson Bay in Relation to Climate Change," *Arctic* 52:294–306.

Stright, M.J., E.M. Lear, and J.F. Bennett, 1999, *Spatial Data Analysis of Artifacts Redeposited by Coastal Erosion: A Case Study of McFaddin Beach, Texas*, OCS Study MMS 99-0068, MMS.

Stroeve, J.C., J. Maslanik, M.C. Serreze, I. Rigor, W. Meier, and C. Fowler, 2011, "Sea Ice Response to an Extreme Negative Phase of the Arctic Oscillation during Winter 2009/2010," *Geophysical Research Letters* 38(2):L02502.

Sulak, K.J., and J.P. Clugston, 1998, "Early Life History Stages of Gulf Sturgeon in the Suwannee River, Florida," *Transactions of the American Fisheries Society* 127:758–771.

SUSIO (State University System of Florida, Institute of Oceanography), 1975, *Compilation and Summation of Historical and Existing Physical Oceanographic Data from the Eastern Gulf of Mexico, Final Report*, Contract 08550-CT4-16, BLM.

SUSIO, 1977, *Baseline Monitoring Studies: Mississippi, Alabama, Florida Outer Continental Shelf, 1975-1976, Volume I: Executive Summary*, Contract 08550-CT5-30, BLM.

Suydam, R.S., 2000, "King Eider (Somateria spectabilis)," Issue 491, *The Birds of North America Online* (A. Poole, ed.), Cornell Lab of Ornithology, Ithaca, New York. Available at http://bna.birds.cornell.edu/bna/species/491. Accessed August 18, 2011.

Suydam, R.S., L.F. Lowry, K.J. Frost, G.M. O'Corry-Crowe, and D. Pikok, Jr., 2001, "Satellite Tracking of Eastern Chukchi Sea Beluga Whales into the Arctic Ocean" *Arctic* 54(3):237–243.

Swilling, W.R., Jr., M.C. Wooten, N. R. Holler, and W. J. Lynn, 1998, "Population Dynamics of Alabama Beach Mice (*Peromyscus polionotus ammobates*) following Hurricane Opal," *American Midland Naturalist* 140:287–298.

Szepanski, M.M., 2007, "Units 25A, 25B, 25D, 26B, and 26C Furbearer," pp. 313–334 in *Furbearer Management, Report of Survey and Inventory Activities*, *1 July 2003–30 June 2006, Project 7.0*, P. Harper (ed.), Alaska Department of Fish and Game, Juneau, Alaska.

Taylor, M., T. Larsen, and R.E. Schweinsburg, 1985, "Observations of Intraspecific Aggression and Cannibalism in Polar Bears (*Ursus maritimus*)," *Arctic* 38:303–309.

Taylor, A.R., R.B. Lanctot, A.N. Powell, F. Huettmann, D.A. Nigro, and S.J. Kendall, 2010, "Distribution and Community Characteristics of Staging Shorebirds on the Northern Coast of Alaska," *Arctic* 63(4): 451–467.

Tesoro Corporation, 2011, *Tesoro Kenai Fact Sheet*. Available at http://www.tsocorp.com/stellent/groups/public/documents/documents/alaskafact.pdf. Accessed July 2011.

Tews, J., M.A.D. Ferguson, and L. Fahrig, 2007, "Potential Net Effects of Climate Change on High Arctic Peary Caribou: Lessons from a Spatially Explicit Simulation Model," *Ecological Modeling* 2007:85–98.

Texas Ornithological Society, 2010, *Accepted Texas Species*. Texas Bird Records Committee, Texas Ornithological Society, Fort Worth, Tex. October 22, 2010.

TFISG (The Federal Interagency Solutions Group, Oil Budget Calculator Science and Engineering Team), 2010, *Oil Budget Calculator, Deepwater Horizon*, Technical Documentation, November.

The McDowell Group, 1990, *An Assessment of the Impact of the Exxon Valdez Oil Spill on The Alaska Tourism Industry*, prepared for Preston, Thorgrimson, Shidler, Gates and Ellis, Seattle, Wash., August. Available at http://www.evostc.state.ak.us/Universal/Documents/Publications/Economic/Econ_Tourism.pdf. Accessed July 15, 2011.

Thieler, E.R., and E.S. Hammar-Klose, 2000, *National Assessment of Coastal Vulnerability to Future Sea-Level Rise: Preliminary Results for the U.S. Gulf of Mexico Coast*, U.S. Geological Survey Open-File Report 00-179.

Thompson, D.C., and K.J. McCourt, 1981, "Seasonal Diets of the Porcupine Caribou Herd," *American Midland Naturalist* 105(1):70–76.

Thompson, M.J., W.W. Schroeder, and N.W. Phillips, 1999, *Ecology of Live Bottom Habitats of the Northeastern Gulf of Mexico: A Community Profile*, USGS/BRD/CR–1999-0001 and OCS Study MMS 99-0004, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La.

Thompson, P.O., W.C. Cummings, and S.J. Ha, 1986, "Sounds, Source Levels, and Associated Behavior of Humpback Whales, Southeast Alaska," *J. Acoust. Soc. Am.* 80(3): 735–740.

Thomsen, F., K. Lüdemann, R. Kafemann, and W. Piper, 2006, *Effects of offshore wind farm noise on marine mammals and fish*, biola, Hamburg, Germany on behalf of COWRIE Ltd, July 6. Available at http://www.offshorewindfarms.co.uk/Assets/BIOLAReport06072006FINAL.pdf. Accessed Sept. 8, 2011.

Thomson, D.H., and W.J. Richardson, 1995, "Marine Mammal Sounds," Chapter 7 in *Marine Mammals and Noise*, Richardson et al. (eds.), Acamdic Press, San Diego, Calif.

Tidwell, M., 2003, *Bayou Farewell: The Rich Life and Tragic Death of Louisiana's Cajun Coast*, Pantheon Books, New York.

Tietsche, S., D. Notz, J.H. Jungclaus, and J. Marotzke, 2011, "Recovery Mechanisms of Arctic Summer Sea Ice," *Geophys. Res. Lett*. 38(2):L02707. doi: 10.1029/2010GL045698.

Titus, J.G., K.E. Anderson, D.R. Cahoon, D.B. Gesch, S.K. Gill, B.T. Gutierrez, E.R. Thieler, and S.J. Williams, 2009, *Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region*, prepared by U.S. Climate Change Science Program and Subcommittee on Global Change Research for U.S. Environmental Protection Agency, Washington, D.C.

Tolbert, C, and M. Sizer, 1996, *U.S. Commuting Zones and Labor Market Areas: A 1990 Update*, U.S. Department of Agriculture: Staff Paper No. AGES-9614.

Tootle, D., C. Tolbert, and E. Shihadeh, 1999, "Sustainable Development in Oil and Gas Country: A Case Study of Abbeville, Louisiana," pp. 228–36 in *Proceedings: Seventeenth Annual Gulf of Mexico Information Transfer Meeting, December 1997*, OCS Study MMS 99-0042, MMS, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La.

Tornfelt 1982 (Section 3.16.2.3)

Tornfelt, E.E., and M. Burwell, 1992, *Shipwrecks of the Alaskan Shelf and Shore: The April 1, 1999 Database*, OCS Study MMS 92-0002, MMS, Alaska OCS Region, Anchorage, Alaska.

Travel Industry Association of America, 2004, *2004 Business Travelers Survey*, National Business Travellers Association/Institute of Business Travel Management, September.

Trefry, J.H., 1981, "A Review of Existing Knowledge on Trace Metals in the Gulf of Mexico," p. 225–259 in *Proceedings of a Symposium on Environmental Research Needs in the Gulf of Mexico (GOMEX*), Vol. II B, NOAA, Environmental Research Laboratory.

Trefry, J.H., R.D. Rember, R.P. Trocie, and J.S. Brown, 2004, *ANIMIDA Task 7 Partitioning of Potential Anthropogenic Chemicals Between Dissolved and Particulate Phases in Arctic Rivers and the Coastal Beaufort Sea*, OCS Study MMS 2004-031, Minerals Management Service, Alaska OCS Region, Anchorage, Alaska.

Trefry, J.H., R.P. Trocine, M.B. Alkire, C.M. Semmler, M. Savoie, R.D. Rember, 2009, cAMINIDA Tasks 3 and 4: Sources, concentrations, composition, partitioning and dispersion pathways for suspended sediments and potential metal contaminants in the coastal Beaufort Sea, OCS Study MMS 2009-014, Minerals Management Service, Alaska OCS Region, Anchorage, Alaska.

Trenberth, K.E., P.D. Jones, P. Ambenje, R. Bojariu, D. Easterling, A. Klein Tank, D. Parker, F. Rahimzadeh, J.A. Renwick, M. Rusticucci, B. Soden, and P. Zhai, 2007, "Observations: Surface and Atmospheric Climate Change," in *Climate Change 2007: The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller (eds.), Cambridge University Press, Cambridge, U.K., and New York, N.Y.

Trowbridge, C.E., W.R. Dunne, M.A. Lambdin, M.M. Byerly, and K.J. Goldman, 2008, *Cook Inlet Area Groundfish Management Report 1996–2004*, Fishery Management Report No. 08-06, Alaska Department of Gish and Game, Anchorage, Alaska.

Tseng, Y.-P., N.R. Wolber, and R.B. Ditton, 2006, *Demographics, Participation, Attitudes, and Management Preferences of Texas Anglers*, Technical Document HD-631, Texas A&M University, Department of Wildlife and Fisheries Sciences, College Station, Texas. Available at http://essm.tamu.edu/people/msorice/ditton/projects/docs/P65.pdf. Accessed September 2, 2011.

Turner, R.E., 2001, "The Effects of Eutrophication on Pelagic and Demersal Marine Food Webs," pp. 371–398 in *Coastal Hypoxia Consequences for Living Resources and Ecosystems,* N.N. Rabalais and R.E. Turner (eds.), *Coastal and Estuarine Studies* 58, American Geophysical Union, Washington, D.C.

Turner, R.E., and D.R. Cahoon, 1988, *Causes of Wetland Loss in the Coastal Central Gulf of Mexico*. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA.

Turner, R.E., E.B. Overton, N.N. Rabalais, and B.K. Sen Gupta (eds.), 2003, *Historical Reconstruction of the Contaminant Loading and Biological Responses in the Central Gulf of Mexico Shelf Sediments*, OCS Study MMS 2003-063, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La.

Twilley, R.R., E.J. Barron, H.L. Gholz, M.A. Harwell, R.L. Miller, D.J. Reed, J.B. Rose, E.H. Siemann, R.G. Wetzel, and R.J. Zimmerman, 2001, *Confronting Climate Change in the Gulf Coast Region: Prospects for Sustaining Our Ecological Heritage*, Union of Concerned Scientists, Cambridge, Mass., and Ecological Society of America, Washington, D.C.

Tynan, C.T., and D.P. DeMaster, 1997, "Observations and Predictions of Arctic Climate Change: Potential Effects on Marine Mammals," *Arctic* 50(4):308–322.

Tynan, C.T., D.P. De Master, and W.P Peterson, 2001, "Endangered Right Whales on the Southeastern Bering Sea Shelf," *Science* 294:1, 894.

United Health Foundation, 2009, *America's Health Rankings 2009: Louisiana*. Available at http://www.dhh.louisiana.gov/offices/publications/pubs-81/American_Health_Rankings_Louisiana.pdf.

University of Alaska, 2011, *Checklist of Alaska Birds*. 17th Edition , 2011. University of Alaska Museum Bird Collection, University of Alaska Fairbanks, Fairbanks, AK.

Urick, R.J., 1971, "The Noise of Melting Icebergs," *J. Acoust. Soc. Am.* 50(1, Part 2):337–341.

Urick, R.J., 1984, *Ambient Noise in the Sea*, Naval Sea Systems Command, Washington, D.C.

USACE (U.S. Army Corps of Engineers), 1999, *Final Environmental Impact Statement. Beaufort Sea Oil and Gas Development/Northstar Project*, U.S. Army Engineer District, Anchorage, Alaska.

USACE, 2010, *Tonnage for Selected U.S. Ports in 2009*, Navigation Data Center, Waterborne Commerce Statistics Center. Available at http://www.ndc.iwr.usace.army.mil//wcsc/portton09.htm. Accessed February 2011.

USCB (U.S. Census Bureau), 2010, *Profile of General Population and Housing Characteristics: 2010. City of Barrow*. Available at http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk.

USCB, 2011a, *2007 Economic Census: Sector 31: EC0731SA1: Manufacturing: Subject Series: Location of Manufacturing Plants: Employment Size for Subsectors and Industries by U.S., State, County and Place: 2007*. Available at http://factfinder.census.gov/servlet/IBQTable?_bm=y&-ds_name=EC0731SA11&-NAICS2007=325110&-ib_type=NAICS2007&-geo_id=04000US01&-geo_id=04000US22&-geo_id=04000US48&-search_results=01000US&-_lang=en. Accessed June 2011.

USCB, 2011b, *State and County Quick Facts*. Available at http://www.census.gov/. Accessed March 2011.

USCB, 2011c, "North Slope Borough" in *State and County Quick Facts*. Available at http://quickfacts.census.gov/qfd/states/02/02185.html. Accessed February 14, 2011.

USCB, 2011d, *Census 2000 Summary File 1 (SF 1) – 100 Percent Data, Minority*. Available at http://www.esri.com/data/download/census2000-tigerline/index.html. Accessed July 18, 2011.

USCB, 2011e, *Census 2000 Summary File 3 (SF 3) – Sample Data, Low-Income.* Available at http://www.esri.com/data/download/census2000-tigerline/index.html. Accessed July 18, 2011.

USCB, 2011f, *2008 County Business Patterns (North American Industry Classification System)*. Last Revised: August 26, 2010. Available at http://www.census.gov/econ/cbp/index.html. Accessed July 15, 2011.

USCB, 2011g, *Census 2000 Summary File 1 (SF 1) 100-Percent Data, Minority.*

USCB, 2011h, *Census 2000 Summary File 3 (SF 3)—Sample Data, Low-Income.*

USCB, 2011i, *Table 1. The Most Populous County Equivalents and Incorporated Places in 2010 in Alaska: 2000 and 2010*. Available at http://2010.census.gov/news/xls/cb11cn83_ak_2010redistr.xls. Accessed September 6, 2011.

U.S. Commission on Ocean Policy, 2004, *An Ocean Blueprint for the 21st Century, Final Report*, Washington, D.C. Available at http://www.oceancommission.gov/documents/full_color_rpt/welcome.html. Accessed May 11, 2011.

U.S. Department of the Navy, 2002, *Draft Environmental Impact Statement (DEIS) for the Introduction of F/A-18 E/F (Super Hornet) Aircraft*, Naval Facilities Engineering Command, Atlantic Division, Norfolk, Va., pp. 3-1, 3-2, 9-1, and 9-2.

U.S. Department of the Navy, 2004, *Environmental Assessment/Overseas Environmental Assessment for East Coast Testing of the Tomahawk Land Attack Missile*, Naval Facilities Engineering Command, Atlantic Division, Norfolk, Va., pp. 3-1 to 3-6.

USDOC (U.S. Department of Commerce), 2011a, *CA25N: Total Employment by Industry, 2008,* Bureau of Economic Analysis, last updated: December 21, 2010.

USDOC, 2011b, *CA06: Compensation by Industry, 2009,* Bureau of Economic Analysis, last updated: December 21, 2010.

USDOE (U.S. Department of Energy), 1997, *Sale of Naval Petroleum Reserve No. 1 (Elk Hills) Kern County, California, Draft Supplemental EIS for the Sale of NPR-1*, DOE/SEIS/PEIR-0158S, Washington, D.C.

USDOI (U.S. Department of the Interior), 2002, *Environmental Impact Statement for the Renewal of the Federal Grant for the Trans-Alaska Pipeline System Right-of-Way (TAPS),* BLM/AK/PT-02/026+2880+990, Argonne National Laboratory, prepared for Bureau of Land Management, Joint Pipeline Office, December.

USDOI and USGS (U.S. Department of the Interior and U.S. Geographical Survey), 1988, "Map of Coastal Erosion and Accretion," *National Atlas of the U.S.A.* Reston, VA.

USDOL (U.S. Department of Labor), 2011, *Local Area Unemployment Statistics, County Data: Labor Force Data by County*, Bureau of Labor Statistics.

USDOT (U.S. Department of Transportation), 2004, *Report on Survey of U.S. Shipbuilding and Repair Facilities 2004,* Maritime Administration, Office of Shipbuilding and Marine Technology, Dec. Available at http://www.marad.dot.gov/documents/2004_-_Report_on_Survey_of_US_Shipbuilding_and_Repair_Facilities.pdf. Accessed June 2011.

USDOT, 2007, *Maritime Trade and Transportation 2007*, Research and Innovative Technology Administration, Bureau of Transportation Statistics. Available at http://www.bts.gov/publications/maritime_trade_and_transportation/2007/pdf/entire.pdf. Accessed September 8, 2011.

USEPA (U.S. Environmental Protection Agency), 1992, Status and Trends of Emergent and Submerged Vegetated Habitats, Gulf of Mexico, U.S.A., U.S. Environmental Protection Agency, Office of Water, Gulf of Mexico Program, Stennis Space Center, MS. EPA 800-R-92-003, September.

USEPA, 2000, *Effluent Guidelines: Environmental Assessment of Final Effluent Limitations Guideline and Standards for Synthetic-Based Drilling Fluids and Other Non-Aqueous Drilling Fluids in the Oil and Gas Extraction Point Source Category*, EPA-821-B-00-014, December.

USEPA, 2001, *National Coastal Condition Report*, EPA-620/R-01/005, Office of Research and Development/Office of Water, Washington, D.C. Available at http://www.epa.gov/owow/oceans/nccr. Accessed February 22, 2011.

USEPA, 2004, *National List of Beaches*, EPA-823-R-04-004.

USEPA, 2005, *Environmental Justice, Basic Information*.

USEPA, 2006, *Level III Ecoregions of the North America* (revision of Omernik 1987), U.S. Environmental Protection Agency National Health and Environmental Effects Research Laboratory, Map M-1. Available at http://www.epa.gov/wed/pages/ecoregions/na_eco.htm. Accessed March 11, 2011.

USEPA, 2008, *National Coastal Condition Report III*, EPA/842-R-08-002, Office of Research and Development/Office of Water, Washington, D.C., Dec. Available at http://water.epa.gov/type/oceb/assessmonitor/downloads.cfm. Accessed February 1, 2011.

USEPA, 2010, *Summary of Water Testing: Hurricanes Katrina and Rita*. Available at http://www.epa.gov/katrina/testresults/water/index.html. Accessed December 13, 2010.

USEPA, 2011a, *National Ambient Air Quality Standards (NAAQS)*. Available at http://www.epa.gov/air/criteria.html, last updated June 3, 2010. Accessed March 29, 2011.

USEPA, 2011b, *The Green Book Nonattainment Areas for Criteria Pollutants*. Available at http://www.epa.gov/oaqps001/greenbk/, last updated Dec. 17, 2010. Accessed March 29, 2011.

USEPA, 2011c, *AirData: Access to Air Pollution Data.* Available at http://www.epa.gov/oar/data/. Accessed April 3, 2011.

USEPA, 2011d, *Comprehensive Conservation and Management Plans*, National Estuary Program. Available at http://water.epa.gov/type/oceb/nep/ccmp_index.cfm. Accessed January 5, 2011.

USEPA, 2011e, *Level III Ecoregions of the Continental United States*, National Health and Environmental Effects Research Laboratory, Revised January.

USEPA, 2011f, *EPA Response to BP Spill in the Gulf of Mexico*. Available at http://www.epa.gov/bpspill/index.html.

USEPA, 2011g, *Basic Information – Contaminated Sediments in Water*, Available at http://water.epa.gov/polwaste/sediments/cs/aboutcs.cfm. Accessed August 30, 2011.

U.S. Fleet Forces, 2010, *Gulf of Mexico Range Complex Final Environmental Impact Statement/Overseas Environmental Impact Statement, Vol. 1.* Available at http://gomexrangecomplexeis.com/Documents/GOMEX_Range_Complex_Final_EIS_OEIS_Vol_1.pdf. Accessed May 10, 2011.

USFWS (U.S. Fish and Wildlife Service), 1978, *Catalogue of Alaskan Seabird Colonies*. U.S. Fish and Wildlife Service Biological Services Program. FWS/OBS-78/78. Department of the Interior, U.S. Fish and Wildlife Service, Washington, D.C.

USFWS, 1987, *Recovery Plan for the Choctawhatchee, Perdido Key and Alabama Beach Mouse*, U.S. Department of the Interior, Southeast Region, Atlanta, Ga.

USFWS, 1991a, "Endangered and Threatened Wildlife and Plants; Endangered Status for the Florida Salt Marsh Vole," *Federal Register* 56(9):1457–1459.

USFWS, 1991b, *Mississippi Sandhill Crane* Grus candensis pulla *Recovery Plan*. Third revision, September 6, 1991. U.S. Fish and Wildlife Service, Southeast Region, Atlanta, Ga.

USFWS, 1994, *Conservation Plan for the Polar Bear in Alaska*, U.S. Department of the Interior, Marine Mammal Management, Anchorage, Alaska, June. Available at http://alaska.fws.gov/fisheries/mmm/polarbear/pdf/THEFINALplan.pdf. Accessed May 16, 2011.

USFWS, 1996, *Spectacled Eider Recovery Plan*, U.S. Fish and Wildlife Service, Anchorage, Alaska.

USFWS, 1997, *Recovery Plan for the Florida Salt Mouse Vole*, U.S. Department of the Interior, Southeast Region, Atlanta, Ga.

USFWS, 1999, *Guide to Management of Alaska's Land Mammals*, U.S. Department of the Interior, Office of Subsistence Management, Anchorage, Alaska.

USFWS, 2001a, *Candidate Species, Section 4 of the Endangered Species Act*. U.S. Fish and Wildlife Service, Endangered Species Program, Arlington, Va. Available at http://www.fws.gov/endangered/esa-library/pdf/candidate_species.pdf. Accessed July 7, 2011.

USFWS, 2001b, Leatherback Sea Turtle (*Dermochelys coriacea*) Fact Sheet. Available at http://www.fws.gov/northflorida/SeaTurtles/Turtle%20Factsheets/PDF/Leatherback-Sea-Turtle.pdf. Accessed September 2, 2011.

USFWS, 2002, *Steller's Eider Recovery Plan*. U.S. Department of the Interior, U.S. Fish and Wildlife Service, Fairbanks, AK.

USFWS, 2004, *Perdido Key Beach Mouse Final Translocation Report*, U.S. Department of the Interior, Panama City Ecological Services Field Office, Panama City, Fla., July.

USFWS, 2006a, "Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for the Perdido Key Beach Mouse, Choctawhatchee Beach Mouse, and St. Andrew Beach Mouse," *Federal Register* 71(197):60238–60370.

USFWS, 2006b, "Endangered and Threatened Wildlife and Plants; Special Rule for the Southwest Alaska Distinct Population Segment of the Northern Sea Otter," *Federal Register* 71(157):46864–46870.

USFWS, 2006c, *Impacts of Hurricanes Katrina and Rita on the U.S. Fish and Wildlife Service and Its Trust Resources, Bell City, LA: Southwest Louisiana National Wildlife Refuge Complex*. Available at http://www.fws.gov/swlarefugecomplex/pdf/Impact.pdf. Accessed June 30, 2011.

USFWS, 2006d, *Kittlitz's Murrelet* Brachyramphus brevirostris. Alaska Seabird Information Series, U.S. Department of the Interior, U.S. Fish and Wildlife Service, Anchorage, AK.

USFWS, 2006e, *Short-tailed Shearwater* Puffinus tenuirostris, Alaska Seabird Information Series, U.S. Fish and Wildlife Service, Anchorage, Alaska.

USFWS, 2007a, *West Indian Manatee* (Trichechus manatus) *5-Year Review: Summary and Evaluation*, U.S. Department of the Interior, Southeast Region, Jacksonville, Fla., and Caribbean Field Office, Boqueron, Puerto Rico. Available at http://www.fws.gov/northflorida/Manatee/2007%205-yr%20Review/2007-Manatee-5-Year-Review-Final-color-signed.pdf. Accessed Aug. 31, 2009.

USFWS, 2007b, "Endangered and Threatened Wildlife and Plants: Designation of Critical Habitat for the Alabama Beach Mouse," *Federal Register* 72(19):4330–4369.

USFWS, 2007c, "Endangered and Threatened Wildlife and Plants; Reclassification of the American Crocodile Distinct Population Segment in Florida From Endangered to Threatened," *Federal Register* 72: 13027-13041.

USFWS, 2008a, *Florida Salt Marsh Vole* (Microtus pennsylvanicus dukecampbelli) *5-Year Review: Summary and Evaluation*, U.S. Department of the Interior, Southeast Region, Jacksonville Ecological Services Field Office, Jacksonville, Fla.

USFWS, 2008b, "Endangered and Threatened Wildlife and Plants; Determination of Threatened Status for the Polar Bear (*Ursus maritimus*) throughout Its Range," *Federal Register* 73(95):28212–28303.

USFWS, 2008c, *Short-Tailed Albatross Recovery Plan*. U.S. Department of the Interior, U.S. Fish and Wildlife Service, Anchorage, AK.

USFWS, 2009a, *U.S. Fish and Wildlife Service Species Profile: West Indian Manatee* (Trichechus manatus). Available at http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=A007. Accessed May 27, 2009.

USFWS, 2009b, *Alabama Beach Mouse* (Peromyscus polionotus ammobates, *Bowen 1968) 5-Year Review: Summary and Evaluation*, U.S. Department of the Interior, Southeast Region, Alabama Ecological Services Field Office, Daphne, Ala.

USFWS, 2009c, *St. Andrew Beach Mouse* (Peromyscus polionotus peninsularis) *5-Year Review: Summary and Evaluation*, U.S. Department of the Interior, Southeast Region, Panama City Field Office, Panama City, Fla.

USFWS, 2009d, "Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for the Southwest Alaska Distinct Population Segment of the Northern Sea Otter," *Federal Register* 74(194):51988–52012.

USFWS, 2009e, *Pacific Walrus* Odobenus rosemarus divergens, Fact Sheet, U.S. Department of the Interior, Alaska Region, Anchorage, Alaska, Aug. Available at http://alaska.fws.gov/fisheries/mmm/walrus/pdf/Walrus_FS.pdf. Accessed March 15, 2011.

USFWS, 2009f, *Polar Bears and Humans Safety Guidelines*, U.S. Fish and Wildlife Service, Marine Mammals Management Office, Anchorage, Alaska, March. Available at http://www.polarbearsinternational.org/sites/default/files/pdf/polar-bears-humans.pdf. Accessed March 15, 2011.

USFWS, 2010a, *St. Andrew Beach Mouse Recovery Plan* (Peromyscus polionotus peninsularis), U.S. Department of the Interior, Southeast Region, Atlanta, Ga.

USFWS, 2010b, "Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for the Polar Bear (*Ursus maritimus*) in the United States," *Federal Register* 75(234):76086–76137.

USFWS, 2010c, *Southwest Alaska Distinct Population Segment if the Northern Sea Otter (Enhydra lutris kenyoni) – Draft Recovery Plan,* U.S. Fish and Wildlife Service, Region 7, Alaska. Available at http://alaska.fws.gov/fisheries/mmm/seaotters/pdf/draft_sea_otter_recovery_plan_small_file.pdf. Accessed March 15, 2011.

USFWS, 2011a, "Endangered and Threatened Wildlife and Plants; 12-Month Finding on a Petition to List the Pacific Walrus as Endangered or Threatened," *Federal Register* 76(28):7634–7679.

USFWS, 2011b, *Pacific Walrus Range*, Map, U.S. Department of the Interior, Alaska Region, Marine Mammals Management, Anchorage, Alaska. Available at http://alaska.fws.gov/fisheries/mmm/walrus/pdf/walrus_range_map.pdf. Accessed March 15, 2011.

USFWS, 2011c, *Interior Clears the Way for Return of Whooping Cranes to Louisiana, Reintroduction of Cranes Expected Later This Month*. News Release, U.S. Fish and Wildlife Service, Southeast Region, February 9, 2011. Available at www.fws.gov/southeast/news/2011/11-02-012.html.

USFWS, 2011d, *Environmental Conservation Online System (ECOS), Species Reports*. Available at http://ecos.fws.gov/tess_public. Accessed March 31, 2011.

USFWS, 2011e, *FWS Deepwater Horizon Spill Response*. U.S. Fish and Wildlife Service. U.S. Department of the Interior. Available at http://www.fws.gov/home/dhoilspill. Accessed July 5, 2011.

USFWS and Gulf States Marine Fisheries Commission, 1995, *Gulf Sturgeon Recovery Plan,* Atlanta, Ga.

USFWS and NMFS (U.S. Fish and Wildlife Service and National Marine Fisheries Service), 1994, "Endangered and Threatened Wildlife and Plants; Final Rule to Remove the Eastern North Pacific Population of the Gray Whale from the List of Endangered Wildlife," *Federal Register* 59(115):31094–31095.

USFWS and NMFS, 2009, *Gulf sturgeon (*Acipenser oxyrinchus desotoi*) 5-Year Review: Summary and Evaluation*, U.S. Fish and Wildlife Service Southeast Region Panama City Ecological Services Field Office and National Marine Fisheries Service Southeast Region Office of Protected Resources.

USGCRP (U.S. Global Change Research Program), 2009, *Global Climate Change Impacts in the United States*, T.R. Karl, J.M. Melillo, and T.C. Peterson (eds.), Cambridge University Press. Available at http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf. Accessed July 5, 2011.

USGS (U.S. Geological Survey), 1988, "Map of Coastal Erosion and Accretion," *National Atlas of the U.S.A.* Reston, VA.

USGS, 2001b, *Wetland Subsidence, Fault Reactivation, and Hydrocarbon Production in the U.S. Gulf Coast Region*. USGS Fact Sheet FS-091-01. September.

USGS, 2003, *100+ Years of Land Change for Coastal Louisiana*, prepared for USGS National Wetlands Research Center, Lafayete, Louisiana, Map ID: USGS-NWRC 2003-03-085.

USGS, 2005, *Migratory Bird Pathways and the Gulf of Mexico*. Fact Sheet 2005-3069. National Wetland Research Center, U.S. Geological Survey, U.S. Department of the Interior, Lafayette, La. June.

USGS, 2008, *Characterization of Northern Gulf of Mexico Deepwater Hard Bottom Communities with Emphasis on Lophelia Coral-Lophelia Reef Megafaunal Community Structure, Biotopes, Genetics, Microbial Ecology, and Geology*, K.J. Sulak, M.T. Randall, K.E. Luke, A.D. Norem, and J.M. Miller (eds.), USGS Open-File Report 2008-1148 and OCS Study MMS 2008-015, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La., April 15.

Valentine, D.L., J.D. Kessler, M.C. Redmond, S.D. Mendes, M.B. Heintz, C. Farwell, L. Hu, F.S. Kinnaman, S. Yvon-Lewis, M. Du, E.W. Chan, F. Garcia Tigreros, and C. J. Villanueva, 2010, "Propane Respiration Jump-Starts Microbial Response to a Deep Oil Spill," *Science,* 330:208–211.

Valkenburg, P., and S. Arthur, 2008, *Alaska Wildlife Notebook Series: Caribou*, Alaska Department of Fish and Game, Juneau, Alaska. Available at http://www.adfg.alaska.gov/static/education/wns/caribou.pdf. Accessed April 11, 2011.

van Beek, J.L., and K.J. Meyer-Arendt (eds.), 1982, *Louisiana's Eroding Coastline: Recommendations for Protection*. Prepared for Coastal Management Section, Louisiana Department of Natural Resources, Baton Rouge, LA.

Van Daele, L.J., 2007a, "Unit 8 Brown Bear," pp. 75–108 in *Brown Bear Management Report of Survey and Inventory Activities 1 July 2004–30 June 2006,* P. Harper (ed.), Alaska Department of Fish and Game, Juneau, Alaska.

Van Daele, L.J., 2007b, *Population Dynamics and Management of Brown Bears on Kodiak Island, Alaska*, Ph.D. dissertation, University of Idaho College of Graduate Studies, Boise, Idaho, Feb. Available at http://www.adfg.alaska.gov/static/home/library/pdfs/wildlife/propubs/vandaele_dissertation.pdf. Accessed March 5, 2011.

Van Daele, L., 2011, *Kodiak Bear Fact Sheet*, Alaska Department of Fish and Game, Juneau, Alaska. Available at http://www.adfg.alaska.gov/index.cfm?adfg=brownbear.trivia. Accessed May 9, 2011.

Van Daele, L.J., and J.R. Crye, 2007, "Unit 8 Furbearer," pp. 97–106 in *Furbearer Management Report of Survey and Inventory Activities 1 July 2003–30 June 2006, Project 7.0,* P. Harper (ed.), Alaska Department of Fish and Game, Juneau, Alaska.

Van Daele, L.J., and J.R. Crye, 2009, "Unit 8 Deer Management Report," pp. 96–112 in *Deer Management Report of Survey and Inventory Activities 1 July 2006–30 June 2008,* P. Harper (ed.), Alaska Department of Fish and Game, Juneau, Alaska.

Veil, J.A., T.A. Kimmell, and A.C. Rechner, 2005, *Characteristics of Produced Water Discharged to the Gulf of Mexico Hypoxic Zone,* Argonne National Laboratory, Argonne, Ill. Available at http://www.evs.anl.gov/pub/doc/ANL-hypoxia-report.pdf. Accessed May 11, 2011.

Viereck, L.A., C.T. Dyrness, A.R. Batten, and K.J. Wenzlick, 1992, The Alaska Vegetation Classification, General Technical Report PNW-GTR-286, USDOA, Pacific Northwest Research Station.

Vors, L.S., and M.S. Boyce, 2009, "Global Declines of Caribou and Reindeer," *Global Change Biology* 15:2626–2633.

Vu, L., M.J. Vanlandingham, M. Do, and C.L. Bankston III, 2009, "Evacuation and Return of Vietnamese New Orleanians Affected by Hurricane Katrina," *Organ Environment* 22: 422–436.

Wade, P.R., A. De Robertis, K.R. Hough, R. Booth, A. Kennedy, R.G. LeDuc, L. Munger, J. Napp, K.E.W. Shelden, S. Rankin, O. Vasquez, and C. Wilson, 2011, "Rare Detections of North Pacific Right Whales in the Gulf of Alaska, with Observations of Their Potential Prey," *Endangered Species Research* 13:99–109.

Walker, N.D., R.R. Leben, and S. Balasubramanian, 2005, "Hurricane-Forced Upwelling and Chlorophyll *a* Enhancement within Cold-Core Cyclones in the Gulf of Mexico," *Geophysical Research Letters* 32:L18610.

Walther, G., E. Post, P. Convey, A. Menzel, C. Parmesan, T.J.C. Beebee, J. Fromentin, O. Hoegh-Guldberg, and F. Bairlein, 2002, "Ecological Responses to Recent Climate Change," *Nature* 416:389–395.

Wallace, R.K., 1996, *Coastal Wetlands in Alabama*, Circular ANR-831, MASGP-96-018, Auburn University, Marine Extension and Research Center, Mobile, AL.

Wang, J., G.F. Cota, J.C. Comiso, 2005, "Phytoplankton in the Beaufort and Chukchi Seas: Distribution, Dynamics, and Environmental Forcing," *Deep-Sea Research Part II* 52:24–26.

Waring, G.T., E. Josephson, K. Maze-Foley, and P.E. Rosel (eds.), 2010, *U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments — 2010,* NOAA Tech Memo NMFS-NE 213, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Science Center, Dec. Available at http://www.nefsc.noaa.gov/publications/tm/tm219. Accessed July 29, 2011.

Wassmann, P., C.M. Duarte, S. Augusti, and M.K. Sejr, 2011, "Footprints of Climate Change in the Arctic Marine Ecosystem," *Global Change Biology* 17:1235–1249.

Waters, M.R., S.L. Forman, T.A. Jennings, L.C. Nordt, S.G. Driese, J.M. Feinberg, J.L. Keene, J. Halligan, A. Lindquist, J. Pierson, C.T. Hallmark, M.B. Collins, and J.E. Wiederhold, 2011, "The Buttermilk Creek Complex and the Origins of Clovis at the Debra L. Friedkin Site, Texas," *Science* 331:1599.

Watkins, W.A. 1981, "Activities and Underwater Sounds of Fin Whales," *Sci. Rep. Whales Res. Inst.* 33: 83–117.

Watkins, W.A., P. Tyack, K.E. Moore, and J.E. Bird, 1987, "The 20-Hz Signals of Finback Whales *(Balaenoptera physalus)*," *J. Acoust. Soc. Am.* 82(6): 1901–1912.

Watts, A.J. (ed.), 1994, *Jane's Underwater Warfare Systems 1994-95*, 6th ed., Jane's Information Group Inc., Surrey, U.K.

Watwood, S.L., P.J.O. Miller, M. Johnson, P.T. Madsen, and P.L. Tyack, 2006, "Deep-Diving Foraging Behavior of Sperm Whales (*Physeter macrocephalus*)," *Journal of Animal Ecology* 75:814–825.

Wawrik, B., and J.H. Paul, 2004, "Phytoplankton Community Structure and Productivity along the Axis of the Mississippi River Plume in Oligotrophic Gulf of Mexico Waters," *Marine Ecology Progress Series* 35:185–196.

Wei, C., G. Rowe, G. Hubbard, A. Scheltema, G. Wilson, I. Petrescu, J. Foster, M. Wicksten, M. Chen, R. Davenport, Y. Soliman, and Y. Wang, 2010, "Bathymetric Zonation of Deep-Sea Macrofauna in Relation to Export of Surface Phytoplankton Production," *Marine Ecology Progress Series* 399:1–14.

Weladji, R.B., D.R. Klein, Ø. Holand, and A. Mysterud, 2002, "Comparative Response of Rangifer tarandus and Other Northern Ungulates to Climate variability," *Rangifer* 22(1):29–46.

Wenz, G.M., 1962, "Acoustic Ambient Noise in the Ocean: Spectra and Sources," *J. Acoust. Soc. Am.* 34(12):1936–1956.

Węsławski, J., M. Kendall, M. Włodarska-Kowalczuk, K. Iken, M. Kędra, J. Legezynska, and M. Sejr, 2011, "Climate Change Effects on Arctic Fjord and Coastal Macrobenthic Diversity — Observations and Predictions," *Marine Biodiversity* 41:71–85.

White, W.A., T.R. Calnan, R.A. Morton, R.S. Kimble, T.G. Littleton, J.H. McGowen, H.S. Nance, and K.E. Schmedes, 1986, *Submerged Lands of Texas, Brownsville-Harlingen Area*. University of Texas, Bureau of Economic Geology, Austin , TX.

Whitten, K.R.,1990, *Movement Patterns of the Porcupine Caribou Herd in Relation to Oil Development*, Federal Aid in Wildlife Restoration Progress Report, Project W-232 Study 3.34, Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau, Alaska.

Whitten, K.R., and R.D. Cameron, 1980, "Nutrient Dynamics of Caribou Forage on Alaska's Arctic Slope, pp. 159–166 in *Proceedings of the Second International Reindeer/Caribou Symposium, Roros, Norway.*

Wilcox, W.J., II, and C.F. Cahill, 2003, "Regional Haze Trends in Alaska: Implications for Protected Class I Visibility Areas," *Environmental Manager* Dec. 2003:34–39.

Wilkinson, T.E., J. Bezaury-Creel, T. Hourigan, T. Agardy, H. Herrmann, L. Janishevski, C. Madden, L. Morgan, and M. Padilla, 2009, *Marine Ecoregions of North America*, Commission for Environmental Cooperation, Montreal, Canada. Available at http://www.cec.org/Page.asp?PageID=924&ContentID=2715. Accessed March 11, 2011.

Wille, P.C., and D. Geyer, 1984, "Measurements on the Origin of the Wind-Dependent Ambient Noise Variability in Shallow Water," *J. Acoust. Soc. Am.* 75(1):173–185.

Williams, K., Z.S. Pinzon, R.P. Stumpf, and E.A. Raabe, 1999, *Sea-Level Rise and Coastal Forests on the Gulf of Mexico*, Open-File Report 99-441, U.S. Geological Survey.

William, R., S. Gero, L. Bejder, J. Calambokidis, S.D. Kraus, D. Lusseau, A.J. Read, and J. Robbins, 2011, "Underestimating the Damage: Interpreting Cetacean Carcass Recoveries in the Context of the *Deepwater Horizon*/BP Incident," *Conservation Letters* 4(3):228–233.

Willms, M.A., 1992, *Checklist to the Birds of the Arctic National Wildlife Refuge, Alaska*, Version 22, May 1998, U.S. Fish and Wildlife Service, Northern Prairie Wildlife Research Center, Jamestown, North Dakota. Available at http://www.npwrc.usgs.gov/resource/birds/chekbird/r7/arcticwr.htm. Accessed August 18, 2011.

Wilson, M.T., 2009, "Ecology of Small Neritic Fishes in the Western Gulf of Alaska. I. Geographic Distribution in Relation to Prey Density and the Physical Environment," *Marine Ecology Progress Series* 392:223–237.

Wilson, S.G., and T.R. Fischetti, 2010, *Coastline Population Trends in the United States: 1960 to 2008, Population Estimates and Projections, Current Population Reports*. Available at http://www.census.gov/prod/2010pubs/p25-1139.pdf. Accessed September 8, 2011.

Winn, H.E., and N.E. Reichley, 1985, "Humpback Whale — *Megaptera novaeangliae,"* pp. 241–274.in *Handbook of Marine Mammals, Vol. 3. The Sirenians and Baleen Whales,* S.H. Ridgway and R. Harrison (eds.), Academic Press, Inc., London, England.

Witzig, J., 1986, "Fishing in the Gulf of Mexico: 1984 Marine Recreational Fishing Results," pp. 103–105 in *Proceedings, Sixth Annual Gulf of Mexico Information Transfer Meeting*, New Orleans. OCS Study MMS86-0073, Minerals Management Service, Gulf of Mexico OCS Reg., New Orleans.

Woodward-Clyde Consultants and Continental Shelf Associates, Inc., 1983, *Southwest Florida Shelf Ecosystem Study – Year 1.* Contract No. 14-12-0001 – 29142, Minerals Management Service, Metairie, La.

WRCC (Western Regional Climate Center), 2011, *Western U.S. Climate Historical Summaries*. Available at http://www.wrcc.dri.edu/Climsum.html. Accessed June 1, 2011.

Wright, F.F., G.D. Sharma, and D.C. Burbank, 1973, "ERTS-1 Observations of Sea Surface Circulation and Sediment Transport, Cook Inlet, Alaska," in *Proceedings of a Symposium on Significant Results Obtained from the Earth Resources Technology Satellite-1*, New Carrolton, Md., NASA, Washington, D.C., March 5–9.

Würsig, B., T.A. Jefferson, and D.J. Schmidly, 2000, *The Marine Mammals of the Gulf of Mexico*, Texas A&M Press, College Station, Texas.

Xing, C., F. Marchetti, and G. Li, 2010, "Benzene Exposure near the U.S. Permissible Limit is Associated with Sperm Aneuploidy," *Environmental Health Perspectives* 118: 833–839.

Xu, Y., M.C. Ross, R. Ryan, and B. Wang, 2005, "Cancer Risk Factors among Southeast Asian American Residents of the U.S. Central Gulf Coast," *Public Health Nursing* 22: 119–129.

Yanez-Arancibia, S., and J. Day, 2004, "Environmental Sub-regions in the Gulf of Mexico Coastal Zone: The Ecosystem Approach as an Integrated Management Tool," *Ocean and Coastal Management* 47(11-12):727–757.

Yeoman, B., 2010, "These Men Don't Cry: Hard Times for Gulf Coast Vietnamese," *OnEarth Magazine*, Dec. 1. Available at http://www.onearth.org/article/these-men-dont-cry-hard-times-for-gulf-coast-vietnamese. Accessed June 17, 2011.

Yochem, P.K., and S. Leatherwood, 1985, "Blue Whale — *Balaenoptera musculus* (Linnaeus, 1758)," pp. 193–240 in *Handbook of Marine Mammals. Volume 3: The Sirenians and Baleen Whales,* S. Ridgway and R. Harrison (eds.), Academic Press, London, England, and Orlando, Fla.

Ytrehus, B., T. Bretten, B. Bergsjø, and K. Isaksen, 2008, "Fatal Pneumonia Epizootic in Musk Ox (*Ovibos moschatus*) in a Period of Extraordinary Weather Conditions," *EcoHealth* 5:213–223.

Yun, K., N. Lurie, and P.S. Hyde, 2010, "Moving Mental Health into the Disaster-Preparedness Spotlight," *New England Journal of Medicine* 363: 1193–1195.

Yvon-Lewis, S.A., L. Hu, and J.D. Kessler, 2011, "Methane Flux to the Atmosphere from the Deepwater Horizon Oil Disaster," *Geophys. Res. Lett.* 38:L01602.

Zavala-Hidalgo, J., A. Gallegos-García, B. Martínez-López, S.L. Morey, and J.J. O'Brien, 2006, "Seasonal Upwelling on the Western and Southern Shelves of the Gulf of Mexico," *Ocean Dynamics* 56:333–338.

Zellen, B.S., 2008, *Breaking the Ice: From Land Claims to Tribal Sovereignty in the Arctic*, Lexington Books, New York.

Zhang, J., M. Steele, and A. Schweiger, 2010, "Arctic Sea Ice Response to Atmospheric Forcings with Varying Levels of Anthropogenic Warming and Climate Variability," *Geophys. Res. Lett.* 37(20):L20505; ISSN: 0094-8276.

Zimmerman, S.T., and L. Jemison, 2008, *Alaska Wildlife Notebook Series: Northern Fur Seal*, Alaska Department of Fish and Game, Juneau, Alaska. Available at http://www.adfg.alaska.gov/static/education/wns/northern_fur_seal.pdf. Accessed April 11, 2011.

Zimmerman, S.T., and S.A. Karpovich, 2008, *Alaska Wildlife Notebook Series: Humpback Whale*, Alaska Department of Fish and Game, Juneau, Alaska. Available at http://www.adfg.alaska.gov/static/education/wns/humpback_whale.pdf. Accessed April 11, 2011.

Zimmerman, S.T., and M.J. Rehberg, 2008, *Alaska Wildlife Notebook Series: Steller Sea Lion*, Alaska Department of Fish and Game, Juneau, Alaska. Available at http://www.adfg.alaska.gov/static/education/wns/steller_sea_lion.pdf. Accessed April 11, 2011.

Zimmerman, S., and B. Small, 2008, *Alaska Wildlife Notebook Series: Orca*, Alaska Department of Fish and Game, Juneau, Alaska. Available at http://www.adfg.alaska.gov/static/education/wns/orca.pdf. Accessed April 11, 2011.

This page intentionally left blank.

4 ENVIRONMENTAL CONSEQUENCES

4.1 ENVIRONMENTAL CONSEQUENCES ASSOCIATED WITH OCS OIL AND GAS ACTIVITIES

This programmatic environmental impact statement (PEIS) evaluates 8 alternatives, including no action (see Chapter 2). All of the action alternatives identify Outer Continental Shelf (OCS) Planning Areas in the Gulf of Mexico (GOM), Cook Inlet, and the Arctic where lease sales may occur under the 2012-2017 OCS Oil and Gas Leasing Program (the Program). Chapter 3 of this PEIS describes the nature and condition of natural and socioeconomic resources that have a potential to be affected by oil and gas (O&G) activities within those OCS Planning Areas under the Program. In general, O&G development follows a four-phase process, beginning with (1) exploration to locate viable deposits, (2) development of the production well and support infrastructure, (3) operation (oil or gas production), and (4) decommissioning of the well once it is no longer productive or profitable.

Since lease- and project-specific details are not known at this time, the analyses in this PEIS take a programmatic approach and evaluate resources on a larger, more regional scale rather than at a lease-block scale (the scale at which project-specific impacts could occur). The evaluation of environmental consequences presented in this PEIS focuses on those resources most likely to be affected during future O&G development under each of the alternatives considered in this PEIS. Some information is currently unavailable, particularly with regard to affected environment baseline changes; however, this information is not essential in order to make a reasoned choice among alternatives at this programmatic stage (see Section 1.3.1.1: Incomplete and Unavailable Information). Exploration and development scenarios have been prepared that identify potential levels of O&G development that may occur as a result of lease sales in the GOM, the Cook Inlet, and the Chukchi and Beaufort Sea Planning Areas under the Program. These scenarios are presented for each alternative later in this chapter and are used for the programmatic impact analyses of this PEIS. More detailed, location-specific impact analyses would be conducted in subsequent lease sale-specific National Environmental Policy Act (NEPA) analyses.

The programmatic evaluation of environmental or socioeconomic impacts presented in this PEIS provides useful information for considering the effects of O&G development on the resources of the OCS (and associated coastal environments) under each alternative. The programmatic analyses identify the types of activities that typically occur during exploration, development, production, and decommissioning; the resources that could be affected by those activities; and the nature and relative magnitude of effects those resources could incur.

4.1.1 Routine Operations and Common Impact-Producing Factors

Impacts from OCS O&G development originate from the specific activities that occur following OCS leasing, and both activities and impacts will vary by the phase of O&G development. Each phase will have a set of impact-producing factors (some unique to a particular phase) that represent O&G development activities that produce physical or environmental conditions that may affect one or more natural, cultural, or socioeconomic resources, and these may vary within each phase depending on the specific activity. For example, an impact-producing factor associated with exploration is noise, which will differ in its nature, magnitude, and duration depending on how it is generated. Noise generated by seismic survey equipment will differ in magnitude, frequency, and duration from noise generated during exploration well drilling or by ship traffic. The resources that could be affected by noise and the nature and magnitude of potential effects will also vary, depending on the source and characteristics of the noise (duration, frequency, magnitude) that is generated.

The nature, magnitude, and duration of each impact-producing factor (and any subsequent environmental effects) will also vary among the four phases of O&G development. For example, noise generated by seismic survey equipment will be relatively short term in duration but very high in magnitude, and will cease once the survey portion of the exploration phase is completed. Similarly, noise from the explosive removal of a platform during the decommissioning phase would be of very short-term duration (effectively a one-time event). In contrast, noise from ship and helicopter traffic that supports production platforms could be generated for 20 years or more, depending on the production lifespan of the platform. Table 4.1.1-1 presents the major categories of impact-producing factors associated with O&G development on the OCS. It is important to note that many impact-producing factors can be associated with multiple O&G development phases, and can be subject to mitigation measures to help reduce impacts.

The following discussions summarize the general types of activities that may be expected during each of the four O&G development phases and identify likely impact-producing factors for each phase. These impact-producing factors, the resources that each may affect, and the nature, magnitude, and duration of possible effects are discussed in more detail in the resource-specific impact sections presented later in this chapter.

4.1.1.1 Exploration

During exploration, typical activities include the conduct of geophysical seismic surveys and possibly the development of exploration wells. During seismic surveys, one or more air guns (or other sound sources) are towed behind a ship at depths of 5–10 m (16–33 ft) and produce acoustic energy pulses that are directed towards the seafloor. The acoustic signals then reflect off subsurface sedimentary boundaries and are recorded by hydrophones, which are typically also towed behind the survey ship. Following analysis of the acoustic data, one or more exploratory wells may be drilled to confirm the presence and determine the viability of the potential hydrocarbon reservoirs identified by the survey. Development of an exploration well typically involves the use of a mobile offshore drilling unit (MODU) (such as a jackup rig, a semisubmersible rig, or drillship) and the placement of infrastructure (such as a drilling template and a blowout preventer) on the seafloor to aid in the drilling. Both the seismic surveys and exploration well development involve the use of ships, whether to tow air guns and hydrophones or to bring drilling equipment and other support materials to the well location.

TABLE 4.1.1-1 Impact-Producing Factors Associated with OCS O&G Development Phases

	O&G Development Phase				
	Exploration				
Impact-Producing Factor	Seismic Survey	Exploration Well	Development	Operation	Decommissioning
Noise	X	X	X	X	X
Seismic noise	X				
Ship noise	X	X	X	X	X
Aircraft noise	X	X	X	X	X
Drilling noise		X	X		
Trenching noise			X		
Production noise				X	
Onshore construction			X		
Platform removal					X
Traffic	X	X	X	X	X
Aircraft traffic		X	X	X	X
Ship traffic	X	X	X	X	X
Drilling Mud/Debris		*X*	*X*		
Bottom/Land Disturbance		X	X		
Drilling		X	X		
Pipeline trenching			X		
Onshore construction			X		
Air Emissions		X	X	X	X
Offshore		X	X	X	X
Onshore			X	X	X
Explosives					X
Platform removal					X
Lighting		X	X	X	
Offshore facilities		X	X	X	
Onshore facilities			X	X	
Visible Infrastructure		X	X	X	
Offshore		X	X	X	
Onshore			X	X	
Space Use Conflicts	X	X	X	X	
Offshore facilities	X	X	X	X	
Onshore facilities			X	X	
Accidental Spills		X	X	X	

Impact-producing factors associated with exploration include noise, ship traffic, drilling mud and debris, seafloor disturbance, air emissions, lighting, visible infrastructure, and space use conflicts (Table 4.1.1-1). Noise will be generated by operating air gun arrays, vessel traffic, drilling, and support aircraft traffic. Resources of primary concern from noise impacts are marine mammals, sea turtles, and fish.

Ship traffic during the seismic surveys or in support of exploration well development has the potential for collisions with marine mammals and sea turtles, while the presence of ship and support aircraft traffic could affect normal behaviors of nearby biota (especially marine mammals). The disposal of drilling mud and debris during exploration well development will also affect local water quality and possibly biota.

Exploration well development will involve seafloor disturbance, primarily through the placement of drilling support infrastructure. This disturbance may affect overlying water quality as well as benthic biota and archeological resources (if present). Air emissions from the MODUs may affect local air quality, while MODU lighting may affect birds. Depending on location, MODUs may also present a visual impact. The conduct of seismic surveys and exploration well development could conflict with other uses of the marine environment at that location.

4.1.1.2 Development

Once exploration has confirmed the presence of a commercially viable reservoir, the next phase of O&G development is the construction of the production platform and drilling of production wells. Production wells are drilled using MODUs, and the type of production platform installed will depend on the water depth of the site and, to a lesser extent, on the expected facility lifecycle, the type and quantity of hydrocarbon product (e.g., oil or gas) expected, and the number of wells to be drilled. The number of wells per production platform depends on the type of production facility, the size of the hydrocarbon reservoir, and the drilling/production strategy for the drilling program. Production platforms may be fixed, floating, or subsea (only in deep water). Fixed platforms rigidly attached to the seafloor are typical in water depths up to 400 m (1,312 ft), while floating or subsea platforms are typically in waters deeper than 400 m (1,312 ft). Floating platforms are attached to the seafloor using line-mooring systems and anchors. Development will also include installation of seafloor pipelines for conveying product to existing pipeline infrastructure or to new onshore production facilities. In shallower waters (<60 m [<200 ft]), pipelines are typically buried to a depth of at least 0.91 m (3 ft) below the mudline. Pipelines may also be buried (trenched) in deeper waters, depending on conditions along the subsea pipeline corridor.

Impact-producing factors of development include noise, ship and helicopter traffic, drilling mud and debris, seafloor and land disturbance, air emissions, lighting, and visible infrastructure. During the development phase, noise will be generated during drilling, by ship and helicopter traffic, pipeline trenching, and onshore construction. Resources that could be affected by development-related noise include marine mammals, sea turtles, marine and coastal birds, and fish. Marine mammals and sea turtles could be affected by collisions with ship traffic supporting platform construction and drilling, while the presence of ship and helicopter traffic could disturb normal behaviors of marine mammals and birds.

The disposal of drilling muds and fluids may affect local water quality and aquatic biota. Some amount of seafloor disturbance will occur as a result of drilling, platform mooring, and pipeline trenching, which would result in some loss of habitat and biota as well as reductions in overlying water quality. Seafloor disturbance could also affect archeological resources if present in the project area. Air emissions from platforms where drilling is occurring as well as at onshore construction sites could affect local air quality. The lighting of offshore platforms could affect birds, while lighting at onshore facilities could affect sea turtles. Visual impacts may be incurred for some developments, depending on the location and nature (size) of the offshore platform or onsite facilities. Development of production wells and platforms as well as of new pipelines and onshore processing facilities could result in some space use conflicts in the project area.

4.1.1.3 Operation

Following completion of the production wells and platform, the facilities are operated to extract the hydrocarbon resource and transport it to onshore processing facilities. During the operation phase, activities center on maintenance of the production wells (workover operations) and platforms. Impact-producing factors associated with normal operations include noise, ship and helicopter traffic, air emissions, lighting, and visible infrastructure (Table 4.1.1-1).

During normal operations, noise will be generated by maintenance activities and by ship and helicopter traffic and may affect marine mammals and fish. Collisions with support ships could affect marine mammals and sea turtles, while ship and helicopter traffic could disturb normal behaviors of nearby biota. As noted for the development phase, lighting of onshore facilities could affect sea turtles, while lighting of offshore platforms could affect birds. Any visual impacts identified for the development phase could continue for the duration of the operation phase. Similarly, some of the space use conflicts incurred during the development phase would continue through production.

4.1.1.4 Decommissioning

Following lease termination or relinquishment, all platforms and seafloor obstructions are required to be removed. All bottom-founded infrastructure is severed at least 5 m (15 ft) below the mudline. Production infrastructure could be removed using explosive or nonexplosive methods. Impact-producing factors associated with decommissioning include noise, ship and helicopter traffic, air emissions, and explosives.

Noise would be generated during either explosive or nonexplosive structure removal, as well as by ship and helicopter traffic supporting removal activities, and could affect marine mammals, sea turtles, and fish. Ship traffic could result in collisions with marine mammals and sea turtles, while ship and helicopter traffic could disturb behaviors of biota in the vicinity of the platform undergoing decommissioning. Air emissions could affect local air quality. Pressure from explosive detonations could injure marine mammals, sea turtles, and fish. Some additional space use conflicts could arise with explosive platform removal.

4.1.2 Accidental Events and Spills

A variety of accidental events or spills may occur during OCS O&G development (Table 4.1.2-1). During normal operations, ship and platform activities generate a variety of solid waste materials, such as plastic containers, nylon rope and fasteners, and plastic bags. The accidental release of such solid waste materials could affect marine mammals, sea turtles, and birds. While sanitary and domestic wastes produced in ships and platforms are routinely processed through onsite waste treatment facilities, the accidental discharge of such releases could affect local water quality and biota.

Ships supporting platform activities may accidentally collide with MODUs or platforms, releasing diesel fuel, which could affect water quality and biota. Loss of well control results in the uncontrolled release of a reservoir fluid that may result in the release of gas, condensate or crude oil, drilling fluids, sand, or water. Historically, most losses of well control have occurred during development drilling operations, but loss of well control can happen during exploratory drilling, production, well completions, or workover operations (MMS 2008a). Releases associated with loss of well control may affect water quality, biota, and space use.

Oil spills are unplanned accidental events. Depending on the phase of O&G development and the location, magnitude, and duration of a spill, natural resources that may be affected include marine mammals, marine and coastal birds, sea turtles, fish, benthic and pelagic invertebrates, water quality, marine and coastal habitats, and areas of special concern (such as marine parks and protected areas). In addition, spills may also affect a variety of socioeconomic conditions such as local employment, commercial and recreational fisheries, tourism, sociocultural systems, and subsistence. Spill scenarios for the GOM, Cook Inlet, and Arctic planning areas have been developed for use in this PEIS and are presented in detail in Section 4.4.2. This draft PEIS also considers the potential effects of a catastrophic discharge event (i.e., a low probability, very large volume accidental oil spill).

4.1.3 Assessment Approach

The environmental consequences discussed in subsequent sections of Chapter 4 address the potential impacts that could be incurred under any of the seven action alternatives (Alternatives 1–7). Because Alternative 1, the Proposed Action, encompasses the six OCS Planning Areas considered for inclusion in the Program, OCS oil and gas activities that could occur following leasing under Alternative 1 may be expected to have the potential to cause impacts over the greatest geographic area. Any such potential impacts could also occur under the other action alternatives (Alternatives 2–7), as each represents a subset of the planning areas included in the proposed action. Thus, the analyses presented in Chapter 4, while focused on the proposed action, are fully applicable to each of the other action alternatives.

TABLE 4.1.2-1 Accidental Events and Spills That May Be Associated with OCS O&G Development Phases

	O&G Development Phase				
	Exploration				
Accidental Event or Spill	Seismic Survey	Exploration Well	Development	Operation	Decommissioning
Solid waste release	X	X	X	X	X
Sanitary waste release	X	X	X	X	X
Vessel collisions	X	X	X	X	X
Loss of well control		X	X	X	
Oil spills		X	X	X	X

It is not possible to identify specific impacts from future OCS O&G development activities without development-specific location and design details. There are, however, general impacts that are typical of offshore O&G development, regardless of where development occurs. For example, the placement of a seafloor pipeline crossing shallow waters to a landfall will require trenching, which will disturb the seafloor and affect the overlying water quality, regardless of whether that pipeline is located in Cook Inlet or in the Western GOM Planning Area. The potential effects of pipeline placement will, however, differ between shallow and deep waters and by the nature of the seafloor communities present along the actual pipeline route.

As previously discussed, lease- and project-specific details are not known at this time. Thus, the analyses in this PEIS take a programmatic approach and evaluate resources on a larger, more regional scale rather than at a lease-block scale (the scale at which project-specific impacts could occur). Thus, the evaluation of environmental consequences presented in this PEIS has focused on those resources most likely to be affected during future O&G development on the OCS under the alternatives presented in Chapter 2.

For each resource, the impact-producing factors identified in Tables 4.1.1-1 and 4.1.2-1 were further examined and refined to identify aspects of those factors specific to the resource under evaluation. The analyses also identified, as applicable, important components of each resource to further refine the relationship between the impacting factors and the resource. For example, for sea turtles, the impact analyses identified four life stages (eggs, hatchlings, juveniles, and adults), four habitat types (nesting, foraging, overwintering, and nursery), and three important behaviors (courtship/nesting, foraging, migration) that could be affected by OCS O&G development activities. The impact analyses then focused on the impact-producing factors that could affect any of these life stages, habitats, or behaviors. Table 4.1.3-1 illustrates the refinement and linkage of impacting factors and important resource components.

TABLE 4.1.3-1 Relationships among Development Phase Impacting Factors and Habitats, Life Stage, and Behavior of Sea Turtles

	Sea Turtle Resource Component										
	Habitat Disturbance or Loss				Life Stage Affected				Behavior Affected		
Development Phase and Impacting Factor	Nesting	Foraging	Overwintering	Nursery	Eggs	Hatchlings	Juveniles	Adults	Foraging	Courtship/ Nesting	Migration
Vessel noise						X	X	X	X		
Aircraft noise											
Drilling noise							X	X			
Trenching noise							X	X	X		
Onshore construction noise								X		X	
Offshore air emissions											
Onshore air emissions											
Aircraft traffic											
Vessel traffic						X	X	X			
Hazardous materials						X	X	X			
Solid wastes						X	X	X			
Drilling mud/debris						X	X	X			
Bottom disturbance from drilling											
Bottom disturbance from pipeline trenching		X	X	X			X	X	X	X	
Offshore lighting											
Onshore construction	X				X	X		X		X	
Onshore lighting	X					X		X		X	
Aircraft noise											
Offshore air emissions											
Onshore air emissions											
Vessel traffic						X	X	X			
Aircraft traffic											
Hazardous materials						X	X	X			
Solid wastes						X	X	X			
Explosive platform removal						X	X	X			
Offshore lighting											

4.1.4 Definition of Impact Levels

The conclusions for most resource analyses use a four-level classification scheme to characterize the impacts that could result with OCS O&G development under the alternatives presented in this PEIS.

4.1.4.1 Impact Levels for Biological and Physical Resources

The following impact levels for biological and physical resources are used for the analysis of water quality, air quality, marine and terrestrial mammals, marine and coastal birds, fish resources, sea turtles, coastal and seafloor habitats, and areas of special concern (such as essential fish habitats [EFHs], marine sanctuaries, parks, refuges, and reserves). For biota, these levels are based on population-level impacts rather than impacts on individuals.

- Negligible: No measurable impacts.

- Minor:
  - Most impacts on the affected resource could be avoided with proper mitigation.
  - If impacts occur, the affected resource will recover completely without mitigation once the impacting stressor is eliminated.

- Moderate:
  - Impacts on the affected resource are unavoidable.
  - The viability of the affected resource is not threatened although some impacts may be irreversible, or
  - The affected resource would recover completely if proper mitigation is applied during the life of the project or proper remedial action is taken once the impacting stressor is eliminated.

- Major:
  - Impacts on the affected resource are unavoidable.
  - The viability of the affected resource may be threatened, and
  - The affected resource would not fully recover even if proper mitigation is applied during the life of the project or remedial action is implemented once the impacting stressor is eliminated.

4.1.4.2 Impact Levels for Societal Issues

The following impact levels are used for the analysis of demography, employment, and regional income; land use and infrastructure; commercial and recreational fisheries; tourism and recreation; sociocultural systems; environmental justice; and archeological and historic resources.

- Negligible: No measureable impacts.

- Minor:
  - Adverse impacts on the affected activity, community, resource could be avoided with proper mitigation.
  - Impacts would not disrupt the normal or routine functions of the affected activity or community.

  - Once the impacting stressor is eliminated, the affected activity or community will, without any mitigation, return to a condition with no measureable effects.

- Moderate:
  - Impacts to the affected activity, community, or resource are unavoidable.
  - Proper mitigation would reduce impacts substantially during the life of the project.
  - A portion of the affected resource would be damaged or destroyed.
  - The affected activity or community would have to adjust somewhat to account for disruptions due to impacts of the project, OR
  - Once the impacting stressor is eliminated, the affected activity or community will return to a condition with no measurable effects if proper remedial action is taken.

- Major:
  - Impacts on the affected activity, community, or resource are unavoidable.
  - Proper mitigation would reduce impacts somewhat during the life of the project.
  - All of the affected resource would be permanently damaged or destroyed.
  - The affected activity or community would experience unavoidable disruptions to a degree beyond what is normally acceptable, and
  - Once the impacting agent is eliminated, the affected activity or community may retain measurable effects for a significant period of time or indefinitely, even if remedial action is taken.

4.2 RELATIONSHIP OF THE PHYSICAL ENVIRONMENT TO OIL AND GAS OPERATIONS

4.2.1 Physiography, Bathymetry, and Geologic Hazards

4.2.1.1 Gulf of Mexico

4.2.1.1.1 Physiography and Bathymetry. The GOM is a small ocean basin measuring 900 km (660 mi) from north to south and 1,600 km (990 mi) from east to west with a mean water depth of about 1,615 m (5,300 ft) (Bryant et al. 1991; GulfBase 2011). The basin is almost completely surrounded by continental landmasses. Its shoreline runs 5,700 km (3,500 mi) from Cape Sable, Florida, to the tip of Mexico’s Yucatan Peninsula, with another 380 km (240 mi) of shoreline on the northwest tip of Cuba (GulfBase 2011).

The continental shelf extends from the coastline to a water depth of about 200 m (660 ft). Width of the shelf varies, ranging from 10 km (6 mi) near the Mississippi Delta to about 280 km

(175 mi) off the southern tip of Florida and the Yucatan Peninsula. Its topographic relief is relatively low. Extending from the edge of the shelf to the abyssal plain is the continental slope, a steep area with high topographic relief and diverse geomorphic features (canyons, troughs, and salt structures). The base of the slope occurs at a median depth of about 2,800 m (9,190 ft). The Sigsbee Deep, located within the Sigsbee Abyssal Plain in the southwestern part of the basin, is the deepest region of the GOM with a maximum depth ranging from 3,750 m (12,300 ft) to 4,330 m (14,200 ft). The GOM basin contains a volume of 2,434,000 km^3 (6.43×10^{17} gal) of water (Shideler 1985; GulfBase 2011).

Antoine (1972) has divided the GOM into physiographic provinces, the components of which correspond to the ecological regions delineated by the Commission for Environmental Cooperation (CEC) (Wilkinson et al. 2009). The physiographic regions presented below are organized from north to south. They are based on the CEC's nomenclature (Level II seafloor geomorphological regions[1]) and incorporate the physiographic descriptions of Antoine (1972), Bryant et al. (1991), Shideler (1985), Wilhelm and Ewing (1972), and GulfBase (2011).

Northern Gulf of Mexico Shelf and Slope. On its west side, the northern GOM shelf and slope extends from the Rio Grande (Texas) to Alabama and from 320 km (200 mi) inland of today's shoreline to the Sigsbee Escarpment. It encompasses the Texas-Louisiana Shelf and Slope and the Mississippi-Alabama Shelf (Figure 4.2.1-1). The major geologic feature in this province is the Mississippi Fan, which extends from the Mississippi River Delta to the central abyssal plain. The upper part of the fan (to a water depth of about 2,500 m or 8,200 ft) has a complex and rugged topography attributed to salt diapirism,[2] slumping, and current scour; the lower part of the fan by contrast is smooth, with a gently sloping surface that merges with the abyssal plain to the southeast and southwest. The Mississippi Canyon cuts the eastern side of the Texas-Louisiana Shelf to the southwest of the Mississippi River Delta. The submarine canyon is thought to have formed from large-scale slumping along the shelf edge. The area is characterized by thick sediments and widespread salt deposits.

To the east, the northern GOM shelf and slope extends from just east of the Mississippi River Delta near Biloxi, Mississippi, to the eastern side of Apalachee Bay (west Florida) and encompasses the West Florida Shelf and Terrace (Figure 4.2.1-1). The shelf in this region is characterized by soft terrigenous (land-derived) sediments. Sediments are thick west of DeSoto Canyon; Mississippi River-derived sediments cover the western edge of the carbonate platform of the West Florida Shelf. The Florida Escarpment, with slopes as high as 45° in places,

---

1 The CEC's Level II seafloor geomorphological regions are determined by large-scale physiography (e.g., continental shelf, slope, and abyssal plain) and extend offshore to a depth of 370 km (200 mi). The designation of Level II regions is helpful to understanding marine ecosystems because it illustrates the importance of depth as a major determinant of benthic marine communities and shows how physiographic features can influence current flows and upwelling (Wilkinson et al. 2009). Other sections (e.g., Section 3.2 on Marine and Coastal Ecoregions) provide finer scale Level III region descriptions that take into account local variables such as water mass, regional landforms, and biological community types on the continental shelf.

2 Salt diapirism refers to a process by which natural salt (mainly halite but also including anhydrite and gypsum) in the subsurface deforms and flows in response to loading pressures from overlying sediments. Because of its low density, salt tends to flow upward from its source bed, forming intrusive bodies known as diapirs. Salt diapirs are common features of sedimentary basins like the Gulf of Mexico (Nelson 1991).

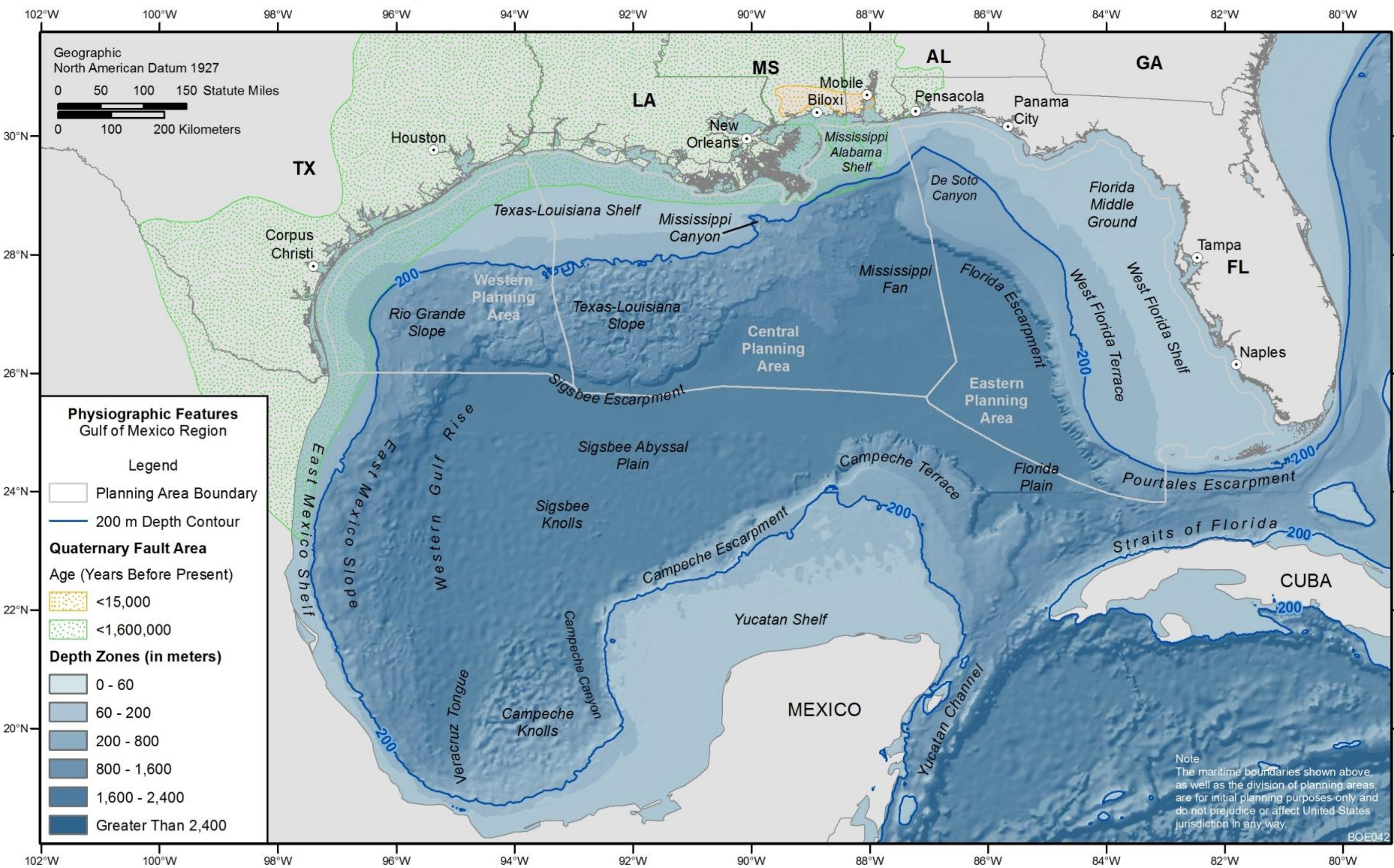

FIGURE 4.2.1-1 Physiographic Regions of the GOM (based on Bryant et al. 1991)

separates the West Florida Shelf from the deeper GOM basin and also forms the southeastern side of DeSoto Canyon.

South Florida/Bahamian Shelf and Slope. This region is the submerged portion of the Florida Peninsula. The region extends along the West Florida coast from Apalachee Bay southward to the Straits of Florida and includes the Florida Keys and Dry Tortugas. Sediments become progressively more carbonate (ocean-derived) from north to south with thick accumulations in the Florida Basin. The basin may have been enclosed by a barrier reef system at one time. The Jordon Knoll, located within the Straits of Florida, is composed of remnants of the ancient reef system.

Gulf of Mexico Basin. The GOM Basin consists of the continental rise, the Sigsbee Abyssal Plain, and the Mississippi Cone. The continental rise is situated between the Sigsbee Escarpment and the Sigsbee Abyssal Plain (Figure 4.2.1-1). It is a large wedge of sediments originating from the unstable continental slope (deposited by gravity flows). The Sigsbee Abyssal Plain is the deep, flat portion of the GOM bottom just northwest of the Campeche Escarpment. It is 450 km (280 mi) long and 290 km (180 mi) wide and covers an area of more than 103,600 km^2 (40,000 mi^2). The plain is underlain by very thick sediments (up to 9 km, or 5.6 mi); the only major topographical features in this region are the small salt diapirs that form the Sigsbee Knolls. The Mississippi Cone lies between the Mississippi Canyon to the west and DeSoto Canyon to the east. It is the portion of the Mississippi River Delta that has accumulated at the base of the continental slope.

4.2.1.1.2 Geologic Hazards. Several types of geologic hazards are known to occur in the marine environment of the GOM region, most of which present a risk to offshore oil and gas activities because they contribute directly or indirectly to seafloor instability. As a result, seafloor instability is likely the principal engineering constraint to the emplacement of bottom-founded structures, including pipelines, drilling rigs, and production platforms.

Geologic hazards within the GOM are common on the northern continental slope (Figure 4.2.1-1) because of its high sedimentation and subsidence rates and the compensating movement of underlying salt. Geologic hazards are frequently concentrated in the areas along the edges of intraslope basins[3] where topography is high and complex. These intervening regions are created by shallow diapiric salt bodies and are steeply sloped and highly faulted. They are also areas of natural fluid and gas migration to the seafloor surface (Roberts et al. 2005). The potential geologic hazards in the GOM region are described below.

Irregular Topography. The regional topography of the continental slope is irregular, consisting predominantly of domes, ridges, and basins. On a more local scale, topographic features include slope failures, mounds, depressions, and scarps[4] (Roberts 2001). Such features

[3] Intraslope basins are flat, featureless areas on the continental slope of the northwestern GOM where sediment depositional processes predominate.

[4] Scarps (or escarpments) are steep bluff-like features formed by the downward displacement of sediments or rocks along a vertical fault plane.

produce a wide range of potential hazards to drill rigs, bottom-laid and buried pipelines, and production platforms. The most topographically rugged province in the region is the Texas-Louisiana Slope, a 120,000- km^2 (46,300-mi^2) area of banks, knolls, basins, and domes where local slope gradients can exceed 20°. Topographic variability in this area is attributed to the movement of salt in the subsurface and the natural venting and seepage of petroleum and other fluids at the seafloor surface (Roberts et al. 2005; Bryant and Lui 2000; Kennicutt and Brooks 1990; Roberts et al. 1998).

Substrate types range from lithified (rock-like) hard bottoms[5] (bioherms, hardgrounds, carbonate banks, and outcrops) to extremely soft, fluid mud bottoms. Hard-bottom substrates are associated with topographic highs (most often created by salt diapirs) and present hazards to activities such as drilling, locating production platforms, and laying pipelines. The coral reefs of the Flower Garden Banks in the northwestern GOM are an example (Roberts et al. 2005; Roberts and Aharon 1994; Schmahl et al. 2011; see also Sections 3.7.2.1.2 and 3.9.1.2.1).

Bedforms and Bedform Migration. Bedforms are depositional features on the seabed that form by the movement of sediment caused by bottom currents. An extensive field of bedforms, ranging in size from small ripples and mudwaves to large furrows, is present at the base of the continental slope (along the Sigsbee Escarpment) in the GOM (Bean 2005; Bryant and Liu 2000). Large bedforms and their migration create potential navigation hazards and may undermine submarine pipelines. Numerous studies of these features relate their morphology and migration to water depth, availability of sediment, grain size, and current velocity (Whitmeyer and FitzGerald 2008).

Deep tow surveys conducted by Texas A&M University have found that the 30-m (98-ft) wide and 10-m (32-ft) deep furrows to the south of the Sigsbee Escarpment parallel the regional contours and extend for tens to hundreds of kilometers. These features indicate the long-term presence of high-velocity bottom currents along the base of the escarpment (Bryant and Liu 2000). Bean (2005) estimates current velocities in this region to be as high as 95 cm/s (37 in./s), significant enough to affect structures on the seafloor or in the water column. The bedforms have steep upstream-facing sides (where deposition takes place), suggesting they migrate in an upcurrent direction (Bean 2005).

Bottom Scour. Vigorous tidal circulation and storm waves have an important effect on the transport of sediments on the surface of the continental shelf. Episodic sediment movement caused by waves and ocean currents can undermine foundational structures and move unanchored bottom-laid pipelines (as reported by Thompson et al. 2005 and Coyne and Dollar 2005). Teague et al. (2006) estimate that in 2004 Hurricane Ivan displaced as much as 100 million m^3 (3.5 billion ft^3) of sediment from a 35 by 15 km (22 by 9 mi) region in the storm's path, causing up to 36 cm (14 in.) of scour at moorings in areas over which the maximum wind stress occurred. Bottom scour occurs as a result of sediment resuspension by

[5] Hard bottoms formed on diapiric high areas beyond the shelf edge during periods of lowered sea level in the late Pleistocene. During this time, the areas provided a substrate for the colonization of sedentary marine organisms. As sea level rose, the remains of the colonized organisms in these areas became fossilized, forming bioherms (e.g., fossilized coral reefs) and shallow banks (Robert et al. 2005).

waves and current-driven transport of entrained sediments. Sediments entrained in bottom currents increase water density and mass, giving the strength to cause further scouring. In addition, wind-generated surface waves apply cyclic pressure to bottom sediments causing seabed motion (liquefaction).

Fluid and Gas Expulsion. There are a wide range of natural fluid and gas[6] expulsion processes in seafloor sediments across the northern GOM continental slope. The geologic features related to these processes are variable and depend largely on the rate and duration of delivery as well as the composition of the fluid and gas expelled (Hardage 2011; Roberts 2001a). These include mud volcanoes, flows, and vents, resulting from rapid-flux or mud-prone processes; gas hydrate mounds and chemosynthetic communities, resulting from moderate-flux processes; and hard bottoms (carbonate mounds, hardgrounds, and nodular masses), resulting from slow-flux or mineral-prone processes (Roberts 2001a, 2002). Below water depths of about 500 m (1,640 ft), moderate-flux processes dominate, promoting gas hydrate formation at or near the seafloor and creating conditions optimal for sustaining dense and diverse chemosynthetic communities. Rapid- and slow-flux processes may also occur on a more local scale at these depths (Roberts 2002). Pockmarks — circular to oval depressions resulting from the removal of sediment near areas of rapid (and possibly explosive) gas expulsion — have been mapped along the northern continental shelf and slope. Some of these features are over 300 m (1,000 ft) in diameter (BOEMRE 2011n).

The main geologic hazard stemming from the processes of fluid and gas expulsion (seeps and eruptions) is seabed slope failure (submarine slumps and slides), especially on the continental slope and within active river deltas and submarine canyons. Fluid and gas releases lower sediment shear strengths and as a result can destabilize seabed structures such as cables, pipelines, and platforms.

Studies using high-resolution seismic and side-scan sonar have shown that the linear spatial distribution of seafloor features caused by fluid and gas expulsion can usually be correlated with faults intersecting the modern seafloor. Faults are important conduits for the upward natural migration of fluids and gases through the sedimentary column to the seafloor (Roberts 2001b). Neurater and Bryant (1990) report that it is the churning action of upwelling fluids and gases that causes a "slurry" of unconsolidated mud to form and migrate to the surface of the seafloor.

Along the Texas-Louisiana Shelf, shallow gas accumulations are most common in old channel systems. Shallow gas accumulations are also found in areas affected by salt uplift where numerous faults form pathways to near-surface sediments, creating small gas pockets that become sealed in thin clay layers (Foote and Martin 1981).

---

[6] Gases (predominantly methane) migrating from the seabed originate from both deep sources (termed thermogenic gases because they are heat-generated) and more shallow sources (termed biogenic or microbial gases because they are derived from the activity of microorganisms). Regardless of origin, high-pressure methane is highly mobile, flammable, and buoyant and poses a great hazard to drilling operations when encountered (Judd and Hovland 2007).

Natural Gas Hydrates. Gas hydrates are naturally occurring solids composed of hydrogen-bonded water lattices (also known as clathrates) that trap methane and other low-weight gas molecules (e.g., carbon dioxide, propane, and ethane). They form in deepwater ocean sediments within a surface-parallel layer referred to as the hydrate stability zone under conditions of high pressure and low temperature. In the GOM, gas hydrate deposits are found in localized deepwater areas at or near the seafloor (intersecting the seafloor at a water depth of about 500 m, or 1,640 ft). They occur as a disseminated accumulation in the pore spaces of sedimentary units across vertical sections ranging in thickness from a few centimeters to several hundred meters. In more massive form, they occur in faults, fractures, and nodules and range in thickness from a few centimeters to several hundred meters. The size and shape of the hydrate stability zone are influenced by the presence of numerous salt features (Boatman and Peterson 2000; Roberts 2001b; MMS 2006a; Frye 2008).

Because they are pressure- and temperature-sensitive, gas hydrates (if present) can easily dissociate and rapidly release large amounts of gas during a drilling operation. Hydrate dissociation may trigger seafloor slumps and catastrophic landslides, which pose significant hazards for offshore oil and gas operations, including the loss of support for drilling and production platforms and pipelines, collapse of wellbore casings, and seafloor subsidence around wellbores where gas has leaked to the surface. As drilling operations in the GOM move into deeper waters, gas hydrate outcrops are likely to be encountered more frequently (Boatman and Peterson 2000; Roberts 2001b; MMS 2006a).

In addition to their natural occurrence in sediments, gas hydrates may also form on drilling equipment and in pipelines in deep water, trapping methane and other gas molecules and posing hazards such as drilling difficulties, blockages and pressure buildup in valves and pipelines, and an increased risk of well control loss (Boatman and Peterson 2000).

Shallow Water Flow. Shallow water flow is a deepwater drilling hazard that occurs when overpressured, unconsolidated sands are encountered at shallow depths, 460 to 2,100 m (1,500 to 7,000 ft) below the seabed (Huffman and Castagna 2001). When encountered, these sands are prone to uncontrolled flow, potentially damaging the well and causing well casing failure — which could result in the loss of the well.[7] In extreme cases, overpressured sands have been known to erupt, creating seafloor craters (due to collapse), mounds, and cracks. Shallow water flow sands are difficult to detect seismically because there is little contrast in acoustic impedance at sand/shale interfaces at shallow depths (Lu et al. 2005; Ostermeier et al. 2002); however, some investigators are having success using high-resolution multi-component seismic data to delineate anomalies to identify zones that might produce shallow water flow (e.g., Hoffman and Castagna 2001).

Slope Failure. Submarine slope failures result from processes that reduce the shear strength of sediment on submarine slopes and/or increase the main driving force (gravity) that promotes the downslope movement of sediments. Hance (2003) summarizes the published literature on submarine slope failure and identifies 14 triggering mechanisms, a subset of which

[7] Shallow water flow is estimated to have occurred in about 70% of all deepwater wells (Hoffman and Castagna 2001).

is relevant to the GOM shelf and slope: (1) sedimentation processes that involve rapid deposition, especially in offshore delta areas and at the base of submarine canyons; (2) increased fluid pressures resulting from the disassociation of gas hydrates and the release and accumulation of free gas; (3) ocean storm waves and subsurface current (internal) waves; (4) tidal events, especially along coastlines; (5) human activities such as construction and dredging, usually along coastlines; (6) salt diapirism, which oversteepens soils on the flanks of diapirs; (7) mud-related volcanic activity; and (8) sediment creep, a process involving the slow movement of large masses of sediment.

Mudflows occur within well-defined gullies along the submerged portion of the Mississippi Delta, creating unstable conditions vulnerable to failure. Areas between the mudflow gullies have lower sedimentation rates and are considered to be generally stable. Active deposition takes place downslope of the gullies. Damage to pipelines and production facilities due to mudflow overruns has been documented in this region (Hitchcock et al. 2010). Other forms of sediment instability along the delta front include collapse depressions, submarine landslides, and shelf-edge slumps (Coleman et al. 1991; Coleman and Prior 1988).

Nodine et al. (2006) also reported pipeline damage by mudslides within (and confined to) the mudflow lobes along the delta front during Hurricane Ivan in 2004.

Faulting. Faulting occurs on a range of scales within the GOM continental shelf and slope, from major growth faults[8] that cut across thousands of meters of sedimentary section to much smaller faults related primarily to salt movement in the shallow subsurface. Vertical offsets along faults create steep scarps on the seafloor, leading to various forms of subaqueous mass movement (falls, slides or slumps, flows, and turbidity flow) that contributes to the seafloor's irregular topography. Faults also provide pathways for the upward migration and expulsion of fluids and gas at the seafloor surface (Roberts 2001b; Coleman and Prior 1988).

Active faults could pose a hazard to oil and gas activities in areas of rapid deposition and subsidence (such as the Mississippi Delta), especially in areas where formation fluids such as water and oil are withdrawn. In the GOM, fault activity is thought to be most prevalent on steep slopes at the shelf edge where sediment accumulation creates loading stress that is periodically relieved by sudden faulting and associated with active salt diapirs on the upper slope (Foote and Martin 1981).

4.2.1.2 Alaska – Cook Inlet

The Cook Inlet Planning Area encompasses the lower half of Cook Inlet (referred to as lower Cook Inlet) and Shelikof Strait. The following descriptions of physiography, bathymetry,

---

[8] Growth faults are normal (extensional) faults that form at the same time massive volumes of sediments are accumulating within an area of high deposition, such as the Mississippi Delta. The fault plane is typically well-defined and is linear or concave and fairly steep. Growth faults exhibit greater offset with increasing depth and extend more than 150 m (500 ft) below the sea floor. They are most common on the outer shelf and upper slope where sediment accumulation and subsidence are greatest (Foote and Martin 1981; MMS 2006; Teague et al. 2006).

and geologic hazards address physiographic features and geologic processes throughout Cook Inlet (including the upper inlet) for completeness.

4.2.1.2.1 Physiography and Bathymetry. Cook Inlet is a northeast-trending, 350-km (220-mi) long tidal estuary on the south-central coast of Alaska. It is situated between the Kenai Peninsula and Alaska Peninsula and extends from Anchorage to the Gulf of Alaska (Figure 4.2.1-2). The inlet is composed of three distinct physiographic regions: the head, the upper inlet, and the lower inlet. The head region lies at the northernmost end of Cook Inlet and consists of two long and narrow bays: Knik and Turnagain Arms, both of which have extensive tidal marsh flats during low tide. Knik Arm begins at the confluence of the Knik and Matanuska Rivers, about 50 km (31 mi) inland; it ranges in width from about 2 to 10 km (1.2 to 6.2 mi). The Port of Anchorage is located on the southeast shore of Knik Arm, at the mouth of Ship Creek. Turnagain Arm extends about 75 km (47 mi) inland to the railroad depot at Portage; it ranges in width from about 2 to 26 km (1.2 to 16 mi). Fire Island is located at the midpoint between Knik and Turnagain Arms, just off the coast of Anchorage (Mulherin et al. 2001).

Upper Cook Inlet is about 95 km (59 mi) long and extends from Point Campbell to the East and West Forelands (Figures 4.2.1-2 and 4.2.1-3). It ranges in width from 20 to 30 km (12 to 19 mi) and narrows to 16 km (10 mi) between the Foreland peninsulas. Several shallow shoals occur in this region, including Middle Ground Shoal, just north of the Forelands and north of the inlet's midline; Beluga Shoal, due south of the mouth of Susitna River, at the inlet's midline; and Fire Island Shoal, due west of Fire Island. Water depths in upper Cook Inlet are generally less than 37 m (120 ft), with the greatest depths at Trading Bay, the largest bay in the upper inlet, just east of the mouth of McArthur River (Mulherin et al. 2001; ADNR 2009a).

Lower Cook Inlet is about 200 km (120 mi) long and lies between the Foreland peninsulas and the inlet's mouth, which opens to the Gulf of Alaska between Cape Douglas on the Alaska Peninsula and Cape Elizabeth on the Kenai Peninsula (Figures 4.2.1-2 and 4.2.1-4). There are several islands within the lower inlet, including Augustine Island, in Kamishak Bay; Chisik Island, at the mouth of Tuxedini Bay; and Kalgin Island, about 30 km (19 mi) south of the Forelands. The Barren Islands and Chugach Islands are located at the inlet's mouth. The bathymetry is characterized as having sloping sides forming a central depression (Cook Trough) that gradually deepens to the south and widens as it approaches the Cook Plateau near the mouth of the inlet. The depression bifurcates to the north into two channels, divided by a narrow shoal (Kalgin Platform) extending southward from Kalgin Island. The Cook Plateau lies between the lower end of the Cook Trough and the top of Cook Ramp, a gently sloping ramp delineating the sandy sediments to the north and muddy sands to the south. The Cook Plateau and parts of the Cook Ramp are covered by bedforms of various sizes. The ramp slopes from a water depth of about 70 m (230 ft) to about 120 to 130 m (390 to 430 ft) as it approaches the north end of the Shelikof Trough (Mulherin et al. 2001; ADNR 2009a; Bouma 1981; Bouma et al. 1978a).

The Chinitna Platform covers most of the western part of lower Cook Inlet (Figure 4.2.1-2). Its surface is smooth with numerous small topographic highs and lows. Most of the bottom is hard and covered by coarse-grained sediment and shells (although embayments

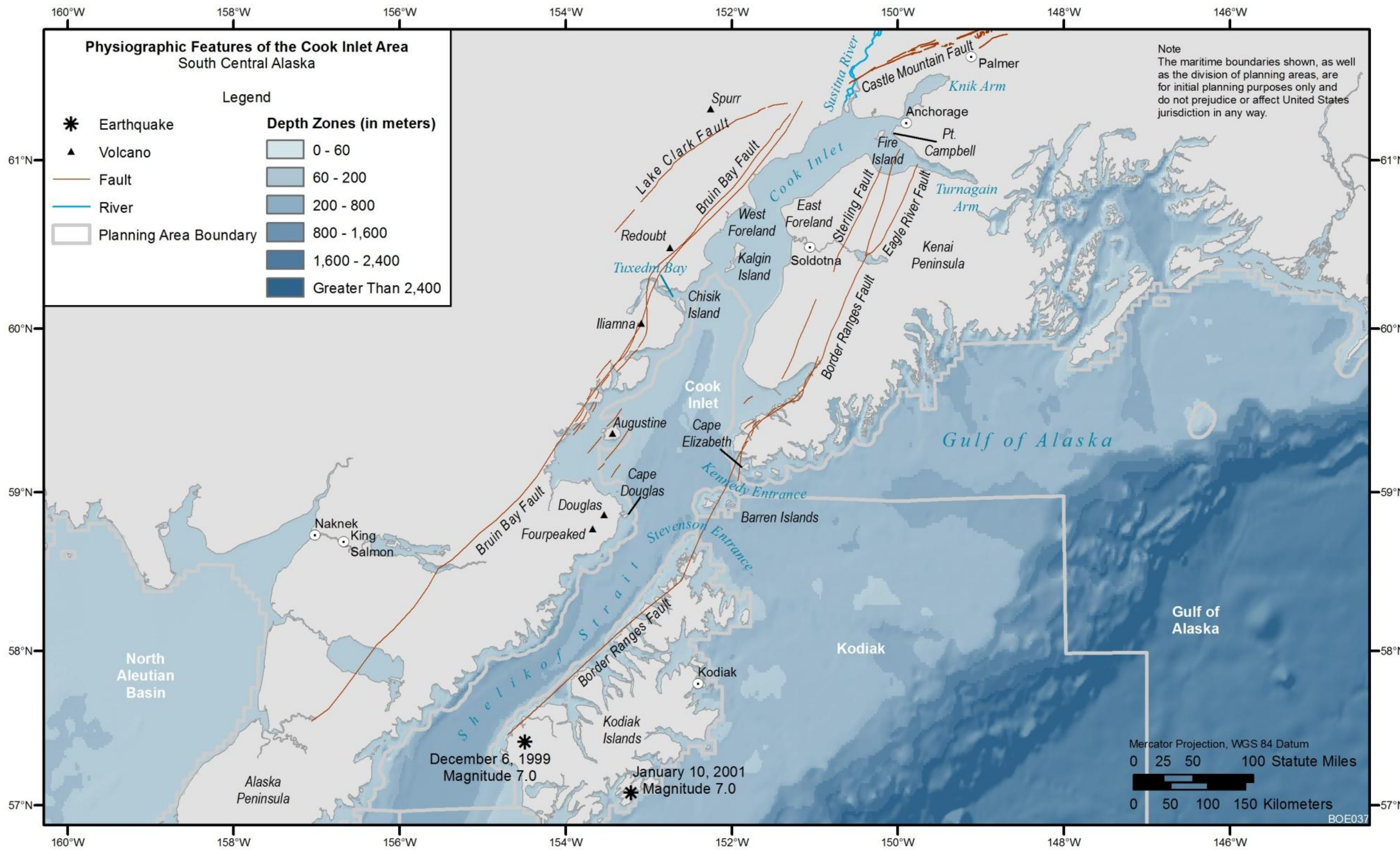

FIGURE 4.2.1-2 Physiographic Features of Cook Inlet (Earthquake data from USGS 2011a; map data for faults from Labay and Haeussler 2001; Troutman and Stanley 2003; and Clough 2011.)

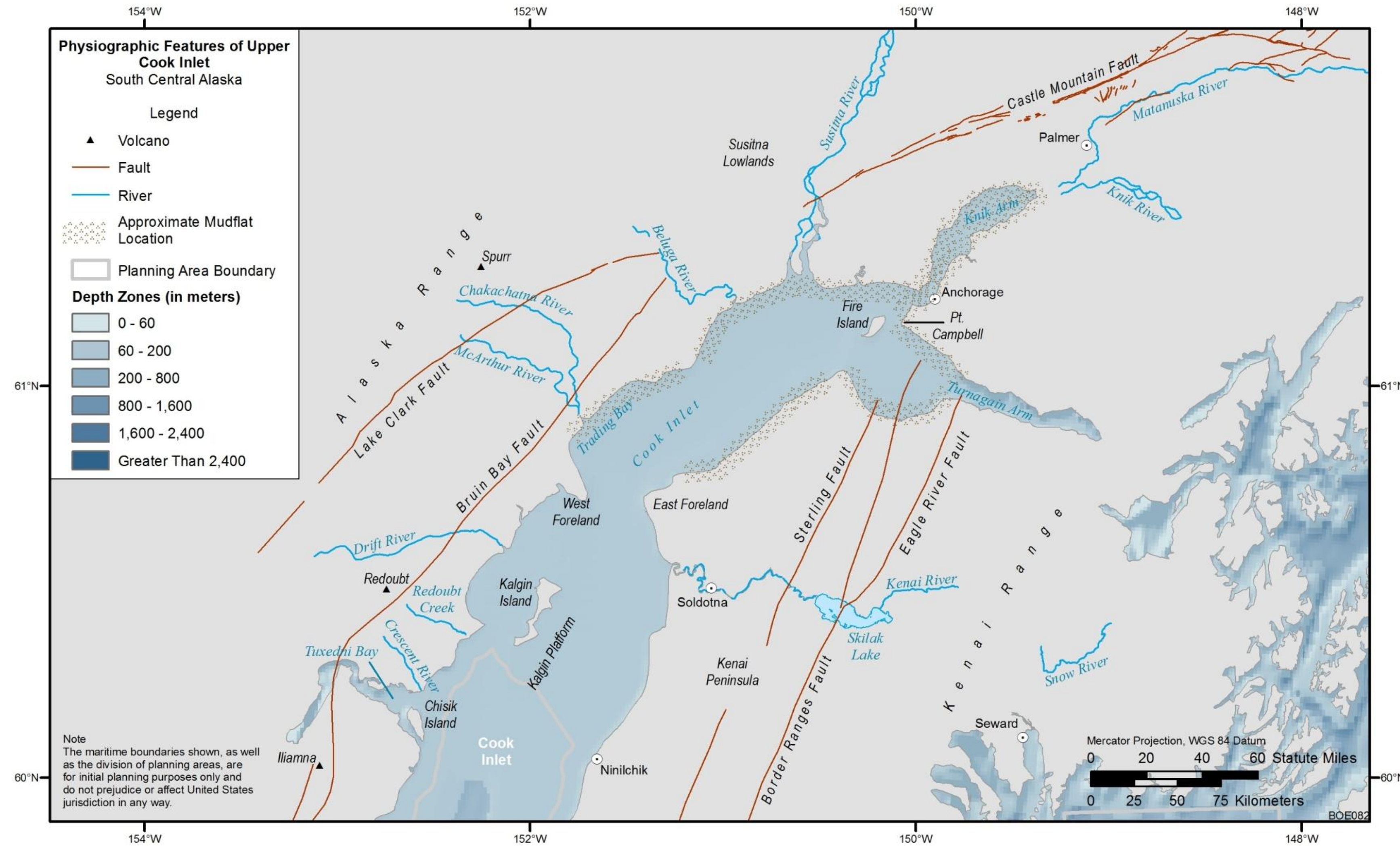

FIGURE 4.2.1-3 Upper Cook Inlet (Map data for faults from Labay and Haeussler 2001; Troutman and Stanley 2003; and Clough 2011; mudflat data from Mulherin et al. 2001.)

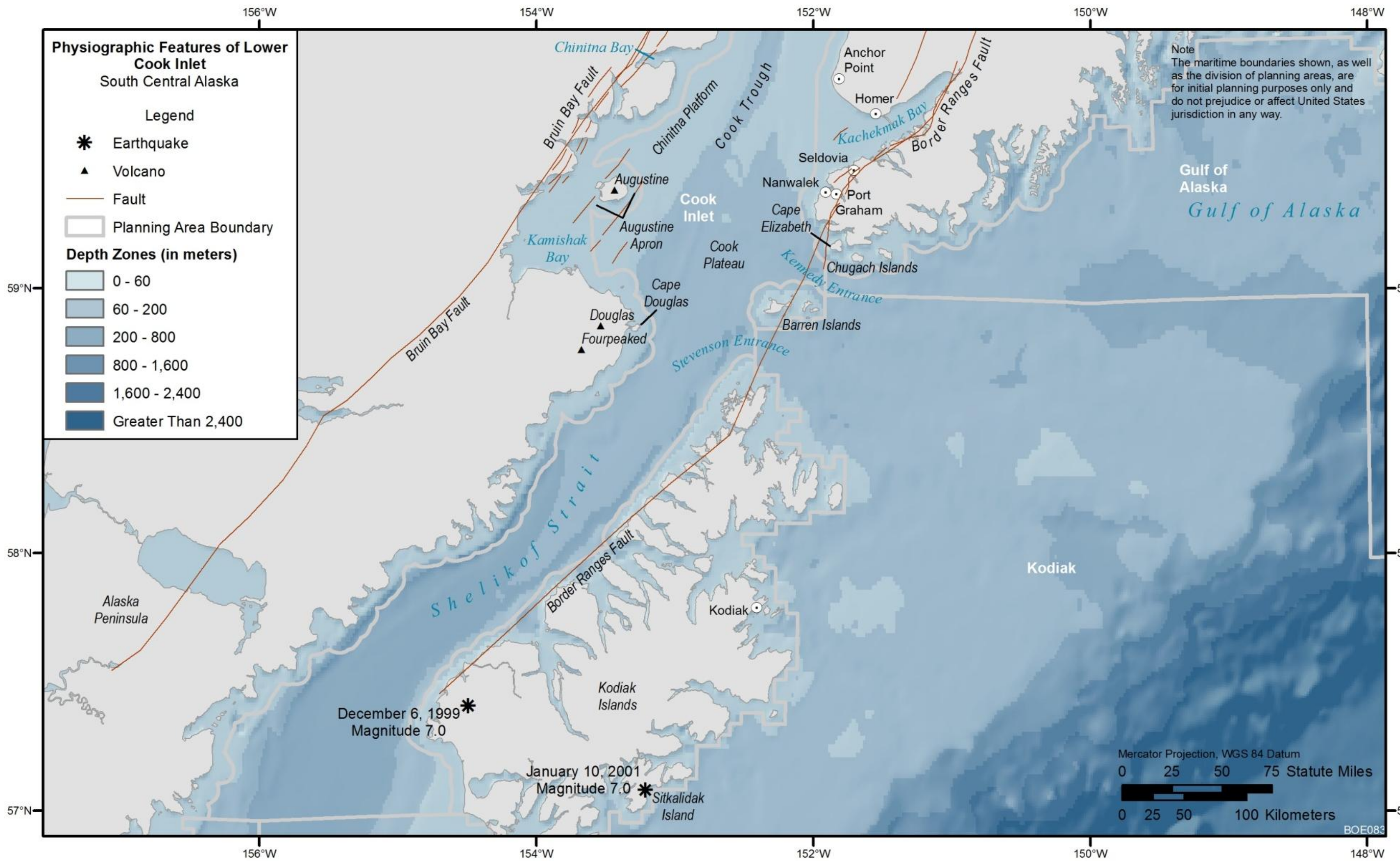

FIGURE 4.2.1-4 Lower Cook Inlet (Earthquake data from USGS 2011a; map data for faults from Labay and Haeussler 2001; Troutman and Stanley 2003; and Clough 2011.)

may have muddy bottoms). Augustine Island is located on the platform, and a shallow area, known as the Augustine Apron, encircles the island (Bouma 1981).

There are three entrances to the lower inlet from the Gulf of Alaska; these are the Kennedy and Stevenson Entrances on either side of the Barren Islands off the northeastern end of the Kodiak Islands and the opening of Shelikof Strait on the inlets' southwestern end.

Shelikof Strait lies between the Kodiak Island group and the Alaska Peninsula and also has a northeast orientation (Figure 4.2.1-2). The strait is about 200 km (120 mi) long, with an average width of about 45 km (27 mi). The seafloor in this region consists of a flat, central platform (coinciding with the Shelikof Trough) that slopes gently to the southwest. The platform is flanked by narrow marginal channels than run alongside the Kodiak Islands and the Alaska Peninsula. Relief on the platform and within the marginal channels can be as high as 100 m (330 ft) locally. Water depths in Shelikof Strait increase gradually in a southwestward direction, ranging from about 80 m (260 ft) at the mouth of Cook Inlet to more than 300 m (980 ft) off the west end of the Kodiak Islands (Hampton et al. 1978; Bouma 1981; Hampton et al. 1981). Deep subsurface faults (offsetting rocks of Tertiary age or older) occur along the margins of Shelikof Strait and run parallel to the shorelines of Kodiak Island and the Alaska Peninsula. Shallow faults are more recently active and occur throughout the strait — along its margins, as growth faults, and in association with structural highs (horsts or remnant volcanic necks) — and trend predominantly to the northeast (Hoose and Whitney 1980).

4.2.1.2.2 Geologic Hazards. Several types of geologic hazards are known to occur in the marine environment of Cook Inlet and Shelikof Strait and may present a risk to offshore oil and gas activities because they are dangerous to navigation or potentially damaging to marine structures. The potential geologic hazards in Cook Inlet and Shelikof Strait, except for sea ice, which is addressed in Section 4.2.2.1.1, are described below.

Seafloor Instability. The generally shallow nature and large tidal range of Cook Inlet (9 m [30 ft]) produce rapid currents. The Coriolis effect is also pronounced at this latitude, and during peak flow, all these factors combine to create strong cross-currents and considerable turbulence (strong currents and turbulence are also generated as tides flow through the constricted Forelands area). High current velocities and turbulence keep fine sediments (silt and clay) in suspension, so they are transported far from their source in the head region — the Susitna and Knik Rivers — and then back again with the incoming tide. As a result, bottom sediments throughout most of the inlet are predominantly coarse-grained (cobbles, pebbles, and sand) with only minor amounts of silt and clay. Grain size distribution in the inlet, which reflects the type and energy of transportation during the tidal cycle, is as follows: (1) sand, in the head region to the east of the Susitna River; (2) sandy-gravel and gravel, in the upper inlet and the upper part of the lower inlet (to Chinitna Bay); and (3) gravelly sand with minor silt and clay, in the lower inlet as far as the Barren Islands (Sharma and Burrell 1970).

MMS (1995a) concluded that the bottom sediments in Cook Inlet provide a stable substrate with no unusual geotechnical issues. This conclusion was based on the nature of bottom sediments in Cook Inlet (mainly coarse-grained), the low rate of sediment accumulation, and the low relief of the seafloor. Previous studies found no areas of soft, unconsolidated sediments or evidence of failed or unstable slopes.[9]

Bedforms and Bedform Migration. Bedforms are depositional features on the seabed that form by the movement of sediment by strong bottom currents. Bedforms are common in Cook Inlet and occur as sand waves, dunes, sand ribbons, sand ridges, and megaripples with wavelengths ranging from 50 to 800 m (160 to 2,600 ft) and heights from 2.0 to 14 m (6.6 to 46 ft). The type of bedform occurring at a given location depends on factors such as sediment size and availability, water depth, and current velocity (Hampton 1982a). Bedform migration and the strong bottom currents that cause it are known to be hazardous to offshore operations in upper Cook Inlet because they undermine or bury bottom-founded structures such as anchors and pipelines (Bouma et al. 1978b; Bouma and Hampton 1986; Whitney et al. 1979; Bartsch-Winkler 1982). Several pipeline failures in Cook Inlet have been attributed to sediment movement that results from current-sediment interaction (ADNR 2009a).

The largest bedform fields in lower Cook Inlet occur in its central and southern parts (especially on Cook Plateau and Cook Ramp) where bottom current velocities may be as high as 50 cm/s (20 in./s) (Whitney and Thurston 1977; Bouma et al. 1978b; Bouma 1981). Studies conducted in the lower inlet indicate sand grains move mainly during storm events and in response to ebb and flood cycles, especially during spring tide (Bouma and Hampton 1986).

Shallow Gas. Shallow gas is a hazard to drilling operations when encountered because it increases the potential for loss of well control. Shallow gas-charged sediments[10] have been documented in Cook Inlet, and loss of well control incidents have occurred at the Steelhead platform (well M-26; 1987–1988) and Grayling platform (well G-10RD; 1985) in upper Cook Inlet north of the West Foreland. The incident at the Grayling platform stopped on its own as a result of well bore collapse that naturally sealed off the escaping fluids and gases. At the Steelhead platform, however, some injuries to workers and damage to the platform occurred as a result of escaping gases that caught fire (ADNR 2009a).

Whitney and Thurston (1981) delineated shallow gas-charged sediment areas at depths of less than 50 m (160 ft) below the seafloor in lower Cook Inlet based on high-resolution seismic profiles. The areas occur to the west of the Barren Islands between bathymetric contours 150 km and 180 km (93 mi and 110 mi) and to the southeast of Augustine Island between bathymetric

---

[9] Studies of sediments in the head region (at the northernmost end of Cook Inlet), however, do indicate soft sediments (e.g., in Knik Arm) that have unstable banks and bottoms and a high liquefaction potential. Surface bedforms are common features in these sediments (Bartsch-Winkler 1982).

[10] Natural gas (predominantly methane) in Cook Inlet sediments likely originates from the decay of trapped organic matter in recent sediments and seepage from deeper sources, as reported by Molnia et al. (1979) for the Gulf of Alaska. Gas from deeper sources in the Cook Inlet basin has two types of occurrences: (1) the shallow reserves of biogenic gas in the Sterling, Beluga, and upper Tyonek Formations of the nonmarine Kenai Group of Tertiary age, at depths less than 2,300 m (7,500 ft); and (2) the oil-associated (thermogenic) gas in the lower Tyonek Formation, the Hemlock Conglomerate, and the West Foreland Formation at the base of the Tertiary section, having migrated from underlying marine source rocks of Jurassic age (Claypool et al. 1980). Regardless of origin, high-pressure methane is highly mobile, flammable, and buoyant and poses a great hazard to drilling operations when encountered (Judd and Hovland 2007).

contours 20 km and 100 km (12 mi and 62 mi) (Whitney and Thurston 1981). Although areas of gas-charged sediments can be identified in high-resolution marine seismic data, the concentrations of gas in sediments are highly variable over small lateral and vertical distances (Hampton 1982b).

Hoose and Whitney (1980) mapped possible gas-charged sediments in the shallow subsurface at the northeast end of Shelikof Strait (also based on high-resolution marine seismic data).

Seismicity. Seismicity in the Cook Inlet region is related to movement along the Alaska-Aleutian megathrust fault as the northwestward-moving Pacific plate subducts into the mantle beneath the North American plate (Figure 4.2.1-5). Shallow crustal earthquakes are generated as a result of deformation of the overriding North American plate; deeper earthquakes occur along the interface of the plates (Benioff Zone) that extends from the trench to depths of 40 to 60 km (25 to 37 mi), deepening to the northwest. Within the subducting Pacific plate, earthquakes can be as deep as 300 km (186 mi) (Rhea et al. 2010).

Major fault systems occur along the margins of the Cook Inlet basin. They include the Castle Mountain, Lake Clark, and Bruin Bay Faults, located to the north and northwest; and the Border Ranges Fault, on the Kenai Peninsula to the southeast (Figure 4.2.1-2). The faults have a northeast strike and are among the largest strike-slip fault systems in Alaska. Of these, only the Castle Mountain Fault has been active in recent times (with several earthquakes with an inferred M_W of 7.1 occurring in the past 4,100 years along the southern slopes of the Talkeetna Mountains) (Labay and Haeussler 2001; Haeussler et al. 2000). There is no evidence of recent or Quaternary movement along the Lake Clark or Bruin faults. Haessler and Saltus (2004) identified a 26-km (16-mi) right-lateral offset on the Lake Clark Fault that likely occurred in the past 34 to 39 million years (Late Eocene), based on aeromagnetic data. The most recent activity on the Border Ranges fault system likely occurred less than 24 million years ago (Neogene); some investigators suggest activity may have been as recent as several thousand years ago (Stevens and Craw 2004).

The highest magnitude earthquakes in Alaska are associated with the Alaska-Aleutian megathrust zone and are common in the Aleutian Islands, the Alaska Peninsula, and the Gulf of Alaska. Since 1900, six earthquakes over magnitude 8.4 have occurred in these regions (some of which predate oil and gas activities in Cook Inlet) (Rhea et al. 2010).

Since 1973, more than 1,200 earthquakes have been recorded in the Cook Inlet region (USGS 2011a). Of these, 10 had magnitudes greater than 6.0. The two largest earthquakes occurred in 1999 and 2001 and were located on Kodiak and Sitkalidak Islands (Figure 4.2.1-2). Each earthquake registered a moment magnitude (M_W)[11] of 7.0 (Figure 4.2.1-2).

---

[11] Moment magnitude (M_W) is used for earthquakes with magnitudes greater than 3.5 and is based on the moment of the earthquake, equal to the rigidity of the earth times the average amount of slip on the fault times the amount of fault area that slipped. Moment magnitude is the preferred magnitude for all earthquakes listed in USGS databases. It replaces the more general usage of “M,” which is used to describe historical earthquakes in the literature. An “M” denotes a magnitude consistent with the Richter scale (USGS 2010).

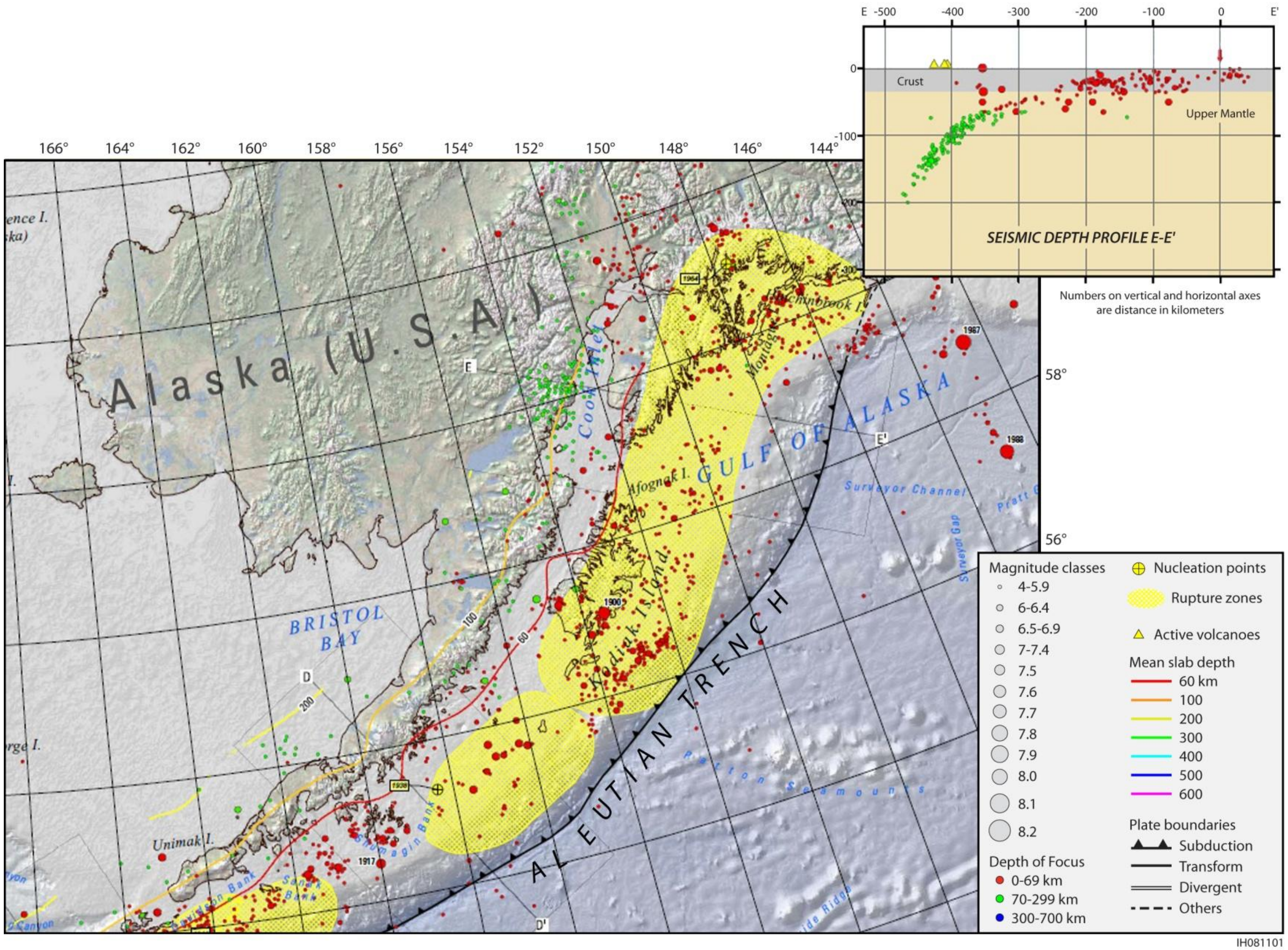

FIGURE 4.2.1-5 The Alaska-Aleutian Megathrust Fault and Subduction Zone (Aleutian Trench) with Seismicity Depth Profile across Cook Inlet (Rhea et al. 2010)

Earthquakes greater than M 6.0 pose a risk to the Cook Inlet region by triggering floods and landslides. Earthquakes greater than M 7.0 may trigger a tsunami and cause emergency events such as fires, explosions, and hazardous material spills and a disruption of vital services (water, sewer, power, gas, and transportation).

Cook Inlet lies within an area where the peak horizontal accelerations of 0.30 and 0.40 g have a 10% probability of exceedance in 50 years (USGS 1999). Shaking associated with this level of acceleration is generally perceived as very strong to severe, and the potential for damage to structures is moderate to heavy (Wald et al. 2005). Given the high intensity of ground shaking and the high incidence of historic seismicity in the Cook Inlet region (i.e., 1,200 earthquakes in the past 40 years with 10 exceeding M 6.0) the potential for liquefaction in inlet sediments is also likely to be high, but only in areas like the head region and upper inlet where sediments are composed of glacial silt and fine sands, as demonstrated by the widespread liquefaction documented in Turnagain Arm during the Great Alaska Earthquake of 1964. Areas like the OCS where bottom sediments are more coarse-grained are not likely to be affected (Greb and Archer 2007).

Volcanic Activity. There are four monitored volcanoes located in the Cook Inlet region (from north to south): Spurr, Redoubt, Iliamna, and Augustine (Figure 4.2.1-2; Table 4.2.1-1). These volcanoes are part of the Aleutian Island Arc, a chain of volcanoes extending from south central Alaska to the far western tip of the Aleutian Islands. Three of these volcanoes (Spurr, Redoubt, and Iliamna) are located to the west of Cook Inlet. Augustine is an island volcano in lower Cook Inlet; it is the most active volcano in the region. All but Iliamna have erupted several times in the past 150 to 200 years and may erupt again in the future (Waythomas et al. 1997; Waythomas and Waitt 1998). Because of their composition, volcanoes in the Cook Inlet region are prone to explosive eruptions. Hazards in the immediate vicinity of the eruption include volcanic ash fallout and ballistics, lahars (mudflows) and floods, pyroclastic flows and surges, debris avalanches, directed blasts, and volcanic gases. Lease areas in Cook Inlet would be out of the range of most of these eruption hazards except during very large eruptions (on the scale of the 1980 Mount St. Helens eruption), which tend to be rare events (Combellick et al. 1995; ADNR 2009a). Ash fall associated with the 2009 eruption of Redoubt forced the temporary closure of the Anchorage Airport (ADN 2009); however, there were no reports that it affected oil and gas operations or damaged infrastructure within or around Cook Inlet.

Drainages with headwaters near the three onshore Cook Inlet volcanoes are susceptible to lahars (mudflows) and floods during volcanic eruptions due to the permanent snow and ice stored in snowfields and glaciers on the upper flanks of the volcanoes that can generate flooding upon melting. For example, the Redoubt eruption that occurred in 1989–1990 caused significant melting of the Drift Glacier, generating lahars that inundated the Drift River valley and threatened the Drift River Oil Terminal. Oil storage tanks were damaged (although the tanks did not rupture) and loading operations at the terminal (and associated pipeline and platform services) were interrupted for several months, but resumed once a protective dike was installed around the tank farm and support facilities. The interruption in operations at the terminal caused a significant financial impact to the area (Waythomas et al. 1997; ADNR 2009a; KPB 2011). Drainages vulnerable to volcanically induced floods are the Chakachatna River drainage (from

1 **TABLE 4.2.1-1 Monitored Volcanoes near Cook Inlet[a]**

Volcano	Description/Location	Historical Eruptions	Potential Hazards
Mount Spurr	Ice- and snow-covered stratovolcano on the west side of Cook Inlet, about 120 km (75 mi) west of Anchorage. Peak; elevation is 3,374 m (11,070 ft).	1953 and 1992 (Crater Peak flank vent about 3.5 km [2 mi] south of summit).	Ash clouds, ash fall and bombs, pyroclastic flows and surges, and mudflows (lahars) that could inundate drainages on all sides of the volcano, but primarily on south and east flanks. Eruptions at the Crater Peak vent were brief and explosive, producing columns of ash.
Redoubt	Stratovolcano on the west side of Cook Inlet, about 170 km (106 mi) southwest of Anchorage. Peak elevation is 3,108 m (10,197 ft).	1902, 1966–1968, 1989–1990, and 2009.	Ash clouds, ash fall and bombs, pyroclastic flows and surges, debris avalanches, directed blasts, volcanic gases, tsunamis, and mudflows (lahars) and floods that could inundate drainages on all sides of the volcano, primarily on the north flank. The 1989–1990 eruption produced a lahar that traveled down the Drift River and partially flooded the Drift River Oil Terminal facility. Significant ash plume. Ash fall from the 2009 eruption forced the airport in Anchorage to close temporarily (ADN 2009); there were no reports of damage to oil and gas operations in Cook Inlet. Tephra from future eruptions could travel several hundred kilometers from the volcano (carried by prevailing winds to the northeast).
Iliamna	Ice- and snow-covered stratovolcano on the west side of lower Cook Inlet, about 225 km (140 mi) southwest of Anchorage and 113 km (70 mi) southwest of Homer. Peak elevation is 3,053 m (10,016 ft).	No historical activity.	Ash clouds, ash fall and bombs, pyroclastic flows and surges, debris avalanches, and mudflows (lahars) and floods that could inundate drainages on all sides of the volcano.
Augustine	Island stratovolcano in lower Cook Inlet, about 290 km (180 mi) southwest of Anchorage and 120 km (75 mi) southwest of Homer. Peak elevation is 1,260 m (4,134 ft).	Most active volcano in region with significant eruptions in 1812, 1883, 1908, 1935, 1963–1964, 1976, 1986, and 2006.	Ash clouds, ash fall and volcanic bombs, pyroclastic flows and surges, debris avalanches, directed blasts, mudflows (lahars) and floods, volcanic gases, tsunamis, and lava flows. A large avalanche on the volcano’s north flank during the 1883 eruption flowed into Cook Inlet and may have initiated a tsunami at Nanwalek, about 90 km (56 mi) to the east.

[a] Volcanoes listed are monitored by the Alaska Volcano Observatory in Anchorage. Other volcanoes in the region west of Cook Inlet include Hayes and Double Glacier. The Hayes volcano is a stratovolcano remnant, almost completely ice-covered; no fumeroles have been observed. Most recent eruptions were more than 3,000 years ago. The Double Glacier volcano is a dome remnant surrounded by the Double Glacier; it is considered to be inactive. There are also numerous unmonitored volcanoes (e.g., Mt. Douglas and Fourpeaked Mountain) on the Alaska Peninsula to the west of the Kodiak Islands.

Sources: USGS 2011b; Waythomas and Waitt 1998; Waythomas et al. 1997; Till et al. 1990.

2

Trading Bay to the McArthur River), the Drift River drainage (from Montana Bill Creek to Little Jack Slough), Redoubt Creek, and the Crescent River. The Drift and Chakachatna Rivers are the most likely to host such floods. Volcanogenic mudflows and floods could affect roads and onshore and offshore infrastructure such as pipelines (Combellick et al. 1995; ADNR 2009a).

Other (more distal) volcanic-related hazards include volcanic ash clouds and tsunamis. Volcanic ash is ejected high into the atmosphere and stratosphere by explosive eruptions and drifts downwind, eventually falling to the ground. Hazards related to ashfalls include damage to mechanical and electronic equipment (e.g., engines, computers, and transformers) and, in more rare events, building collapse. Volcanic ashfalls in Cook Inlet are typically less than a few millimeters in thickness and occur with an average frequency of a few every 10 to 20 years (Combellick et al. 1995; ADNR 2009a).

An eruption from Augustine volcano in 1883 caused a debris avalanche that entered Cook Inlet and initiated a tsunami that caused four 4.6 to 9.1 m (15 to 30 ft) waves to hit Nanwalek about 90 km (56 mi) to the east (Waythomas and Waitt 1998; KBP 2011). Waves of 4.6 m (15 ft) also reportedly struck Port Graham. Boats were swept into the harbor and several residences were flooded, but damage was minor because the tide was low at the time (KBP 2011). While the risk of coastal damage from locally generated tsunamis is potentially high, the probability of occurrence is low. The configuration of Cook Inlet and its narrow entrances reduce the likelihood that a tsunami generated outside the inlet would create a significant hazard (Bouma and Hampton 1986).

Flooding. The U.S. Geological Survey (USGS) reports that floods in the Cook Inlet drainage basin result from intense, warm rains originating in the Pacific Ocean. They are also caused by the release of water from glacier-dammed lakes or ice jams (and by tsunamis and seiches, discussed in the next section). Nearly all major floods occur between July and early October, but they can also occur during snowmelt season (May to June) if the snowpack is above average (Brabets et al. 1999).

Since streamflow monitoring began in the late 1940s, at least four major floods have occurred in the drainage basin, covering large areas of the basin and causing considerable property damage (Brabets et al. 1999):

- *May 1971*. Snow cover was greater than average along the Alaska Range, and below-normal air temperatures delayed snowmelt until July, creating conditions conducive to flooding. Inundated areas included northeast and west Anchorage and parts of the Susitna and Matanuska River basins.

- *October 1986*. A large Pacific storm system moved onshore over south central Alaska, causing record-setting rainfall that caused flooding in the lower Susitna River Valley, with recurrence intervals greater than 100 years.

- *August 1989*. Record rainfall caused several streams in the Anchorage area to exceed prior record peak discharges. The Knik River also recorded a peak discharge at a 100-year recurrence.

- *September 1995*. Remnants of a tropical storm caused flooding along the Skwentna River, the Knik River and tributaries, the Kenai River, and along Glacier Creeks (Girdwood). Several rivers discharging to Knik Arm had peak flows estimated to have been greater than the 100-year flood.

Other floods in the Cook Inlet drainage basin have occurred from glacier-dam outbursts that result when glacial movement opens a pathway for water trapped behind a glacier to be released. Rivers on the west side of the upper inlet are subject to outburst floods of great magnitude as a result of sudden drainage of large, glacier-dammed lakes; among these are the Beluga, Chakachatna, Middle, McArthur, Big, and Drift Rivers. One of the largest outburst floods occurred in 1969 (and again in 2007) when water released from glacier-dammed Skilak Lake lifted ice on the frozen river and severely scoured the river banks as a surge of water and large chunks of ice travelled downstream. Outburst floods also occur on the Kenai River (east of Cook Inlet) where a glacier-dammed lake at the headwaters of the Snow River fails every two to 2–5 years. Historically, the Knik River near Palmer (at the northernmost end of Cook Inlet) has flooded when glacier-dammed Lake George fails. Such floods occur more frequently in the fall and can be especially severe if the lakes or the Kenai River are already high or frozen (Brabets et al. 1999; Combellick et al. 1995; ADNR 2009a; KPB 2011).

Ice jam flooding occurs during the spring breakup process when strong ice or constrictions in a river (bends or obstructions like islands or gravel bars) create jam points that cause moving ice along the breakup front to stop (NOAA 2011a). It also occurs when low-density ice masses (frazil ice) become trapped and pile up under surface ice. The ice stoppage causes water levels to rise and flood the adjacent land. Ice jams are more often associated with single-channel rivers in interior and northern Alaska than in rivers of the Cook Inlet drainage basin, but a flood from an ice jam downstream of Skilak Lake in the Kenai River watershed (east of Cook Inlet) occurred in 1969 after an outburst from Skilak Glacier at the head of Skilak Lake, creating a record high river stage (74.25 m [22.63 ft]) and causing severe damage in Soldotna. Ice jams are unpredictable and have the potential to be worse than 100- or 500-year events, causing heavy damage to bridges, piers, levees, jetties, and other structures along the riverbank (Brabets et al. 1999; NOAA 2011a; ADNR 2009a; KPB 2011).

Hazards from flooding result from inundation, riverbank instability and erosion, high bedload transport, deposition at the river mouth, and channel modification and mainly affect onshore facilities (e.g., terminal facilities and pipelines) (ADNR 2009a). Assessing flood potential and community vulnerability is difficult because significant natural and man-made changes occur within floodplains over short time intervals. The KPB has begun Federal Emergency Management Agency (FEMA) flood insurance rate mapping updates, which are scheduled to be completed in late 2010. A vulnerability assessment to identify the population, property, and environment that may be exposed to flooding is also planned for Seward (KPB 2011).

Tsunamis and Seiches. A tsunami is a series of long ocean waves generated by the displacement of a large volume of water caused by earthquakes, volcanic eruptions, submarine landslides, or onshore landslides that rapidly release large volumes of debris into the water. Most tsunami waves affecting south central Alaska are generated along subduction zones bordering the Pacific Ocean where motion along a dip-slip fault and the elastic rebound of subducting crust, produced by an earthquake of magnitude greater than 6.5 on the Richter scale, causes vertical displacement of the seafloor. The great seismicity associated with the subduction zone of the Aleutian-Alaskan megathrust fault system makes the southern coastal region of Alaska, especially the Gulf of Alaska and the Aleutian Islands, highly susceptible to tsunamis (Costello 1985).

Tsunamis are typically not hazardous to vessels and floating structures on the open ocean because of their small wave heights (less than a few feet). However, they are potentially very damaging to coastal regions and nearshore facilities because wave heights can increase significantly as tsunamis approach shallow water. High, breaking waves that reach the shoreline at high tide cause much more damage than waves that are low and nonbreaking or that occur at low tide (Combellick and Long 1983; MMS 1992).

Because of the shallow, elongated configuration of Cook Inlet and its narrow entrances, the hazard from distant tsunamis is low. The hazard from local tsunamis is also low because there are no active surface faults in the inlet, no adjacent steep slopes to serve as sources of massive slides into the inlet, and no evidence of thick, unstable seafloor deposits that could fail and create massive underwater slides. Local landslide-generated tsunamis, however, can be quite large and potentially damaging, as demonstrated by the series of 4.6 to 9.1 m (15 to 30 ft) waves that reportedly hit Nanwalek and Port Graham on the east side of lower Cook Inlet as a result of a debris avalanche caused by the eruption of Augustine volcano in 1883 (Waythomas and Waitt 1998; KBP 2011). Future eruptions of Augustine could potentially generate a tsunami in lower Cook Inlet if significant volumes of volcanic debris were to enter the sea rapidly (although this remains a topic of debate). Modeling studies indicate that a moderate wave is possible (with lead times of about 27 to 125 min), but the likelihood of a tsunami is considered to be low. None of the last five eruptions of Augustine volcano, including the latest one in 2006, resulted in a tsunami; nevertheless, the West Coast and Alaska Tsunami Warning Center and the Alaska Volcano Observatory continue to refine their public outreach strategy to deal with a volcanogenic tsunami because local consequences of such an event could be high (Neal et al. 2011; Waythomas and Waitt 1998; ADNR 2009a).

Seiches are periodic oscillations of standing waves in partially or completely enclosed water-filled basins like lakes, bays, or rivers triggered by changes in wind stress or atmospheric pressure and, less commonly, by landslides and earthquakes (McCulloch 1966). In Alaska, they may also be generated by the collapse of deltas into deep glacial lakes (KPB 2011). An example is the Lituya Bay earthquake of 1958 (M_W 8.2), which caused a landslide at the head of Lituya Bay (on the Gulf of Alaska) and generated a seiche with a wave run-up of about 530 m (1,750 ft) (MMS 1992; Bouma and Hampton 1986).

During the Great Alaska Earthquake of 1964 (M_W 9.2), tsunamis were generated by uplift of the seafloor and seiches were generated by landslides in semiconfined bays and inlets (USGS 2011b; MMS 1992). Because the Kenai Peninsula is susceptible to earthquakes with magnitudes greater than M 6.0, the Kenai Peninsula borough mitigation plan rates the coastal communities and facilities in lower Cook Inlet (south of the Forelands) as highly vulnerable to tsunamis — vulnerable communities include Port Graham, Nanwalek, Seldovia, Homer, Anchor

Point, and Ninilchik. The tsunami risk for upper Cook Inlet, however, is considered low because of its relatively shallow depth and its distance from the lower end of the inlet (KPB 2011).

4.2.1.3 Alaska – Arctic

4.2.1.3.1 Physiography and Bathymetry. The Arctic region is located along the arctic coastline of Alaska. It is composed of the Beaufort Sea, Chukchi Sea, and Hope Basin Planning Areas (Figure 4.2.1-6). The Beaufort Sea stretches from the Alaska-Yukon border westward to Point Barrow. Here, the continental shelf has very low relief (on average 1 m/km; Craig et al. 1985) and extends 60 to 120 km (37 to 75 mi) from shore to water depths of 60 to 70 m (200 to 230 ft). Large-scale physiographic features are rare on the shelf, although barrier islands (rising several meters above sea level) and shoals (rising 5 to 10 m [16 to 33 ft] above the seabed) occur in a chain on the inner shelf along the 20-m (66-ft) depth contour, parallel to the shoreline. These features are migrating to the west at rates of about 20 to 30 m (66 to 98 ft) each year (MMS 2008c). Beyond the shelf is the Alaska rise and slope, an area where gravity-driven slope failures greatly influence the seafloor morphology (Grantz et al. 1994).

The Chukchi Sea is a broad embayment of the Arctic Ocean. It lies to the west of the Beaufort Sea, between Point Barrow to the east and Cape Prince of Wales to the west (Figure 4.2.1-6). The continental shelf in this region has low relief and a gentle slope to the north. Water depths range from about 30 to 60 m (98 to 200 ft) on the shelf and drop sharply to greater than 3,000 m (9,800 ft) into the Arctic basin to the north and east. There are several shoals on the shelf. Two prominent shoals, Herald Shoal to the west and Hanna Shoal to the east (at depths less than 20 m [66 ft] below sea level), are separated by a broad area that is about 35 to 40 m (110 to 130 ft) deep with a central channel. Isolated shoals also occur in the nearshore region (along the north and west coasts) in water depths of 20 to 30 m (66 to 98 ft). Hope Basin, a broad and shallow valley with water depths of about 50 m (160 ft), is located to the southwest of Point Hope (MMS 2008c). The outer edge of the shelf is dissected by gullies and large erosional features (Phillips et al. 1988).

The Beaufort and Chukchi shelves are separated by the Barrow Sea Valley, a 200-km (120-mi) long, flat-bottomed basin incised by fluvial erosion during the Pleistocene epoch and interglacial marine currents (Figure 4.2.1-6). The valley ranges in depths from about 100 to 250 m (330 to 820 ft) (Craig et al. 1985; Phillips et al. 1988).

4.2.1.3.2 Geologic Hazards. Several types of geologic hazards are known to occur in the marine environment of the Beaufort and Chukchi Seas and may present a risk to offshore oil and gas activities because they are dangerous to navigation or potentially damaging to marine structures. The potential geologic hazards in the Arctic region, except for sea ice and permafrost, which are addressed in Section 4.2.2.1.2 and 4.2.2.2, are described below.

Offshore and Coastal Currents. Marine currents along the central Beaufort shelf are primarily wind-driven and are strongly regulated by the presence or absence of ice. Sediment is

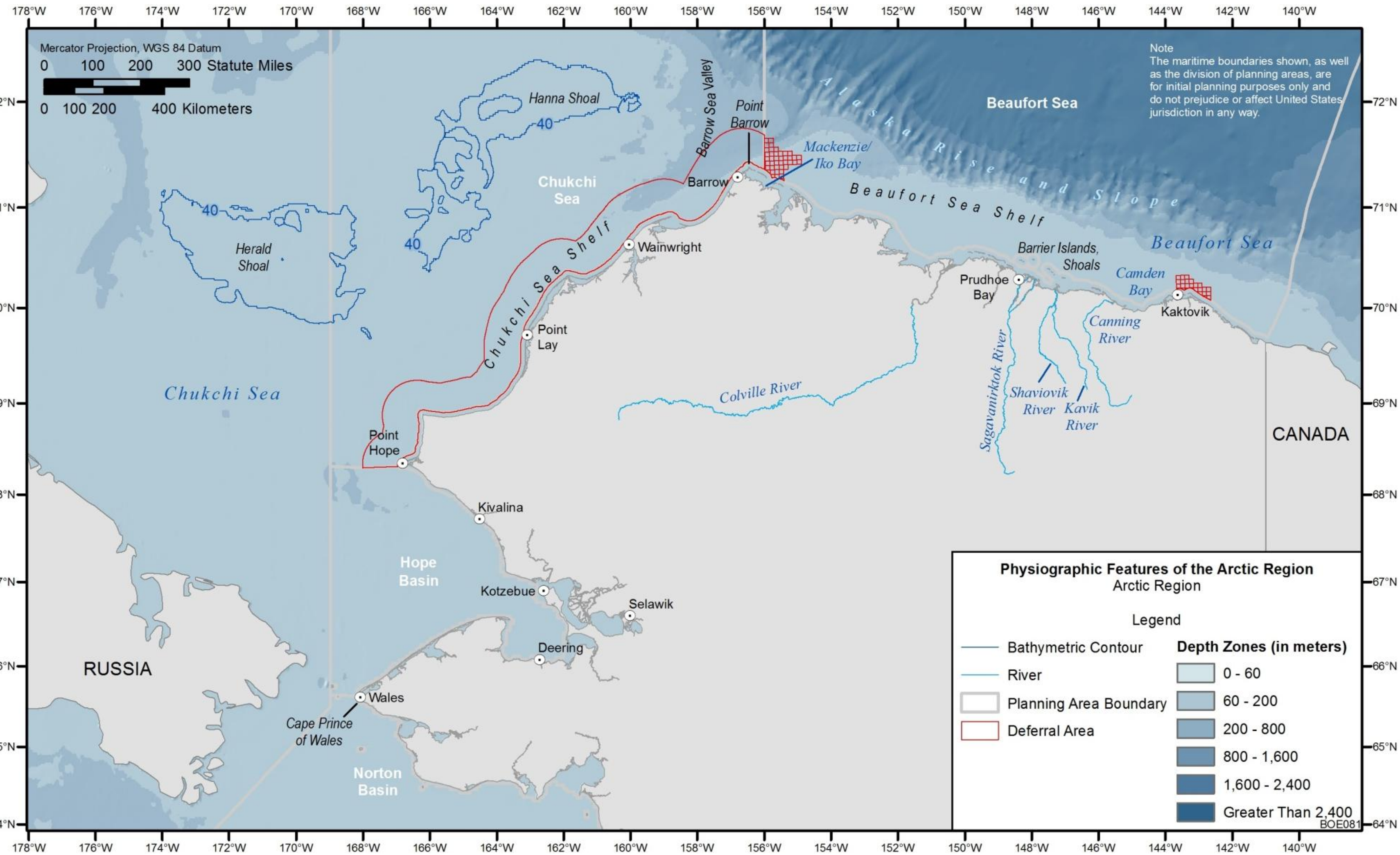

FIGURE 4.2.1-6 Physiographic Features of the Arctic Region

transported by these currents along the barrier islands and the coastal promontories, although, because of the short open water season, the annual rate of longshore sediment transport is relatively low. The currents along the inner shelf generally flow to the west in response to the prevailing northeast wind, with current reversals occurring close to shore during storms. Farther from the shoreline, on the open shelf, the currents average between 7 and 10 cm/s (2.8 to 3.9 in./s). During storms, east-flowing currents have been measured with velocities of up to 95 cm/s (37 in./s), although typical storm current velocities are an order of magnitude lower. Under the ice in the winter, the currents are usually less than 2 cm/s (0.79 in./s), although some currents have been measured at up to 25 cm/s (9.8 in./s) in areas around grounded ice blocks (Hopkins and Hartz 1978; ADNR 2009a).

Geostrophic currents occur on the outer shelf, flowing parallel to the shelf-slope break. These currents have been measured at velocities of up to 50 cm/s (20 in./s) and can travel in both easterly and westerly directions. Since the tidal range on the central Beaufort shelf is small, approximately 15 to 30 cm (5.9 to 12 in.), the tidal currents exert only minor influences on the sedimentary regime. When the water flow on the shelf is restricted by bottomfast ice, these currents can act as important scouring agents (Craig et al. 1985; ADNR 2009a).

Offshore structures must be designed to withstand strong marine currents, loading from ice forces, and severe storms in the Beaufort Sea. Production platforms will typically be bottom-founded (gravity base) to withstand conditions that change with the seasons. Drill ships for exploration are not bottom-founded; therefore, they can only operate in low ice cover conditions. Artificial or natural gravel islands must be fortified and built to withstand coastal currents as well as the forces of moving sea ice for the lifespan of the producing field. To this end, they may require periodic maintenance in response to heavy storms (ADNR 2009a).

Flooding. Floods due to seasonal snowmelt and ice jams occur annually along most of the rivers in the Arctic region and many of the adjacent low terraces. Spring ice breakup on rivers often occurs over the first few days of a three-week period of flooding in late May through early June. Up to 80% of the flow occurs during this period. The impact of flooding is in large part related to the magnitude and timing of seasonal ice breakup. The formation of ice jams is especially associated with catastrophic flooding. Some of the most damaging floods are associated with an above-average snowpack that is melted by rainstorms and sudden warming (ADNR 2009a).

Significant bank erosion may occur during flooding, depending on the amount of water and its level with respect to the river bank and the nature of the sediment (or ice) load. Ice carried along by rivers can produce significant erosion, especially if breakup occurs during a low river stage. Spring floodwaters inundate large areas of the deltas, and on reaching the coast spread over stable ground and floating ice up to 30 km (19 mi) from shore. When floodwater reaches openings in the ice often associated with tidal cracks, thermal cracks, and seal breathing holes, it rushes through with enough force to scour the bottom to depths of several meters (a process known as strudel scouring) (ADNR 2009a).

Along the Beaufort shelf, strudel scour craters have formed up to 6 m (20 ft) deep and 20 m (66 ft) across. In a study for the Northstar Pipeline, strudel scours were found in water depths of 2.2 to 5.4 m (7.2 to 18 ft), with the greatest scour occurring at depths of 3 to 4 m (9.8 to 13 ft). Sheltered coastal areas and bays adjacent to major rivers (such as the Colville, Sagavanirktok, and Canning) are particularly susceptible to strudel scouring. In these areas, deltas can be totally reworked by strudel scouring in several thousand years, although the scours can be filled in very rapidly (ADNR 2009a).

In addition to seasonal flooding, many rivers along the coast are subject to seasonal icing before spring thaw. This is due to overflow of the stream or groundwater under pressure, often where frozen or impermeable bed sections force the winter flow to the surface to freeze in a series of thin overflows, or where spring-fed tributaries overflow wide braided rivers. In areas of repeated overflow, residual ice sheets often become thick enough to extend beyond the floodplain margin. These large overflows and residual ice sheets have been documented on the Sagavanirktok, Shaviovik, Kavik, and Canning Rivers (ADNR 2009a).

Seasonal flooding of lowlands and river channels is extensive along major rivers of the Arctic region. Thus, measures must be taken before facility construction and field development to prevent impacts on structures and environmental damage (ADNR 2009a).

Barrier Island and Bedform Migration. Barrier islands along the Beaufort shelf consist of dynamic constructional islands and remnants of the Arctic coastal plain (ACP). As the barrier islands along the Beaufort shelf are migrating westward and landward due to erosion and redeposition by waves and currents, they are generally becoming narrower and breaking up into smaller segments (Hopins and Hartz 1978). During the open water season, longshore drift, storm surges, and ice push contribute to the erosion, migration, and breakup of these islands, which may permanently affect their size and influence on coastal processes.

Along the Chukchi shelf, asymmetrical bedform features, including small sand waves, larger shore-parallel shoals, and the grouped features of the Blossom Shoals, occur in water depths ranging from less than 15 m (50 ft) to approximately 60 m (200 ft) and extend to distances of up to 160 km (100 mi) offshore. The migration of sand waves and other bedforms can cause problems to offshore facilities by undermining or burying fixed structures, anchors, moorings for submersibles, and pipelines, which can rupture (Bouma and Hampton 1986).

Overpressured Sediments. Along the Beaufort and Chukchi shelves, extremely high pore pressures are likely to be found in deep basins (Kaktovik, Camden, and Nuwuk) where Cenozoic strata are very thick. For example, in the Point Thomson area, pore pressure gradients as high as 0.8 psi/ft (far exceeding the normal gradient of 0.433 psi/ft) have been measured in sediments at burial depths of 4,000 m (13,100 ft) (Craig et al. 1985; ADNR 2009a).

Encountering overpressured sediments during drilling can result in a loss of well control or uncontrolled flow (if formation pressures exceed the weight of drilling mud in the well bore). Identifying locations of overpressured sediments by seismic data analysis and adjusting the drilling mud mixture accordingly reduce this risk (ADNR 2009a).

Shallow Gas Deposits and Natural Gas Hydrates. Shallow gas deposits have been mapped using high-resolution seismic data in isolated areas within the continental shelf and slope regions of the Beaufort and Chukchi Seas. A recent investigation by the Joint Russian-American Long-Term Census of the Arctic Project team identified a pockmark field on the Chukchi Plateau. The pockmarks are typically related to the explosive release of gas (or gas-saturated water or oil)[12] (Astakhov et al. 2010). On the middle and inner shelf, gas is concentrated in buried Pleistocene delta and channel systems, along active faults overlying natural gas sources and in pockets within and beneath permafrost very near to shore. On the outer shelf and slope, shallow gas is likely to occur in association with a large body of gas hydrate and at the head of the landslide terrain on the outermost region of the shelf and upper slope. The origins of shallow gas may be biogenic or thermogenic; in either case, its presence poses a hazard to bottom-founded structures because it can reduce the shear strength of sediments. Loss of well control may also occur when drilling operations encounter overpressured gas below the seabed (Grantz et al. 1982a, b; ADNR 1999).

Natural gas hydrates are unique compounds consisting of ice-like substances composed of gas trapped within water molecules. They are common in offshore regions under low-temperature, high-pressure conditions as well as at shallower depths associated with permafrost. In the Beaufort and Chukchi Seas, gas hydrates have been found at shallow depths under permafrost along the inner shelf and onshore at Prudhoe Bay and at the Mount Elbert well in Milne Point where downhole coring and logging operations were recently completed (ADNR 2009a).

One of the main problems associated with gas hydrates is dissociation, which causes unstable conditions by increasing fluid pressure and reducing sediment shear strength. Natural mechanisms leading to gas hydrate dissociation include sea level decrease and sediment temperature increase. Man-made mechanisms include heat transfer during petroleum production that leads to melting of hydrates. During drilling, rapid decomposition of gas hydrates can cause a rapid increase in pressure in the wellbore, gasification of the drilling mud, and the possible loss of well control. If the release of the hydrate gas is too rapid, a loss of well control can occur, and the escaping gas could ignite. In addition, the flow of hot hydrocarbons past a hydrate layer could result in hydrate decomposition around the wellbore and loss of strength of the affected sediments (ADNR 2009a).

Dissociation of gas hydrates is a potential cause of submarine slope failures. Acoustic records indicate a stretch of slumps in the Beaufort Sea along the shelf-edge break. The slumps extend for at least 500 km (310 mi) in an area of known gas hydrates and should be considered during exploration and development activities (ADNR 2009a).

Because gas hydrates and shallow gas deposits pose risks similar to overpressured sediments, the same mechanisms for well control should be employed to reduce the danger of loss of life or damage to the environment (ADNR 2009a).

Sediment Sliding, Slumping, and Subsidence. Locally high rates of deposition of unconsolidated sediments on the increased gradient of the continental shelf edge may form

[12] On the Chukchi Plateau, pockmarks may indicate areas of rapid gas release; however, their size and morphology are also consistent with thermokarst depressions developed along the Arctic shoreline (Astakhov et al. 2010).

unstable slopes that lead to intensive soil movements such as slumping, gravitational creep, turbidity or debris flows, and mudslides. A chaotic sediment slide terrane exists along the length of the Beaufort shelf and upper slope, seaward to the 50- to 60-m (160- to 200-ft) isobath. The distinct landslide types in this area include large bedding-plane slides and block glides. Sediment slumping, possibly associated with permafrost melting, has been observed north of the Mackenzie Delta in Canadian waters and may also disrupt buried pipelines and damage drilling structures (Grantz et al. 1982b).

Sediment slumping may also occur in association with active faulting. Regionally high rates of deposition on the continental shelf may cause isostatic adjustments and deep-seated gravity faulting (active faulting). Active gravity faults related to large rotational slump blocks occur on the outer Beaufort shelf and upper slope due to increased gradients along the shelf-slope break (Grantz and Dinter 1980).

Seismicity. Ground shaking during a major earthquake can cause consolidation problems in artificial gravel islands used as drilling platforms and affect bottom-founded structures. Earthquakes can also cause vertical and/or horizontal displacement along faults, uplift or subsidence, surface tilt, ground failure, and inundation (due to tsunamis) — all of which may affect the integrity of development infrastructure.

Several types of shallow faults occur on the Beaufort shelf, including high-angle, basement-involved normal faults (Barrow Arch in Harrison Bay); listric growth faults; and down-to-the-north gravity faults along the shelf-slope break. There has been no seismicity associated with the high-angle faults in Harrison Bay in recent times and there is little evidence of Quaternary movement, but these faults may act as conduits for gas migration (Grantz et al. 1982a, b; Craig et al. 1985).

The Camden Bay area, located at the northern end of a north-northeast trending band of seismicity extending northward from east-central Alaska, is seismically active, and near-surface faults show marked evidence of Quaternary movement. Since monitoring began in 1978, numerous earthquakes have occurred in the area along the axis of the northeast-southwest trending Camden anticline, ranging in magnitude from 1 to 6 (Craig et al. 1985; Grantz et al. 1982a, b).

There is no historical record of seismicity on the Chukchi shelf; however, sediment-covered fault scarps in the northern Chukchi Sea suggest Quaternary movement along faults in this region (Thurston and Theiss 1987; Grantz et al. 1982a).

The region along Alaska’s northern coast lies within an area where the peak horizontal acceleration with a 10% probability of exceedance in 50 years is between 0.03 and 0.07 g (Wesson et al. 2007). Shaking associated with this level of acceleration is generally perceived as weak, and the potential for damage to structures is negligible (Wald et al. 2005).

4.2.2 Sea Ice and Permafrost

4.2.2.1 Sea Ice

4.2.2.1.1 Cook Inlet. Ice cover in Cook Inlet is seasonal, forming in the fall (October to November; although the lower inlet is usually still ice-free in December) and disappearing completely in the spring. However, the dates of onset and clearance can vary considerably from year to year. The U.S. Army Corps of Engineers' (USACE) report *Marine Ice Atlas for Cook Inlet, Alaska* (Mulherin et al. 2001) provides a description of the factors that favor and discourage ice growth. It notes that offshore platforms built in Cook Inlet follow ice design criteria specified by the American Petroleum Institute. Since 1984, the National Weather Service (NWS) has provided analysis and forecasts for the extent, concentration, and stage of development of ice to aid commercial navigation, as well as fishing and tourist activities in the inlet (NWS ice chart archives are maintained by the Alaska State Climate Center in Anchorage); the National Ice Center also prepares semiweekly analyses throughout the ice season.

There are four types of ice that form in Cook Inlet: pack ice, shorefast ice, stamukhi, and estuarine and river ice. Pack ice is freely floating sea ice that forms directly from the freezing of seawater. In the shallow and turbulent waters of Cook Inlet, a major component of pack ice is "frazil" ice, which occurs as low-density masses of slushy, unconsolidated ice on the water surface. Floating ice poses the greatest hazard to navigation and marine structures. Between 1964 and 1986, at least eight incidents involving sea ice in Cook Inlet were recorded by the U.S. Coast Guard (USCG), most resulting in damaged pilings and docks in the Port of Anchorage area. In 1988, a small crude oil spill resulted when a tanker was punctured by ice. Several similar ice-related incidents have been recorded since then (Mulherin et al. 2001).

Shorefast ice is unmoving ice that remains firmly attached to the shoreline or other stationary structures once it forms. It forms directly by the freezing of seawater and from the piling and refreezing of ice or the flooding of snow on top of the ice. One form of shorefast ice, "beach ice," forms during flood tide as water freezes with mud and bonds to the sea bottom. When the air temperature is colder than seawater, this ice becomes progressively thicker with each successive high tide, accumulating as much as 2.5 cm (1 in.) of ice per tidal flood. The ice usually breaks free before it reaches about 0.5 m (1.6 ft) in thickness. Once freed, it becomes floating (pack) ice and drifts into deeper water (Mulherin et al. 2001).

Stamukhi are a form of sea ice that have broken and piled upward (hummocked) due to winds, tides, or thermal expansion. Under the right conditions (e.g., repeated wetting and accretion of seawater), they form the massive ice blocks (ice cakes) common to Cook Inlet. Stamukhi as thick as 12 m (40 ft) have been reported. Their large size makes them very hazardous to shipping vessels (Mulherin et al. 2001).

Much of the ice in Cook Inlet derives from freshwater sources — estuaries and rivers — especially in the head region and upper inlet. Estuarine ice is similar to sea ice but is significantly stronger. It is commonly entrained in pack ice and presents the same hazards to navigation and marine (shoreline) structures. River ice is discharged into the inlet during spring breakup; ice pieces can be as thick as 2 m (6.7 ft) (Mulherin et al. 2001).

4.2.2.1.2 Arctic Region. The Beaufort shelf is ice-covered between mid-October and mid-June, with a typical ice-free period during August and September. Sea ice begins forming in late September to early October and becomes continuous nearshore by mid-October. This ice remains through the winter and starts to break up in July, but the nearshore region is not ice-free until early August. In recent years, breakup has occurred earlier by as many as 21 and 6 days along the Beaufort and Chukchi coasts, respectively. Ice-free coastlines now occur over a month earlier along the Beaufort coast (ADNR 2009a; MMS 2008c).

During the winter months, ice occurs within three main nearshore and offshore zones: the landfast zone, the shear zone (also called the active or stamukhi zone), and the pack ice zone. Landfast ice forms along the shore and develops seaward in the early fall, extending 25 to 50 km (16 to 31 mi) from shore by late winter. This ice is up to 2 m (6.6 ft) thick and is considered stable because it is relatively stationary (moving less than a few meters after it forms). Small movements of the ice are related to storm fronts, which cause narrow leads and rubble fields in this zone (Reimnitz and Barnes 1974; MMS 2008c; ADNR 2009a).

The shear zone (stamukhi zone) is a transitional zone between landfast ice and the highly mobile pack ice, occurring approximately 20 to 60 km (12 to 37 mi) from the coast in water depths of about 20 to 100 m (60 to 330 ft). Fragments of seasonal ice and multiyear ice ridges are common in this zone. Ice ridges range in thickness from 10 to 12 m (33 to 39 ft) with an average thickness of 6 m (20 ft). It is here where ice is constantly being reworked and shifted and ice gouging (discussed below) occurs most intensely (ADNR 2009a; MMS 2008c).

Seaward of the stamukhi zone is the pack ice zone, which marks the shoreward edge of the permanent polar ice cap. It consists of multiyear ice, ice ridges, and ice island fragments that migrate westward in response to the clockwise circumpolar gyre (Reimnitz and Barnes 1974; ADNR 2009a). The drift rate of ice in this zone can be as high as 20 km/day (12 mi/day) (MMS 2008c).

The Chukchi shelf is largely covered by ice between mid-November and mid-June; August and September are typically ice-free. Ice thicknesses in the region are generally less than 1.2 to 1.4 m (3.9 to 4.6 ft) during the annual cycle. Multiyear ice is common in the Chukchi Sea; extensive ridging (with a ridge frequency of 3 to 5 per kilometer and sail heights of 1.5 to 3.7 m [4.9 to 12 ft]) is also common (MMS 2008c).

Sea ice poses a potential hazard to coastal and offshore structures; for example, concrete island drilling structures could be pushed off location, ice could override a fixed structure, or a marine pipeline could be damaged where it comes ashore. Facilities exposed to the potential risks of each sea ice zone must be designed and fortified to accommodate ice forces (ADNR 2009a).

Ice Scouring (Ice Gouging and Strudel Scour). The continental shelf below the Beaufort and Chukchi Seas is vulnerable to ice gouging and strudel scour, both of which must be taken into consideration when siting and designing subsea pipelines. Ice gouging results when ice ridges or icebergs with deep keels, moving under the influence of forces such as wind and ocean currents, run aground and penetrate the seabed, leaving linear to curvilinear deep furrows. Strudel scour occurs in relatively shallow water in the spring during river breakup when overflood waters spreading over bottomfast ice sheets and draining with high velocity through holes in the ice sheet (e.g., tidal cracks, thermal cracks, and seal breathing holes) erode the underlying sediments, leaving behind circular or linear areas of scour in the seabed. The magnitude and frequency of strudel scour events are affected by the timing and location of overflooding river discharge (and the effects of ice jams), and the types of surface features present (e.g., drainage cracks and fissures). Pipelines should be trenched to depths below the predicted scour depth and should be designed to withstand the forces associated with the gouging process, which can cause significant soil displacement (MMS 2008c; ADNR 2009a).

Although ice gouges are found across the entire Beaufort shelf, they are concentrated in the stamuhki zone, between the 10- and 30-m (33- and 98-ft) depth contours, with the most intense gouging on the up-drift side of shoals and islands bordering the stamuhki zone. In this region, crossing frequencies of 1 to 6 gouges/km/yr and a maximum gouge depth of 3.9 m (13 ft) have been reported. Ice gouges have a general east-west orientation, reflecting the prevailing wind and surface current directions; however, on the inner shelf where shoals and other bottom features deflect the ice, orientations are more variable. Off Prudhoe Bay, the inner boundary of high-intensity ice gouging is controlled by the location of the island chains, about 15 to 20 km (9.3 to 12 mi) offshore. In Harrison Bay, where there are no barrier islands, ice gouges are concentrated in areas of abundant ice ridge formation (MMS 2008c; Craig et al. 2005).

Ice gouging is less frequent inshore of the stamuhki zone (with reported crossing frequencies ranging from 1 to 2 gouges/km/yr) (MMS 2008c). It is also less severe in this region because gouges are rapidly buried by sand waves or sediment sheets (loose, coarser grained sediments in the nearshore region degrade more rapidly than the more cohesive, fine-grained sediments offshore). The incidence of ice gouging also decreases with increasing water depth offshore of the stamuhki zone since the number of ice keels large enough to reach the bottom decreases. Along the outer shelf edge, strong geostrophic currents smooth the older ice gouges by eroding or filling them in (ADNR 2009a).

Little survey data on ice gouging features are available for the Chukchi Sea, and repetitive mapping that would allow observed gouges to be dated and gouge rates to be estimated has not been done. However, gouge geometry (depth and width) and density have been recorded over broad areas in the Chukchi Sea, to a maximum water depth of 60 m (200 ft). The most significant ice gouging occurs on the main part of the continental shelf at water depths of 30 to 60 m (98 to 200 ft) where surficial sediments consist of thin deposits of sand and gravel overlying stiff consolidated clay or dense sandy gravel. In this region, a maximum gouge depth of 4.5 m (15 ft) was observed within a water depth of 35 to 40 m (110 to 130 ft). Gouges may be many kilometers long and tens of meters wide, and their dominant orientation is northeast-southwest (MMS 2008c; Phillips et al. 1978).

The areas adjacent to the Herald and Hanna shoals have only limited ice gouging (no gouge depths were recorded). Nearshore areas where water is shallow (less than 30 m [98 ft]) have an average gouge depth of 0.8 m (2.6 ft) and also have a low ice gouging density (MMS 2008c; Toimil 1978). Nearshore sediments are reworked by waves and currents to the extent that ice gouge morphology is readily obliterated by erosion and/or burial (Barnes and Reimnitz 1979). In general, ice gouging is more prevalent in the northern part of Chukchi Sea because the extent and duration of ice cover is greater. In the southern part of the Sea, the longer open water season allows for more reworking of the seabed by wave and current action, which likely masks evidence of past gouging (MMS 2008c).

Ice Movement (Ice Ride-up, Ice Override, and Icebergs). Continuous, large-scale ice movements in the Beaufort Sea are caused by major current systems (e.g., the Beaufort Gyre), tidal currents, or geostrophic winds. Local, short-term movements result mainly from wind, wave, and current action, particularly during storms. During a single ice season, ice movements create zones of landfast and pack ice. Zone boundaries fluctuate with seasonal ice growth and movement. Ice movements at a given site may have a predominant direction due to geography and environmental conditions (ADNR 2009a).

On islands and coastal regions throughout the Beaufort Sea, both ice ride-up (or ice push) and ice override events erode and transport significant amounts of sediment. Ice ride-up occurs where strong wind or currents force ice blocks onshore, pushing the sediment from the coast into the ridges farther inland. These processes are particularly important to consider for the outer barrier islands, where ice ride-up ridges may be as high as 2.5 m (8.2 ft) and extend 100 m (330 ft) inland, and man-made structures are along the coast. They also have the potential to alter shorelines and nearshore bathymetry, increasing the risk of damage to man-made structures by erosion. Several accounts of damage to structures due to ice ride-up events have been documented along the Beaufort coast. For example, in January 1984, ice overtopped the Kadluck, an 8-m (26-ft) high caisson-retained drilling island located in Mackenzie Bay (MMS 2003e; ADNR 2009a).

Ice override occurs both offshore and onshore wherever ice overrides rafted ice or ice ride-ups along the coastline. Ice override onshore will add an additional dead load to a buried pipeline in the transition area from offshore to onshore beginning where the ice contacts the sea floor. This dead load, along with the force being exerted by the ice and the strength of soil, must be considered in pipeline design (ADNR 2009a).

Icebergs in the Beaufort Sea are rare but may be present as a result of calving off Nansen Island. Natural ice islands have also been observed on occasion. Ice islands are produced by the breakup of portions of the Ellesmere Ice Shelf and occur as tabular icebergs of the Arctic Ocean. They are usually 40 to 50 m (130 to 160 ft) thick with lateral dimensions that range from tens of meters to tens of kilometers. The annual risk of an iceberg or ice island impacting an offshore production facility is estimated to be 1 in 1,000 years; however, there is no threat to exploration or development activities in more shallow, nearshore regions (MMS 2008c; ADNR 2009a).

4.2.2.2 Subsea and Coastal Permafrost (Arctic Region)

Bonded permafrost formed on the Beaufort shelf during the Pleistocene lowstands of sea level to several hundred meters below the exposed shelf (Wang et al. 1982; Hunter and Hobson 1974). During the subsequent highstands of sea level, melting of the permafrost occurred, in part due to geothermal heating and saline advection of seawater into the sediments (MMS 1985; MMS 2003e). Currently, permafrost is known to be present onshore and is inferred to be present offshore in the Beaufort Sea Planning Area (MMS 1985). Subsea permafrost is inferred but has not been identified beneath the Chukchi Sea shelf (MMS 1987). Depths to the top of subsea permafrost in the Beaufort shelf are highly variable, and the thickness of the permafrost is unknown (MMS 1985). There is a transition from bonded permafrost on land that is unstable when thawed to generally thaw-stable materials offshore.

Thaw subsidence (also known as thermokarst subsidence) and frost heave associated with permafrost in the Arctic region can create potential hazards to onshore oil and gas operations. The geologic record during the last Arctic glacial-to-interglacial transition indicates that global warming played a key role in disrupting the thermal balance of permafrost and initiating regional thaw subsidence. And some of the thermokarst activity (e.g., melting of ice wedges) over the last 100 to 150 years can also be attributed to global warming (Murton 2008). Oil and gas related activities may also contribute to this process. These include drilling through permafrost layers; building and maintaining crude oil pipelines; placement and operation of bottom-founded structures; and construction of artificial islands, causeways, and berms. Subsea permafrost that contains trapped gas may melt during the drilling of wells or the subsequent production activities in areas surrounding the borehole, causing subsidence and rupture of the well casings and potentially leading to loss of well control.

4.2.3 Physical Oceanography

4.2.3.1 Gulf of Mexico

The physical conditions of ocean waters have the potential to disrupt activities relating to oil and gas production that occur on the continental shelf and slope, as well as in deepwater regions of the GOM. Coherent water motions and breaking waves can fatigue and damage oil and gas platforms and facilities, limit the timing of supply boats and drilling operations, and suspend all operations during extreme conditions such as hurricanes or tropical storms (MMS 2005a; Kaiser and Pulsipher 2007). As waves approach deck heights of platforms and supply ships, they can put equipment and personnel at risk (MMS 2005b). Storm events can also produce large forces near the ocean bottom that can scour sediments and affect pipelines and platform structures (Det Norske Veritas 2007; Cruz and Krausmann 2008; Wijesekera et al. 2010). Additionally, water currents and waves affect the horizontal and vertical transport of spilled oil, as well as contribute to the physical conditions that control natural weathering processes such as evaporation, emulsification, and oxidation (NOAA 2002; NRC 2003b).

The GOM is a partially enclosed sea covering an area of approximately 1.5 million km^2 (579,153 mi^2) and is connected to the Caribbean Sea and the Atlantic Ocean. The bathymetry of the GOM can be generalized as having a wide continental shelf along its northern and southern edges, prominent escarpments, and a relatively flat ocean floor (Bouma and Roberts 1990; see Figure 4.2.1-1. Circulation patterns in the GOM are the result of complex interactions among the bathymetry of the basin and forcing mechanisms that include winds, atmospheric conditions, water density (related to temperature and salinity), and the Loop Current (described below) (e.g., Oey et al. 2004; Sturges and Kenyos 2008). The GOM can be characterized as a two-layered system with respect to circulation patterns having a surface layer of up to 1,000 m (3,281 ft) in depth and a deep layer reaching down to the ocean floor at depths of approximately 4,000 m (13, 123 ft) (Lugo-Fernandez and Green 2011).

A generalized depiction of major circulation patterns and bathymetry of the GOM is shown in Figure 4.2.3-1. The Loop Current and its associated meso-scale eddies are the dominant circulation features (Oey et al. 2005). Effects associated with Earth's rotation set up a western boundary current that is a part of an anticyclonic (clockwise) circulation pattern found in the western half of the GOM (Sturges and Blaha 1975; Sturges 1993). Over the continental shelf of Texas and Louisiana, wind-driven downcoast currents are common, with an opposite current along the continental slope (Cochrane and Kelly 1986; Nowlin et al. 1998; Zavala-Hidalgo et al. 2003). Currents along the continental shelf off Mississippi-Alabama show a pattern of complex cyclonic and anticyclonic eddy pairs with strong inter-annual variability, and they are also influenced by the positioning of the Loop Current (Brooks and Giammona 1991; Jochens et al. 2002). Deepwater circulation follows a counterclockwise pattern and consists primarily of low-frequency waves that receive energy from the Loop Current and its eddies (Hamilton 1990, 2007).

Understanding the circulation patterns and physical oceanographic conditions is vital for improving oil and gas production and exploration activities with respect to preserving the environment (Ji 2004; Lugo-Fernandez and Green 2011). In the GOM, the energetic water currents and waves that have the greatest potential to affect oil and gas activities can be characterized as those associated with episodic weather events (e.g., hurricanes and tropical storms), large-scale circulation patterns including the Loop Current and its associated meso-scale eddies, vertically coherent deepwater currents, and high-speed jets (DiMarco et al. 2004).

4.2.3.1.1 Hurricanes and Tropical Storms. Tropical conditions normally prevail over the GOM from June until October, and in a typical year, 11 tropical storms will form in the region with approximately 6 reaching hurricane status (Blake et al. 2007). Hurricanes and tropical storms can increase surface current speeds to between 1 and 2 m/s (3.2 and 6.8 ft/s) in continental shelf regions (Nowlin et al. 1998; Teague et al. 2007), as well as produce current speeds of more than 0.5 m/s (1.6 ft/s) in deeper waters on the continental slope (Brooks 1983; Teague et al. 2007). Recorded wave heights during recent hurricanes have shown an increasing pattern, with maximum wave heights exceeding 30 m (98 ft), which are greater than the current 100-year storm criteria for platform deck heights (MMS 2005b; Jeong and Panchang 2008). Storm surges can impact infrastructure along coasts and have been reported to range between 2 and 8 m (7 and 26 ft) for hurricanes reaching the northern coast of the GOM (NOAA 2011b).

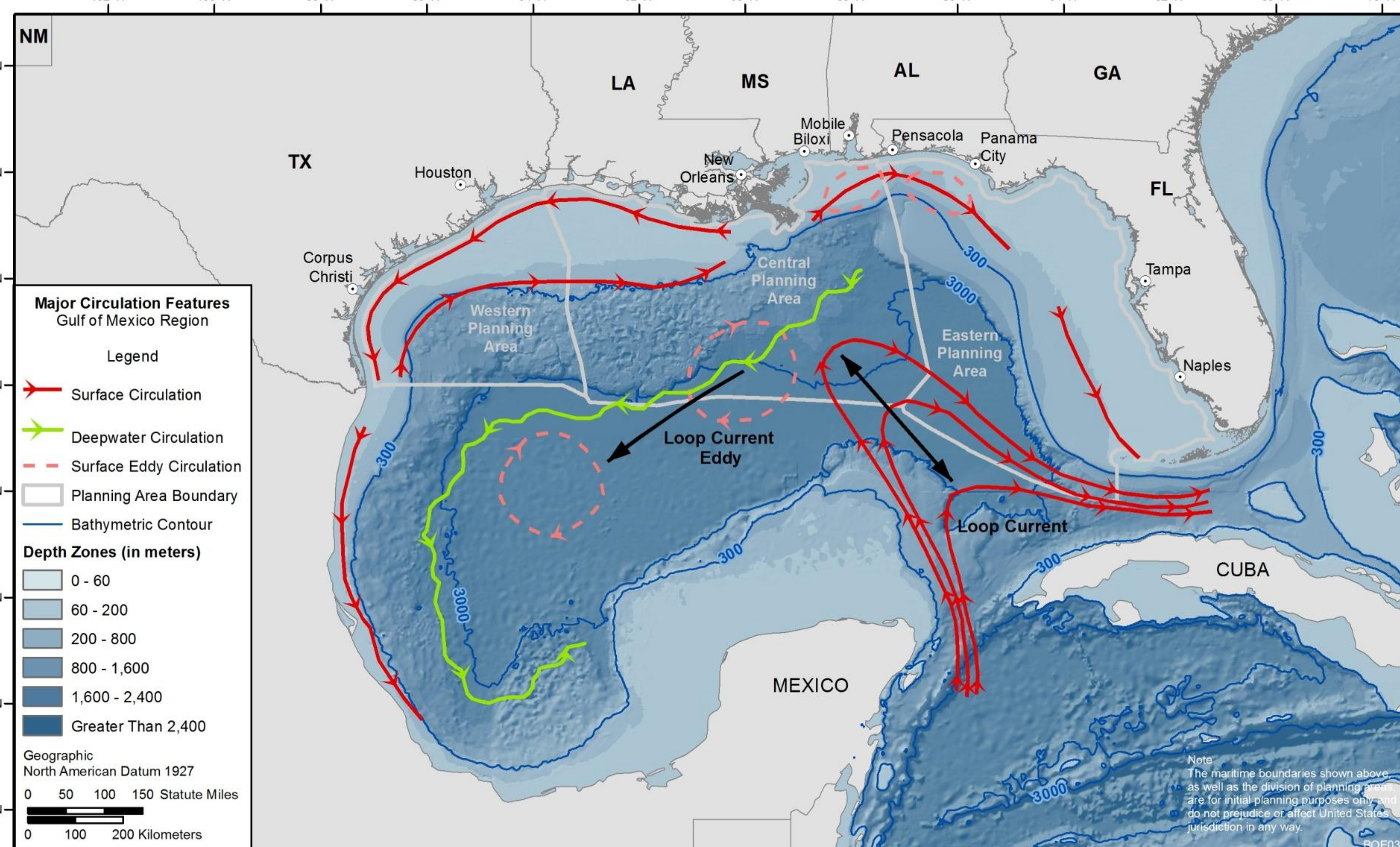

FIGURE 4.2.3-1 Generalized Circulation Patterns in the GOM

Extensive observations of hurricane-induced currents and waves were not available until recent years, starting with Hurricane Ivan in 2004, which passed over an extensive array of instrumented moorings of the U.S. Naval Research Laboratory's Slope to Shelf Energetics and Exchange Dynamics (SEED) program (Stone et al. 2005; Teague et al. 2006a). As Hurricane Ivan approached the northern GOM in the fall of 2004, wind stresses produced downwelling conditions on the continental shelf with advective onshore surface currents and offshore currents in the lower portion of the water column (Mitchell et al. 2005; Teague et al. 2007). Current speeds on the continental shelf were often greater than 1.1 m/s (3.6 ft/s) with many flow reversals during the passage of the hurricane, and strong waves prevailed for up to 10 days in the wake of the hurricane's passage (Teague et al. 2007; Wijesekera et al. 2010). Sediment scour on the continental shelf was observed to be more than 100 million m^3 (81071 ac-ft) over a region of 525 km^2 (203 mi^2) (Teague et al. 2006b). Maximum wave heights associated with Hurricane Ivan reached 28 m (92 ft) with significant wave heights (average wave height of the upper-third-largest waves) reach 16 m (52 ft) (Jeong and Panchang 2008).

Hurricanes Ivan, Katrina, and Rita (2004 and 2005) were some of the most powerful hurricanes to enter the GOM (Stone et al. 2005) and were very damaging to oil and gas facilities and production operations (Cruz and Krausmann 2008). The strong winds, rapid currents, high waves, and sediment scour associated with Hurricane Ivan damaged offshore platforms, production wells, and pipeline systems resulting in a disruption of 10% of the GOM's production over a four-month period (MMS 2005c). Hurricanes Katrina and Rita resulted in more than 150 platforms (approximately 4% of the total number of platforms in the GOM) being damaged or destroyed primarily by effects associated with wave inundation (Cruz and Krausmann 2008). In response to these recent and severe hurricane events, industry and regulators are reexamining offshore oil and gas structural designs to improve their resistance to hurricanes, especially with respect to deck heights to resist wave inundation, as well as mooring anchors and pipeline designs to prevent damage by sediment scouring and mudslides (Abraham 2005; MMS 2005b).

4.2.3.1.2 Loop Current and Loop Current Eddies. The dominant circulation pattern in the GOM is the Loop Current, which can be generalized as a horseshoe-shaped circulation pattern that enters through the Yucatan Channel and exits through the Florida Straits (Figure 4.2.3-1). The Loop Current covers approximately 10% of the GOM's area (Hamilton et al. 2000; Lugo-Fernandez and Green 2011), has surface current speeds up to 1.8 m/s (5.9 ft/s) (Oey et al. 2005), and is present down to an 800-m (2,625-ft) depth (Nowlin et al. 2000; Lugo-Fernandez 2007). The incoming water of the Loop Current through the Yucatan Channel is typically warmer and saltier than the GOM waters, which in combination with its highly inertial circulation pattern generates energetic conditions that drive circulation patterns throughout the entire GOM (Lugo-Fernandez 2007; Jochens and DiMarco 2008; Lugo-Fernandez and Green 2011).

The Loop Current is not a stagnant circulation, as it alters its orientation angle and periodically extends northwesterly into the GOM with filaments being observed to intrude onto the continental slope near the Mississippi River Delta (Muller-Karger et al. 2001; Oey et al. 2005). As the Loop Current extends north to approximately 27°N, an instability causes the formation of an anticyclonic eddy (Loop Current Eddy) to separate off from the Loop

Current (Hamilton et al. 2000; Vukovich 2007). The physical mechanisms that trigger these Loop Current Eddy separations and their frequency of occurrence are not fully understood (Chang and Oey 2010; Sturges et al. 2010), but the period between Loop Current Eddy separations ranges from 0.5 to 18.5 months (e.g., Vukovich 2007). A linear relationship that exists between the period between Loop Current Eddy separations and the retreat latitude of the Loop Current following separation results from a balance in vorticity between water entering and water exiting the GOM that is displaced by the intrusion of the Loop Current moving toward the northern slope region (Lugo-Fernandez and Leben 2010). Loop Current Eddies typically have a diameter of 300 to 400 km (186 to 248 mi), current speeds between 1.5 to 2 m/s (4.9 to 6.6 ft/s), and speeds up to 0.1 m/s (0.3 ft/s) at a 500-m (1,640-ft) depth (Brooks 1984; Cooper et al. 1990). Loop Current Eddies migrate to the west and southwest under forces induced by the Earth's curvature and rotation with translation speeds ranging from 2 to 5 km/day (1.2 to 3.1 mi/day) (Brooks 1984; Oey et al. 2005).

Loop Current Eddies typically affect deepwater regions (depths greater than 400 m [1,312 ft]) of the GOM and have the potential to disrupt exploration, drilling, and production activities (Crout 2009). Currents associated with Loop Current Eddies have the ability to cause vortex-induced vibrations that can damage platforms and drilling equipment (Kaiser and Pulsipher 2007). It has been estimated that a sustained current of 2 m/s (6.6 ft/s) can use up the fatigue life of certain mooring system components in 1 week (DiMarco et al. 2004).

4.2.3.1.3 Deepwater Currents and Subsurface Jets. Oil and gas exploration and production activities are expanding more and more to deepwater regions of the GOM, which is what motivates the current research emphasis in deepwater currents (McKone et al. 2007; Lugo-Fernandez and Green 2011). Energetic waves and high-speed jets can affect the transport of pollutants such as drilling fluids and oil, as well as physical structures relating to oil and gas operations (DiMarco et al. 2004). For example, the Deep Water Horizon oil spill of 2010 demonstrated the need to understand how deepwater currents affect underwater oil spill plumes (e.g., Adcroft et al. 2010).

Deepwater currents (depths greater than 1,000 m [3,281 ft]) along the northern GOM are typically characterized as meandering waves (referred to as topographic Rossby waves [TRWs]) that are vertically coherent with some degree of bottom intensification, have periods greater than 10 days, are largely decoupled from surface circulations, and have a propagation velocity on the order of 9 km/day (5.6 mi/day) (Hamilton 1990, 2009; Sturges et al. 2004). The energy source of these deepwater currents is not fully realized, but recent studies suggest that the Loop Current generates deepwater eddies near the Campeche Terrace that excite wave propagation westward along the continental slope of the northern GOM (Oey 2008). Additionally, high-energy waves (with periods of less than 10 days) have been observed locally along the Sigsbee Escarpment with maximum speeds of 0.9 m/s (3 ft/s) at depths below 1,500 m (4,921 ft) (Donohue et al. 2008). The analysis by Hamilton (2009) suggests that highly energetic TRWs along the Sigsbee Escarpment generate a mean deepwater flow to the west along the steep escarpment, which acts as the main deepwater transport pathway from the western to the eastern GOM, and that in the western GOM, TRWs are less energetic but interact in a similar fashion with the continental slope to form a generalized mean deepwater flow to the south along the base of the continental slope off Mexico (the generalized deepwater flow path is shown in Figure 4.2.3-1).

Subsurface jets are characterized as currents with no surface expression, having durations on the order of hours to days, speeds in excess 0.4 m/s (1.3 ft/s), and observed currents up to 2 m/s (6.6 ft/s) (DiMarco et al. 2004). Subsurface jets occur at shallow depths (150–600 m [492–1,968 ft]) and in deep waters, and they are typically produced by the downward propagation of inertia in the wake of a storm passage or the interactions of eddy circulations and the topography of the continental slope (DiMarco et al. 2004; Fan et al. 2007). Deepwater jets are difficult to measure because of their limited spatial and temporal extents, but observations from moored instruments in the northwestern GOM show deepwater jets having maximum currents speeds between 0.5 and 0.8 m/s (1.5 and 2.6 ft/s) with durations on the order of 1 to 8 days (Hamilton and Badan 2009).

4.2.3.2 Alaska Region

Sea ice, ocean currents, tides, waves, and storm surges affect offshore oil and gas operations on the Alaska continental shelf and facilities located near the coastline. Typical currents and waves do not threaten the physical integrity of production equipment; however, cold air temperatures and the spray from waves can freeze on structures, causing structural damage as well as affecting the buoyancy of supply and drilling vessels to the extent of capsizing ships (Jones and Andreas 2009). Tides are considered minor along the coastal regions of the Arctic Ocean (NRC 2003a; Weingartner 2003), but tidal ranges in Cook Inlet are considered among the largest in the world (Archer and Hubbard 2003). Impacts of storm surges vary by season from coastal flooding during summer and fall events to ice gouging and damage associated with ice ride-up (wind-driven surge of ice onto shore) during winter and spring storm events (Lynch et al. 2008). While all these oceanographic factors influence oil and gas operations, the primary design consideration for platforms, vessels, pipelines, and other structures is the presence of sea ice and its interactions with currents, tides, and the bathymetry of the Alaska continental shelf (Weeks and Weller 1984; NRC 2003a).

The climate of the Arctic region is complex because of its multiple interactions with oceanic and terrestrial systems, and effects associated with global climate change have resulted in significant changes to the Arctic's atmospheric and oceanographic conditions over the past couple of decades (e.g., Morison et al. 2000; Arctic Council and IASC 2005). Air temperatures in the regions north of 60°N have warmed at a faster rate than that of the overall northern hemisphere over the past century (Arctic Council and IASC 2005). During the 1990s, several studies revealed a warming trend in the layer of Arctic Ocean water with origins from the Atlantic Ocean (Carmack et al. 1995; Grotefendt et al. 1998; Gunn and Muench 2001), as well as an overall increase in Arctic Ocean sea surface temperatures and lower surface-layer salinities along regions of the Beaufort Sea and the Chukchi Sea (Morison et al. 2000; Comiso 2003; Comiso et al. 2003).

The warming of air and water temperatures in Arctic regions generates variability in key factors and processes controlling oceanographic conditions, which include precipitation and snow patterns, freshwater and sediment inputs to oceans, thermohaline circulation patterns (controlled by temperature and salinity gradients), and the aerial coverage and composition of sea ice (Morison et al. 2000; Arctic Council and IASC 2005; Bonsal and Kochtubajda 2009). Changes in oceanic conditions have also corresponded with sea level rise in the Arctic Ocean (Proshutinsky et al. 2001). Predicting oceanic responses to climate change is difficult because of complex interactions (often nonlinear) among factors such as water and air temperatures, sea ice, sea level rise, and thermohaline circulation patterns (e.g., Wang et al. 2003).

Alaskan coastal waters are largely covered by sea ice with some open-water areas for three-quarters of the year, from October until June, with the minimum sea ice extent occurring in September as sea ice begins to form and the maximum extent in March (Weeks and Weller 1984). Sea ice properties vary according to its age and the physical conditions under which it forms, melts, refreezes, and reforms (Gow and Tucker 1991). A general classification of sea ice includes ice formed along shores known as landfast ice and ice formed at sea called drift ice, which can conglomerate to form pack ice or ice floes (Mulherin et al. 2001). Landfast ice gradually advances seaward in the fall, rapidly retreats in the spring, and can break up and reform several times in between. Ice floes move according to wind and currents and can collide and pile on top of one another to form pressure ridges, as well as converge to form well-defined ice-free openings, or polynyas (Mahoney et al. 2007). Another important distinction in sea ice is the difference between newly formed first-year sea ice and multiyear sea ice, which by definition is summer minimum sea ice extent (Lemke et al. 2007).

The spatial and temporal variability in sea ice extent and thickness are controlled by local climate and oceanic factors, with many studies indicating a decreasing trend in Arctic sea ice over recent decades (e.g., Johannesen et al. 1995; Parkinson 2000; Comiso 2002). Sea ice extent, as observed mainly by remote sensing methods, has decreased at a rate of approximately 3% per decade starting in the 1970s (Johannesen et al. 1995; Parkinson et al. 1999). However, multiyear sea ice has decreased at a rate of nearly 9 to 12% per decade since the 1980s (Comiso 2002; Perovich et al. 2010). Since 2000, the extent of summer sea ice was at record lows in 2002 (Serreze et al. 2003), 2004 (Stroeve et al. 2005), 2007 (Perovich et al. 2008), and 2010 (Richter-Menge and Jeffries 2010). Sea ice thickness has also decreased during recent decades, with average sea ice draft (the depth of ice below sea level) values decreasing by as much as 1.3 m (4 ft) (Rothrock et al. 1999) and sea ice volumes decreasing at a rate of 4% per decade since 1948 (Rothrock and Zhang 2005). These recent trends in declining sea ice are a result of anthropogenic influences and natural climate variability, and recent climate simulations suggest that natural climate variability has the potential to cause a stabilization to a slight recovery of sea ice trends over short times scales on the order of a decade or less in the beginning part of the twenty-first century (Kay et al. 2011).

The interactions of sea ice with currents and waves have the potential to create hazardous conditions and damage physical structures though ice gouging, ice ride-up, and scouring, and to block vessel traffic (Weeks and Weller 1984). Landfast ice is typically not a concern as it exerts nominal internal stresses to structures, but ice floes formed during breakup conditions near shore or out in open pack ice areas have velocities on the order of 1 m/s (3 ft/s) (Stringer and Sackinger 1976). Ice gouging is caused by grounded ice keels within ice floes moving in response to wind and currents that typically occur in regions parallel to shorelines (Shapiro and

Barnes 1991). Ice gouging is of particular concern for pipelines, as seabed gouging depths can often exceed 3 m (10 ft), affecting coastal regions with up to 50 m (164 ft) of water depth (Weeks and Weller 1984). Ice ride-up occurs as repeated ice floes converge on shore, pile on top of each other, and pile shoreward under continued momentum. Ice ride-up events frequently occur during the spring and fall and can affect structures that are on the order of 50 m (164 ft) inland (Kovacs and Sodhi 1980). In spring, river floodwaters can inundate coastal areas covered by sea ice and potentially break through the ice, generating jet flows and scour craters in the sediments below (process referred to as strudel scour), which can damage pipelines and support structures. Strudel scour craters can be more than 4 m (13 ft) deep and 15 m (49 ft) across and can last up to 2–3 years before being refilled (Reimnitz and Kempema 1982). Strudel scour occurs most commonly near river deltas extending outward to water depths of 6 m (20 ft) (Hearon et al. 2009).

Sea ice also affects oil spill cleanup and weathering processes, as well as acting as a transport mechanism for spilled oil (Stringer 1980). Oil transport and reaction processes are significantly altered for waters that contain more than 30% aerial coverage of sea ice in comparison to open ocean waters (NRC 2003b). The presence of ice and lower water temperatures typically result in lower rates of oil weathering processes such as evaporation, emulsification, and oxidation (Thomas 1983); lower rates of dispersion because of the increased viscosity of oil at lower temperatures (Payne et al. 1991) and the presence of sea ice also has the potential to confine oil spills (Weeks and Weller 1984). Conversely, enhanced transport of oil by sea ice conditions can occur along open water channels or polynyas or by oil incorporation into moving ice floes (Payne et al. 1987). Empirical relationships describing the fate and transport of spilled oil-sea ice interactions are presented in Buist et al. (2008). Ultimately, the fate of oil in the presence of sea ice largely depends on the season (summer ice free, winter ice cover, and fall ice formation), as well as the age and morphology of the sea ice, because these factors determine the ability of the oil to reach reactive areas for oil weathering processes to occur as well as the weathering reaction rates (Payne et al. 1991; NRC 2003b).

4.2.3.2.1 Arctic Ocean: Beaufort Sea and Chukchi Sea. The Beaufort Sea and Chukchi Sea are semi-enclosed seas connected to the Arctic Ocean located along the northern coast of Alaska. The Chukchi Sea is a shallow, continental shelf sea with depths typically less than 50 m (164 ft) that receives Pacific Ocean water through the Bering Strait (Woodgate et al. 2005). The Beaufort Sea consists of a narrow (approximately 100 km [62 mi] wide) continental shelf before a shelfbreak that occurs near the 200-m (656-ft) water depth contour followed by a portion of the Canadian Basin of the Arctic Ocean (Weingartner 2003). The continental shelf region of the Beaufort and Chukchi Seas contains small shoals and barrier islands that affect shelf circulation patterns and are typically associated with the location of ice ridges (NRC 2003a).

The general circulation patterns in the Beaufort and Chukchi Seas are shown in Figure 4.2.3-2. Circulation in the Canadian Basin of the Arctic Ocean is dominated by the Beaufort Gyre, which is typically a clockwise (anticyclonic) circulation forced by prevailing atmospheric high pressure over the Arctic, but can reverse to a counterclockwise (cyclonic) circulation during summer months or prolonged periods of atmospheric low pressure

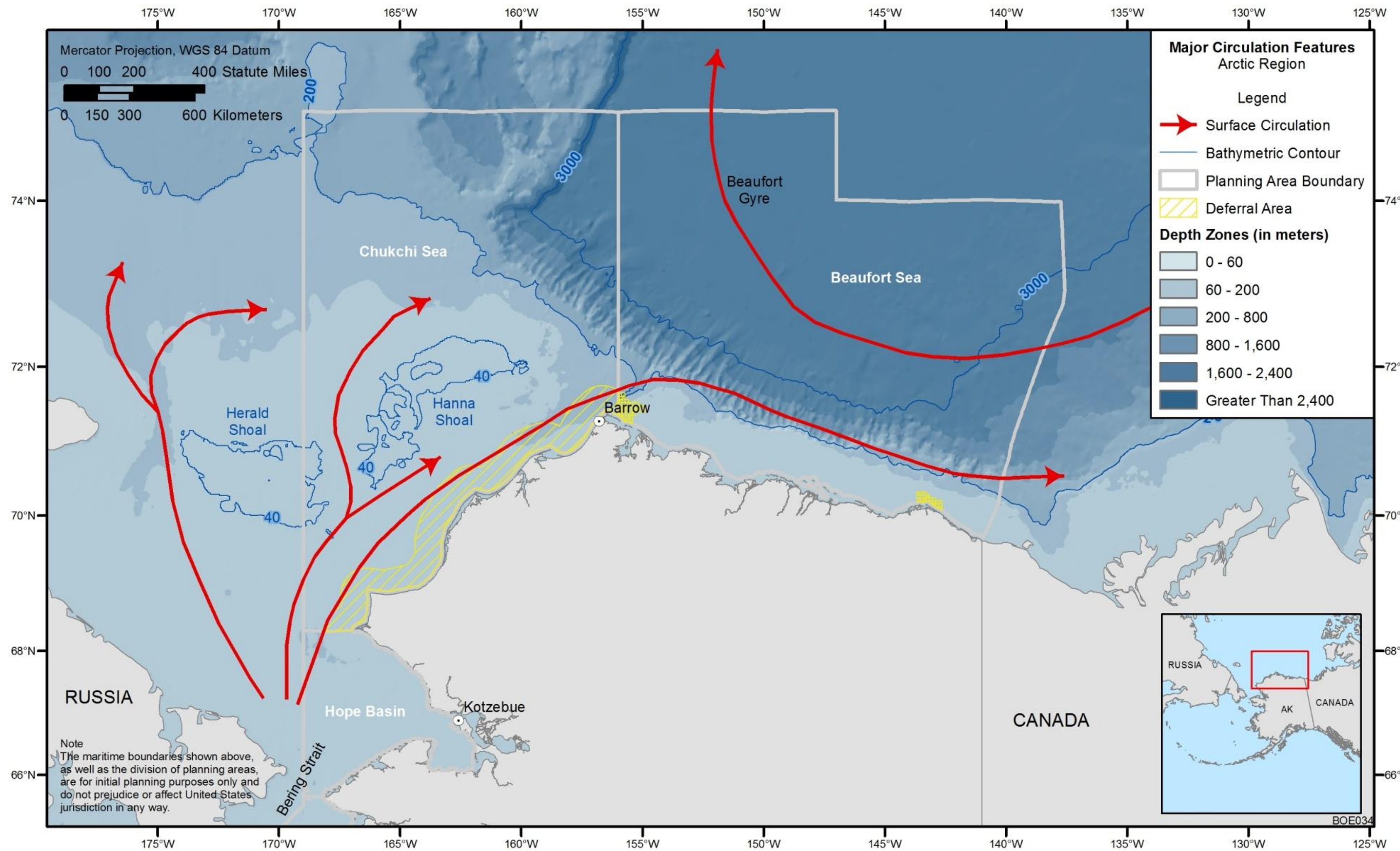

FIGURE 4.2.3-2 Generalized Circulation Patterns in the Chukchi Sea and Beaufort Sea

(Proshutinsky et al. 2003; Asplin et al. 2009). The sea level slope between the Pacific Ocean and the Arctic Ocean drives water through the Bering Strait into the Chukchi Sea, which separates into three principal branches of northward flow among Herald Shoal, Hanna Shoal, and the Alaskan coast (Weingartner et al. 2005; Woodgate et al. 2005; Weingartner et al. 2010). Currently, it is not fully understood how Pacific Ocean waters moving across the Chukchi Sea interact with circulation patterns off the shelfbreak of the Beaufort Sea, but evidence suggests the presence of narrow currents near the Beaufort shelfbreak with prevailing eastward flow and seasonal variability in surface and subsurface intensified currents (Pickart 2004; Spall et al. 2008; Nikolopoulos et al. 2009; Okkonen et al. 2009; Pickart et al. 2010; Weingartner et al. 2010). During the summer open-water season, current speeds along continental shelf areas often exceed 0.2 m/s (0.7 ft/s) with maximum speeds as high as 1 m/s (3 ft/s) in certain regions of constricted flow such as the Bering Strait and Barrow Canyon; during ice-covered seasons, current speeds are generally less than 0.1 m/s (0.3 ft/s) (Weingartner et al. 1998, 2009; Weingartner and Okkonen 2001).

The coasts of the Beaufort Sea and Chukchi Sea consist of river deltas, barrier islands, exposed bluffs, and large inlets; inland is characterized by low-relief lands underlain by permafrost (Jorgenson and Brown 2005). The combination of wind-driven waves, river erosion, and sea ice scour with highly erodible coastal lands creates the potential for high erosion rates along the Beaufort Sea and Chukchi Sea coasts (Kowalik 1984; Mars and Houseknecht 2007). From 1950 to 1980, the coastal erosion rates averaged 0.6 m/yr (2 ft/yr), and over the period from 1980 to 2000 this rate has increased to 1.2 m/yr (3.9 ft/yr) (Ping et al. 2011).

Present and future offshore oil and gas operations in the Beaufort and Chukchi Seas need to take into account climate change impacts on circulation and sea ice patterns. The complex circulation patterns on the Arctic continental shelf are affected by water temperature and density gradients and freshwater inputs of varying temperature from rivers as well as increased sea ice and glacier melting over recent years (Yamamoto-Kawai et al. 2009). Furthermore, reductions in sea ice have been more apparent in nearshore areas associated with landfast ice (typically extending out between 5 and 50 km [3 and 31 mi] from shore) in comparison to offshore regions (Mahoney et al. 2007; Fissel et al. 2009). A recent study has also shown that remote-sensing of sea ice extent may not always distinguish between first-year and multiyear sea ice, which is an important distinction in sea ice quality for supporting exploration activities, biotic habitats, and waterway access (Barber et al. 2009). The summer open ice season that determines when ships can enter the coastal regions along the north Alaskan coast has trended toward an earlier opening date in the spring and a later closing date in the fall (Fissel et al. 2009; Markus et al. 2009). While decreased sea ice has the potential to support more shipping activity in the Arctic, it is likely that hazardous ice floes will persist (Stewart et al. 2007), and decreases in landfast ice could result in increased impacts on coastlines through wave damage and ice ride-up (Arctic Council and IASC 2005).

4.2.3.2.2 Cook Inlet and Shelikof Strait. Cook Inlet and Shelikof Strait are located on the continental shelf of the Gulf of Alaska, which is a semi-enclosed basin of the Pacific Ocean surrounded by the steep terrain of the Alaskan coast. The continental shelf region is characterized as having a complex bathymetry of channels, island chains, and embayments.

Cook Inlet is a large embayment with a length of 330 km (205 mi) along a northeast to southwest axis that is approximately 37 km (23 mi) wide in the northeast near Anchorage and 83 km (52 mi) wide at its mouth (Gatto 1975). The upper and lower portions of Cook Inlet are formed by the coastline constriction that occurs near the West Forelands to the north of Kalgin Island. The Shelikof Strait, located southwest of Cook Inlet between the Alaskan coast and the Kodiak Islands, forms a fairly uniform channel that is approximately 270 km (168 mi) in length and 45 km (28 mi) wide (Muench and Schumacher 1980). Figure 4.2.3-3 shows the location of Cook Inlet and Shelikof Strait along with major circulation patterns.

The circulation along the continental shelf of the Gulf of Alaska is dominated by the Alaskan Coastal Current, which is driven by winds and freshwater runoff of the numerous rivers and glaciers along the Alaskan coast (Stabeno et al. 2004). Alaskan Coastal Current waters enter Cook Inlet through the Kennedy and Stevenson Entrances and flow northward along the eastern side of the inlet as the result of Coriolis forces (induced by the rotation of the Earth) and then cross over to the western side of the inlet because of the shoreline geometry near the Forelands (Rappeport 1982). Observed circulation patterns suggest a net outflow of surface flows out of the inlet, which implies that there is a net inflow of deepwater flows into the inlet (Potter and Weingartner 2010). Cook Inlet is estuarine in character because of the mixing of marine waters from the Alaskan Coastal Current and freshwater inflows from several rivers, resulting in complex density-driven circulation patterns (Rappeport 1982; Mulherin et al. 2001). The Matanuska River, Knik River, and Susitna River combined contribute more than 70% of the freshwater inputs to Cook Inlet in the northern basin, as well as act as a significant source of suspended sediments that can reach concentrations greater than 1,700 mg/L (Gatto 1975). Riverine inputs of freshwater and sediments to the northern portion of Cook Inlet vary seasonally, and their resulting influences on temperatures and salinity generate seasonal variability in circulation patterns in Cook Inlet (Okkonen et al. 2009).

The circulation patterns in Cook Inlet are significantly influenced by the strong semidiurnal tide pattern with corresponding tidal amplitudes that range between 4.2 and 5 m (14 and 16.4 ft) in the lower portion and up to 9.0 m (29.5 ft) in the upper portion of Cook Inlet near Anchorage (Rappeport 1982; Archer and Hubbard 2003). Tidal currents travel at speeds ranging between 1 and 4 m/s (3 and 13 ft/s) (Whitney 2000; Oey et al. 2007). Average water depths in Cook Inlet vary from 18.3 m (60 ft) in the upper portion to 36.6 m (120 ft) near its mouth, with several deep channels along its longitudinal axis that contain sand dunes with heights on the order of 2 m (7 ft) (Haley et al. 2000). The interaction of density-driven circulation and tidal currents results in rip currents that form persistently along the deep channels (Haley et al. 2000; Whitney 2000), which can often be observed by turbidity color changes, as well as the accumulation of surface debris and foam along rip current edges (Rappeport 1982). The ebbing flow out of Cook Inlet combines with Alaskan Coastal Current waters and enters the Shelikof Strait, where water depths are on the order of 200 m (656 ft) and average current speeds range between 0.2 m/s (0.7 ft/s) in the winter and 0.1 m/s (0.3 ft/s) in the summer (Muench and Schumacher 1980). The southwest flow out of the Shelikof Strait merges with the Alaskan Stream (the western boundary current of the Gulf of Alaska) approximately 200 km (124 mi) southwest of Kodiak Island (Stabeno et al. 2004; Rovegno et al. 2009).

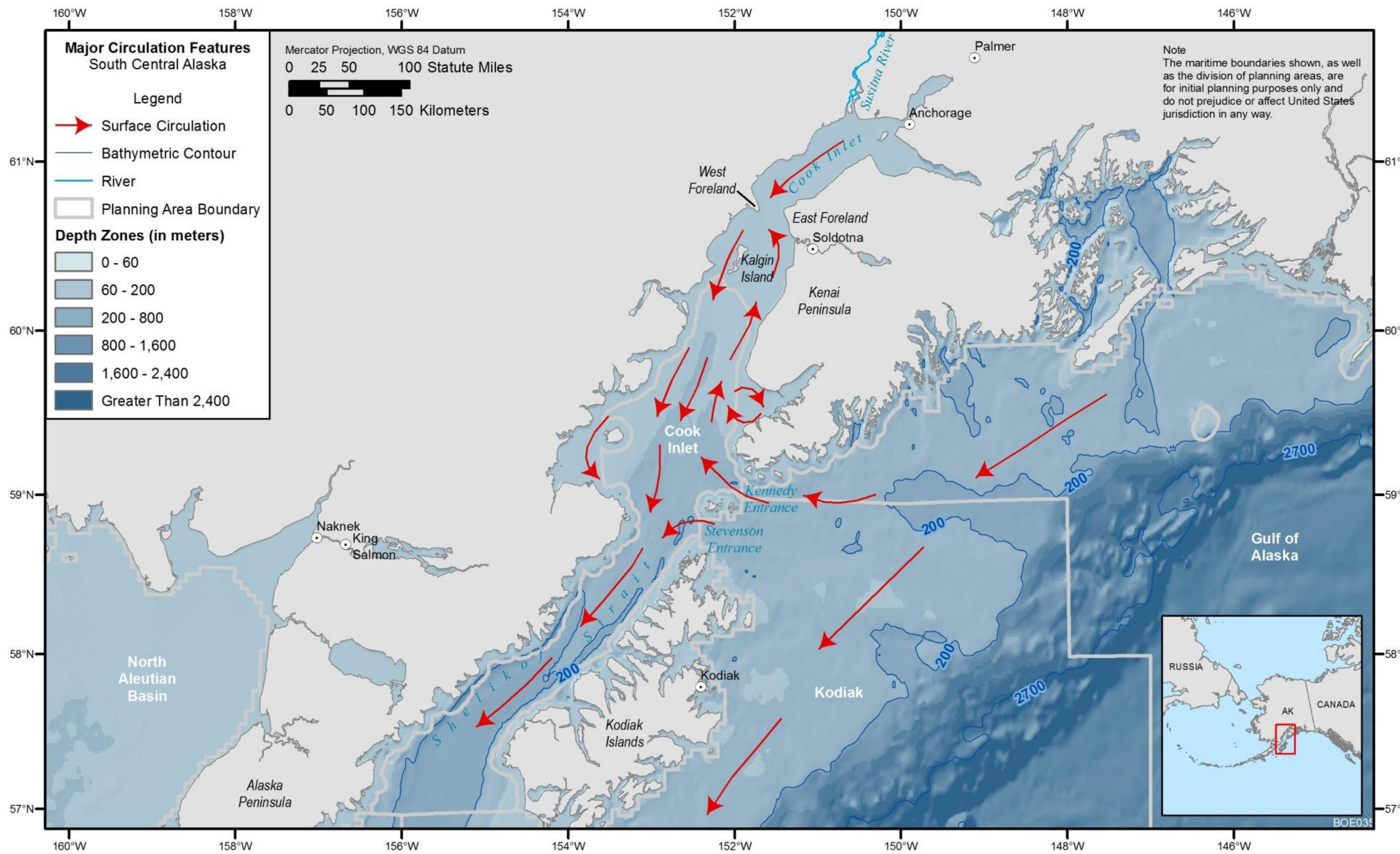

FIGURE 4.2.3-3 Generalized Circulation Patterns in Cook Inlet and the Shelikof Strait

Significant wave heights (average wave height of the upper-third-largest waves) are typically 0.6 m (2 ft) in the lower portion of Cook Inlet and the Shelikof Strait, but maximum wave heights of 5.5 m (18 ft) have been recorded during storm events (Rappeport 1982). Tsunamis can occur in response to volcanic activity of Mount St. Augustine on Augustine Island in the southwestern portion of lower Cook Inlet. Modeling results of the 1883 tsunami suggested wave heights of amplitude 1.2 to 1.8 m (3.9 to 5.9 ft) (Kienle et al. 1986). However, more recent modeling results suggest that the timing of a tsunami with the tidal phase can result in a fivefold amplification of wave heights near the shores of Anchor Point (Kowalik and Proshutinsky 2010).

Ice floes moving with tidal currents are the largest threat to navigation and marine structures in Cook Inlet. According to Mulherin et al. (2001), three types of sea ice form in Cook Inlet: pack ice, landfast ice, and stamukhi ice (forms by stacking of low-tide formed ice sheets on the sediment surface). The sea ice forms in the upper portion of Cook Inlet in the fall, while the lower portion is typically ice free until December. Stamukhi ice stacks can reach 7.5 to 12.2 m (24.6 to 40 ft) in thickness and typically become ice floes that move away from the shore because of buoyancy forces. During the fall-winter ice-covered season, the ice pack can cover between 10 and 80% of Cook Inlet, which becomes completely ice free each spring (Muench and Schumacher 1980; Mulherin et al. 2001).

4.3 ASSESSMENT OF ISSUES OF PROGRAMMATIC CONCERN

4.3.1 Multiple Use Issues and Marine Spatial Planning

The activities that may occur and the facilities that may be installed on the OCS as a result of the Program are described in Section 4.4.1, which presents a scenario for the projected amounts of oil and gas exploration and development activities and the number of facilities and pipelines that are estimated to take place or be installed during the program, if Alternative 1, the Proposed Action, is implemented. Comparisons with other alternatives are provided later in the document, but the analyses presented in Sections 4.3 and 4.4 would apply, as appropriate, across all the alternatives. Much of the rest of this chapter is concerned with assessing potential impacts from these activities and facilities on the environmental resources that are analyzed in the PEIS. In some areas, these oil and gas facilities and activities also create a potential for space use conflicts with other activities and facility sitings not related to oil and gas development. This section discusses the other major activities and facilities on the OCS that could occur and coexist with oil and gas construction and activities during the program and, as a result, create potential space use conflicts. These conflicts could include situations in which the presence of oil and gas infrastructure and associated support, exploration, and production activities preclude, or are precluded by, other uses of the OCS; or situations in which oil and gas facilities and activities in combination with other types of activities and infrastructure could threaten the ecological sustainability of the area. Typically, the Bureau of Ocean Energy Management (BOEM) has managed OCS space and multiple use issues through coordination with other State and Federal agencies that manage and regulate activities on or near the OCS, and has developed regulations, lease stipulations, and other mechanisms to restrict oil and gas activities to avoid conflict with other activities taking place in the same area. In recent years, Coastal and Marine Spatial

Planning (CMSP) has emerged as a new paradigm and planning strategy for coordinating all marine and coastal activities and facility constructions within the context of a national zoning plan.

4.3.1.1 Multiple Use Issues

4.3.1.1.1 Department of Defense Use Areas. Military Use Areas, established off all U.S. coastlines, are required by the U.S. Air Force (USAF), Navy, Marine Corps, and Special Operations Forces for conducting various testing and training missions. Military activities can be quite varied, but they normally consist of air-to-air, air-to-surface, and surface-to-surface naval fleet training; submarine and antisubmarine training; and Air Force exercises. Offshore military areas (including military dumping areas) are present in some OCS planning areas. Section 3.9.1.2.3 of this draft PEIS discusses offshore military use areas in the OCS planning areas being considered for the proposed action.

Aircraft operated by all U.S. Department of Defense (USDOD) units train within a number of special use airspace (SUA) locations that overlie the military operating areas, as designated by the Federal Aviation Administration (U.S. Fleet Forces 2010). SUAs are the most relevant to the oil and gas leasing program because they are largely located offshore, extending from 5.6 km (3 NM or 3.5 mi) outward from the coast over international waters and in international airspace.

There are 21 U.S. military bases along the coasts of the planning areas being considered for oil and gas leasing in the proposed action: 18 bases along the GOM coast and 3 in the vicinity of the Cook Inlet Planning Area. In addition, there are four active USAF radar sites located on the coast bordering the Beaufort and Chukchi Sea Planning Areas. They are all Long-Range Radar Sites, and each site has restricted areas within certain facilities. Access to each is only for personnel on official business and with approval of the commander of the USAF's 611th Air Support Group. While there are a number of military use restriction areas (danger zones or restricted areas) in the GOM (see Figure 3.9.1-2), there are no such restrictions in the waters of the Cook Inlet Planning Area or the Beaufort and Chukchi Sea Planning Areas (National Marine Protected Areas Center 2008). In the Cook Inlet Planning Area, the closest danger zone is Blying Sound, which is managed by the U.S. Navy and located to the east of Cook Inlet near Prince William Sound. The Blying Sound Danger Zone is rarely activated, and there are no use restrictions for most of the year.

Danger zones are defined as water areas used for a variety of hazardous operations (Marine Protected Areas Center 2008; U.S. Fleet Forces 2010). Danger zones may be closed to the public on a full-time or intermittent basis. Restricted areas are water areas defined as such for the purpose of prohibiting or limiting public access. Restricted areas generally provide security for Federal Government property and/or protect the public from the risks of damage or injury that could arise from the Federal Government's use of that area.

There are more than 40 military warning areas in the northern GOM area, designated by the USAF for the conduct of various testing and training missions, and by the U.S. Navy for various naval training and testing operations. Most of these areas overlie waters that are less than 800 m (2,600 ft) in depth (Figure 3.9.1-2).

Although offshore oil and gas activities have the potential to affect military activities, the USDOD and U.S. Department of the Interior (USDOI) have cooperated on these issues for many years and have developed mitigation measures that minimize the potential for conflicts. For example, stipulations are applied to oil and gas leases in critical military use areas. Whenever possible, close coordination between oil and gas operators and the military authorities for specific operational areas is encouraged and, in some cases, is required under these lease stipulations. In some instances where the military requires unimpeded access to specific areas on the OCS, specific lease blocks have been deleted from one or more proposed lease sales.

The USDOI will continue to coordinate with the USDOD regarding future lease offerings, new areas of industry interest, and current or proposed areas of military operations. As part of this coordination, applicable stipulations would continue to be routinely evaluated and modified, as necessary, to minimize or eliminate conflicts. An example of this process was the inclusion of three previously deferred blocks (Mustang Island Blocks 793, 799 and 816) in the Western GOM Planning Area in OCS Lease Sales 192 and 196, subject to a recently revised Lease Stipulation of Operations in the Naval Mine Warfare Area.

Offshore oil and gas development under the proposed action within the Alaska Region would not interfere with standard or routine military practices. Additional vessel traffic resulting from industry development and exploration would simply increase existing traffic and not affect military activities. The BOEM works in cooperation with the USCG regarding industry exploration and development in waters off the coast of Alaska.

4.3.1.1.2 Liquefied Natural Gas Facilities. Natural gas is liquefied to concentrate a much greater volume of product in a given space to facilitate storage and/or transportation. Use of liquefied natural gas (LNG) reduces the volume it occupies by a factor of more than 600, making the transportation of gas in tankers economical. Environmental effects specific to LNG transportation and facilities are associated with explosions and fires and with the cryogenic and cooling effects of either an accidental release of LNG or the release of cooled water during the vaporization process. In the GOM, most, if not all, LNG facilities are expected to use an open-loop vaporization process that uses a throughput of approximately 130 to 250 million gallons per day of seawater to raise the temperature of the LNG from –260°F to 40°F. This process produces a discharge of seawater that has been cooled by as much as 20°F. These discharges are expected to occur in water depths ranging from 18 to 55 m (60 to 280 ft). This large volume of cool, dense water could create an impact on the surrounding environment, rendering the area uninhabitable by local species of invertebrates and fish, especially in the GOM. The magnitude of this impact is still unknown since there is only one facility (the Gulf Gateway facility) currently operating. The potential cumulative effect of multiple facilities also needs consideration. In addition to the thermal discharge, biocides are added to prevent fouling of the flow through the system.

These facilities operate by offloading vaporized LNG from tankers into the existing offshore natural gas pipeline system. Although BOEM does not permit or regulate these facilities, their increased presence and use on the OCS will create space use issues and will add to the existing mix of potential offshore cumulative impacts. Currently, only one LNG facility has been constructed and is operating on the GOM OCS. The Gulf Gateway Energy Bridge, which was brought into service in March 2005, is located in 85.3 m (280 ft) of water in West Cameron, South Addition Block 603, approximately 116 mi (187 km) offshore of the Texas–Louisiana border. The Gulf Gateway Energy Bridge is capable of delivering natural gas at a base load rate of 500 Bcf per day.

Other LNG facilities on the OCS are currently in some stage of the permitting process. The Bienville Offshore Energy Terminal is a planned LNG facility located 63 mi (101 km) south of Mobile Point, Alabama. The initial application for the facility was withdrawn on October 9, 2008, and a revised application, submitted on June 30, 2009, featured a redesigned terminal using "closed-loop" ambient air technology for LNG vaporization. The application was approved in 2010. In Louisiana, the Main Pass Energy Hub is a converted sulfur and brine mining facility. This LNG facility is expected to begin operations sometime in 2011 or 2012.

4.3.1.1.3 Alternate Energy Development. In April 2009, the President and the Secretary of the Interior announced the final regulations for the OCS Renewable Energy Program, which was authorized by the Energy Policy Act of 2005. The final regulations (74 CFR Part 81: 19638–19871) govern management of the BOEM Renewable Energy Program by establishing a program to grant leases, easements, and right-of-ways (ROWs) for renewable energy development activities on the OCS. Renewable energy from the OCS may come from technologies and projects that harness offshore wind energy, ocean wave (hydrokinetic) energy, or ocean current (hydrokinetic) energy.

Multiple Federal agencies have responsibilities for the regulation and oversight of renewable energy development on the OCS. The BOEM issues leases and grants for both OCS wind and hydrokinetic projects and permits the construction and operation of wind facilities. The Federal Energy Regulatory Commission will permit the construction and operation of hydrokinetic facilities on BOEM-issued wave and current energy leases. The BOEM also has the authority to issue ROWs for offshore transmission lines that would link OCS renewable energy projects in order to facilitate efficient interconnection of the OCS projects to the onshore electric grid.

As required by the Energy Policy Act, the BOEM will issue leases on a competitive basis unless it determines that no competitive interest exists. After a lease is acquired, the developer must submit and receive approval of appropriate plans (for wind energy projects) or license applications (for hydrokinetic projects). At the end of the lease term, the developer must decommission the facilities in compliance with BOEM regulations.

There are currently no commercial hydrokinetic or wind energy projects on the OCS in the planning areas under consideration for the Program. The BOEM, in coordination with relevant states, has identified Wind Energy Areas (WEAs) offshore of the mid-Atlantic coast.

Although OCS oil and gas leasing and development activities could interfere with future OCS wind energy renewable energy projects (and vice-versa), the BOEM offshore oil and gas and offshore renewable energy programs will be coordinated to ensure that leasing and development activities under both programs are carried out with as little conflict between the two programs as possible. The identification of any future WEAs in areas with high or expected levels of oil and gas development (such as the GOM) will also be closely coordinated between the two programs. No such WEAs, however, have been identified in any of the BOEM OCS planning areas being considered for oil and gas leasing under the proposed action, nor are any wind or kinetic energy developments anticipated there during the program.

4.3.1.2 Coastal and Marine Spatial Planning

On July 19, 2010, the President signed Executive Order (EO) 13547, *Stewardship of the Ocean, Our Coasts, and the Great Lakes*, establishing a national policy for the stewardship of these resources. This national policy identifies Coastal and Marine Planning (CSMP) as one of the nine objectives. Furthermore, it outlines a framework for effective CMSP to address conservation, economic activity, user conflict, and sustainable use of the ocean, coasts, and Great Lakes.

Despite the existence of numerous articles on CMSP (e.g., see papers in *Marine Policy*, Vol. 32, 2008) and the incorporation of marine spatial planning (MSP) principles by various nations into their resource management practices (e.g., EO 13547; the National Oceanic and Atmospheric Administration (NOAA) CSMP Program, http://www.cmsp.noaa.gov/program/index.html), a standard, universally accepted definition of MSP currently does not exist. Most existing definitions are phrased in broad terms and objectives, such as the United Nations Educational, Scientific and Cultural Organization (UNESCO) definition, "[MSP] … is a public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that have been specified through a political process" (UNESCO-IOC 2010).

Although NEPA is not usually seen as a spatial planning exercise, the PEIS for the Program and subsequent NEPA evaluations effectively are, at least in part, just that. The draft PEIS identifies broad areas of the OCS where oil and gas leasing may occur and identifies in a spatial and temporal context the potential for impacts on natural and social resources and systems that could occur with subsequent oil and gas leasing in those areas. The subsequent lease sale and post-lease NEPA analyses identify the specific areas and time frames where and when mitigating measures need to be applied to address potentially unacceptable impacts on natural resources and socioeconomic resources and systems. One outcome of this NEPA process, therefore, is the identification of areas on the OCS where BOEM regulates and manages oil and gas operations to meet economic and social objectives in a manner compatible with environmental sustainability objectives.

Table 4.3.1-1 describes ways in which the objectives and methods of CMSP are compatible with or differ from those of the Five-Year Programmatic EIS. While there are

TABLE 4.3.1-1 Comparison of the Objectives and Methods of CMSP with Those of the 2012-2017 OCS Oil and Gas Leasing Program PEIS[a]

Coastal and Marine Spatial Planning	Programmatic EIS
Envisioned as a tool to make ecosystem-based management of marine resources possible.	Uses a broad scale appropriate for an ecoregional approach for evaluating potential impacts.
Large Marine Ecosystems (LMEs) used to define spatial boundaries.	Large Marine Ecosystems (LMEs) used to define spatial boundaries.
Based on hierarchal scale-based approach addressing different issues and at different scales at each level of analysis, and in which each level provides context for the next lower level.	The NEPA concept of tiering is based on a hierarchal scale-based approach in which the programmatic EIS provides the general context for the more detailed analyses in the lease sale EIS.
Used to develop areas identifying ecologically sensitive regions as well as areas suitable for specific human uses.	Used as the first step in a planning process to develop areas where oil and gas operations will be regulated to be consistent, in combination with other uses of the area, with current environmental sustainability objectives.
Used to plan for existing and proposed offshore uses, while reconciling economic, social, and environmental demands on an area.	Programmatic cumulative analysis evaluates all differing economic, social, and environmental demands on an area to inform the decision on program timing, size, and locations.
Based on multiple sector planning approach.	Focused on the effects of a single sector on other sectors.

[a] Highlighted text shows areas of particular similarity.

fundamental similarities and overlaps between the objectives and approaches of CMSP and the 2012-2017 PEIS, a major distinction between the two planning approaches is that the PEIS perspective focuses on the single use of the OCS for hydrocarbon exploration, extraction, and transportation, whereas the CMSP focuses on reconciling all economic, social, and ecosystem uses of an area in developing a CMS plan.

The National Ocean Policy framework document divides U.S. waters (mean high water mark to 200 NM) into nine regions based on Large Marine Ecosystem (LME) boundaries. CMS plans will be created and implemented at the regional level though stakeholder input. It is anticipated that the plans will serve as an overlay for decisions made under existing regulatory mandates. In effect, regional CMS plans once approved by the National Ocean Council (NOC) will assist the BOEM programmatic EIS process in making informed decisions.

4.3.2 Health Impact Assessment

4.3.2.1 National Environmental Policy Act

The National Environmental Policy Act and its related Federal guidelines (40 CFR 1508.8; 1978) have explicit language that requires the evaluation of both direct and indirect effects of the oil and gas industry on human health as well as the effects on low-income and minority populations (CEQ 1997). NEPA regulations instruct agencies to evaluate "the degree to which the proposed action affects public health or safety" (Berner 2011). Although these mandates exist, limited health information is currently included in Federal EISs. With the addition of the discussion of health issues in the planning stages, the impacts on human health can be considered beforehand, public and decision-maker awareness can be promoted, and prevention or mitigation can be built into the operations (Bhatia 2007; Niven and McLeod 2009). This would, in essence, change the process from reactionary to precautionary, thus attempting to remove or control health issues at the source (Niven and McLeod 2009).

4.3.2.2 Potential Impacts on the Human Environment

Offshore oil and gas activities have the potential to cause both adverse and beneficial impacts on human health. The exploration and development phases of oil and gas activities are beneficial because they require a large and diverse labor force to build the platforms, exploratory rigs, and various ships, boats, and barges necessary for working offshore (Luton and Cluck 2003). Increases in the labor force can promote the economy and development of infrastructure in these communities (Berner 2011).

Effects on the human environment can be both positive and negative, specifically with respect to psychological effects. The announcement of a leasing decision can affect humans in a positive way because it can boost the economy and bring much needed infrastructure development, while possible negative effects could be related to additional stress and anxiety over oil spills and impacts on the natural resources that communities use for a subsistence lifestyle (NRC 2003). Negative impacts on the human environment vary based on whether they are the result of routine events or the result of the threat/event of an accidental oil spill.

4.3.2.3 Potential Impacts of Routine Events Oil and Gas Activities

The North Slope Borough, Alaska, and the Alaska regional office of BOEM, through a Memorandum of Understanding, have evaluated the effects of the oil and gas industry on humans in the region. Appendix J of the *Beaufort and Chukchi Sea Planning Areas Oil and Gas Lease Sales 209, 212, 217, and 221 Draft Environmental Impact Statement* (OCS EIS/EA MMS 2008-0055) presents a full evaluation of these effects and is hereby incorporated by reference in this PEIS (http://www.alaska.boemre.gov/ref/EIS%20EA/ArcticMultiSale_209/_DEIS.htm).

Public concerns regarding pollution of locally harvested fish and game, loss of traditional food sources and hunting grounds, and rapid social changes are examples of negative impacts on humans in Alaska. The harvesting of wildlife resources in the North Slope of Alaska contributes widely to the cultural, nutritional, and economic way of life of the residents living there (NRC 2003). These impacts could affect both physical and mental health of Native tribal communities. Changes in the traditional way of life can lead to deteriorating physical well-being and mental health as well as increased domestic violence and substance abuse. North Slope tribal communities are concerned about the impacts of noise associated with routine operations on bowhead whale migration routes, as they depend on these whales for subsistence (NRC 2003). If the whales migrate farther offshore, there are increased safety risks for the whalers themselves who must travel in more dangerous seas to hunt. Increased stress and anxiety from oil and gas development may contribute to the mental health issues of Alaskans (NRC 2003).

The increased development has increased the smog and haze near some villages, which could be the cause for increased instances of asthma. Air quality is a major concern for the residents who live there (NRC 2003). The impacts of the proposed action on air quality and related health concerns are discussed in Section 4.4.4. Increased rates of diabetes are likely the result of residents consuming higher concentrations of nonsubsistence foods such as shortening, lard, butter, and bacon, and consuming less fish and marine mammal products (Ebbesson et al. 1999 referenced in NRC 2003).

However, the increased revenue from the oil and gas industry can promote the economy and improve infrastructure of these more remote locations, resulting in beneficial impacts (Berner 2011). Alaska Natives have recognized that they have benefited by receiving monies to spend on public works and facilities, as well as better health care and counseling centers (NRC 2003).

As discussed in Section 4.4.14, Environmental Justice, much of the Alaska Native population resides in the coastal areas of Alaska. Any new onshore and offshore infrastructure occurring between 2012 and 2017 could be located near these populations or near areas where subsistence hunting occurs. Any adverse environmental impacts on fish and mammal subsistence resources from installation of infrastructure and routine operations of these facilities could have disproportionately higher health or environmental impacts on Alaska Native populations. Mitigation measures, cooperative agreements between Native and industry groups, and government-to-government consultations are designed to limit the effects from routine events.

4.3.2.4 Potential Impacts of Accidental Spills

4.3.2.4.1 Gulf of Mexico. The impacts on human health as a result of oil spills can be broken down into several categories. Goldstein et al. (2011) list the categories as "those related to worker safety; toxicological effects in workers, visitors, and community members; mental health effects from social and economic disruption; and ecosystem effects that have consequences for human health." Initial concerns focus on the short-term toxicological effects to humans such as nausea, dizziness, eye irritation, headaches, and respiratory and dermal irritation, but more research is necessary to understand long-term effects (Goldstein et al. 2011). Impacts on air quality include the emission of pollutants from the oil and the fire emissions that are hazardous and possibly fatal to humans, as well as the dispersant mist resulting from the application of the chemical dispersants on the oil (BOEMRE 2011). The impacts of the proposed action on air quality are fully discussed in Section 4.4.4.

After an accidental release of oil into the environment, the more volatile, water-soluble, and degradable compounds will be weathered and degraded, leaving behind the heavier, less degradable elements. These heavier elements, when combined with sand on beaches, form tar balls, which can be encountered by beachgoers for some time. Humans walking along the beach can absorb these heavier elements through the soles of their feet and subsequently into their bloodstream (OSAT-2 2011). Beachgoers may also inhale petroleum hydrocarbons present as vapors or attached to airborne particles (OSAT-2 2011). Other immediate effects of particular concern are heat stroke and exhaustion and the inappropriate use of personal protective equipment by cleanup crews, especially in the GOM. In the case of the Deepwater Horizon event, elevated rates of post-traumatic stress disorder, depression, alcohol abuse, and conflicts between domestic partners were observed (Goldstein et al. 2011). A large part of the GOM region's economy is based on the oil and gas industry and the harvesting of seafood. Restrictions placed on these industries due to an oil spill can increase the anxiety levels of humans and may contribute mental health issues (Goldstein et al. 2011).

Oil spills have the potential to impact certain groups of people more than others based on their current state of health. For example, GOM coast populations include communities that are still recovering from Hurricane Katrina, and "among the 50 States, Louisiana ranks 44th to 49th (depending on the metric used, with 1st being the best) in the overall health of residents, rates of infant death, death from cancer, premature death, death from cardiovascular causes, high-school graduation, children living in poverty, health insurance coverage, and violent crime" (United Health Foundation 2009 as referenced in Goldstein et al. 2011). As discussed in Section 4.4.14, there are areas in the GOM of environmental justice concern. It is possible these low-income and minority populations could be affected to a greater extent than the general population because of their dietary reliance on wild coastal resources, their reliance on these resources for other subsistence purposes such as sharing and bartering, their limited flexibility in substituting wild resources with those purchased, and their likelihood of participating in cleanup efforts and other mitigating activities.

4.3.2.4.2 Arctic and Cook Inlet. The Native tribes of the North Slope have serious concerns about what would happen if there was an accidental oil spill in the Arctic region. An oil spill could have physical, psychological, social, economic, spiritual, and cultural impacts on the Native Alaskans. Major areas of concern are with impacts on subsistence resources, air quality, and oil spill cleanup. These concerns are related to how and if it would be cleaned up and how the International Whaling Commission would react if the spill greatly impacted the bowhead whale population (NRC 2003). The impacts of the proposed action on air quality are discussed in Section 4.4.4. The North Slope Borough, Alaska, and the Alaska regional office of BOEM have, through a Memorandum of Understanding, evaluated the effects of the oil and gas industry on humans in the region. Appendix J of the *Beaufort and Chukchi Sea Planning Areas Oil and Gas Lease Sales 209, 212, 217, and 221 Draft Environmental Impact Statement* (MMS 2008) presents a full evaluation of these effects.

Oil spills can affect human health in Alaska through the same ways as discussed for the GOM; additionally, major concerns involving the impacts on human health due to oil spills relate to the subsistence lifestyle of Native Alaskans. Humans can be affected through contact with the contaminants, such as through inhalation, skin contact, or intake of contaminated foods; through reduced availability of subsistence resources; through interference with subsistence harvest patterns; and stress due to fears of long-term implications of the spill (MMS 2007d as referenced in MMS 2008).

As discussed in Section 4.4.14, there are areas in the Alaska region that are of environmental justice concern. Much of the Alaska Native population resides in the coastal areas of Alaska, and subsistence activities of Native communities could be affected by accidental oil spills, with the potential health effects of oil spill contamination of subsistence foods being the main concern. Mitigation measures, cooperative agreements between Native and industry groups, and government-to-government consultations are designed to limit the effects from oil spills.

4.3.2.5 Conclusion

Health effects are discussed throughout this PEIS, as appropriate. The State of Alaska is currently developing an approach to integrate health analysis into the EIS by way of a Health Impact Assessment (HIA) (Berner 2011). An HIA is a scientific method used to assess the potential effects of a policy on the health of a population and the distribution of those effects, and it brings together stakeholders to find a solution (Quigley 2006, CEQ 1981, referenced in Berner 2011). The overall purpose of HIAs is "to inform and influence decision making on proposals and plans, so health protection and promotion are effectively integrated into them" (Quigley et al. 2006). This programmatic-level EIS acknowledges that there will be impacts on human health, both positive and negative, from the proposed action, but it is a broad-level document discussing the impacts over entire planning areas. It would be more appropriate to discuss impacts to site-specific populations at the lease sale level when a better understanding of who will be affected is clear.

4.3.3 Invasive Species

EO 13112, *Invasive Species*, defines invasive species as species that are non-native (or alien) to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health. Invasive species can be plants, animals, or pathogens. Nationwide, invasive species are associated with environmental damages and losses totaling over $138 billion annually (Pimentel et al. 2000). More than 50,000 invasive species have been documented to date in the United States, and roughly 42% of threatened and endangered species in this country are considered at risk primarily because of invasive species

(Pimentel et al. 2005). Effects of invasive species can be devastating on both habitat and native species and may (1) include a decrease in biological diversity of native ecosystems, (2) decrease the quality of important habitats for native fish and invertebrate species, (3) reduce habitats needed by threatened and endangered species, (4) increase direct and indirect competition with aquatic plants and animals, and (5) pose human health risks (http://www.invasivespeciesinfo.gov/whatis.shtml).

Oil and gas activities may play a part in the introduction of invasive species or may provide substrate and habitat encouraging the establishment of invasive species. Drillships and semisubmersibles are used and relocated throughout the world's oceans. Over time, fouling, encrusting, and boring organisms will attach to these devices. Unintentional introductions may occur when these drilling rigs are relocated to a new region such as the GOM. These same drillships and semisubmersibles may transport and release ballast water containing invasive plankton, larval invertebrates, or even fish, which may then become established due to the availability of acceptable habitat, plentiful food supply, and lack of predators.

Since 1998, there have been at least 16 documented cases of rigs being brought into the GOM from other parts of the world. Some rigs operating in the GOM were constructed or recently modified in Singapore, Taiwan, and Scotland. Newly built rigs undergoing their last year of construction stand in waters of surrounding shipyards. A year is sufficient time for fouling and encrusting organisms to colonize rig surfaces. One large semisubmersible was kept in Mobile Bay, Alabama, for 1 yr. Prior to being placed in Mobile Bay, it had spent 6 months drilling off the coast of Trinidad.

Oil and gas drilling rigs, platforms, and pipelines provide substrate and habitat for sessile organisms. Invasive mussels, barnacles, and corals are known to use rigs and platforms as attachment sites. Many marine organisms require hard surfaces to use as attachment sites for all or part of their natural history. Jellyfish have a polyp stage that requires hard substrate. Polyps settling on rigs in one location and then transported to another region can asexually reproduce. One polyp can produce up to 300 new jellyfish. Currently, there are thousands of oil and gas platforms in the GOM, each of which can provide a hectare or more of hard substrate that can support algae, mollusks, and other sessile invertebrates (Atchison et al. 2008). No-activity-zone natural reefs provide 104.5 km^2 (40.3 mi^2) of hard substrate, which could be used for settlement sites.

Above-water platform structures may also encourage the colonization of new habitat by invasive species. Many migratory bird species use the platform structures as stopover spots while crossing the GOM (Russell 2005). Ongoing research funded by the BOEMRE is studying the interactions between migrating birds and oil and gas structures off the Louisiana coast.

A number of invasive species have been recorded from the OCS planning areas considered for oil and gas leasing in the proposed action. In the GOM, invasive species reported since the mid-1900s include the brown mussel (*Perna perna*), the Australian spotted jellyfish (*Phyllorhiza punctata*), the pink jellyfish (*Drymonema dalmatina*), two species of hydroids (*Cordylophora caspia* and *Garveia franciscana*), a sea anemone (*Diadumene lineata*), a polychaete worm (*Hydroides elegans* and *Ficopomatus enigmaticus*), the Atlantic copepod

(*Centropages typicus*), four barnacle species (*Balanus amphitrite*, *B. reticulatus*, *B. trigonus*, and *Tetraclita stalactifera stalactifera*), and four species of isopod (*Sphaeroma walkeri*, *S. terebrans*, *Limnoria* spp., and *Ligia exotica*). Some of these species are native to other parts of the world (e.g., the brown mussel is native to Africa and South America), while other species are native to North American marine habitats but not to the GOM (e.g., the Atlantic copepod *Centropages typicus*). Suggested avenues of initial introduction of these various species include discharge of ballast water, dumping of ballast rock, or attachment to vessel surfaces.

Although invasive species are a worldwide problem, Alaska has far fewer invasive species compared to the rest of the nation (Piorkowski 2003a). Relatively few aquatic invasive species have been introduced and become established in Alaska compared to other States. This is, in part, due to Alaska's plant and animal transportation laws, geographic isolation, northern climate, small human population, and relatively few concentrated disturbed habitat areas (Fay 2002). However, a non-native amphipod and a colonial tunicate have been found in Alaskan waters. Potential introduction pathways include the movement of large ships and ballast water from the United States west coast and Asia, and the relocation of previously used docks and pier timbers (ADFG 2011). While invasive species impacts, to date, are low, potential threats must be monitored because a significant portion of Alaska's economy, including sport and commercial fishing, depends upon the pristine and natural quality of its aquatic ecosystems. Climate change may also affect the ability of marine invasives to become established (Invasive Species Advisory Committee 2010). For example, changes in water temperature or precipitation regimes (and associated runoff into coastal waters) may make areas more favorable for an invasive species to become established or spread.

Exploratory drilling of Federal leases offshore of Alaska requires bringing rigs and/or vessels to Alaska. Such rigs or vessels may come from the GOM, the West Coast, or foreign waters and be contaminated with species alien to Alaska. Such species may be attached to the hull structure (e.g., sponges and barnacles), hitch a ride on the vessel (e.g., rats, insects, crustaceans, and mollusks), or be transported via ballast water (e.g., crustaceans and mollusks). Once brought to Alaska, alien species contaminating a rig or vessel may subsequently disperse into Alaska's ecosystems.

Although introduction of invasive species to Alaskan waters could occur through the import and placement of offshore oil/gas structures, the threat has not been considered significant. The Alaska Aquatic Nuisance Species Management Plan (Fay 2002) considers activities other than oil/gas structures major pathways for the introduction of aquatic alien species, including aquaculture; aquarium trade; biological control; boats, ships, and aircraft; channels, canals, and locks; live bait; nursery industry; scientific research institutions, schools, and public aquariums; recreational fisheries enhancement; restaurants; and seafood retail and processing.

Vessels, including those used by the oil/gas industry, do pose more potential for introducing invasive species than oil/gas structures. For example, Hines and Ruiz (2000) reported finding 13 species of crustaceans and 1 species of fish arriving at Port Valdez in the ballast water of oil tankers voyaging from San Francisco Bay or Long Beach, California. The issue of invasive species and ballast water is managed by the USCG under the National Invasive

Species Act of 1996. The USCG has promulgated regulations (33 CFR Part 151) to make compliance with ballast water guidelines mandatory. Therefore, oil- or gas-related vessels are required to abide by these requirements in order to reduce the potential for introduction of invasive species.

4.3.4 Risk of a Low-probability, Catastrophic Discharge Event

4.3.4.1 Introduction

The risk of potentially severe consequences of oil spills, especially the risk and consequence of low-probability, large volume spills, is an issue of programmatic concern. Although unexpected and accidental, large spills may result from OCS exploration or development operations involving facilities, tankers, pipelines, and/or support vessels. Incidents with the greatest potential for catastrophic consequences are losses of well control with uncontrolled releases of large volumes of oil, where primary and secondary barriers fail, the well does not bridge (bridging occurs when the wellbore collapses and seals the flow path), and the flow is of long duration (Holand 1997). The term "catastrophic discharge event" is used in this section to describe an event that results in a very large discharge into the environment that may cause long-term and widespread effects on marine and coastal environments.

In general, historical data show that loss of well control events resulting in oil spills are infrequent and that those resulting in large accidental oil spills are even rarer events (Anderson and Labelle 2000; Anderson in preparation; Bercha Group 2006, 2008; Izon et al., 2007). The Norwegian SINTEF Offshore Blowout Database, which tracks worldwide offshore oil and gas blowouts, where risk-comparable drilling operations are analyzed, supports the same conclusion (IAOGP 2010). New drilling regulations and recent advances in containment technology may further reduce the frequency and size of oil spills from OCS operations. However, as the 2010 DWH event illustrated, there is a small risk for very large spills to occur and result in unacceptable impacts, some of which have the potential to be catastrophic.

A fundamental challenge is to accurately describe this very small risk, especially since there have been relatively few large oil spills that can serve as benchmarks (Scarlett et al. 2011). Prior to the DWH event, the three largest spills on the OCS were 80,000, 65,000 and 53,000, and all occurred before 1971. From 1971 to 2010 there were 253 well control incidents, 53 of which spilled oil. Excluding the DWH event, less than 2,000 bbl were spilled from these 53 well control incidents. During this same period, more than 41,500 wells were drilled on the OCS and almost 16 Bbbl of oil produced. The National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling has recently argued for a more rigorous and transparent oil spill risk and planning process to support government and industry decision making (2011). At the present time, there is a not an ideal, standardized approach to characterizing the risk of spill occurrence and consequence across all relevant space and time scales, consistent with inherent uncertainties associated with different regional factors and different exploration or production operations (Pritchard and Lacy 2011).

Historically, BOEM has characterized oil spill risk using the Oil Spill Risk Analysis (OSRA) model to identify the risk of oil released from numerous locations on the OCS contacting environmental resources. BOEM performs OSRA modeling in support of individual lease sales and certain exploration/development plans. BOEM also considers risk during the review of an operator's Exploration Plan, Development and Production Plan (or Development Operations Coordination Document), and/or Application for Permit to Drill (APD). The same OSRA runs often form the basis for spill risk and resource contact analysis in industry-submitted plans. The APD describes the drilling procedures and technology that are planned to be used to drill a specific well under the specific geologic, geophysical, and environmental conditions that exist at the site. BOEM evaluates the APD to determine whether the operator's drilling plan is appropriate for the drilling risk of the site.

Industry often prepares sophisticated, well-specific risk assessments for exploration or development wells. The hazards-based or well-specific approach can use event-tree, fault-tree, and "safety case" analytical methods (Cooke et al. 2011; DNV 2010). Well-specific quantitative risk analysis (QRA) is frequently performed by operators (e.g., Mechanical Risk Integrity, BlowFAM, BowTieXP), where risk is quantified and compared to acceptance criteria and thresholds. Such quantitative risk analysis considers formation/well characteristics, technology and procedures, and human error/management (which is frequently a root cause of many well control incidents). The recently promulgated Safety and Environmental Management System (SEMS) rule, building on API Recommended Practices (RPs) 14C, 14J, and 75, now requires all OCS operators to identify, address, and manage safety and environmental hazards during design, construction, start-up, operation, and maintenance activities.

To support the planning decision involved in establishing a 5-yr schedule of lease sales, detailed analyses of highly variable, region-specific and/or well-specific risk is neither feasible nor appropriate. At this decision juncture, the critical realization is that the risk of a spill with catastrophic consequences albeit small, is not zero. Different OCS regions and operations may have different risk profiles (Scarlett et al. 2011). This section assesses the importance of different catastrophic discharge event risk factors in different program areas. This discussion is presented to bring into focus critical risk factors, acting individually or in combination, that may occur in program areas so that additional consideration is given to these issues during the Program. In addition, recent regulatory changes implemented since the DWH event that BOEM believes contributes to risk reduction are summarized.

4.3.4.2 Risk Factors Influencing Occurrence, Size, Containment, Response, and Fate/Consequence of a Catastrophic Discharge

Risk is the combination of the probability of an event and the magnitude of the consequences of that event. While BOEM primarily analyzes spills in context of routine small spills and accidental large spills, this programmatic discussion on risk focuses on low-probability, very large volume, long-duration OCS spills with the potential for catastrophic effects (40 CFR 1502.22). Such a catastrophic discharge event may result in "large-scale damage involving destruction of species, ecosystems, infrastructure, or property with long-term effects, and/or major loss of human life" (Eccleston 2010). Such a spill is defined by the

National Oil and Hazardous Substances Pollution Contingency Plan as a “spill of national significance” or “a spill which due to its severity, size, location, actual or potential impact on the public health and welfare or the environment, or the necessary response effort, is so complex that it requires extraordinary coordination of federal, state, local, and responsible party resources to contain and cleanup the discharge” (40 CF. Part 300, Appendix E). For a spill to be considered a catastrophic discharge event, its potential discharge volume must be such that catastrophic effects could occur. As previously discussed, long duration uncontrolled flows from a well control incident provide the greatest volumes of potential flow and are the spill sources considered in this section. A scenario of maximum spill volume and duration is presented in Table 4.3.4-1, describing catastrophic discharge characteristics in different program areas. The discharge rate, volume, extent, and duration varies with geologic formation, well design, and engineering characteristics, spill response capabilities, and time to containment. The potential volume of oil that could enter the environment fundamentally depends on the success of intervention, containment, response efforts at the incident site, or the length of time needed to stop the flow from the well by drilling a relief well. The effect of discharged oil not recovered is influenced by various weathering processes and response measures, such as use of dispersants and burning. The potential adverse effects also vary with time of year and location of release relative to winds, currents, land, and sensitive resources, specifics of the well (i.e., flow rates, hydrocarbon characteristics, and infrastructure damage), and response capability (i.e., speed and effectiveness). A catastrophic discharge event does not inherently equate to a spill with catastrophic effect. Instead, impacts depend critically on the spill size, oil type, environmental conditions, resources present and exposed, toxicity and other impact mechanisms, and population/ecosystem resilience and recovery following direct exposure.

Industrial Economics, Inc., and Environmental Research Consulting, under contract to BOEM, identified a suite of factors that may contribute to loss of well control and affect the size and duration of catastrophic discharge event, differences in efficacy of containment and response, and differences in fate. They include the following:

- Geologic formation and hazards;
- Water depth and hazards;
- Geographic location (including water depth);
- Well design and integrity;
- Loss of well control prevention and intervention;
- Scale and expansion;
- Human error;
- Containment capability;
- Response capability;

TABLE 4.3.4-1 Risk Factors That Affect a Catastrophic Discharge Event

Risk Factors	Factors That Affect Occurrence	Factors That Contribute to Catastrophic Consequences
Geology	Drilling location, drill depth; mature vs. frontier areas Reservoir pressure and volume Seabed complexity Shelf hazards	Larger reservoir volume Higher reservoir pressures Uncertainty associated with drilling in frontier areas
Water Depth	Increased water depth increases complexity of operation	Shallow water depth increases probability of contact with humans, sensitive species and sensitive environments
Well Design and Integrity	Drill string length Cementing and casing design Well integrity New technologies (e.g., associated with expansion) Prevention systems (e.g., BOPs, Backup control systems, ROVs) Human error Scale of operations and expansion	Exploratory drilling and improper well construction Prevention system failure Source of blowout: wells and platforms (as opposed to pipelines) Human error, often involving lack of understanding of new technologies
Loss of well control prevention and intervention	Improperly maintained equipment	Mechanical failure Equipment failure
Scale and expansion	Complexity of operations both physical and operational Human error Coordination and management	Human error Coordination and management
Human error	Lack of training and preparedness Extreme working environments	Lack of training Failure to take precautionary measures
Containment Capability	N/A	Subsea vs. surface containment
Response Capability	N/A	Distance from shore (duration) Response capability in remote areas Capping at the well vs. drilling relief well vs. chemical and mechanical response
Geography	Region-specific meteorology: temperature, extreme weather, prevalence of ice	Distance to shore: proximity to coastline increases probability of catastrophe Hurricanes associated with high-volume spills

TABLE 4.3.4-1 (Cont.)

Risk Factors	Factors That Affect Occurrence	Factors That Contribute to Catastrophic Consequences
Oil types, weathering and fate	Temperature of oil: higher oil temperatures and lower water temperatures (e.g., Arctic) increase likelihood of breakage Tidal patterns Currents and hurricanes	Oil weathering and evaporation Mechanical recovery, dispersal, or burning Transport/ice Oil persistence Ambient temperatures affect rate of oil flow from blowout location

- Oil types and weathering/fate; and

- Specific regional geographic considerations, including oceanography and meteorology.

Many of these factors apply to drilling, abandonment, containment, response, and effects of the event and contribute to the overall catastrophic discharge risk associated with an OCS area, or even a particular well. The interplay of these factors is relevant to evaluating the risk of a catastrophic discharge event and ensuing consequences (Table 1). As the BP report concluded on the DWH event, a complex series of connected mechanical failures, human judgments, engineering design mistakes, and operational, implementation, and team interactions often contribute to incidents (BP 2010). Many of the risk factors are interrelated, and some factors both increase and decrease cumulative risk depending upon whether one is evaluating the risk of occurrence or the consequence of that occurrence. Moreover, some risk factors may contribute to more or less risk depending on the specific situation.

4.3.4.2.1 Loss of Well Control Occurrence.

Geologic Conditions. Depending on the region, the geology of the OCS varies greatly in character and oil and gas exploration potential. Risk assessments of mature areas (areas where prior drilling operations have occurred) benefit from previous geological exploration and well development. Alternatively, frontier areas, such as the Arctic, are relatively underexplored and do not have long registries of geological data or previous attempts at well drilling. This adds additional risk to frontier operations. Though improvements in seismic technology allow three-dimensional modeling of sub-seafloor geology, frontier areas inherently are characterized by greater risk (USGS 2011; National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling 2011). Geologic data in deepwater and ultra-deepwater frontiers in the GOM is growing, as is the industry's understanding of the geological variability and risks, especially as operators continue to develop leases tied to these oil-rich areas.

Because of variations in shallow and deep geologic framework, exploration and drilling often encounter numerous challenges including shallow hazards, such as seafloor instability, shallow water flow, permafrost, and gas hydrate, shallow gas and sour gas zones, as well as relatively deeper hazards, such as salt, and tar zones (Close et al. 2008; Nuka and Pearson 2010; Shaughnessy et al. 2007). In deepwater reservoirs in the GOM, narrow margins in pore pressure and fracture gradient, over-pressurized and low pressure zones, and reservoir compartmentalization (including low flow assurance) can represent key engineering challenges (Cunha et al. 2009; IHS/GPT 2011). Such geological differences across the different regions represent key concerns for the potential influence geology exerts on wellbore integrity, a key element in drilling and developing wells.

Most of the larger reservoirs being targeted on the shallow GOM shelf produce natural gas. There are comparatively fewer plays capable of very large oil discharges as compared to deep water. In shallow water, the relatively lower formation pressure typically results in a higher margin of safety, although encountering shallow gas represents a substantial hazard. The pressure margin allows operators to change the weight of the drilling mud by several pounds per gallon to balance formation pressures. In additional, a large number of shallow-water wells actually require positive external stimulation to produce and facilitate flow of the product from the drilling site.

In general, geologic pressure (pore pressure) and temperature increase with depth. Offshore oil reservoirs can be highly pressurized and compressed under thousands of feet of unconsolidated sediment, salt bodies, and sedimentary rock. The true vertical depth of some reservoirs may exceed 9,144 m (30,000 ft). Deep wells are known to have pressure ratings exceeding 20,000 pounds per square inch (psi) (USDOI 2010; Midé 2010). As pressure and pressure gradients increase, drilling operations become more challenging and necessitate careful balancing of pressures to prevent either the collapse of the well (from excessive pore pressures) or fracturing of the rock and loss of circulation (from excessive drilling pressure). Deeper reservoirs also tend to feature larger volumes of oil. In the event of a well blowout, wells tapped into larger reservoirs can potentially release more oil into the environment and at greater discharge rates since flow rates depend in part on temperature and pressure. Uncontrolled flow rate, or “open flow potential,” can be over 100,000 bbl per day.

Water Depth: Rig and Well Complexity. Water depth alone is not a strong predictor of well control incidents, but it is related to the complexity of technology and operations (Jablonowski 2007; Malloy, 2008; Cohen and Krupnick 2011). Exploration wells are most often drilled in open water where no platform exists. Jackups, submersibles, semisubmersibles, and drillships, collectively referred to as mobile offshore drilling units (MODUs), are commonplace in exploration drilling, whereas modular rigs installed on platforms are more commonly used in production wells. Drilling of a production well often involves interaction with a production platform and the existing wells on the platform. Water depth not only drives the drilling technology, but also influences well design and construction practices, as well as safety measures used to mitigate risk of well control incidents. As oil prices remain relatively high, exploration and production firms venture into deeper waters where larger reservoirs of oil are known to exist. While contingent on a number of factors, deepwater and ultra-deepwater oil operations may have higher safety incidence rates owing to rig complexity, although there have been and continue to be a greater number of loss of well control events in shallow water (Shultz 1999; Jablonowski 2007; Izon et al. 2007; Cohen and Krupnick 2011).

Alhough definitions of exact depth ranges vary, shallow water depths are generally defined as less than 200 m (656 ft). Shallow water exploration and development rigs involve comparatively simple well construction, allow direct access to well control prevention mechanisms, are less susceptible to deepwater currents (although waves and strong coastal currents are in play), and do not face complications with pressure and temperature variations found with deepwater and ultra-deepwater wells. In addition, shallow water depths allow surface blowout preventer (BOP) placement where preventative maintenance and service can be done directly by rig operators. At the same time, GOM infrastructure in shallow water tends to be older and may be more prone to mechanical failure. Depending on water depth, OCS exploration wells in the Arctic may be drilled from an artificial island; large, usually bottom-anchored drilling structures; or a drill ship.

The greater complexity of wells and specialized equipment used on deepwater and ultra-deepwater rigs may present more opportunity for mechanical breakdown and accidents (Jablonowski 2007). Well complexity increases the number of routine operations and incidence of unusual operations, such as stuck pipe and complex casing and cementing programs (Jablonowski 2007). Complexity also increases the number of individual tasks that need to be performed on a well, complicating procedures and communication.

Deepwater depths are roughly defined as seabed depths that exceed 200 m (656 ft) but are less than 1,500 m (4,921 ft). Because of the extreme depths of deepwater drilling, these operators can no longer utilize traditional fixed platforms directly on the seabed, and different technologies and procedures are required. Deepwater drilling rigs are multi-point moored to the sea floor or, more recently, dynamically positioned. More complex operations such as mooring, station keeping, riser management, and deepwater well control may complicate operations and increase the number of procedures prone to errors and equipment prone to failure. The newest platforms incorporate advanced technology, about which few data on long-term success or incidents have been gathered (USDOI 2011b). The technologically advanced BP Thunder Horse platform, for instance, intended to be BP’s largest producer in the GOM, flooded because of the backward installation of a valve. Deepwater wells require subsea BOP placement at depths unreachable for human service; ROVs become necessary. Maintenance, repair, and assurance of proper functioning of such mechanisms are more difficult at greater depths.

Ultra-deepwater is a relatively new class of wells defined as exceeding wellhead depths of 1,500 m (4,921 ft). Similar to deepwater platforms, ultra-deepwater rigs are floating semi-submersibles and dynamic positioned drill ships. Ultra-deepwater wells require intricate and complex platforms, structures, and equipment to operate. High hydrostatic pressures and low ambient temperatures in such deep waters necessitate heavier and more specialized equipment. The extended depth demands larger platforms and operating rigs to handle the added drilling materials, as well as storage capacity.

Well Design and Integrity. Well construction is a process with numerous stages preceding well abandonment or production. Construction of an offshore well involves different types of setting agents, pipe, casing, cements, wellhead technology, rigs and platforms, drilling muds (synthetic or water based), and cleaning/preparation agents. These differ by environment, with deepwater wells requiring distinctly different construction and technologies to withstand conditions at extreme hydrostatic pressures and lower temperatures.

Since the process of sub-seabed drilling cannot be directly observed, drilling operators in an offshore environment are reliant on secondary indicators to ensure proper construction of the well. Geophysical imaging, pressure readings, and reclaimed fluid testing are some of the secondary indicators used in drilling at depth. Though these tests lend accuracy in mapping pressure zones, impediments such as pockets of gas, shallow water flows, faults, salt deposits, or rubble zones are not always forecast.

The primary function of a well system is to reliably contain, control, and transport hydrocarbons to the surface. In general, risks are determined by well bore parameters and an operator's familiarity with the well bore. Drilling engineers must constantly monitor pore pressures, fracture gradients, fluid circulation, and abnormal pressure zones to avoid loss of well control. When drilling into frontier or new reservoirs, limited knowledge of wellbore parameters can increase risk of accidents. The number of barriers are often scaled with the likely consequence of failure; multiple barriers are often used to achieve adequate reliability and avoid leaks. Complex hole sizing, drilling string, wellhead technology, and mud programs, as well as casing and cementing designs are required to reach target depths in deep water and ultra-deep water. Mud, casing, and cementing programs must be designed, refined, and implemented as well bore parameters and formation characteristics are being monitored.

Drilling mud/completion fluid pressure is the primary well control barrier for drilling and well intervention operations (PCCI 1999). When this fluid hydrostatic pressure drops below that of the formation, a kick occurs, which means that formation fluid enters the wellbore. Casing and cementing programs, diverters, BOPs, and wellheads can provide backup (secondary or redundant) barriers to prevent a blowout when a kick occurs. Casing and cement, as well as drilling or completion fluids, are used to ensure the fluids in a formation do not enter the wellbore during drilling and completion operations. For production operations, a packer/tubing string and tree may provide the primary well control barrier. The production casing and wellhead system provide a backup barrier in case of a packer or tubing string leak.

In 2008, BOEMRE published guidelines on the various steps towards managed pressure drilling, a process that avoids the continuous flow of formation fluids, to facilitate better planning of drilling operations (Eschenbach and Harper 2011). Further drilling safety procedures and practice guidelines have been submitted by BOEMRE in recent years due to the 2010 DWH incident, including the new Drilling Safety Rule and SEMS rule. Under these and other rules, drilling practices must properly address and manage known and possible risks with adequate mitigation and safety technology (USDOI 2010; USGS 2011).

Well integrity issues arise with the cement used in construction. Fluids used to clean and prepare the well for cement are either water-, synthetic-, or oil-based, which can contaminate cement. At sub-seabed depths of 5,486 m (18,000 ft) or more, heavy cleaning fluids run the risk of not filling their intended purpose and contaminating subsequent cementing jobs. Cementing problems were associated with 18 of 39 blowouts between 1972 and 1999 in the GOM (Izon et al. 2007). However, the majority of these cement-related blowouts were of short duration, primarily released natural gas, and involved shallow strings in a well-surface casing. Mechanical indicators such as negative pressure testing and pressure and heat gauges to test cement integrity have also come under scrutiny for lack of accuracy; the pressure gauges used for negative pressure testing for Macondo were accurate to ± 400 psi, a rather imprecise measure (OPG 2011). It is presumed both cementing issues and mechanical failure may have been a factor in the Macondo well blowout (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling 2011; JITF 2011).

When considering the risk of loss of well control, it is important to distinguish among the different types of wells, including exploration, development, and production wells. Exploration wells are drilled in open water from a mobile offshore drilling unit, whereas production and development wells are often drilled under an existing platform. In general, exploration may involve greater uncertainty due to the availability of geologic data, nature of drilling technology, and unique barrier factors, such as BOP placement (Eschenbach and Harper 2011). From 1971 to 2010, there have been over a total of 41,781 wells drilled in the OCS. Of these, 26,245 were development wells, 15,491 were exploration wells, and 43 were core tests or relief wells. The overall OCS well control incident rate for drilling was 1 loss of well control incident per 292 wells drilled (1 per 201 for exploration wells, and 1 per 410 for development wells). These well control incident rates include all well control incident rates related to drilling operations whether or not a spill occurred. Despite the increased risk of drilling wells on undeveloped frontiers, procedures followed in drilling exploratory wells may be more conservative (i.e., safer) to account for this increased level of uncertainty (Eschenbach and Harper 2011).

In the GOM from 1980 through 2004, there was a relatively higher number of well releases during development drilling and well workover operations as compared to exploration drilling. This contrasts with worldwide trends where more well releases tend to occur during exploratory drilling (Holand 2006). Holand (2006) attributes this to the fact that more development wells are actually drilled. Hurricanes or ship collisions caused approximately 50% of the production blowouts (Holand 2006). Simultaneous operations of drilling and production also increase the risk of incidents when drilling production wells. Another root cause of sustained blowouts during completion and workover is the positive potential for pressurized hydrocarbons and limited bridging tendency with flow through perforations or gravel pack (Flak 1997).

In general, the riskier wells include wildcat wells (first well into formation), offset wells (wells drilled near another well that encountered drilling trouble zones or past well control problems), and extended or ultra-deep drilling (SPE Advisory Summit 2011). Deepwater and ultra-deepwater wells require complex infrastructure, planning, and execution to construct; therefore, facilities and volume of production tend to get larger with distance from shore and water depth (Shultz 1999). The complex nature of the formations, combined with the drilling depths in high-pressure/high-temperature conditions required to reach the target zones, presents a challenge to drilling engineers (Close et al. 2008). This challenge is highlighted in the greater number of casing strings required to drill to target depth, which in turn creates the challenge in achieving good cement isolation in a tight tolerance annuli (Close et al. 2008; Chatar et al. 2010). Despite such challenges, over 2,300 deepwater development wellbores and approximately 2,600 deepwater exploration wellbores have been drilled. Of these, the Macondo well is the only exploration well to involve a blowout and large oil spill. No spills have occurred for deepwater development wells.

Loss Well of Control Prevention and Intervention. A blowout occurs when there is failure to control a kick and regain pressure control, and can be defined as an uncontrolled flow of formation fluids. Oskarsen (2004) classifies offshore operations blowouts in three groups:

- Surface blowouts characterized by fluid flow from a permeable formation to the rig floor;

- Subsurface blowouts characterized by fluid flow at the well at the mudline, where the exit conditions are controlled by the seawater; and

- Underground blowouts characterized by fluid flow from one formation zone to another, typically by using the wellbore as a flow path.

Potential scenarios for each blowout type are described in Oskarsen (2004). Blowout rates by different phases of exploration and production operations and relative water depths are available in Holand (2006). Although high hydrostatic pressures at depth will aid in choking any flow from potential blowout points (PCCI 1999), two independent barriers are typically used for well control. The primary barrier is usually the hydrostatic pressure exerted by the well mud/synthetic fluid column (either static or dynamic). The secondary barriers typically include the pressure control equipment such as the BOP, the diverter system, the wellhead (innermost casing hanger seal), and the choke/kill line valves. These barriers are routinely used during drilling, completion and workover operations. If the well is flowing (i.e., producing oil and/or gas), the primary barrier is that closest to the reservoir (PCCI 1999).

Individual BOP systems are used during drilling operations to prevent unrestrained release of crude oil from reservoirs. BOPs are composed of all systems required to operate them, including flexible joint, annular preventer, ram preventer, connector, choke and kill lines, choke manifold and auxiliary equipment (USDOI 1996). The specific type of BOP may influence the loss of well control and well releases. For example, fault tree analysis in the DNV Beaufort Sea Study showed that there is substantial risk reduction with BOPs having two sets of blind shear rams spaced at least 1.2 m (4 ft) apart. The study concluded that the reliability of a two blind shear system is 99.32%, compared to 99% for a single blind shear ram (Midé, 2010). Despite the seemingly low percentage, an increase of 0.32% in BOP reliability raises the estimated number of wells that can be drilled before an uncontrolled blowout to 6,213 from 4,225 (Midé 2010).

In shallow-water wells, BOPs are placed above the sea on the rig, allowing for periodic repair and maintenance. The operations of surface BOPs are not subject to all of the complicating factors associated with subsea BOPs, and they are more accessible for repair and intervention. However, surface BOPs that are placed on floating facilities (as opposed to jack-up rigs) present other significant risks. The high-pressure riser and casing from the seafloor to the rig can be exposed to dynamic stresses. A failure of a high-pressure riser due to these stresses can lead to uncontrolled flow below the surface BOP system located on the floating facility. Well operations from a floating platform with a surface BOP stack and a high-pressure riser (through the water column) are higher risk operations than drilling from a jack-up rig or a fixed platform. The single high-pressure riser (or in some cases, a dual riser system) used by floating platforms is subject to environmental forces such as current induced vibration that make it more susceptible to stress fatigue. Jack-up rigs and fixed production platforms have more casing strings tied back to the surface of the rig or platform, which provide additional external support for the pressured casing. In addition, because these tied-back casing strings are used in shallower water operations with a shorter water column, they are less exposed to current-induced stress.

Deepwater and ultra-deepwater wells have subsea BOPs that are affixed directly to the well on the seafloor. Deepwater and ultra-deepwater seafloor depths exceed depths at which human operators can work, thus requiring submersibles and emergency backup control systems. These systems can demonstrate failures. For example, the main control system of BOPs has a failure rate of approximately 50% at depths of 800–1,200 m (2,625–3,937 ft), and approximately 7% at depths of 1,200–2,100 m (3,937–6,890 ft) (Midé 2010). Midé (2010) suggested that this is because less variability exists in relatively calmer waters at deepest depths (e.g., currents and marine life do not affect machinery as much in deep water). Important technology includes the acoustic backup system, which communicates with the BOP system in the event of electrical and hydraulic connection loss with the wellhead. DNV (2010) reported a 25% reliability of current acoustic backup systems. ROV activation of the BOP using the secondary control system has a 75% success rate.

Overall, more research and development is necessary to increase the success rates of control systems in order to reduce the risk of deepwater drilling operations. Evidence for the containment response to the DWH incident, as well as a review of industrial and governmental containment response, suggests that mitigation technology has not kept pace with extraction technology that enabled industry to drill in increasingly deeper waters (IPIECA 2008; Cohen et al. 2010). However, industry and regulatory enhancements are under development to address control systems (USDOI 2010; DNV 2010).

Scale and Expansion. Scale and expansion of OCS operations increases the complexity of drilling and production operations. Factors associated with scale include the number of wells, new types of production facilities, new methods of transporting oil, higher levels of production, the addition of simultaneous operations during production, and higher rates of pumping. Expansions in scale of oil production require more well and platform construction, along with higher production volumes. New technologies necessitated by an increased scale of operations may be associated with higher levels of risk, especially when technologies are not fully developed. The number of incidents reported increases with more complex operations, in particular with deepwater operations which, by their very nature, often entail greater scale, expansion, and complexity (Cohen and Krupnick 2011). Large-scale oil production involves the use of subsea well complexes and large central processing and storage facilities, about which little data on long-term success and incidents have been gathered. The OCS operations in the GOM are moving farther offshore and incorporate more complex drilling and production operations. For example, the Shell Perdido Project is simultaneously connected to 22 different wellhead sites (Shell 2011b). A production facility of this scale, in addition to being in ultra-deep water, typifies the trend in scale and expansion (Shell 2011a).

More complex facilities and operations require equally complex management structures. Operations of greater scale entail a complex set of relations between different operators, contractors, and management groups. While the probability of release on more complex facilities has not been actively studied, it is noted that the Macondo well suffered from insufficient correction of known concerns prior to blowout because of management and communication issues between operators and contractors (National Academy of Sciences 2010; JITF 2011).

Human Error. Human error, or combinations of human and mechanical failure, are the root cause of many OCS accidents and spills (Jablonowski 2007; Muehlenbachs et al. 2010). Low-probability, high-impact failures such as the Macondo well blowout indicated more stringent requirements were necessary (Winter 2010; DOI 2010). In the case of the Macondo well, operators misread pressure readings, authorized high-risk activities, disregarded warning signs, and overlooked the checks and balances that exist in regulatory assignments, while mechanical BOP failure compounded the severity of the release (Winter 2010; National Oil Spill Commission 2011). The new SEMS rule recognizes this gap and establishes a mandatory program to ensure OCS operators identify, address, and manage safety and environmental hazards and impacts during design, construction, start-up, operation, inspection, and maintenance activities. This systemic approach to managing risk and ensuring safety and environmental protection should provide more focus on the risk of system failures as well as on the human factors that could contribute to an incident (SPE Advisory Summit 2011).

Level of training and safety culture are important factors in determining the number of safety and well control incidents (Jablonowski 2007; Vinnem et al. 2010). A well-trained crew that has participated in numerous practice exercises will decrease the probability of a spill caused by human error. Lack of proper training has been a significant issue in the last decade, probably because of a lack of incidents (Etkin 2011). Previously, standard industry practice often permitted operation of technical equipment with on-the-job training or one-week training courses. The MMS published final regulations for Well Control and Production Safety Training (30 CFR 250, SubpartO) in 1997 (amended on August 14, 2000). Recently, the advent of new regulations (the SEMS rule) and requirements for personnel on platforms and working on drilling operations aims to eliminate the current gaps in industry-required trainings. Individuals working in specific technical jobs are now required to attend annual training and certification, and operators are required to perform job safety and hazards analyses (DOI 2010; BOEMRE 2010; OGP 2011). Other factors such as climate and temperature could affect worker performance. For instance, colder temperatures in the Arctic lead to higher probabilities of human error due to the extreme working conditions (Eschenbach and Harper 2011).

4.3.4.2.2 Containment and Response. The effectiveness of containment and spill response dictates the amount of oil released in the environment. Area and operation-specific oil spill contingency plans, as well as actual containment and response efforts, will be designed around many of factors that contribute to the risk of spill occurrence and fate of oil in the water. Assuming the correct containment plan is in place, the risk of poor planning and containment execution still exists (USCG 2011).

If the BOP fails, other options are available to control the blowout, including capping/shut-in, capping/diverting, surface stinger, vertical intervention, offset kill, and relief wells (Neal Adams Firefighters, Inc. 1991). Of these methods, a relief well is often considered most important, and may be required immediately (even if it is not the first choice), since it is typically considered the principal solution for well control. The amount of time required to drill a relief well may depend upon the complexity of the intervention (e.g., depth of formation), the location of a suitable rig, the operations that may be required to release the rig, and any problems mobilizing personnel/equipment.

Once the oil has reached the sea's surface, the first few hours of a spill are the most critical for response efforts. Boomers and skimmers should be deployed immediately to contain the oil and *in situ* burning and dispersant use should be evaluated to supplement mechanical collection methods. Since *in situ* burning and dispersant use are time sensitive, responders should ensure the necessary supplies for either method (e.g., flame-resistant booms) are available.

If a spill cannot be contained at the site's wellhead (subsea), a response effort may be required to restrict the surface spreading of oil in the water, especially from the shore. The following sections outline the methods of containment, as well as the risks and considerations unique to each.

Water Depth, Distance from Shore, and Other Variables. As shown by the DWH event, the loss of well control in deeper depths presents containment obstacles and challenges that would not necessarily be encountered during a loss of well control in shallow waters. Although many of the same techniques used in shallow water were used to attempt to control the Macondo well, the well control efforts were hindered by water depth, which required reliance solely upon the use of ROVs for all well intervention efforts. This is a concern in deep water because the inability to quickly regain control of a well increases the size of a spill, as occurred during the DWH event. Other complications associated with responding to a deepwater blowout include inaccessibility of the well, methane hydrate formation at lower seafloor water temperatures, and the need to work with larger and less-available support equipment due to the greater water pressure. The inverse relationship holds true for emergency response to spills. The closer the well is to shore, the quicker the potential response.

Distance from shore, coupled with response measures, fundamentally drive the size of the impacted area. Oil-spill contact potential, the likelihood of released oils contaminating areas or materials of interest (e.g., beaches, wildlife, sensitive environments), decreases with greater distance from shoreline (IPIECA 2008; JITF 2010). As physical distance from sensitive areas and shores increases, sea waters, currents, waves, and other biological processes are able to dilute and digest more of the spilled oil. Volume alone does not determine the impact of the releases. Releases close to shore may have greater effects, especially when concentrated into inlets or smaller areas (IPIECA 2008).

In some respects, offshore spill events in the Arctic and sub-Arctic may offer a few advantages to responders. Ice can serve as a natural oil boom and dampen surface waves, while cold weather slows the rate of oil evaporation – making it easier to burn. Shore ice may also provide a physical barrier, limiting shore contact to oil. However, spill removal companies have testified that icy waters actually make traditional techniques (booming and skimming) significantly less effective (CRRC 2009). A spill during the fall freeze-up would be the most dangerous time for a spill, and even chemical response methods would be limited (Nuka and Pearson 2011). The Arctic is sparsely populated and infrastructure is not abundant. Thus, the ability to appropriately respond to incidents remains a concern (USGS 2011). Ice-free seasons are relatively short (around three months a year), and ice state may influence the ability to drill a relief well. The relatively shallow Arctic depths could result in more contact potential in the event of a catastrophic spill. Should spilled oil persist in the water column, there is concern that suspended oil could become trapped in ice.

Status of Technology to Physically Contain. OCS operators are now required to submit documentation that they are able to deploy adequate containment resources to respond to a blowout or other loss of well control. In general, subsea containment at the wellhead is ideal and most effective because it contains the oil at the source. Perhaps the most significant hurdle to the development of containment at the blowout point (subsea) has been cost (BOEMRE 2010; PCCI 1999). Given the low historical probability of a significant blowout occurrence and limited use of subsea containment equipment, industry development of cost-effective equipment has not historically occurred, although that has changed in response to new regulatory requirements.

As mentioned, containing oil at the wellhead is the ultimate goal in the event of a blowout. However, subsea collector technologies have historically presented some operational challenges given design and installation difficulties (PCCI 1999). For subsea oil containment, the technical hurdles to be overcome during a deepwater blowout include the behavior of deepwater currents; the ability to manipulate heavy objects on the seabed; the ability to design subsea collectors that are flexible enough to cap a large range of subsea wellhead assemblies and accommodate a high volume of recovered oil, gas, and water; the ability to approach the blowing well and install containment devices on the seafloor; and the lack of standardization in subsea wellhead design.

ROVs capable of manipulating heavy objects, especially collector technologies, near the seafloor and in turbulent conditions caused by the blowout, are limited. In fact, even relatively minor blowout plumes have rendered many ROVs useless. Aside from the risk of physical damage from plumes, the following risk factors exist related to ROV use:

- Sufficient surface support or subsea lifting devices such as syntactic foam buoys are required to assist the ROV with heavy object lifting;

- Subsea currents can complicate ROV use; and

- Navigation systems and/or sensors can be damaged from the blowout plume.

In comparison, subsea containment in shallow water is less complicated; for example, it is easier to mobilize equipment and avoid hydrate formation at the relatively warmer seafloor temperatures.

The DWH event and implementation of NTL No. 2010-N10, however, has created new impetus for industry-driven containment technology. For example, Marine Well Containment Company (MWCC) – a partnership between ExxonMobil, Chevron, ConocoPhillips, and Shell – has announced the release of its seabed containment system (Helman 2011). According to the company, the unit features the ability to do the following:

- Contain 60,000 bbl per day of liquid and 120 million standard ft^3 of gas;

- Inject dispersants; and

- Be placed in water up to 3,048 m (10,000 ft) deep.

This system is intended to address the weakness of the BP containment dome that caused its failure during the DWH event (Helman 2011). The system can inject antifreeze-like chemicals to inhibit natural gas hydrate build-up, which created spill containment complications during the DWH event. Of course, whether Marine Well Containment Company's system will work as effectively as it claims will not be known until another blowout event occurs.

Another option for source control and containment is through the use of the equipment stockpiled by Helix Energy Solutions Group, Inc. The Helix initiative involves more than 20 smaller energy companies and supplements the MWCC response effort. Helix has maintained the equipment it found useful in the DWH event response and is offering it to oil and gas producers for use. Together, the ships and related equipment can accommodate up to 55,000 bbl of oil/day, 70,000 bbl of liquid natural gas, and 95 MMcf of natural gas at depths up to 2,438 m (8,000 ft).

Shell is developing equivalent shallow-water containment technology for use in the Arctic. The company is under increasing scrutiny from industry stakeholders to ensure that an event similar to the one that happened in the GOM will not occur in the Arctic. Shell has pre-staged response equipment and vehicles designed for Arctic conditions that can be activated immediately (Dyer 2011). For example, in the 2011 Revised Outer Continental Shelf Lease Exploration Plan, Shell's spill response plan includes oil spill response (OSR) vessels with an ice-capable Oil Spill Response Barge (OSRB) and associated tug (Point Oliktok tug and Endeavor barge), a tank vessel for storage of any recovered liquids (Mikhal Ulyanov), and associated smaller workboats. In addition, Shell's plan includes two vessel of opportunity skimming systems (VOSSs) to assist with containment and recovery, along with an arctic oil storage tanker to provide storage of recovered oil (BOEMRE 2011). Shell has committed to having a pre-fabricated subsea collection system with surface capability to capture and dispose of oil, and has indicated that this system is in final design.

Aside from subsea containment, subsea dispersant injection into the well or blowout jet zone is considered to be one of the most promising measures to contain the *effects* of the oil spill. Design concepts to date require advanced planning to incorporate the appropriate equipment for dispersant injection into the drilling infrastructure/equipment (e.g., subsea stack or BOP). The industry is now focused on wellhead-independent injection systems; this method involves applying dispersants into the blowout plume. As noted above, MWCC's system includes a subsea injection capability. However, the environmental tradeoffs of subsea dispersant use (similar to surface dispersant use, discussed in the following section) continue to be debated and have been poorly documented based on limited prior application (USEPA 2011b).

Mechanical Recovery Methods. Mechanical recovery methods include the use of booms, barriers, and skimmers, as well as natural and synthetic sorbent materials (NRC 2003). Of all response efforts, mechanical methods exhibit the least impact on the environment and are considered to be the first line of defense against surface oil spread (USEPA 2011d).

Booming and skimming are the two most widely used mechanical containment methods. The effectiveness of these two measures will depend on the volume of the oil spill, location of the well, and sea conditions. For example, at remote open-sea well locations, the immediate availability of sufficient oil storage and/or oil-water separators may be limited (BOEMRE 2010; PCCI 1999). Booms and skimmers become less effective in higher wave swells and wind, and in fast currents. Three main types of skimmers exist, each with characteristics that may make them more effective given certain ocean and spill conditions. Weir and suction skimmers operate best on smooth water with little debris; oleophilic skimmers are the most flexible, can be used on spills of any thickness, and may work most effectively on water that has rough ice debris (e.g., in Alaska) (USEPA 2011e). Although oil recovery efforts must withstand the harsher climate conditions of the Arctic, a research program conducted by SINTEF in 2010 concluded that the mechanical recovery of oil spills is possible despite difficulties associated with maneuvering skimmers through ice (Sorstrom et al. 2010). In any environment, collection rates of 20% are considered exceptional in most cases (USEPA 2011e). In the case of the DWH event, skimmers only accounted for the removal of 3 or 4% of the released oil because of relatively low efficiency (USCG 2011).

The DWH event tested new, “enhanced” booms and skimmers, which may help expand the range and efficiency of recovery in open water and near shore. Advances have been made to create booms that can withstand rough sea conditions and more viscous oil, including in cold-water conditions offshore Norway (McKay 2011). As a result, the effectiveness of recovery both on open water and near shore can be expected to increase, especially given the attention of the USCG to this matter (USCG 2011).

Sorbent materials capture oil through absorption or adsorption and are often used to supplement booming and skimming. Lighter oil products (e.g., gasoline, diesel fuel, benzene) are absorbed more easily, while thicker oil responds better to adsorption (USEPA 2011f). While generally effective, the use of sorbents is less practical with extremely large spills or in windy conditions.

Chemical and Biological Methods. Surface dispersants (chemical-based) can be applied via boats, aircraft, or helicopters. A two- to three-day window following an event generally exists to use dispersants (BOEMRE 2010); therefore, pre-approval of dispersal as a contingency method and of specific dispersant use is essential (NRC 2006). Since the toxicity of dispersants is an important consideration (IPIECA 2008; NRC 2005), mechanical containment methods are the preferred initial response. Very large spills may require immediate application of dispersants.

The effectiveness of dispersants (compared to booming and skimming methods) is more dependent on sea conditions. Studies indicate that dispersants are most effective at salinities close to that of normal seawater (NRC 2005). In addition, dispersants work best in warmer water (USEPA 2011b).

Gelling agents react with oil to form rubber-like solids that can then be removed from the water via nets or skimmers. Gelling agents can be most effective for small to moderate spills in moderately rough seas. The volume of gelling agent required can be as much as three times that of the oil spill; therefore, for larger spills, it is impractical to use this method. Moderately rough seas provide increased mixing effect of the agents with the oil, resulting in greater solidification (USEPA 2011c).

The use of biological agents (i.e., bioremediation) for oil spill response is an emerging area of research. Bioremediation is the act of adding materials (e.g., microorganisms) to the environment to increase the rate of natural biodegradation. Currently, two technologies – fertilization and seeding – are being used in the United States for oil spill remediation (USEPA 2011a). Unlike the other methods covered in this section, bioremediation is a longer-term response effort.

***In Situ* Burning.** Burning is an effective method to remove much of the oil once it has reached the water's surface and reduces the need for storage of recovered oil. Weathering properties of the oil will affect whether or not surface burning is a viable option. For burning to work effectively, oil thickness must be at least 1 to 2 mm and water-in-oil emulsion must be 50% or less (NOAA 1997).

The weathering properties of oil in icy waters are also important for recovery efforts. Studies have shown that, in general, oil in icy waters weathers at a slower rate than in open waters. The slower weathering process of oil in the Arctic Ocean increases the opportunity of successful *in situ* burning, which efficiently reduces free floating oil and oil collected in booms (Sorstrom et al. 2010). *In situ* burning has been successful in cases where oil was trapped in ice (Nuka and Pearson 2010; S.L. Ross Environmental 2010).

A factor that could limit the application of *in situ* burning is the impact on human health due to gas and particulate release from oil burning. Studies estimate that 5 to 15% of the oil is converted to particulates (mostly soot) but that public exposure is not expected unless the smoke plume sinks to ground level. However, *in situ* burning raises general concerns over air quality impacts (NOAA 1997).

4.3.4.2.3 Fate.

Oil Type. Various oil types have varying characteristics, including pour point, viscosity, weight, and composition. In general, lighter oils tend to be less viscous and can be byproducts of crude oils such as diesel and gasoline. Lighter oils tend to be less toxic, although some from the GOM tend to have higher concentrations of toxic compounds (Etkin 2011). Heavier oils tend to resist weathering and dispersant application, and then may persist in the water column for long periods of time (USGS 2011; USDOI 2010; Etkin 2011).

Evaporation. Evaporation occurs when oil comes in contact with air on the surface of the water. Evaporation rates are a function of numerous dynamics including oil viscosity, ambient temperature, sunlight exposure, and oil type (IPIECA 2008). In general, lighter oils such as diesel or gasoline will dissipate quickly or evaporate from the water, although evaporation is slower in colder temperatures. More viscous or heavy forms of oil will tend to persist longer and resist evaporation (USDOI 2011b). Compared to other oil-producing regions, a greater portion of oils extracted from the GOM tend to be lighter crude oils. Because such oils persist for a shorter period of time, they may cause less long-term damage and lower cleanup costs. The viscosity of Arctic oils varies, but due to colder surface temperatures and a generally cooler average climate, these oils are thought to evaporate more slowly, become trapped in ice, or become viscous and suspended in the water column (USGS 2011; USDOI 2011b).

Weathering. Weathering of oil in the sea results from a number of factors, including exposure to atmosphere, currents, biological organisms, and tidal patterns. In general, lighter oils such as diesel and gasoline weather quickly (Dickins 2011; IPIECA 2008; Etkin 2011). Higher ambient temperatures also accelerate weathering. The warm waters of the GOM are thought to help oil to dissipate, although this may not be the case for all oils, especially those generated in deepwater environments where ambient temperatures can be lower (USDOI 2010; IPIECA 2008; Etkin 2011). In cases where releases become suspended in the water column, long-term persistence may occur and potentially threaten marine life and economic activity tied to the marine environment.

The weathering characteristics of spilled oil influence the range of drift and spreading considered within spill trajectory assessments and dictate the effectiveness of chemical dispersants, *in situ* burning, or mechanical responses. Conditions in the Arctic may lead to longer term oil persistence. Denser, more viscous oils in colder temperatures weather at very slow rates, potentially persisting on rocks for years (USGS 2011). Cold water also increases the probability that oil from a spill will solidify in the water, persisting indefinitely and rendering cleanup more difficult. However, weathering in the Arctic will be contingent on the season and weather (Dickins 2011). If oil is exposed to more air and sunlight, evaporation and dispersion due to weathering may also accelerate. Due to the variability in seasons (and in particular the ice pack), it is important to consider the timing of the release in the Arctic to evaluate the potential for long-term damage to the surrounding marine and coastal environments.

Transport. The transport and behavior of oil and gas released into oceans varies greatly depending on the conditions of the area. The magnitude and spread of transport may depend on water depth, ocean currents, meteorological events, and geographic specific factors including the prevalence of ice. Fluids released into deep water, for instance, are subject to high hydrostatic pressure and low ambient temperature, increasing the oil's persistence and its potential to transport to coastlines. A shallow water release from a high-pressure formation with a high velocity may result in a turbulent mixing of the gas, oil, and water, with the mixture quickly transported to the surface by the expanding gas under decreasing hydrostatic pressure (PCCI 1999). Research as part of the DeepSpill Joint Industry Project indicates that above the point of separation, gas bubbles and large oil droplets rise toward the surface while smaller, dispersed oil droplets may be entrained in deepwater currents at the terminus of the jet phase (Johansen et al. 2001; S.L. Ross Environmental 1997). Deepwater spills increase the potential for oil remaining trapped throughout the water column, and this increases the risk of oil transport to other regions and water bodies, although the oil is expected to be highly dispersed.

Meteorological events specific to the GOM may potentially transport spilled oil to shallow and coastal areas, increasing the risk of catastrophic consequences. Major meteorological events specific to the GOM are cold fronts and hurricanes. The wind force and magnitude of the storms in the area have the potential to expand the affected area of an oil spill. Typically occurring between June 1 and November 30, hurricanes also have the potential to destroy production facilities and precipitate releases. Data on platform spills also show that oil spills that result from hurricane damage in the GOM have been larger in volume, accounting for approximately 43% of large (>1,000 bbl) spills (Eschenbach and Harper 2011). During hurricane passages in the GOM, production is shut-in and facilities are evacuated. This reduces the probability of a very large release of oil from facilities.

Another major cause of physical transport that is specific to the GOM is the Loop Current, a warm ocean current that wraps around the western coast of Cuba and the panhandle of Florida. The current dominates upper ocean circulation in the eastern and central GOM, and transports approximately 30 million m^3 of water per second, with a variance of about 10%. Speeds may exceed 150 cm/s at the surface with velocities as high as 5 cm/s at 1,000-m (3,280-ft) depths. In both shallow and deep water, currents are dominated by cyclonic and anticyclonic eddies that vary in magnitude and frequency, which increases the uncertainty associated with effects on drilling operations (Donohue et al. 2006). The these characteristics exhibited by the GOM Loop Current impose uncertainties during drilling operations and in the event of an oil release. The vast amount of water transported throughout the GOM by the Loop Current highlights the potential for the current and its associated eddies to transport oil from a spill to the shelf and coastal areas, as well as water bodies outside of the GOM (USDOI 2007). Due to the proximity of the current to the shelf and sensitive coastal areas, there is concern regarding the rapid transport of oil in the event of a release. In many cases, the frontal boundary at the edge of the Loop Current may limit the extent of transport. In addition, highly persistent oil, especially in deepwater locations, may remain in the ocean for an indefinite period of time, increasing the potential for the Loop Current to carry oil to sensitive coastal areas (USDOI 2007).

In the Arctic Ocean, an important transport vehicle and barrier is ice. Offshore of the shore-fast zone, the motion of the ice will be expected to transport the oil that is associated with the ice. Field tests conducted by SINTEF Materials and Chemistry demonstrated that ice can help contain a spill, and act as a natural barrier to the spread of oil (Brandvik et al. 2010). Studies have shown that when ice coverage exceeds 10–20%, the higher ice coverage can trap spilled oil within newly formed ice (Sorstrom et al. 2010). Oil trapped in ice naturally prevents the spilled oil from affecting sensitive habitats and coastal areas, and prevents it from dispersing and spreading to other bodies of water. Physically removing ice that encases spilled oil is a potential solution in extreme cold temperatures. During the winter of 1998, 90% of the oil spilled in the St. Lawrence River was recovered by removing 1,369 tons of ice (recovering

10 tons of oil) (S.L. Ross Environmental 2010). Ocean currents in the Arctic are influenced by cyclonic and anticyclonic eddies pushing released oil in numerous directions.

4.3.4.3 Regional Risk Profiles

The previous discussion of risk factors has been used to develop generalized regional risk profiles for the areas under consideration for the Program. Figure 4.3.4-1 presents a conceptual framework for considering the sequence of events, circumstances, and factors that define a low-probability discharge event and contribute to the even lower potential for catastrophic consequences. The catastrophic discharge event sequence is divided into two principal phases: risk of occurrence and containment, and risk of fate and consequence. This framework conservatively assumes that a relief well is needed to kill a wild well following a loss of well control incident.

The top part of Figure 4.3.4-1 shows risk factors related to the occurrence of a well incident and the ability to contain and recover oil discharge at the well site up to the time needed to drill a relief well. The ability to mitigate these risks factors directly reduces the duration and volume of the oil spill and likelihood that the spill will be a catastrophic event. Reducing the risk of well control incidents, particularly for frontier exploration wells with the potential to release catastrophic discharge volumes, is of primary importance to avoid any risk of oil in the environment. As detailed in Section 4.3.4.3.4, BOEM implemented substantive regulatory improvements following the DWH event to identify and mitigate risk factors that contribute to well integrity and operational safety incidents.

If well barriers and intervention fails, containment and response at the well site becomes the next critical line of defense to minimize the volume of oil being released into the ocean. Mitigating the factors that constrain the ability to contain oil at the well site minimizes the degree and duration of exposure that may otherwise occur prior to a relief well being completed weeks to months later (or potentially longer in the Arctic depending on location and ice conditions). New seabed containment systems developed for the GOM have the potential to contain 60,000 bbl of oil per day. This system, if as effective as stated, could contain over 5,000,000 bbl of oil during a 90-day discharge period and significantly reduce the nature of exposure. Equivalent systems and/or capabilities are being developed to enhance containment in the Arctic. As detailed in the subsequent discussion in Section 4.3.4.3.4, BOEM has implemented substantive regulatory improvements following the DWH event to ensure industry has appropriate containment capability.

The lower part of Figure 4.3.4-1 shows factors that affect the fate and, in part, drive the consequences of oil released into and transported through the larger environment. These factors are not absolute risk factors, *per se*, because they do not operate in one direction, either increasing or decreasing risk, across all ecological and human use resources. Usually response actions taken to manage the fates or consequences of a spill involve considerations of tradeoffs among potential impacts. For example, dispersants may be applied to protect coastal habitats and resources from contact with a heavy, surface oil slick, but at the risk of exposing resources occupying the marine water column to the effects of dispersants and dispersed oil. Physical

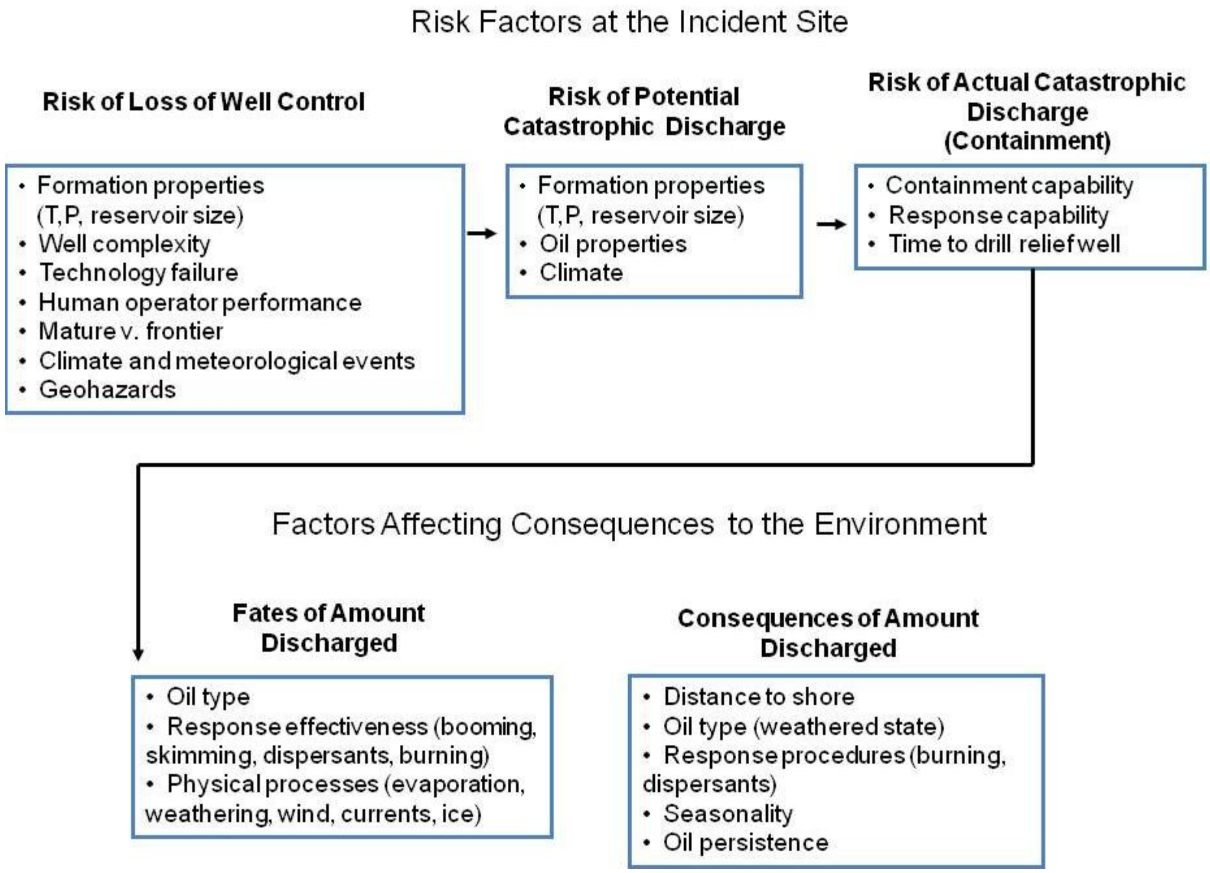

FIGURE 4.3.4-1 Factors Affecting a Catastrophic Discharge Event

processes such as the Loop Current in the GOM could transport dispersed oil across large areas within and outside the GOM, but whether or not this effect is considered a risk factor depends on whether the ecological or human use concerns focus on the effects of a widespread but dilute oil presence or on the effects of higher oil concentrations on critical resources within a more localized area. Even distance to shore does not operate unambiguously as a risk factor since drilling in deeper waters located farther offshore could increase drilling risk and potential impacts to pelagic marine resources, but at the same time reduce the risk of contact with coastal habitats and resources.

4.3.4.3.1 Catastrophic Discharge Event Scenarios. BOEM has prepared credible scenarios of catastrophic discharge for each planning area that are used in later effects analyses (Table 4.3.4-2). The scenarios do not account for potential discharge mitigating factors such as well barriers, well intervention, or effective containment and response. Instead, oil is conservatively assumed to flow from the well until the well is killed using a relief well. The volume presented is a potential volume released. When accounting for containment, subsurface and surface dispersion, evaporation, mechanical recovery, and *in situ* burning, the actual amount released is assumed to be less. The principal factors driving the potential release amount and duration are geologic, well design, and oil type properties (which determine maximum discharge

TABLE 4.3.4-2 Program Area Catastrophic Discharge Scenarios[a]

Program Area	Volume (Mbbl)	Duration (days)	Factors Affecting Duration
Gulf of Mexico	0.9–7.2	30–90	Water depth and drill depth determines timing of relief well
Arctic			
Chukchi Sea	1.4–2.2	40–75	Timing relative to ice free season and/or
Beaufort Sea	1.7–3.9	60–300	availability of rig to drill relief well
Cook Inlet	0.075–0.125	50–80	Availability of rig to drill relief well

[a] The GOM OCS region has estimated the discharge rate, volume of a spill, and the extent and duration for a catastrophic spill event for both shallow and deep water (in part) based on information gathered and estimates developed for the 1979 Ixtoc (1979) and the DWH (2010) oil spills. The Alaska OCS Region has estimated a very large oil spill scenario based on a reasonable, maximum flow rate for each OCS planning area, taking into consideration existing geologic conditions and information from well logs. The number of days until a hypothetical blowout and discharge from a well could be contained was also estimated. These are discharge volumes and do not account for decreases in volume from containment or response operations.

rate) and time frame required for drilling a relief well. The time frame required for drilling a relief well is principally governed by water and reservoir depth, timing of year, and availability of drilling rigs.

Such a scenario is a low-probability, accidental event. Bercha (2008) has reported the historical spill frequency for a spill greater than or equal to 150,000 bbl for GOM and North Sea well drilling as 3.42×10^{-4} per well. Accounting for Arctic specific variables, Bercha calculated a slightly smaller frequency of 3.94×10^{-4} per well for a spill greater than or equal to 150,000 bbl.

The principal risk factors that would affect drilling operations, containment, and response in Gulf of Mexico and Arctic program areas are summarized below. Cook Inlet is not considered further because of the relatively small size of the estimated catastrophic discharge event there compared to other program areas.

4.3.4.3.2 Gulf of Mexico Risk Profile. Drilling operations in deep water came under close scrutiny following the DWH event in April, 2010. A suspension on approving drilling plans and permits in deep water was imposed by the Secretary in July 2010. The Secretary lifted the suspension in October 2010 based on the implementation of new regulatory reforms to improve OCS drilling safety and a better understanding of the root causes of the DWH event. The safety of drilling in deepwater areas of the GOM remains an issue of concern, as witnessed by comments received during scoping. As stated earlier, water depth by itself does not impose risk; rather, it is the drilling technology and the relative inaccessibility of the well site on the seafloor that imposes risk from deepwater operations. Figure 4.3.4-2 highlights risk factors that

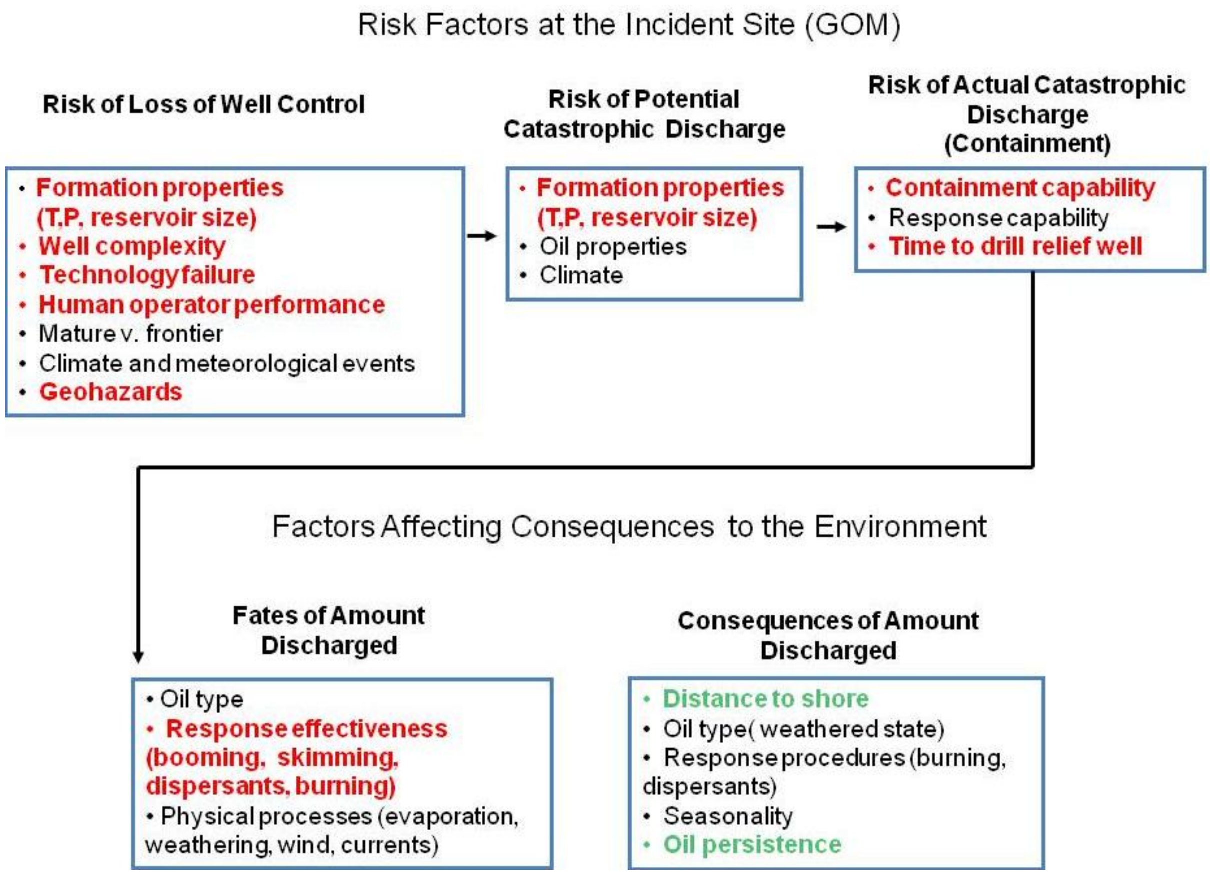

FIGURE 4.3.4-2 Principal Factors Affecting a Catastrophic Discharge Event in the Gulf of Mexico

apply to risks particular to deepwater wells (red text). The figure also highlights risk reduction factors associated with drilling in deep water compared to drilling in shallow water (green text).

Loss of Well Control.

Geologic Properties. Deepwater geologic formations tend to have higher temperatures and pressures than shallow water formations. In addition to varying oil properties, the differences in pressure regimes may contribute to relatively greater discharge rates. In addition, deepwater formations tend to hold larger volumes of hydrocarbons. The combination of the high temperature and pressure regime and comparatively large reservoir volumes create conditions that favor potentially catastrophic releases. When considering all OCS wells, the average vertical drill depth for boreholes in shallow water (less than 201 m [660 ft]) is approximately 2,864 m (9,400 ft), compared to 4,115 m (13,500 ft) in waters deeper than 201 m (660 ft). The drill depth required to reach target reservoirs requires more information about shallow and deep geologic hazards to avoid engineering and well integrity challenges. The time required to intervene using a relief well is also greater, because of the relative depth of the intervention zone. Because of the steeper gradient of the continental slope where deepwater wells are often drilled, compared to the gentler slope on the continental shelf, deepwater wells may be more subject to mass movement and other seafloor instabilities that, if unanticipated, may increase the risk of a loss of well control incident. To avoid these complications, BOEM requires well shut-in prior to the passage of hurricanes, which are the most frequent cause of large-scale seafloor movements.

Well Complexity, Technology Failure and Human Performance. More complex wells and technology are often required in deepwater drilling to address the higher pressures and temperatures and greater drilling depths that will be encountered. This places greater demands on human and technology performance, especially where hydrostatic pressures are substantial greater due to an average 762-m (2,500-ft) greater water depth. Furthermore, the inaccessibility of the seafloor to humans at deepwater well sites means that the subsea BOP systems used at deepwater drill sites are inaccessible to human maintenance, inspection, and intervention in the event they are activated as a result of a loss of well control event. Deepwater drilling sites use ROVs and other indirect methods of intervening in a loss of well control incident at the seafloor.

Containment and Response. The drilling of a relief well in deep water will likely take longer than in shallow water because of the greater water depth, greater drill depth, and more complex drilling conditions the relief well would encounter. Table 4.3.4-2 estimates that up to 90 days may be needed after the loss of well control event to drill the relief well and kill the wild well. During that time, the success of containment and response at the well site would be a critical factor governing whether sufficient oil is released into the environment to have catastrophic consequences. Containment and response is expected to be more challenging in areas with deeper water because of the greater distances from land support bases and staging areas. Progress has been made in the GOM to develop effective containment and response technology for deepwater conditions, including deep dispersant application.

Fate and Consequence. Should containment and response at the well site fail to prevent discharge of oil into the ocean environment, response and oil recovery would continue as the oil discharge spreads. Response operations could be more challenging to support in deeper water because of the greater distances from shore bases, as well as the fact that the area of surfaced oil would continue to increase as deepwater currents exported oil to the shelf.

Because deepwater wells are located at greater distances offshore than shallow wells, high concentrations of oil are less likely to contact important ecological and human use coastal resources. In addition, the risk of persistence of the oil in the environment would likely be less in deepwater events because oil released there would be less likely to contact coastal wetland and estuarine areas where it could become incorporated into wetland soils and persist for long periods of time.

Summary. The principal risk that applies to deepwater drilling in the GOM occurs as a result of drilling and containment/response risks associated with the use of drilling technologies at these depths. As described below, BOEM has been aggressively pursuing regulatory changes to address and mitigate risks associated with these deepwater drilling and containment issues. It is not necessarily true that a deepwater, large volume spill would have more environmental consequences than a smaller spill occurring in shallow water. Deepwater spills may, in part, impose less risk on highly valued coastal areas because of their distance offshore, which allows for more natural weathering and dispersion. In comparison, shallow shelf spills may more rapidly contact low-energy estuarine and wetland areas.

4.3.4.3.3 Arctic Risk Profile. An ongoing concern in the Arctic is the environmental effects of a large oil spill on sensitive marine and coastal habitats that occur there within a land-sea-ice biome that supports a traditional subsistence life style for Alaska native populations and provides important habitats for migratory and local faunal populations. The ability to respond to and contain a very large discharge event under the extreme climatic conditions and seasonal presence of ice is of particular concern. Figure 4.3.4-3 highlights factors that apply to risks particular to operations in the Arctic related to extreme cold and the presence of ice.

Loss of Well Control. While some formation properties of the Arctic OCS are expected to have pressures, temperatures, and volumes sufficient to produce a discharge that could result in catastrophic consequences (Table 4.3.4-2), drilling risks associated with these formation characteristics are not directly related to issues of extreme cold and presence of ice. Instead, the fact that the Arctic OCS is largely a frontier geologic province contributes risk to Arctic drilling operations (USGS 2011).

Human error while working under extreme weather conditions on the Arctic OCS could increase the risk of loss of well control in certain circumstances where established procedures are not followed. However, when accounting for other Arctic specific variables, the incident rate of loss of well control is expected to be lower than for exploration and development operations in the GOM (Bercha et al. 2008).

To address some of the risk inherent in Arctic operations, the BOEM regulations include specific requirements for conducting operations in the Arctic, such as locating the BOP in a well cellar (a hole constructed in the sea bed) to position the top of the BOP below the maximum potential ice gouge depth, using special cements in areas where permafrost is present, enclosing or protecting equipment to assure it will function under subfreezing conditions, and developing critical operations and curtailment procedures which detail the criteria and process through which the drilling program would be stopped, the well shut in and secured and the drilling unit moved off location before environmental conditions (such as ice) exceed the operating limits of the drilling vessel.

Containment and Response. Much of risk from a catastrophic event that is particular to the extreme climate of the Arctic is associated with containment and response issues at the well site. The time needed to drill a relief well varies from 40 to 300 days depending on the timing of the event relative to the ice free season, since the well site may become inaccessible when solid or broken ice is present. During that time, the ability to mount effective containment and response efforts under broken or solid ice conditions is a critical factor.

Fate and Consequence. Response away from the well site could also be hindered and/or aided by broken and solid ice. In addition, some options available to manage fates of spills have not been previously used in larger-scale operations the Arctic to fully evaluate their

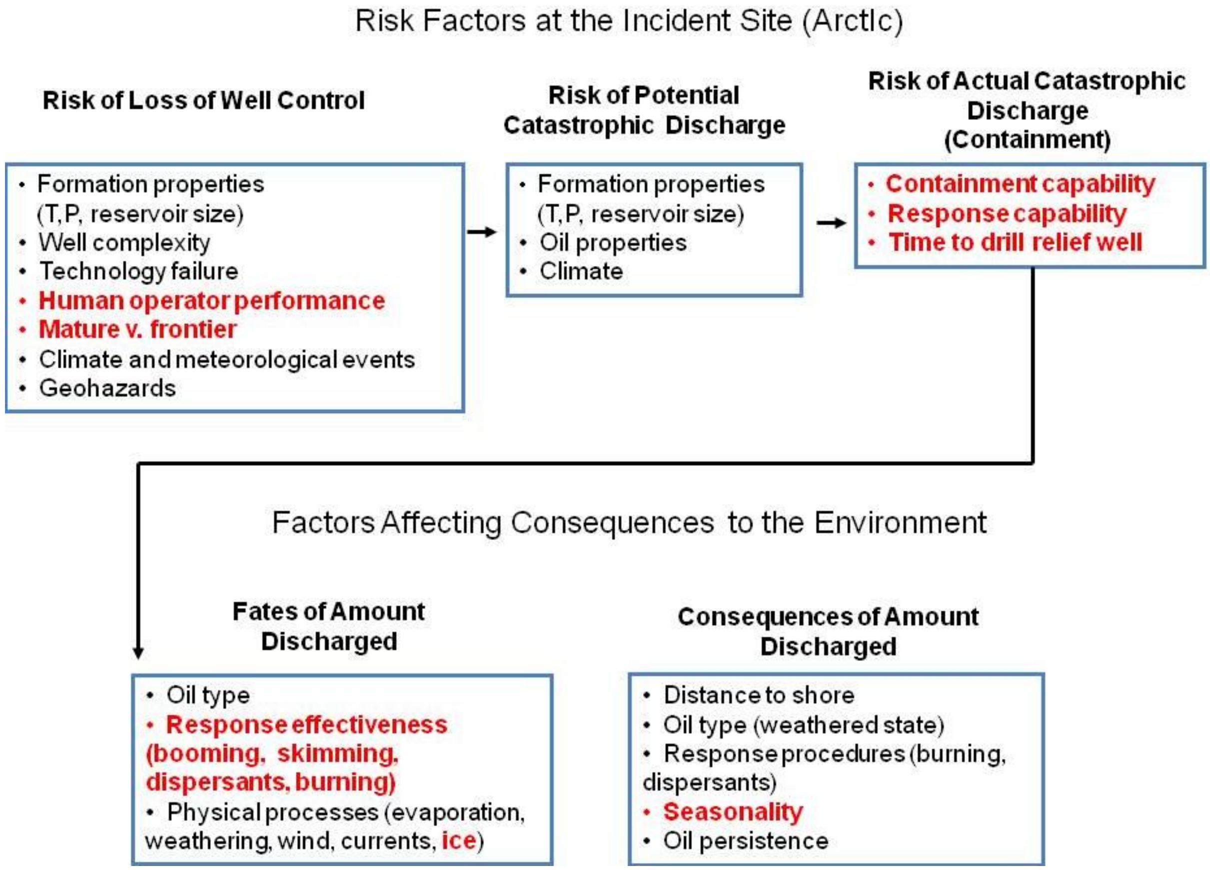

FIGURE 4.3.4-3 Principal Factors Affecting a Catastrophic Discharge Event in the Arctic

effectiveness, such as burning and dispersant use, although state-of-the art research on these response techniques suggest they could decrease the volume of oil in the water (SINTEF 2010).

4.3.4.3.4 Recent Regulatory Reforms Implemented to Reduce Risk. In the event of a spill, there is no single method of containment and response that would be 100% effective. While recent enhancements in intervention, containment, and response should reduce spill volume and mitigate certain environmental effects, the principal corrective action is still a relief well, and drilling a relief well to kill a wild well takes time. This highlights the fundamental importance of prevention. In response to the DWH event and in recognition that advances in prevention were critical, BOEM overhauled the offshore regulatory process reforming, through both prescriptive and performance-based regulation and guidance, as well as OCS safety and environmental protection requirements. The reforms strengthen the requirements for all aspects of OCS operations from well design to workplace safety to corporate accountability. The other logical capability needing improvement is spill response. New measures and reforms adopted by BOEM to strengthen safety, spill prevention, and spill response include the following:

- Drilling Safety Rule, Interim Final Rule to Enhance Safety Measures for Energy Development on the Outer Continental Shelf (Drilling Safety Rule);

- Workplace Safety Rule, Safety and Environmental Management Systems (SEMS Rule):

- NTL 2010-N06, Information Requirements for Exploration Plans, Development and Operations Coordination Documents on the OCS (Plans NTL);

- NTL 2010-N10, Statement of Compliance with Applicable Regulations and Evaluation of Information Demonstrating Adequate Spill Response and Well Containment Resources (Certification NTL); and

- Enhanced inspection and enforcement procedures, including strengthened training program.

Drilling Safety Rule. The prescriptive Drilling Safety Rule addresses well bore integrity and well control equipment and procedures. The rule effectively implements many of the recommendations made in the May 27, 2010, USDOI report Increased Safety Measures for Energy Development on the Outer Continental Shelf (USDOI 2010). BOEMRE amended drilling regulations related to subsea and surface blowout preventers, well casing and cementing, secondary intervention, unplanned disconnects, recordkeeping, well completion, and well plugging.

Well integrity provides the first line of defense against a blowout by preventing a loss of well control. It includes the appropriate use of drilling fluids and the well bore casing and cementing program. These are used to balance pressure in the borehole against the fluid pressure of the formation, preventing an uncontrolled influx of fluid into the wellbore. Provisions in the rule addressing well bore integrity include the following:

- Making mandatory American Petroleum Institute’s (API) standard, RP 65 – Part 2, Isolating Potential Flow Zones During Well Construction (an industry standard program);

- Requiring submittal of certification by a professional engineer that the casing and cementing program is appropriate for the purposes for which it is intended under expected wellbore pressure;

- Requiring two independent test barriers across each flow path during well completion activities (certified by a professional engineer);

- Ensuring proper installation, sealing, and locking of the casing or liner;

- Requiring BOEM approval before replacing a heavier drilling fluid with a lighter fluid; and

- Requiring enhanced deepwater well control training for rig personnel.

Well control equipment is used to bring a well back under control in the event of a loss of well control. Well control equipment includes the BOP and control systems that activate the BOP, either through a control panel on the drilling rig or through ROVs that directly interface with the BOP to activate appropriate rams. Provisions in the rule that focus on the enhancement of well control equipment include the following:

- Submittal of documentation and schematics for all control systems;

- Requirements for independent third party verification that the blind-shear rams are capable of cutting any drill pipe in the hole under maximum anticipated surface pressure;

- Requirement for a subsea BOP stack equipped with ROV intervention capability (at a minimum the ROV must be capable of closing one set of pipe rams, closing one set of blind-shear rams, and unlatching the lower marine riser package);

- Requirement for maintaining a ROV and having a trained ROV crew on each floating drilling rig on a continuous basis;

- Requirement for auto shear and deadman systems for dynamically positioned rigs;

- Establishment of minimum requirements for personnel authorized to operate critical BOP equipment;

- Requirement for documentation of subsea BOP inspections and maintenance according to API RP 53, *Recommended Practices for Blowout Prevention Equipment Systems for Drilling Wells*;

- Require testing of all ROV intervention functions on subsea BOP stack during stump test and testing at least one set of rams in initial seafloor test;

- Require function testing auto shear and deadman systems on the subsea BOP stack during the stump test and testing the deadman system during the initial test on the seafloor; and

- Require pressure testing if any shear rams are used in an emergency.

A section-by-section summary of major regulatory changes is provided below.

Subsea ROV and Deadman Function Testing — Drilling. Previous regulations at 30 CFR 250.449(b) required a stump test of the subsea BOP system. In a stump test, the subsea BOP system is placed on a simulated wellhead (the stump) on the rig floor. The BOP system is tested on the stump to ensure that the BOP is functioning properly. The new regulatory section at 30 CFR 250.449(j) requires that all ROV intervention functions on the subsea BOP stack must be tested during the stump test and one set of rams must be tested by an ROV on the seafloor. Autoshear and deadman control systems activate during an accidental disconnect or loss of power, respectively. The new regulatory section at 30 CFR 250.449(k) requires that the autoshear and deadman systems be function-tested during the stump test, and the deadman system tested during the initial test on the seafloor. The initial test on the seafloor is performed as soon as the BOP is attached to the subsea wellhead. These new requirements will confirm that a well will be secured in an emergency situation and prevent a possible loss of well control. The ROV test requirement will ensure that the dedicated ROV has the capacity to close the BOP functions on the seafloor. The deadman-switch test on the seafloor verifies that the wellbore closes automatically if both hydraulic pressure and electrical communication are lost with the drilling rig. These regulatory changes will not affect shallow wells or facilities since they do not use subsea BOPs or ROVs.

Subsea ROV and Deadman Function Testing—Workover/Completions. Previous regulations did not require subsea ROV function testing of the BOP during workover or well completion operations. The new regulatory sections 30 CFR 250.516(d)(8) and 250.616(h)(1) extend the requirements added to deepwater drilling operations (discussed in the previous section) to well completion operations and workover operations using a subsea BOP stack.

Negative Pressure Tests. Previous regulation at 30 CFR 250.423 required a positive pressure test for each string of casing, except for the drive or structural casing string. This test confirms that fluid from the casing string is not flowing into the formation. The new regulatory section at 30 CFR 250.423(c) requires that a negative pressure test be conducted for all intermediate and production casing strings. This test will reveal whether gas or fluid from outside the casing is flowing into the well and ensures that the casing and cement provide an effective seal. Maintenance of pressure under both tests ensures proper casing installation and the integrity of the casing and cement.

Installation of Dual Mechanical Barriers. Previous regulations did not require the installation of dual mechanical barriers. The new regulatory section at 30 CFR 250.420(b)(3) requires the operator install dual mechanical barriers in addition to cement barriers for the final casing string. These barriers prevent hydrocarbon flow in the event of cement failure at the bottom of the well. The operator must document the installation of the dual mechanical barriers and submit this documentation to BOEM within 30 days after installation. These new requirements will ensure that the best casing and cementing design will be used for a specific well.

Professional Engineer Certification for Well Design. Previous regulations at 30 CFR 250.420(a) specified well casing and cementing requirements, but did not require verification by a registered professional engineer. The new regulatory section at 30 CFR 250.420(a)(6) requires that well casing and cementing specifications must be certified by a registered professional engineer. The registered professional engineer will verify that the well casing and cementing design is appropriate for the purpose for which it is intended under expected wellbore conditions.

Emergency Cost of Activated Shear Rams. Previous regulations did not address BOP inspection following use of the blind-shear ram or casing shear ram. The new regulatory section at 30 CFR 250.451(i) requires that, if a blind-shear ram or casing shear ram is activated in a well control situation where the pipe is sheared, the BOP stack must be retrieved, fully inspected, and tested. This provision will ensure the integrity of the BOP and that the BOP will still function and hold pressure after the event.

Third Party Shearing Verification. Regulation 30 CFR 250.416(e) requires information verifying that BOP blind-shear rams are capable of cutting through any drill pipe in the hole under maximum anticipated conditions. This regulation has been modified to require the BOP verification be conducted by an independent third party. The independent third party provides an objective assessment that the blind-shear rams can shear any drill pipe in the hole if the shear rams are functioning properly.

Workplace Safety Rule. The BOEMRE promulgated the performance-based SEMS rule on October 15, 2010, requiring full implementation for all OCS facilities and operators no later than November 15, 2011. The SEMS Rule establishes a holistic, performance-based management tool in which offshore operators are required to establish and implement programs and systems to identify potential safety and environmental hazards when they drill, clear protocols for addressing those hazards, and strong procedures and risk-reduction strategies for all phases of activity, from well design and construction to operation, maintenance, and decommissioning. It also requires operators to have a comprehensive safety and environmental impact program designed to reduce human and organizational errors. SEMS applies to all OCS oil and gas operations and facilities under BOEM and BSEE jurisdiction including drilling, production, construction, well workover, well completion, well servicing, and DOI pipeline activities. SEMS also applies to all OCS oil and gas operations on new and existing facilities under BOEM and BSEE jurisdiction including design, construction, start-up, operation, inspection, and maintenance. The performance-based SEMS rule helps to define clear roles and responsibilities, in which BOEM define the performance goals while the operator is responsible to ensure that these goals are met. Operators do not rely on the authorities to ensure safety. Empowering industry to develop the framework specific to improve safety and environmental performance of facilities and operations and holding them responsible to that greater standard should eliminate the most frequent causes of historic incidents that have occurred during OCS activities. Training and auditing are an integral part of the SEMS rule to ensure contractors and subcontractors have robust policies and procedures in place.

The SEMS Rule is based on API RP 75, which was previously a voluntary program to identify, address, and manage safety hazards and environmental impacts in oil and gas operations. The 13 elements of API RP 75 that 30 CFR 250 Subpart S now make mandatory include:

- Defining the general provisions for implementation, planning and management review, and approval of the SEMS program;

- Identifying safety and environmental information needed for any facility such as design data, facility process such as flow diagrams, and mechanical components such as piping and instrument diagrams;

- Requiring a facility-level hazard risk assessment;

- Addressing any facility or operational changes including management changes, shift changes, contractor changes;

- Evaluating operations and written procedures;

- Specifying safe work practices, manuals, standards, and rules of conduct;

- Training, safe work practices, and technical training, including contractors;

- Defining preventive maintenance programs and quality control requirements

- Requiring a pre-startup review of all systems;

- Responding to and controlling emergencies, evacuation planning, and oil-spill

- Contingency plans in place and validated by drills;

- Investigating incidents, procedures, corrective action, and follow-up;

- Requiring audits every 4 yr, to an initial 2-yr reevaluation and then subsequent 3-yr audit intervals; and

- Specifying records and documentation that describes all elements of the SEMS program.

Implementation of SEMS requires periodic lessee or independent third party comprehensive audits of the 13 elements defined in API RP 75 and included above. BSEE may participate in lessee or independent third party audits and may also conduct independent audits. BSEE-conducted audits may be announced or unannounced. Any deficiencies found in SEMS audits must be addressed in a corrective action plan (CAP) and must be submitted to BSEE within 30 days of submittal of the audit report. If BSEE determines that an operator's SEMS program is not in compliance, BSEE may issue an incidence of non-compliance (INC), assess civil penalties, or initiate probationary or disqualification procedures from serving as an OCS operator. The required SEMS plan and audits are designed to improve, enhance, communicate and document the identification and mitigation of safety and environmental hazards for offshore facilities and activities resulting in safer and environmentally sound working conditions through teamwork, training and communication among all parties for all activities on the OCS.

One of the most important elements that fosters improved industry-wide risk management is the facility-level hazard analysis. The purpose of the analysis is to identify, evaluate, and reduce the likelihood and/or minimize the consequences of uncontrolled releases of oil and gas and other safety or environmental incidents. API RP 14 C, *Recommended Practice for Analysis, Design, Installation, and Testing of Basic Surface Safety Systems for Offshore Production Platforms* and API RP 14J, *Recommended Practice for Design and Hazards Analysis* *for Offshore Production Facilities*, identify accepted practices. In addition, this element requires a job hazard analysis (operations/task level) be performed to identify and evaluate hazards of a job/task for the purpose of hazards control or elimination.

Information Requirements for Exploration Plans, Development and Production Plans, and Development Operations Coordination Documents on the OCS (Plans NTL). The Plans NTL, effective June 18, 2010, set new standards regarding the content of information needed in exploration and development plan submittals to describe a blowout and worse-case discharge scenario. This NTL explains the procedures for the lessee or operator to submit supplemental information for new or previously submitted Exploration Plans (EP) or Development and Production Plans (DPP). The required supplemental information includes the following: (1) a description of the blowout scenario as required by 30 CFR 250.213(g) and 250.243(h); (2) a description of their assumptions and calculations used in determining the volume of the worst-case discharge required by 30 CFR 250.219(a)(2)(iv) or 30 CFR 250.250(a)(2)(iv) and (3) a description of the measures proposed that would enhance the ability to prevent a blowout, to reduce the likelihood of a blowout, and to conduct effective and early intervention in the event of a blowout, including the arrangements for drilling relief wells and any other measures proposed. The early intervention methods of the third requirement could include the surface and subsea containment resources that BOEMRE announced in NTL2010-N10 (Certification NTL).

Statement of Compliance with Applicable Regulations and Evaluation of Information Demonstrating Adequate Spill Response and Well Containment Resources (Certification NTL). The Certification NTL, effective on November 8, 2010, requires lessees and operators using subsea or surface BOPs on floating facilities (i.e., deepwater) to provide a statement verifying compliance with new well containment and oil spill response requirements prior to being granted a Permit to Drill/Modify (APD/APM). Specifically, the statement, signed by an authorized company official, indicates that authorized activities will be in compliance with all applicable regulations, including the requirements of the Drilling Safety Rule.

The NTL also informs lessees that BOEM will be evaluating whether or not each operator has submitted adequate information demonstrating that it has access to and can deploy surface and subsea containment resources to promptly respond to a blowout or other loss of well control. Although the NTL does not provide that operators submit revised OSRPs that include this containment information at this time, operators were notified of BOEM's intention to evaluate the adequacy of each operator to comply in the operator's current OSRP; therefore, there is an incentive for voluntary compliance.

The benefits of the new requirements include the following:

- Improving the response time for offshore vessels to remove damaged equipment and install a capping stack;

- Reducing the amount of time a well flows into the sea compared with previous well blowouts;

- Providing more robust well designs relative to expected pressures and fluids in the well to fully contain the well after installation of the capping stack;

- Determining the well's potential to broach to the seafloor if the well design fails under the shut-in pressure with installed capping stack, and

- Determining the surface vessels configuration and containment capacities if the well has to flow to the surface for processing and capture.

In the event of a well blowout, OCS operators must demonstrate the capability to remove damaged well equipment and install a capping stack (with a pressure rating higher than the calculated mud line shut-in pressure) to stop the uncontrolled flow of oil from the well. If the well design fails under the shut-in pressure, the operator must demonstrate the capability to flow and process the oil and gas from the well into surface containment vessels. Although not explicitly stated in the Certification NTL notice, BOEM requires operators to demonstrate that the well design is adequate to contain an uncontrolled flow. BOEM uses a Level 1 Well Containment Screening Tool (WCST) for all initial reviews prior to APD approval. The Level 1 WCST is useful for wells that can be fully shut-in without causing underground flow, using very conservative assumptions and simple calculations (no requirement for computer simulations). However, not all wells can pass a Level 1 screening successfully due to high pressure and/or light formation fluids expected in the well. The Level 2 WCST Analysis uses field/offset data and more advanced calculations to demonstrate equipment and well integrity. The Level 2 WCST Analysis also identifies failure points and possible loss zones which must be addressed in a consequence analysis. The WCST developed by BOEM and offshore operators working together on the design of the containment approval process under oil spill response has resulted in more robust well designs that reduce the risk of prolonged well flow into the sea and increase the chance of successfully capping and stopping the flow of oil in less than 15 to 30 days.

On December 13, 2010, BOEMRE issued additional guidance to encourage operators to voluntarily include additional subsea containment information in their OSRPs. The guidance indicates that BOEM will review OSRPs, in support of plan submittals, for the following specific information relating to subsea containment (in addition to that listed in the Certification NTL):

- Source abatement through direct intervention;

- Relief wells;

- Debris removal; and

- If a capping stack is the single containment option offered, the operator must provide

- the reasons that the well design is sufficient to allow shut-in without broach to the

- seafloor.

Enhanced Inspection and Enforcement Procedures, Including Strengthened Training Program. As of October 1, 2011 the new BSEE is responsible for enforcement of safety and environmental regulations. BSEE undertakes both annual scheduled inspections and periodic unscheduled (unannounced) inspections of oil and gas operations on the OCS. The inspections are to assure compliance with all regulatory constraints that allowed commencement of the operation. The annual inspection examines all safety equipment designed to prevent blowouts, fires, spills, or other major accidents. These annual inspections involve the inspection for installation and performance of all facilities' safety-system components. The primary objective of an initial inspection is to assure proper installation and functionality of their safety and pollution prevention equipment. After operations begin, additional announced and unannounced inspections are conducted. Unannounced inspections are conducted to foster a climate of safe operations, to maintain a BSEE presence, and to focus on operators with a poor performance record. These inspections are also conducted after a critical safety feature has previously been found defective. Poor performance generally means that more frequent, unannounced inspections may be conducted on a violator's operation. The inspectors follow the guidelines as established by the regulations, API RP 14C, and the specific BOEM-approved plan. The BSEE inspectors perform these inspections using a national checklist called the PINC list. This list is a compilation of yes/no questions derived from all regulated safety and environmental requirements.

BSEE administers an active civil penalties program (30 CFR 250 Subpart N). A civil penalty in the form of substantial monetary fines may be issued against any operator that commits a violation that may constitute a threat of serious, irreparable, or immediate harm or damage to life, property, or the environment. BSEE may make recommendations for criminal penalties if a willful violation occurs. In addition, the regulation at 30 CFR 250.173(a) authorizes suspension of any operation if the lessee has failed to comply with a provision of any applicable law, regulation, or order or provision of a lease or permit. Furthermore, the Secretary may invoke his authority under 30 CFR 250.185(c) to cancel a nonproductive lease with no compensation. Exploration and development activities may be canceled under 30 CFR 250.182 and 250.183.

Predecessor bureaus to BSEE established a robust training program for inspectors to ensure that personnel involved in installing, inspecting, testing, and maintaining safety devices are qualified. As a preventive measure, all offshore personnel must be trained to operate oil-spill cleanup equipment, or the lessee must retain a trained contractor(s) to operate the equipment for them. BSEE offers numerous technical seminars to ensure that personnel are capable of performing their duties and are incorporating the most up-to-date safety procedures and technology in the petroleum industry. In 1994, the Office of Safety Management created this Agency's Offshore Training Institute to develop and implement an inspector training program. The Institute introduced state-of-the-art multimedia training to the inspector work force and has produced a series of interactive computer training modules. As of June 2011, BOEMRE established the National Offshore Training Center, thereby developing the agency's first formal training curriculum, which has been piloted with new inspectors. Twenty-four additional courses will be developed covering specific areas of offshore inspections.

Following the DWH oil spill, BSEE now requires multiple-person inspection teams for offshore oil and gas inspections. This internal process will improve oversight and help ensure that offshore operations proceed safely and responsibly. The new process will allow teams to inspect multiple operations simultaneously and thoroughly, and enhance the quality of inspections on larger facilities. In addition, BSEE engineers and inspectors now fly offshore to witness required testing of all ROV intervention functions on the subsea BOP stack during the stump test (on the rig floor at surface) and testing at least one set of rams during the initial test on the seafloor, and required function testing of autoshear and deadman systems on the subsea BOP stack during the stump test and testing the deadman system during the initial test on the seafloor. These reviews and inspections of the BOP systems and maintenance provide additional oversight by BSEE to reduce the risk of an uncontrolled blowout by ensuring that BOP systems are maintained and functional in the event of a well control event.

Relevance to Risk Reduction in Drilling Operations (including deep water). In the aftermath of the DWH Event, President Obama directed the Secretary of the Interior to identify new precautions, technologies, and procedures needed to improve the safety of oil and gas development on the OCS. At the same time, the Secretary directed BOEMRE to exercise its authority under the OCSLA to suspend certain drilling activities so that the bureau could (1) ensure that drilling operations similar to those that lead to the DWH oil spill could operate in a safe manner when drilling resumed, (2) ensure extensive spill response resources directed toward the spill would be available for other spill events, and (3) provide adequate time to obtain input enhance intervention and containment capability and promulgate regulations that address issues described in the Safety Measures Report (USDOI 2010).

BOEMRE collected a large amount of information through public hearings and other meetings held specifically on the DWH oil spill and through public comments on rulemaking efforts. The information collection, review, and analysis efforts resulted in new regulations, planned Notices to Lessees and Operators (NTLs), and BOEM/BSEE procedures that address drilling safety, oil-spill response, and enhanced inspection procedures. New exploration plans, applications for permits to drill, and OSRP plans are be subject to higher engineering and environmental review standards. In addition, the oil and gas industry has cooperatively formed Joint Industry Task Forces in subsea well control and containment and oil spill preparedness and response. While Joint Industry Task Force recommendations will not have the force of regulation, the recommendations may provide the basis for enhanced industry standards or future rulemaking processes. Similarly, the Secretary of the Interior established the Ocean Energy Safety Advisory Committee to facilitate the development of new regulations, collaborative research and development, advanced training, and implementation of best practices in drilling safety, well intervention and containment, and oil spill response.

The DWH event demonstrated that advances in drilling, safety, and spill response did not keep pace with increasingly complex operations, and evidenced the need to strengthen oversight of offshore drilling operations by raising the standards for drilling and workplace safety, spill containment, and spill response. The measures described above create a more robust regulatory system that strikes the right balance to ensure that energy development is conducted safely and in an environmentally responsible manner, while also being more efficient, transparent and responsive.

4.4 ENVIRONMENTAL IMPACTS OF ALTERNATIVE 1 – PROPOSED ACTION

4.4.1 Exploration and Development Scenario

4.4.1.1 Gulf of Mexico

Oil and gas leasing and development have been occurring in the GOM for over 50 years. There are a total of 29,097 lease blocks (each approximately 23 km^2 [3 mi × 3 mi]) and a total of 3,280 active platforms in the Western, Central, and Eastern GOM OCS Planning Areas. Predictable patterns of activity have become established for the planning areas, and these were used to estimate future activity within the GOM OCS Region Planning Areas that could occur under this scenario (Table 4.4.1-1). This scenario of future development and activity was generated using best professional judgment for the purpose of analysis only and does not constitute official forecasts or policy recommendations.

The scenario information in Table 4.4.1-1 is initially assumed to have the potential to occur anywhere within the areas of the GOM Planning Areas included in the proposed action (Figure 4.4.1-1).

In the analysis of potential environmental impacts associated with the leasing program, additional assumptions are used to identify potential oil and gas development activity levels to more specific marine and coastal areas under consideration in a particular analysis. The GOM OCS may be divided into continental shelf and slope regions, and this distinction is important to both the occurrence of oil and gas within the GOM hydrocarbon basin and to ecosystem characteristics and processes within the GOM Large Marine Ecosystem. Assumed levels of oil and gas infrastructure and production that would occur on the continental slope and shelf are shown in Table 4.4.1-2. This information suggests that while the amounts of well drilling and gas production will be approximately the same on the shelf as on slope (51% versus 49%, respectively), most new platforms will be installed in shallow water (in depths <200 m [<660 ft]) on the continental shelf. In contrast, most oil production (93%) will occur in deeper water (at depths >200 m [>660 ft]) on the continental slope.

This assumed difference by depth of infrastructure development and oil and gas production suggests similar differences in the resources that could be affected by normal exploration and development (E&D) activities on the OCS. For example, 87% of all new platform development is assumed to occur in waters of the inner continental shelf at depths of 60 m (about 200 ft) or less (Table 4.4.1-2). Thus, resources occurring in these shallower areas may be expected to be more likely to encounter, and be affected by, normal well development and operation than would resources restricted to deeper areas of the OCS.

TABLE 4.4.1-1 Proposed Action (Alternative 1) – Exploration and Development Scenario for the GOM

Scenario Element	Gulf of Mexico
Number of sales	12
Years of activity	40–50
Potentially available oil (Bbbl)[a]	2.7–5.4
Potentially available natural gas (tcf)	12–24
Platforms	200–450
FPSOs[b]	0–2
No. of exploration and delineation wells	1,000–2,100
No. of development and production wells	1,300–2,600
Miles of new pipeline	2,400–7,500
Vessel trips/week	300–600
Helicopter trips/week	2,000–5,500
New pipeline landfalls	0–<12
New pipe yards	4–6
New natural gas processing facilities	0–12
Platforms removed with explosives	150–275
Drill Muds/Well (tons)	
Exploration and delineation wells	1,000
Development and production wells	1,000
Drill Cuttings/Well (tons)	
Exploration and delineation wells	1,200
Development and production wells	1,200
Produced Water/Well/yr (tbbl)[c]	
Oil well	130 (highly variable)
Natural gas well	35 (highly variable)
Bottom Area Disturbed (ha)[d]	
Platforms	150–2,500
Pipeline	2,000–11,500

[a] Bbbl = billion barrels.

[b] Floating production, storage, and offloading systems.

[c] Based on 1.04 bbl produced water/bbl of oil, and 86 bbl produced water/1 million cf gas (Clark and Veil 2009); tbbl = thousand barrels.

[d] Assumes 0.67 ha (1.6 ac) per platform and 0.8–1.6 ha (2.0–4.0 ac) per mile of pipeline.

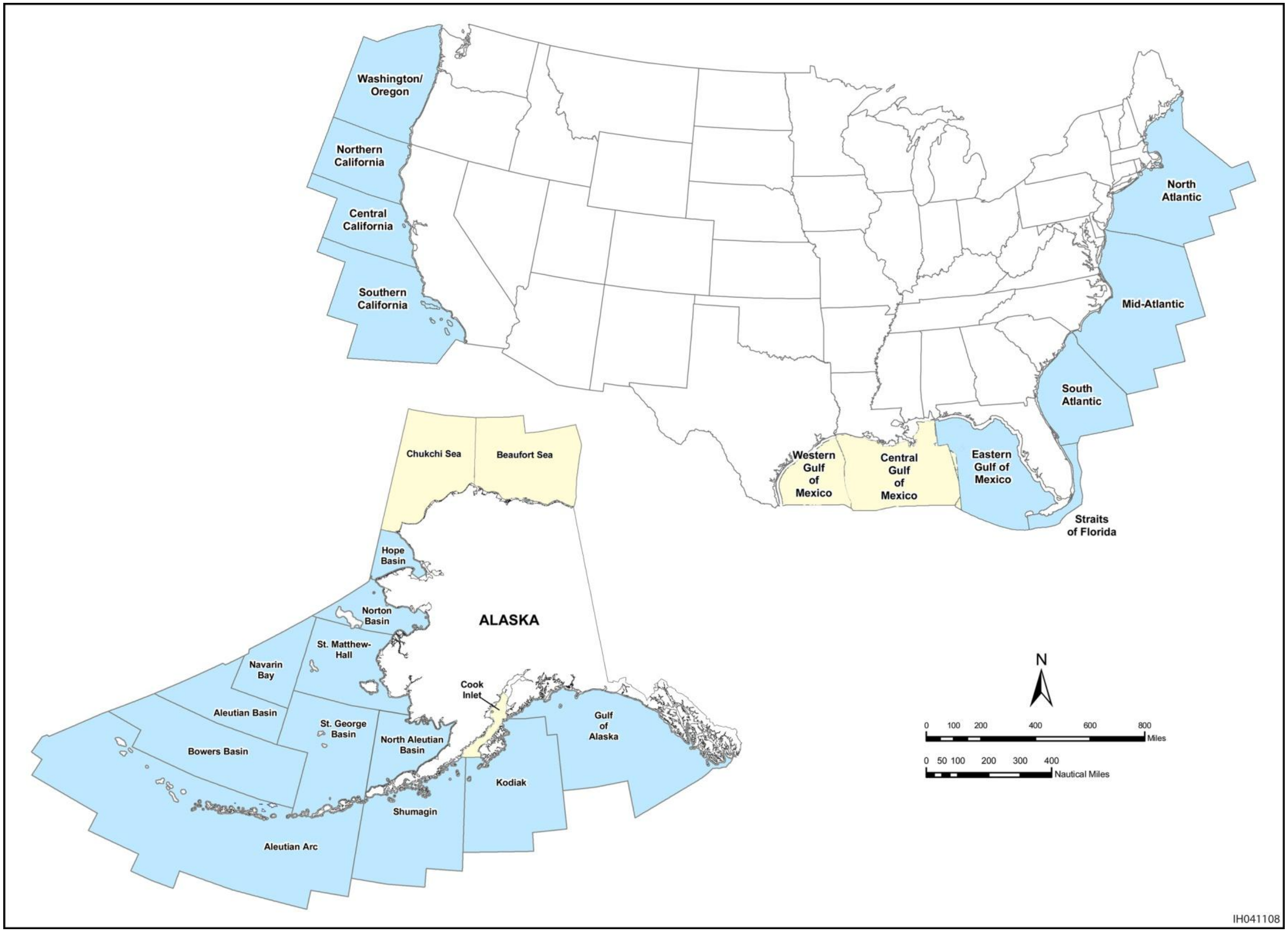

FIGURE 4.4.1-1 OCS Planning Areas Where Leasing for Oil and Gas Development May Occur under the 2012-2017 OCS Leasing Program

TABLE 4.4.1-2 Depth Distribution of New Infrastructure and Expected Natural Gas and Oil Production on the GOM OCS

			% of New Wells		% of New Platforms		% of New Gas Production		% of New Oil Production	
OCS Depth Zone (m)	OCS Area	OCS Sub-area	OCS Area	OCS Sub-area	OCS Area	OCS Sub-area	OCS Area	OCS Sub-area	OCS Area	OCS Sub-area
0–60	Shelf	Inner	52	37	95	87	51	37	7	5
60–200		Outer		15		8		14		2
200–800	Slope	Upper	48	12	5	2	49	7	93	12
800–1,600		Mid		20		2		22		44
1,600–2,400				-[a]		-		-		-
>2,400		Lower		16		1		20		37

[a] No wells, platforms, or production are expected for this depth range.

4.4.1.2 Alaska – Cook Inlet

The Cook Inlet has had oil and gas operations in State waters since the late 1950s and currently possesses a well-established oil and gas infrastructure. There has been no oil and gas activity in the Cook Inlet Planning Area. A single sale in Cook Inlet is included in the proposed action as a special interest sale, meaning that the planning process for the sale will not start until industry expresses an interest in holding the sale. The most recent OCS lease sale in Cook Inlet was in 2004 when no leases were purchased. The most recent sale in which OCS leases were purchased occurred in 1997 when two leases were purchased.

Table 4.4.1-3 summarizes the assumed levels of exploration and development that could occur under the proposed action (Alternative 1). Oil and gas development that could occur in the Cook Inlet OCS Planning Area under the proposed action is expected to use both new and existing infrastructure. Exploration drilling would employ fixed rigs (such as jack-up and mobile gravity-base rigs) in water depths up to 150 ft (46 m) and floating rigs (semisubmersible rigs, drill ships, or barges) in deeper water areas. Production wells will most likely use fixed platforms with subsea well tie-backs to supplement on-platform wells. New subsea pipelines would connect offshore installations to existing onshore facilities. Oil and gas would be carried by new onshore pipelines over relatively short distances to existing oil refineries in Nikishi and natural gas transmission facilities in the Kenai area, respectively.

TABLE 4.4.1-3 Proposed Action (Alternative 1) – Exploration and Development Scenario for Cook Inlet

Scenario Element	Cook Inlet
Number of sales	1
Years of activity	40
Oil production (Bbbl)[a]	0.1–0.2
Natural gas production (tcf)[a]	0–0.7
Platforms	1–3
No. of exploration and delineation wells	4–12
No. of development and production wells	42–114
Miles of new offshore pipeline	25–150
Miles of new onshore pipeline[b]	50–105
Vessel trips/week	1–3
Helicopter trips/week	1–3
New pipeline landfalls	0–1
New shore bases	0
New processing facilities	0
New waste disposal facilities	0
Platforms removed with explosives	0
Drill Fluids/Well (bbl)	
Exploration and delineation wells	500 – discharged at well site.
Development and production wells	All treated and disposed of in the well.
Drill Cuttings (dry rock)/Well (tons)	
Exploration and delineation wells	600 – discharged at well site.
Development and production wells	All treated and disposed in the well.
Bottom Area Disturbed (ha)	
Platforms (1.5 ha/platform)	1.5–4.5
Pipeline (1.4 ha/mile)	35–210

[a] Bbbl = billion barrels; tcf = trillion cubic feet.

[b] New onshore pipelines would deliver oil to existing refineries in Nikiski and natural gas to transmission facilities in the Kenai area.

4.4.1.3 Alaska – Arctic

In contrast to oil and gas development in the GOM OCS, and with the exception of a single production site (Northstar) that has an actual surface location in Alaskan State waters, there has been no development activity from a structure in Arctic OCS areas. Since 1979, ten lease sales have been held in the Beaufort Sea Planning Area and three in the Chukchi Sea Planning Area (http://www.alaska.boemre.gov/lease/hlease/LeasingTables/lease_sales.pdf). The 2008 Lease Sale 193 for the Chukchi Sea Planning Area (MMS 2007a) is of note because of the high industry interest expressed through the acquisition of 487 leases and the more than $2.7 billion received by the government in high bids. No activity has resulted from this lease sale because of litigation that remains unresolved at the time this draft PEIS is being written. The scenario put forth for the Arctic in the 2012–2017 program in Table 4.4.1-4, however, assumes that the exploration and development activities anticipated as a result of Sale 193 will have occurred prior to the beginning of the development and production activities listed in the table. In particular, the scenario was developed using the assumptions that the discovery and development of a 1-Bbbl oil field has already occurred, a pipeline has been installed from the OCS production area in the Chukchi Sea to Point Belcher near Wainwright, Alaska, and support base facilities have been constructed there as well. As a result of these assumptions, the scenario in Table 4.4.1-4 includes no new pipeline landfalls or support bases, since these would have already been constructed as a result of Sale 193 (BOEMRE 2011n). Also, oil discoveries less than 1 Bbbl were assumed not to be economically feasible in the Program, because an initial larger field needed to justify the construction of a pipeline to shore and coastal service facilities. It is assumed that development as a result of lease sales under the Proposed Action Alternative would utilize existing infrastructure, and that fields smaller than 1.0 Bbbl could be produced.

The draft PEIS assumes that the most likely locations for oil and gas activities in the Arctic OCS will be in the areas that have been already leased in recent sales. While activities within the entire Chukchi and Beaufort Sea Planning Areas will be considered in the analyses that follow, the analyses assume that the most likely locations for exploration and development activities will occur in the areas shown in Figure 4.4.1-2. It is assumed that these areas reflect industry's current assessment of the best hydrocarbon prospects through its large investments in acquiring the leases. It is reasonable to assume that industry will explore and develop these areas before moving into other areas currently considered less promising.

In the Beaufort Sea Planning Area, exploration is assumed to use artificial gravel islands or extended-reach drilling in shallow waters (<6 m [20 ft]), mobile platforms in mid-depths (6–18 m [20–60 ft]), and drill ships in deeper areas of the shelf. Because of severe winter ice pack conditions, it is assumed that development would be limited to the shelf and to depths less than 91 m (300 ft) and platform installation would occur only in the summer (open water) season. Production operations will use gravity-base platforms or gravel islands in shallow water (<12 m [40 ft]) and larger gravity-base platforms in deeper waters (up to 91 m [300 ft]). Oil produced at the platforms will be delivered via trenched subsea pipelines to existing onshore facilities.

In the Chukchi Sea Planning Area, with its greater water depths (>30 m [100 ft]) and more remote location, exploration drilling is expected to employ drill ships. As in the Beaufort Sea, concerns regarding severe winter ice conditions will also limit exploration and development to the shelf and depths <91 m (300 ft) and only in the summer (open water) season. Production operations will use large gravity-base structures with trenched subsea pipelines to transport the oil to landfalls.

In both areas, elevated onshore pipelines will convey the oil and gas from the landfall facilities to production facilities at Prudhoe Bay for ultimate entry to the Trans-Alaska Pipeline System (TAPS). Based on the assumption that a natural gas pipeline connecting the North Slope with the lower 48 States will be in place and operational by 2020, natural gas from the Chukchi and Beaufort Seas may be transported by new and existing aboveground pipelines for entry into such a pipeline (assuming capacity is available in the 2030–2035 time frame).

TABLE 4.4.1-4 Proposed Action (Alternative 1) – Exploration and Development Scenario for Arctic Alaska

Scenario Element	Beaufort Sea	Chukchi Sea
Number of sales	1	1
Years of activity	50	50
Oil production (Bbbl)[a]	0.2–0.4	0.5–2.1
Natural gas production (tcf)[b]	0–2.2	0–8.0
Platforms	1–4	1–5
No. of exploration wells	6–16	6–20
No. of production wells	40–120	60–280
No. of subsea production wells	10	18–82
Miles of new offshore pipeline	30–155	25–250
Miles of new onshore pipeline	10–80	0
Vessel trips/week	1–12	1–15
Helicopter trips/week	1–12	1–15
New pipeline landfalls	0	0
New shore bases	0	0
Drill Fluids/Well (bbl)		
Exploration and delineation wells	500 – discharged at well site	500 – discharged at well site
Development and production wells	All treated and disposed of in the well.	All treated and disposed of in the well.
Drill Cuttings (dry rock)/Well (tons)		
Exploration and delineation wells	600 – discharged at well site	600 – discharged at well site
Development and production wells	All treated and disposed in the well.	All treated and disposed in the well.
Bottom Area Disturbed		
Platforms (1.5 ha/platform)	1.5–6.0	1.5–7.5
Pipeline (1.4 ha/mile)	42–217	35–350
Surface Soil Disturbed		
Pipeline[c]	73–584	0

[a] Bbbl = billion barrels.

[b] Assumes that a natural gas pipeline from the North Slope will be operating by 2020 and have capacity for new supplies in 2030–2035; tcf = trillion cubic feet.

[c] Assumes 46 m (150 ft) wide construction ROW; 7.3 ha (18 ac)/mi.

4.4.2 Accidental Spill Scenario

Oil spills are unplanned accidental events. Depending on the phase of O&G development and the location, magnitude, and duration of a spill, natural resources that may be affected include marine mammals, marine and coastal birds, sea turtles, fish, benthic and pelagic invertebrates, water quality, marine and coastal habitats, and areas of special concern (such as marine parks and protected areas). Spills may also affect a variety of socioeconomic conditions such as local employment, commercial and recreational fisheries, tourism, and subsistence. For

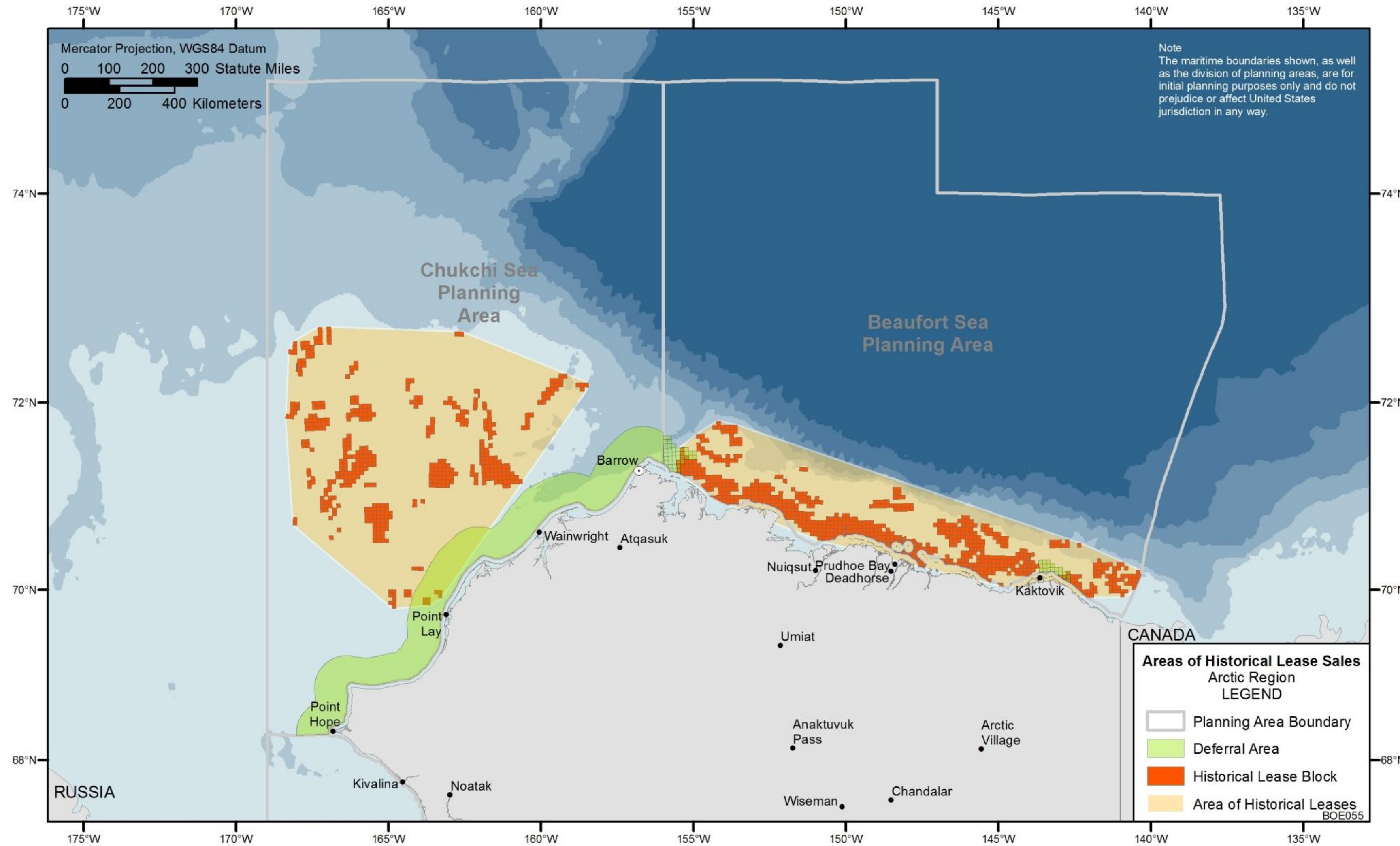

FIGURE 4.4.1-2 Areas of Historical Lease Sales in the Beaufort and Chukchi Seas OCS Planning Areas

this draft PEIS, assumptions have been made about the occurrence and location of small and large oil spills associated with the Program. Table 4.4.2-1 presents the assumptions for the GOM, the Beaufort and Chukchi Seas, and Cook Inlet. The draft PEIS also considers the potential impacts of a very large but low probability catastrophic discharge events (CDE), and the assumptions for such events are presented in Table 4.4.2-2.

The source and number of assumed accidental spills were based on the volume of anticipated oil production in each area, the assumed mode of transportation (pipeline and/or tanker), and the spill rates for large spills. It is also assumed that these spills would occur with uniform frequency over the life of the proposed action. Platform spills are assumed to occur in areas proposed for lease consideration. Pipeline spills are assumed to occur between the proposed lease areas and existing infrastructure. Tanker and barge spills are assumed to occur along the tanker and barge routes from the lease areas to shore facilities.

Spills from tankers carrying oil produced in the Beaufort and Chukchi Sea Planning Areas are assumed to occur outside of those planning areas. It is assumed that oil produced in the Beaufort and Chukchi Sea Planning Areas would be delivered by offshore and onshore pipe to TAPS, with subsequent delivery to the Valdez terminal facilities followed by tanker transport to West Coast ports. Some tankering could also occur in the GOM to transport oil from floating production, storage, and offloading (FPSO) facilities expected to operate in areas of the GOM distant from existing pipelines.

4.4.2.1 Spill Size Assumptions

Spill size will vary greatly depending on the amount of oil released over a period of time as a result of a single accidental event. For this draft PEIS, hypothetical spill sizes were developed using OCS and U.S. tanker spill databases. The sizes of the assumed spills for each spill type (platform, pipeline, tanker, or barge) are approximately equal to the median spill sizes of historical spills for each spill type. Three categories of spill sizes are considered: small, large, and catastrophic.

Small Spills. Analysis of historical data from the GOM, Pacific, and Alaska OCS regions (Anderson, in preparation; MMS 2007b, 2008a). Examination of these data shows that most offshore oil spills have been <1 bbl, accounting for approximately 95% of all OCS spills, yet only less than 5% of the total volume of oil spills on the OCS (Anderson, in preparation; Anderson and LaBelle 2000). Most of the total volume of OCS oil spilled (95%) has been from spills ≥10 bbl. Between 1971 and 2009, 41,514 exploratory and development/production operation wells were drilled on the OCS, and almost 16 billion bbl (Bbbl) of oil was produced. During this period, there were 249 well control incidents during exploratory and development/production operations on the OCS. These incidents were associated with exploratory and development drilling, completion, workover, and production operations. Of these well control incidents, 50 resulted in releases of crude oil ranging from <1 bbl to 450 bbl. In 2010, there were 4 additional well control events. The loss of well control, explosion, and fire on the DWH MODU resulted in the release of an estimated 4.9 million bbl of crude oil until the well was capped on July 15, 2010.

TABLE 4.4.2-1 Oil Spill Assumptions for the Proposed Action (Alternative 1)

		Number of Spill Events[a]		
		Gulf of Mexico Region	Arctic Region	South Alaska Region
Scenario Elements	Assumed Spill Volume	Western, Central, and Eastern Planning Areas	Beaufort and Chukchi Planning Areas	Cook Inlet
Oil Production (Bbbl)[b]		2.7–5.4	0.7–2.5	0.1–0.2
Large (bbl)	≥1,000			
pipeline	1,700[c]	2–5	1–2	1 spill from
platform	5,100[d]	1–2	1	either
tanker	3,100–5,800[e]	1		
Small (bbl)[f]	≥50 to <1,000	35–70	10–35	1–3
	≥1 bbl to <50	200–400	50–190	7–15

[a] The assumed number of spills are estimated using the 1996–2010 spill rates in Anderson (in preparation). For the Alaska OCS region, the 1996–2010 spill rates were compared to fault-tree rates in Bercha Group Inc (2008a, b, 2006). The greater number of spills from Anderson (in preparation) is represented here.

[b] Bbbl = billion barrels.

[c] During the last 15 years (1996–2010), 7 oil spills ≥1,000 bbl occurred from U.S. OCS pipelines. The median spill size was 1,720 bbl. The maximum spill size between 1996 and 2010 from U.S. OCS pipelines was 8,212 bbl.

[d] During the last 15 years (1996–2010), 2 oil spills ≥1,000 bbl occurred from U.S. OCS platforms. During Hurricane Rita, one platform and two jack-up rigs were destroyed, and a combined total of 5,066 bbl was spilled. The median spill size, when not accounting for a decreasing trend in the rate of platform spills, over 1964–2010, is 7,000 bbl.

[e] 3,100 bbl for tankers in the GOM; 5,800 bbl for TAPS tankers transporting Alaska OCS oil.

[f] The number of spills <1000 bbl is estimated using the total spill rate for both pipeline and platform spills.

On the basis of the historical OCS spill data, for this draft PEIS small spills are considered to be ≤1,000 bbl in volume (Table 4.4.2-1). Small spills are further divided into two groups: small spills ≤50 bbl and small spills >50 bbl but ≤1,000 bbl (Table 4.4.2-1).

Large Spills. The spill-size assumptions used for large spills are based on the reported spills from production in the GOM and Pacific OCS and what is anticipated as likely to occur (Anderson, in preparation; MMS 2007b, 2008a; Anderson and LaBelle 2000); there have been no large oil spills in the Alaska OCS region. For this PEIS, a large spill is considered to be ≥1,000 bbl. Between 1964 and 1999, there were 11 platform spills and 16 pipeline spills ≥1,000 bbl on the OCS (Anderson and LaBelle 2000). Between 2000 and 2010, there were 2 platform spills and 4 pipeline spills ≥1,000 bbl (Anderson, in preparation). The median sizes of these large spills from pipelines and platforms for 1964–2010 are 4,550 and 7,000 bbl,

TABLE 4.4.2-2 Catastrophic Discharge Event Assumptions[a]

Program Area	Volume (million bbl)	Duration (days)	Factors Affecting Duration
Gulf of Mexico	0.9–7.2	30–90	Water depth
Arctic			
Chukchi Sea	1.4–2.2	40–75	Timing relative to ice-free season and/or
Beaufort Sea	1.7–3.9	60–300	availability of rig to drill relief well
Cook Inlet	0.075–0.125	50–80	Availability of rig to drill relief well

[a] The Gulf of Mexico OCS region has estimated the discharge rate, volume of a spill, and the extent and duration for a catastrophic spill event for both shallow and deep water (in part) based on information gathered and estimates developed for the Ixtoc (1979) and the Deepwater Horizon (2010) oil spills. The Alaska OCS region has estimated a very large oil spill scenario based on a reasonable, maximum flow rate for each OCS Planning Area, taking into consideration existing geologic conditions and information from well logs. The number of days until a hypothetical blowout and discharge from a well could be contained was also estimated. These are discharge volumes and do not account for decreases in volume from containment or response operations.

respectively (Anderson, in preparation). The median sizes of these large spills from pipelines and platforms for 1996–2010 are 1,700 and 5,100 bbl, respectively (Anderson, in preparation). From 1971 to 2010, the DWH event in 2010 was the only loss of well control incident on the OCS that resulted in a spill volume ≥1,000 bbl. This catastrophic discharge event is discussed separately below.

Catastrophic Discharge Event. The CDE estimate is intended to provide a scenario for a low-probability event with the potential for catastrophic consequences. Past oil spills that may be relevant include the *Exxon Valdez* oil spill (262,000 bbl) (non-OCS program related) in Prince William Sound, south central Alaska, the Ixtoc oil spill (3,500,000 bbl) (non-OCS program related) in the western GOM, and the DWH event (4,900,000 bbl) in the northern GOM (McNutt et al. 2011). For this draft PEIS, CDEs were developed for each program area, taking into account considerations of water depth, weather conditions (such as ice cover) and the potential availability of response equipment for drilling relief wells. For the GOM Planning Areas, the CDE volumes range from 900,000 to 7,200,000 bbl, depending on the depth at which the loss of well control occurs (Table 4.4.2-2). For the Cook Inlet Planning Area, the CDE volume estimates range from 75,000 to 125,000 bbl, depending on the availability of a rig to drill a relief well. For the Chukchi Sea and Beaufort Sea Planning Areas, the CDE volume estimates range from 1,400,000 to 2,100,000 bbl and 1,700,000 to 3,900,000 bbl, respectively. For these CDE estimates, the range in volumes depends on the timing of the CDE relative to the ice-free (open water) season and on the availability of a rig to drill a relief well.

4.4.2.2 Spill Number Assumptions

The number of spills <1,000 bbl assumed to occur during the years of activity of the proposed action is estimated by multiplying the oil spill rate for each of the spill size groups by the projected oil production as a result of the proposed action. Details on the methodology for estimating spill rates (and thus spill number) can be found in Anderson (in preparation). As shown in Table 4.4.2-1, most spills assumed to occur during the duration of the proposed action would be in the small-volume category (≤1,000 bbl). As the spill size increases, the occurrence rate decreases, so the number of estimated spills decreases. Estimates of the number of large spills for the Beaufort and Chukchi Sea Planning Areas were also derived from fault-tree modeled rates and compared to the rates from Anderson (in preparation) (Bercha Group, Inc. 2008).

4.4.3 Potential Impacts on Water Quality

4.4.3.1 Gulf of Mexico

This section analyzes impacts on GOM coastal and marine waters. Coastal waters, as defined here, include the bays and estuaries along the coast and State waters extending out to the inward boundary of the territorial seas. Marine waters extend from this boundary out to the Exclusive Economic Zone, or approximately 322 km (200 mi) from the coast.

Table 4.1.1-1 details impacting factors associated with oil and gas activities and the development phase in which they can occur. The following factors affecting water quality have been identified: disturbance of bottom sediments, wastes and disposal, vessel traffic, and accidental spills. The water quality stressor activities associated with oil and gas development are shown in Table 4.4.3-1.

Discharges to waters of the GOM are regulated by National Pollution Discharge Elimination System (NPDES) OCS General Permit No. GMG290000 until Sept 30, 2012, for the western GOM (off of Texas and Louisiana) and NPDES OCS General Permit No. GMG460000 until March 31, 2015, for the eastern GOM, including the Mobile and Viosca Knoll lease blocks in the Central Planning Area.

Common impacts on water quality in both coastal and marine areas include impacts from vessel traffic, well drilling, and operational discharges. During drilling, drilling muds are circulated down a hollow drill pipe, through the drill bit, and up the annulus between the drill pipe and the borehole. Drilling muds are used for the lubrication and cooling of the drill bit and pipe. The muds also remove the cuttings that come from the bottom of the oil well and help prevent loss of well control by acting as a sealant. The drilling muds carry drill cuttings (i.e., crushed rock produced by the drill bit) to the surface. The drilling muds are then processed on the platform to remove the cuttings and recycled back down the well. The separated cuttings are, in most cases, discharged to the ocean. There are three classes of drilling muds used in the

TABLE 4.4.3-1 Water Quality Impact Matrix

	Water Quality			
Stressor and O&G Activity	Coastal Water	Shelf Water	Deepwater	Marine Water
Vessel Traffic Exploration, Construction, Operation, Decommissioning	X	X	X	X
Well Drilling: Exploration, Development	X	X	X	X
Pipelines: Trenching, Landfalls, Construction	X	X		X
Chemical Releases: Drilling, Normal Operational Discharges, Sanitary Wastes	X	X	X	X
Platforms: Anchoring, Mooring, Removal	X	X	X	X
Onshore Construction	X			
Oil Spills	X	X	X	X

industry: water-based muds (WBMs), oil-based muds (OBMs), and synthetic-based muds (SBMs) (Neff et al. 2000). The WBMs used in most offshore drilling operations in U.S. waters consist of fresh- or saltwater, barite, clay, caustic soda, lignite, lignosulfonates, and/or water-soluble polymers. The OBMs use mineral oil or diesel oil as the base fluid rather than fresh- or saltwater. They offer several technical advantages over WBMs for difficult drilling operations; however, because of their persistence and adverse environmental effects, OBMs and associated cuttings have been banned from ocean discharges in U.S. waters and must be transported to shore for disposal (Neff et al. 2000). The synthetic-based fluids (SBFs) are a family of products developed in the 1990s to provide drilling performance similar to that of oil-based fluids, but with improved biodegradation characteristics and decreased ecotoxicity (Neff et al. 2000). The types that would be used most frequently would be those that meet the requirements of the NPDES permit. The SBF-wetted cuttings are permitted for ocean discharge, while the spent fluid is transported to shore for reuse or disposal (Neff et al. 2000).

Discharges of drilling muds and cuttings during normal operations are regulated by NPDES general permits issued by the U.S. Environmental Protection Agency (USEPA). In areas where disposal of drilling muds and/or cuttings at sea are permitted under an NPDES general permit and BOEM and BSEE regulations, their environmental effects are localized because of settling, mixing, and dilution (Montagna and Harper 1996; Neff et al. 2000; Continental Shelf Associates 2004c). The majority of cuttings are found within 250 m (820 ft) of a drilling site (Continental Shelf Associates 2004c). Constituents of SBF cuttings have been found in an approximately 1 ha (2.5 ac) area surrounding a drilling rig at concentrations that may cause harm to wildlife (Neff et al. 2000).

Produced water is water that is brought to the surface from an oil-bearing formation during oil and gas extraction. It is the largest individual discharge produced by normal operations. Small amounts of oil are routinely discharged in produced water during OCS operations. The USEPA has set an effluent limitation of 29 mg/L for the oil content of produced waters (MMS 2007b). Produced water may contain specialty chemicals added to the well for process purposes (e.g., biocides and corrosion inhibitors) and chemicals added during treatment of the produced water before its release to the environment (e.g., water clarifiers). Produced water can have elevated concentrations of several constituents, including salts, petroleum hydrocarbons, some metals, and naturally occurring radioactive material (NORM). Petroleum hydrocarbons in produced water discharges are a major environmental concern. The most abundant hydrocarbons in produced water are benzene, toluene, ethylbenzene, and xylenes (BTEX) and low-molecular-weight saturated hydrocarbons. The BTEX compounds rapidly evaporate into the atmosphere, leaving behind less volatile, heavier compounds (weathering) (NRC 2003b). Polycyclic aromatic hydrocarbons (PAHs) are heavier hydrocarbons in produced water and are a concern because of the toxicity of some PAHs and their persistence in the marine environment (Rabalais et al. 1991).

The NORM waste in produced water includes the radium isotopes Ra-226 and Ra-228 and is a concern because it is radioactive. However, in produced water discharges, radium coprecipitates with barium sulfate and is not available for uptake by organisms (Neff 2002).

Generally, the amount of produced water is low when production begins but increases over time near the end of the field life. In a nearly depleted field, production may be as high as 95% water and 5% fossil fuels (Rabalais et al. 1991). The National Research Council (2003a) estimated that the total amount of produced water being released into GOM waters was 660 million bbl/yr in the 1990s. Between 1996 and 2005, the annual volume of produced water varied between 432 million bbl/yr and 686 million bbl/yr, with an average discharge of 596 million bbl/yr (MMS 2007b).

Before being discharged into the ocean, produced water is typically treated and must meet NPDES requirements regarding discharge rate, contaminant concentration, and toxicity, thereby reducing the potential for contamination. However, the discharge of produced water into the sea may degrade water and sediment quality in the immediate vicinity of the discharge point because of its potential constituents. Studies have shown contaminated sediments exist in areas up to 1,000 m (3,280 ft) from a produced water discharge point, indicating water quality in that zone has been affected by produced water discharges (Rabalais et al. 1991). Because discharge points are typically much farther apart than 1,000 m (3,280 ft), no interactions that would measurably affect water quality are expected between them, and background concentrations are expected to exist away from the immediate discharge location. Two recent studies have shown that produced water discharges do not make a significant contribution to the hypoxic conditions that are seen in the GOM (Veil et al. 2005; Bierman et al. 2007).

Normal operations for the proposed action would also involve the use of vessels with associated impacts. Compliance with NPDES permits and USCG regulations would prevent or minimize most impacts on the environment caused by ship traffic.

The placement of drilling units and platforms would disturb bottom sediments and produce turbidity in the water. This impact would be unavoidable; however, these impacts would be temporary and water quality would return to normal (e.g., background concentrations of suspended solids) within minutes to hours without mitigation because of mixing, settling, and dilution.

4.4.3.1.1 Routine Operations.

Coastal Waters. Routine activities potentially affecting coastal water quality include pipeline landfalls, well completion activities, platform construction, and operation discharges. The estimated exploration and development scenario for the GOM for the proposed action is presented in Table 4.4.1-1 and estimated depth distribution of the activities in Table 4.4.1-2.

Construction and installation of exploratory and development wells (up to 100 and 600, respectively), platforms (up to 450), and offshore pipelines (up to 12,000 km [7,500 mi]) would affect water quality and disturb habitats (see Table 4.4.1-1). Such activities would disturb bottom sediments and increase the turbidity of the water in the area of construction. Trenching operations to bury pipelines would produce turbidity (i.e., increased suspended solids) in the coastal waters along pipeline corridors. The disturbance of bottom sediments caused by these operations would be unavoidable. However, these impacts would be temporary, and water quality would return to normal (i.e., background concentrations) without mitigation, once these activities were completed because of settling and mixing.

Construction of new onshore support facilities (up to 11 pipeline landfalls, 6 pipe yards, and 12 processing facilities) could affect the quality of nearshore and fresh waters in the GOM Planning Areas. During land site preparation, vegetation is typically cleared from the area, compacting the topsoil, because of the constant movement of heavy machinery. This compaction would reduce the water retention properties of the soil and increase erosion and surface runoff from the site. Water quality would be degraded by increases in site runoff of particulate matter, heavy metals, petroleum products, and chemicals to local streams, estuaries, and bays. Proper siting of facilities and requirements associated with NPDES construction permits should largely mitigate these impacts.

The OCS service and construction vessel traffic to and from platform sites within the planning area (up to 600 vessel trips per week) would also affect water quality through the permitted release of operational wastes. Routine vessel-associated discharges that could affect coastal water quality include sanitary wastes and bilge water. Bilge water discharges from support vessels could contain petroleum and metals from machinery. Bilge water and sanitary discharges to larger coastal water channels would produce local and temporary effects because of the large volume of water available to dilute the discharges and the presence of currents that would promote mixing. However, in confined portions of some channels, there might be insufficient water volume or currents for mixing and dilution. In such regions, water quality could be degraded. Compliance with applicable NPDES permits and USCG regulations would prevent or minimize most impacts on receiving waters. Discharges in coastal areas are regulated by State-issued or Federal NPDES permits specifically for coastal areas.

Produced water discharges were banned in coastal waters of the GOM in the late 1990s, and reinjection of produced water is practiced in coastal areas to avoid discharges (NRC 2003b; Wilson 2007).

Marine Waters. Marine waters can be divided into continental shelf waters and deep waters. Continental shelf waters are defined as those waters that lie outside of the coastal waters and have a depth less than 305 m (1,000 ft). Deep waters are located in regions that are equal to or deeper than 305 m (1,000 ft).

Routine operations that could affect water quality include anchoring, mooring, drilling and well completion activities, well testing and cleanup operations, flaring/burning, facility installation and operations, support service activities, decommissioning, and site clearance. Construction and installation of exploratory and development wells (up to 1,200), platforms (up to 450), and offshore pipelines (up to 12,000 km [7,500 mi]) would affect water quality and disturb habitats (see Table 4.4.1-1).

As with coastal areas, OCS vessel traffic to and from platform sites within the planning area (up to 600 vessel trips per week) would also affect water quality through the permitted release of operational wastes (such as bilge water). Because of the relatively small volumes that would be discharged, these waste materials would be quickly diluted and dispersed, and any impacts on water quality would be highly localized and temporary. Compliance with applicable NPDES permits and USCG regulations would prevent or minimize most impacts on receiving waters.

Sanitary and domestic waste and deck drainage would occur from platforms, drilling vessels, and service vessels as part of normal operations and could contribute to water quality degradation. However, sanitary and domestic wastes would be routinely processed through onsite waste treatment facilities before being discharged overboard, and deck drainage would be treated onsite to remove oil and then discharged. Sand and sludge recovered from the treatment processes would be containerized and shipped to shore for disposal. Impacts on water quality from such discharges would require no mitigation because of the treated nature of the wastes, the small quantities of discharges involved, and the mixing and dilution of the wastes with large volumes of water.

Discharges associated with drilling and production are discussed in Section 4.4.3.1. Normal operations for the proposed action would also involve the use of vessels with associated impacts, such as those discussed for related impacts on coastal areas. Compliance with NPDES permits and USCG regulations would prevent or minimize most impacts on the environment.

The placement of drilling units and platforms would disturb bottom sediments and produce turbidity in the water. Pipeline trenching, required in water depths less than 61 m (200 ft), would also produce turbidity along pipeline corridors. This impact would be unavoidable; however, these impacts would be temporary, and water quality would return to normal (e.g., background concentrations of suspended solids) within minutes to hours without mitigation because of mixing, settling, and dilution.

As discussed in Section 3.4.1.2, hypoxic conditions exist on the Louisiana-Texas shelf. The size of the hypoxic zone varies from year to year. The hypoxic zone attained a maximum measured extent in 2002, when it encompassed about 22,000 km^2 (8,494 mi^2). Normal operations from oil and gas production in the GOM could affect the extent and severity of the hypoxic zone through discharges and accidental releases. Very preliminary calculations reveal that ammonium and oil and grease contained in produced water are a small percentage of that contributed by the Mississippi River to the hypoxic zone (Rabalais 2005). A study that monitored oxygen-demanding substances and nutrients in the produced water discharges from 50 platforms found that produced water discharges contributed less than 1% of the oxygen-demanding substances to the hypoxic zone (Veil et al. 2005).

For the proposed action, the compositions and volumes of discharges would be expected to be about the same as those observed historically, and compliance with existing NPDES permits would minimize impacts on receiving waters (e.g., through limitations on concentrations of toxic constituents). Water quality likely would recover without mitigation when discharges ceased because of dilution and dispersion.

Although deepwater operations and practices are similar to those used in shallower environments, there are some significant differences. Three of these are seafloor discharges from pre-riser and riserless drilling operations, discharge of cuttings wetted with SBFs, and more extensive and frequent use of chemical products to enhance oil and gas throughput because of the temperatures and pressures present at the seafloor, including their use within pipelines to facilitate the transport of large quantities of methanol and other chemicals to and from the shore.

Floating production facilities are used in deepwater rather than conventional, bottom-founded (i.e., fixed) platforms. These deepwater facilities include floating production semisubmersibles, tension leg platforms, and spars (Harbinson and Knight 2002). Often these facilities are surface hubs for several subsea systems. Therefore, in deep water, there will be far fewer and more widely spaced surface facilities than on the shelf, but these facilities will have increased discharges of produced waters over time due to the larger volume being processed.

In order to enhance the throughput of oil and gas in deep water, more extensive and frequent use of some chemical products is anticipated because of the temperatures and pressures encountered at the seafloor. Chemicals most likely to be present in deepwater operations and drilling include monoethylene glycol, methanol, corrosion inhibitors, and biocides (Grieb et al. 2008). The toxicity of these substances varies, but the impact on water quality would be temporary and localized (within feet of a release), due to the small quantities in which they would likely be released and the amount of dilution and mixing that would occur in a subsea environment (Grieb et al. 2008).

Deepwater activities could incrementally increase support activities and the expansion, construction, or modification of onshore support bases due to the deeper draft of these support vessels. The impacts resulting from this growth would be common to all OCS support facilities (point-source waste discharges, runoff, dredging, and vessel discharges) and not specific to deepwater activities. Short-term degradation of water quality might increase at a few support base locations that would be expected to grow as a consequence of deepwater activities (including Corpus Christi, Galveston, and Port Fourchon).

4.4.3.1.2 Accidents.

Coastal Waters. Accidental releases could affect the quality of coastal water in the GOM. The magnitude and severity of impacts would depend on spill location and size, type of product spilled, weather conditions, and the water quality and environmental conditions at the time of the spill.

Under the proposed action, the number and types of spills assumed to occur in the GOM Planning Area include up to seven large spills (i.e., ≥1,000 bbl), up to five spills at a volume of 1,700 bbl from pipelines, up to two spills at a volume of 5,000 bbl from platforms, and up to one spill at a volume of 3,100 bbl from a tanker. Between 35 and 70 small spills with volumes between 50 and 999 bbl are assumed to occur, as well as between 200 and 400 very small spills with volumes between 1 and 50 bbl (Table 4.4.2-1).

Weathering processes that transform the oil, such as volatilization, emulsification, dissolution, chemical oxidation, photo-oxidation, and microbial oxidation, may reduce impacts of oil spills in the GOM Planning Areas on coastal water quality (NRC 2003b; NOAA 2005). Dissolution, which is a small component of weathering, can be important to biological communities because the most soluble fractions are often the most toxic (Shen and Yapa 1988). Because oil is generally less dense than water, it would tend to float on the sea surface. Lighter oil fractions such as BTEX would readily evaporate from the surface and, therefore, would not be a continuing source of potential water contamination. Following a spill, light crude oils can lose as much as 75% of their initial volume to evaporation as the lighter components (e.g., BTEX) change from the liquid to the gas phase; medium-weight crude oils can lose as much as 40% (NRC 2003b).

If a large spill occurred in enclosed coastal waters or was driven by winds, tides, and currents into an enclosed coastal area, water quality would be adversely affected. These impacts could be increased if they occurred in areas with degraded water quality, such as areas continuing to be affected by the DWH. Similarly, if a large tanker spill were to happen near port, adverse impacts on coastal waters could occur. In such a low-energy environment (i.e., an environment in which there is limited wave and current activity), the oil would not be easily dispersed, and weathering could be slower than it would be in the open sea. Effects on water quality could persist if oil reached coastal wetlands and was deposited in fine sediments, becoming a long-term source of pollution because of remobilization. In such locations, spill cleanup might be necessary for the recovery of the affected areas. Potential impacts from spill response and cleanup activities are discussed below. As a result of the DWH event, residual oil was still being removed from shorelines as of January 2011 (Geoplatform 2011a, b). However, supratidal buried oil, small surface residue balls, and submerged oil mats are three types of residual oil from the DWH spill in the nearshore zone that were identified as being more damaging to completely remove from coastal habitats than to let them remain and naturally attenuate (OSAT-2 2011). Oiled shorelines might also be washed with warm or cold water, depending on the shore's location.

Small oil spills (<1,000 bbl) or very small oil spills (<50 bbl) would produce small but measurable impacts on water quality. Assuming that all small and very small spills would not occur at the same time and place, water quality would rapidly recover without mitigation because of mixing, dilution, and weathering. However, impacts could be increased if they occurred in areas with degraded water quality, such as areas continuing to be affected by the DWH event.

Marine Waters. Accidental releases could affect the quality of marine waters in the GOM Planning Areas. The number and types of spills assumed to occur in the GOM Planning Areas are the same as those discussed above for coastal waters. The magnitude of these impacts and the rate of recovery would depend on the location and size of the spill, the type of product spilled, weather conditions, and environmental conditions at the time of the spill. Failures of production-related piping, seals, and connections have been identified as key risks for releases that may affect water quality in deepwater environments, with loss of well control presenting the highest risk of environmental impacts (Grieb et al. 2008). Because of the depths of some deepwater drilling operations, servicing any leak identified during subsea drilling and production operations would be more difficult and require remotely operated vehicles for depths greater than 610 m (2,000 ft) (Grieb et al. 2008). Each piping connection presents a potential for leakage due to human error, corrosion, or erosion (Grieb et al. 2008). In general, oil spilled below the surface rises rapidly as droplets that coalesce to form a slick. Standard response procedures for a spill could then be used.

Because deepwater operations can be located far from shore, tankers could be used to shuttle crude oil to shore stations. This transport of oil from operations in deep water has the potential to produce spills that could affect coastal waters within a very short time if the spill occurred near the port. It is expected that such spills could release approximately 3,100 bbl of oil. Such a release could retain a large volume of oil in the slick at the time it contacted land.

Small oil spills (<1,000 bbl) and very small oil spills (<50 bbl) would have measurable impacts on water quality. If it is assumed that all small and very small spills would not occur at the same time and place, water quality would rapidly recover without mitigation because of mixing, dilution, and weathering.

Spill Response and Cleanup. Spill response and cleanup activities in coastal and marine water could include, depending on location, use of chemical dispersants, *in situ* burning, use of vessels and skimmers, and beach cleaning and booming (BOEMRE 2011k).

Dispersants are combinations of surfactants and solvents that work to break surface oil into smaller droplets that then disperse on the surface and into the water column. Many factors affect the behavior, efficacy, and toxicity of a particular dispersant, including water temperature, surface salinity, wave and wind energy, light regime, water depth, type of oil, concentration of dispersant, how the dispersant is applied (constant or intermittent spikes), and exposure time to organisms. Dispersants are used to degrade an oil spill more quickly through increasing surface area and to curtail oil slicks from reaching shorelines (Word et al. 2008). As oil breaks into smaller droplets, it can distribute vertically in the water column. If oil droplets adhere to sediment, the oil can be transported to the seafloor and interstitial water in the sediment. In shallow nearshore waters, wind, wave, and current action would more likely mix the dispersant-oil mixture into the water column and down to the seafloor environment. Chemically dispersed oil is thought to be more toxic to water column organisms than physically dispersed oil, but the difference is not clear-cut, and generally the toxicity is within the same order of magnitude (NRC 2005b).

In situ burning is used to reduce an oil spill more quickly and to curtail oil slicks from reaching shorelines. *In situ* burning could increase the surface water temperature in the immediate area and produce residues. The uppermost layer of water (upper millimeter or less) that interfaces with the air is referred to as the microlayer. Important chemical, physical, and biological processes take place in this layer, and it serves as habitat for many sensitive life stages and microorganisms (GESAMP 1995). Disturbance to this layer through temperature elevation could cause negative effects on biological, chemical, and physical processes.

Residues from *in situ* burning can float or sink depending on the temperature and age of the residue. Floating residue can be collected; however, residues that sink could expose the benthic waters and sediment to oil components as the residue degrades on the seafloor.

The NOAA Office of Response and Restoration states, "Overall, these impacts [from open water *in situ* burning] would be expected to be much less severe than those resulting from exposure to a large, uncontained oil spill" (NOAA 2011d).

Oiled shorelines might be washed with warm or cold water, depending on the shore's location. Oil dispersants and surface washing agents used to clean up a spill could also be a source of impacts to water quality for coastal areas in the event of a spill (EIC and NCSE 2010; Coastal Response Research Center 2010). Beach cleaning and booming activities could result in effects from suspended sediment in waters and resettlement of sediments elsewhere, possible resuspension of hydrocarbons, and runoff of treatment-laden waters that could affect nearshore temperature and nutrient concentrations (BOEMRE 2011k).

Catastrophic Discharge Event. For the GOM Planning Areas, a low-probability CDE could have a volume of 900,000 to 7,200,000 bbl (Table 4.4.2-2). A catastrophic discharge event in either coastal or marine water could present sustained degradation of water quality from hydrocarbon contamination in exceedence of State and Federal water and sediment quality criteria. These effects could be significant depending upon the duration and area impacted by the spill. Additional effects on water quality would occur from response and cleanup vessels, *in situ* burning of oil, dispersant use, discharges and seafloor disturbance from relief well drilling, and activities on shorelines associated with cleanup, booming, beach cleaning, and monitoring.

4.4.3.2 Alaska – Cook Inlet

This section analyzes impacts on coastal and marine waters in the Cook Inlet Planning Area. Coastal waters, as defined here, include the bays and estuaries along the coast and State waters extending out to the inward boundary of the territorial seas. Marine waters extend from this boundary out to a water depth of 200 m (656 ft).

Section 4.1.1 details impacting factors for activities associated with oil and gas activities and the development phases in which they can occur. The following factors affecting water quality have been identified: disturbance of bottom sediments, wastes and disposal, vessel traffic, and accidental spills. The water quality stressor activities associated with oil and gas are shown in Table 4.4.3-1. Note that no onshore construction or pipeline landfalls are anticipated for the Cook Inlet Planning Area for the lease sales during 2012-2017 period.

Discharges to waters of Cook Inlet are regulated by NPDES OCS General Permit No. AKG-31-5000 until July 2, 2012.

Common impacts on water quality in both coastal and marine areas include those from vessel traffic, well drilling, and operational discharges. The types of impacts expected are the same as those discussed above in Section 4.4.3.1.

4.4.3.2.1 Routine Operations.

Coastal Waters. Routine activities potentially affecting coastal water quality include pipeline landfalls, well completion activities, platform construction, and operational discharges. The estimated exploration and development scenario for Cook Inlet is presented in Table 4.4.1-3.

Construction and installation of exploratory and development wells (up to 12 and 114, respectively), platforms (up to 3), and offshore pipelines (up to 240 km [150 mi]) would affect water quality and disturb habitats (see Table 4.4.1-3). Trenching operations to bury pipelines would produce turbidity (i.e., increased suspended solids) in the coastal waters along pipeline corridors. Increased water turbidity would also result from placing drilling units and platforms. The disturbance of bottom sediments caused by these operations would be unavoidable. However, these impacts would be temporary, and water quality would return to normal (i.e., background concentrations) without mitigation, once these activities were completed, because of settling and mixing.

Construction of new onshore pipelines (up to 169 km [105 mi]) would also impact coastal water quality in the Cook Inlet Planning Area. Proper siting of facilities and requirements associated with NPDES construction permits would largely mitigate these impacts. The impacts on water quality would range from negligible to minor, depending on site location and construction and mitigation activities.

Increased turbidity from construction and installation activities would occur in the immediate area of the activity. Contaminants introduced into Cook Inlet waters by these activities would be diluted and dispersed by complex currents associated with the tides (diurnal tidal variations at the upper end of the Cook Inlet at Anchorage can be 9 m [30 ft]), estuarine circulation, wind-driven waves, and Coriolis forces (MMS 2003a; Royal Society of Canada 2004). Seawater enters the Lower Cook Inlet from the Gulf of Alaska at the Kennedy Entrance south of the Kenai Peninsula, and fresh water enters the inlet from numerous streams along the east, north, and west shorelines; major freshwater inputs include the Susitna and Kenai Rivers. Seawater circulates northward in Cook Inlet along its eastern boundary, mixes with fresh water in the northern end, and flows southward along the western boundary. Water exits the lower Cook Inlet through Shelikof Strait and discharges into the Gulf of Alaska (MMS 2002a).

Surface currents in Cook Inlet can exceed 5 knots (5.7 mph), and bottom currents can reach 1.5 knots (1.7 mph) (Royal Society of Canada 2004). Approximately 90% of waterborne contaminants would be flushed from the lower Cook Inlet within about 10 months (MMS 2003a). Contaminants flushed from Cook Inlet would pass through Shelikov Strait and enter the Gulf of Alaska. Because of dilution, settling, and flushing, impacts from these activities would be local and temporary.

In addition to affecting the turbidity of coastal waters in the Cook Inlet, construction activities would produce waste materials. The majority of wastes generated during construction and developmental drilling would consist of drill cuttings and spent muds (MMS 2002a). Drilling muds and cuttings generated when installing exploration and delineation wells would be discharged at the well site. The volume of drilling fluids and cuttings vary depending upon the well characteristics, but, in general, fluids average approximately 500 bbl/well, and drill cuttings would comprise the equivalent of approximately 600 tons/well of dry rock. Thus, under the proposed action, up to 6,000 bbl of drilling fluids and up to 7,200 tons of drill cuttings could be disposed of in the waters of the Cook Inlet Planning Area. All drilling muds and cuttings associated with development and production wells would be treated and reinjected into the well. Discharge of drilling muds and cuttings would increase turbidity in the vicinity of the well. The discharge would contain trace metal and hydrocarbon constituents that would be suspended in the water column and subsequently deposited on the seafloor. These drilling discharges must comply with NPDES permit requirements regarding the discharge amount, rate, and toxicity, which would greatly reduce the impact to water quality.

Because all produced water would be discharged down hole, there would be no impacts on water quality from these operational discharges. Domestic wastewater would also be generated by these activities. This material would be injected into a disposal well. Solid wastes, including scrap metal, would be hauled offsite for disposal at an approved facility.

The OCS service and construction vessel traffic to and from platform sites within the planning area (up to nine vessel trips per week) would also affect quality through the permitted release of operational wastes. Routine vessel-associated discharges that could affect coastal water quality include sanitary wastes and bilge water. Bilge water discharges from support vessels could contain petroleum and metals from machinery. Bilge water and sanitary discharges to larger coastal water channels would produce local and temporary effects because of the large volume of water available to dilute the discharges and the presence of currents that would promote mixing. However, in confined portions of some channels, there might be insufficient water volume or currents for mixing and dilution. In such regions, water quality could be degraded. Compliance with applicable NPDES permits and USCG regulations would prevent or minimize most impacts on receiving waters. Discharges in coastal areas are regulated by State-issued or Federal NPDES permits specifically for coastal areas.

The National Research Council (2003b) estimated that the total amount of produced water being released into Cook Inlet waters was 45.7 million bbl/yr in the 1990s. Produced water can contain hydrocarbons, salts, and metals at levels toxic to marine organisms. Before being discharged into the ocean, produced water is typically treated and must meet NPDES requirements regarding discharge rate, contaminant concentration, and toxicity, thereby reducing the potential for sediment contamination. However, under the current NPDES permits, new facilities would not be allowed to discharge produced water into Cook Inlet. Under the proposed action, it is anticipated that all produced waters would be treated and reinjected into the well. Therefore, no impacts on water quality are expected to result from produced water.

Marine Waters. Routine operations that could affect marine water quality in the Cook Inlet Planning Area include anchoring, mooring, drilling and well completion activities, well testing and cleanup operations, flaring/burning, facility installation and operations, support service activities, decommissioning, and site clearance. These activities would disturb the seafloor and increase the suspended sediment load in the water column. Offshore pipelines in Alaska are normally placed in a dredged trench in waters less than about 60 m (197 ft) deep. Dredged material from the trenches can be used to cover the pipeline. Fill deposited during artificial island construction also increases turbidity. As these operations are reversed and structures removed, increased turbidity would reoccur. In general, plumes from these activities extend a few hundred meters to a few kilometers down current, but the length of the plume would depend on rate and duration of discharge, sediment grain size, current regime, source type, water column turbulence, and season. The direction of plume movement would be influenced by the general circulation pattern in the planning area and local ambient conditions. Suspended sediments in the plumes are expected to have toxicity ranges that are generally described as nontoxic to slightly toxic (National Academy of Sciences 1983). Overall, it is anticipated that the impacts on water quality from routine operations would be localized and temporary. As with coastal water impacts, dilution, settling, and rapid flushing would minimize any long-lasting impacts on water quality.

Adverse water quality impacts would also be produced by routine discharges of domestic waste (e.g., wash water, sewage, and galley wastes) and deck drainage (platform and deck washings, and gutters and drains, including drip pans and work areas). Domestic waste would increase suspended solids in the receiving water, thereby increasing turbidity and biological oxygen demand. Sanitary and domestic wastes are monitored in accordance with the NPDES permit. Established effluent limitations and guidelines published in 40 CFR Part 435, and operator compliance should minimize impacts on ambient water quality. Such impacts would be local and temporary.

The principal discharges of concern during drilling would be muds and cuttings. Drilling muds and cuttings generated when installing exploration and delineation wells would be discharged at the well site. All drilling muds and cuttings associated with development and production wells would be treated and reinjected into the well. See the discussion above for coastal waters for further information on potential impacts of discharging drilling muds and cuttings.

During operations, all produced water would be reinjected into the well in the Cook Inlet Planning Area, there produced water generated from activities associated with the proposed action would have no impacts on marine water quality.

As with coastal waters, OCS vessels traveling to and from platform sites within the planning area (up to three vessel trips per week per platform) could affect local water quality as a result of operational discharge of waste fluids. Because of dilution, settling, and flushing, water quality impacts from such discharges would be localized and temporary.

4.4.3.2.2 Accidents.

Coastal Waters. Accidental releases could affect the quality of coastal water in the Cook Inlet. The magnitude and severity of impacts would depend on the spill location and size, type of product spilled, weather conditions, and the water quality and environmental conditions at the time of the spill.

Under the proposed action, the number and types of spills assumed to occur in the Cook Inlet Planning Area include up to one large spill (i.e., ≥1,000 bbl) from either a platform (5,100 bbl) or a pipeline (1,700 bbl), up to three small spills with volumes between 50 and 999 bbl; and up to 15 very small spills with volumes between 1 and 50 bbl (Table 4.4.2-1). For conservative analysis (i.e., one in which impacts would be greater than those that would actually occur), all the spills are assumed to occur in Cook Inlet coastal waters. Such spills would adversely affect water quality. A spill in isolated coastal waters, in shallow waters under thick ice, or in rapidly freezing ice could cause sustained degradation of water quality to levels that are above State or Federal criteria for hydrocarbon contamination. Concentrations could exceed the chronic criterion of 0.015 ppm total hydrocarbons, but this exceedance would probably occur over a relatively small area. Persistent small spills in such areas could result in local chronic contamination. In most cases, spills would be rapidly diluted. In some cases, however, water quality could be degraded to a greater extent.

Weathering processes that transform the oil, such as volatilization, emulsification, dissolution, chemical oxidation, photo-oxidation, and microbial oxidation, may reduce impacts of oil spills on coastal water quality in the Cook Inlet Planning Area (NRC 2003b; NOAA 2005). Dissolution, which is a small component of weathering, can be important to biological communities because the most soluble fractions are often the most toxic (Shen and Yapa 1988). Because oil is generally less dense than water, it would tend to float on the sea surface. Lighter oil fractions such as BTEX would readily evaporate from the surface and, therefore, would not be a continuing source of potential water contamination. Following a spill, light crude oils can lose as much as 75% of their initial volume to evaporation as the lighter components (e.g., BTEX) change from liquid to gas phase; medium-weight crude oils can lose as much as 40% (NRC 2003b).

Spills would tend to move in directions consistent with established circulation patterns for the planning area (i.e., northward along the Kenai Peninsula and southward along the Alaska Peninsula). Actual flow paths would be affected by winds, tides, ice cover, temperature, and cleanup activities.

If a large spill were to happen near port, there could be adverse impacts on coastal waters. In such a low-energy environment (i.e., an environment in which there is limited wave and current activity), the oil would not be easily dispersed, and weathering could be slower than it would be in the open sea. Effects on water quality could persist if oil reached coastal wetlands and was deposited in fine sediments, becoming a long-term source of pollution because of remobilization. In such locations, spill cleanup might be necessary for the recovery of the affected areas. Potential impacts to water quality from spill cleanup activities are discussed below.

Small oil spills (<1,000 bbl) or very small oil spills (<50 bbl) would produce small but measurable impacts on water quality. Assuming that all intermediately sized and small spills would not occur at the same time and place, water quality would rapidly recover without mitigation because of mixing, dilution, and weathering.

Under arctic conditions (i.e., cold water and cold air temperatures), weathering processes, such as volatilization, would also be much slower than in warmer climates (MMS 2008b); under calm conditions and cold temperatures in restricted waters, vertical mixing and dissolution would be reduced (MMS 2008b). If the spill were to occur on ice or under ice, oil would be trapped and essentially remain unchanged until breakup occurred and the ice began to melt. The volatile compounds from such a spill would be more likely to freeze into the ice within hours to days rather than dissolve or disperse into the water below the ice. A hydrocarbon plume in the water column underneath the ice could persist with concentrations that exceed ambient standards and background levels for a distance greater than that in the open sea (MMS 2008b). Impacts on coastal waters from a large spill would depend on the season, type, and composition of the spill, weather conditions, and size of the spill.

Marine Waters. Accidental hydrocarbon releases in the marine environment can occur at the surface from tankers or platforms or at the seafloor from the wellhead or pipelines. The number of potential spills estimated for Cook Inlet marine waters are conservatively assumed to be the same as those discussed above for coastal waters. In general, oil spilled below the surface rises rapidly as droplets that coalesce to form a slick. Standard response procedures for a spill could then be used. In open marine waters, evaporation, advection, and dispersion generally reduce the effects of toxic oil fractions and their degradation products to below State and Federal criteria for hydrocarbon contamination. Sustained degradation of water quality to levels exceeding the chronic criterion of 0.015 ppm total hydrocarbon contamination is unlikely. However, levels could exceed this standard over several thousand square kilometers for a short period of time (about 30 days), depending on the size, location, and season of the spill. Marine spills would tend to move in directions consistent with established circulation patterns for the planning area (i.e., northward along the Kenai Peninsula and southward along the Alaska Peninsula). Actual flow paths would be affected by winds, tides, ice cover, temperature, and cleanup activities. The persistence of oil slicks would generally last less than 1 year. Large oil spills assumed under this alternative would become more likely as the volume of assumed oil production increases. Water quality would eventually recover, but recovery time could be decreased by oil-spill cleanup activities.

Spill Response and Cleanup. Spill response and cleanup activities in both coastal and marine waters could include, depending on location, use of chemical dispersants, *in situ* burning, use of vessels and skimmers, drilling of a relief well, and beach cleaning and booming (BOEMRE 2011k). Potential impacts to water quality from each of these spill response and cleanup activities are discussed above in Section 4.4.3.1.2. However, clean up of large spills in the open sea off of south central Alaska could be hindered by several factors. There could be limited access to oil slicks contained between ice floes during a large part of the year. There could also be reduced oil flow into recovery devices because of increased viscosity and precipitation of wax crystals, as well as decreased oil adhesion to the recovery unit material and a high percentage of free water in the recovered product due to mixing of the oil slick with slash ice and snow (MMS 2008b). In winter, icebreakers could affect the movement of spilled oil that may be trapped beneath or in the ice (BOEMRE 2011k).

If an oil spill occurred in winter, *in situ* burning would be limited by the lack of open water to collect oil and open water in which to burn it. If burning could occur in winter on a limited scale, sea ice would melt in the immediate vicinity of the burn.

Catastrophic Discharge Event. For the Cook Inlet Planning Area, a low-probability CDE could have a volume of between 75,000 and 125,000 bbl (Table 4.4.2-2). A catastrophic discharge event in coastal or marine water could present sustained degradation of water quality from hydrocarbon contamination in exceedence of State and Federal water and sediment quality criteria. These effects could be significant depending upon the duration and area impacted by the spill. Additional effects on water quality could occur from response and cleanup vessels, *in situ* burning of oil, dispersant use, discharges and seafloor disturbance from relief well drilling, and activities on shorelines associated with cleanup, booming, beach cleaning, and monitoring. Impacts from the spill would again depend on the spill size and composition, weather conditions, and the location of the spill.

4.4.3.3 Alaska – Arctic

This section analyzes impacts on coastal and marine waters in the Arctic region. Coastal waters, as defined here, include the bays and estuaries along the coast and State waters extending out to the inward boundary of the territorial seas. Marine waters extend from this boundary out to a water depth of 200 m (656 ft).

Table 4.1.1-1 details impacting factors associated with oil and gas activities and the development phase in which they can occur. The following factors affecting water quality have been identified: disturbance of bottom sediments, wastes and disposal, vessel traffic, and accidental spills. The water quality stressor activities associated with oil and gas development are shown in Table 4.4.3-1.

The current Arctic NPDES General Permit for wastewater discharges from Arctic oil and gas exploration (No. AKG-33-0000) expired on June 26, 2011. USEPA will reissue separate NPDES exploration General Permits for the Beaufort Sea and the Chukchi Sea prior to the 2012 drilling season. USEPA expects that tribal consultation and public comment on the new proposed Arctic oil and gas exploration permits would occur in fall 2011. The USEPA Region 10 website will post updates to its website as they become available at http://yosemite.epa.gov/r10/water.nsf/npdes+permits/arctic-gp.

Common impacts on water quality in both coastal and marine areas include those from vessel traffic, well drilling, and operational discharges. The types of impacts expected are the same as those discussed above in Section 4.4.3.1.

4.4.3.3.1 Routine Operations.

Coastal Waters. Construction and installation of exploratory wells (up to 16 in the Beaufort Sea Planning Area and up to 20 in the Chukchi Sea Planning Area), development wells (up to 120 in the Beaufort Sea Planning Area and up to 280 in the Chukchi Sea Planning Area), subsea production wells (up to 10 in the Beaufort Sea Planning Area and up to 82 in the Chukchi Sea Planning Area), platforms (up to 4 in the Beaufort Sea Planning Area and up to 5 in the Chukchi Sea Planning Area), and offshore pipelines (up to 249 km [155 mi] in the Beaufort Sea Planning Area and up to 402 km [250 mi] in the Chukchi) would affect water quality. Such activities would disturb bottom sediments and increase the turbidity of the water in the area of the construction. Because pipelines in shallow waters are buried using a trenching method, installation would initially release sediment to the water column. Moderate impacts on water quality (i.e., turbidity) from such construction and installation activities would occur in the immediate area of the activity. These impacts would be local and short term as settling and mixing occurred.

Drilling muds and cuttings generated when installing exploration and delineation wells would be discharged at the well site. All drilling muds and cuttings associated with development and production wells would be treated and reinjected into the well. For exploration wells, the volume of drilling fluids and cutting vary depending upon the well characteristics, but, in general, fluids average approximately 500 bbl/well and drill cuttings would comprise the equivalent of approximately 600 tons/well of dry rock. Thus, under the proposed action, up to 8,000 bbl of drilling fluids and up to 9,600 tons of drill cuttings could be disposed of in the waters of the Beaufort Sea Planning Area and up to 10,000 bbl of drilling fluids and up to 12,000 tons of drill cuttings could be disposed of in the waters of the Chukchi Sea Planning Area. Discharge of drilling muds and cuttings would increase turbidity in the vicinity of the well. The discharge would contain trace metal and hydrocarbon constituents that would be suspended in the water column and subsequently deposited on the sea floor. These drilling discharges must comply with NPDES permit requirements regarding the discharge amount, rate, and toxicity, which would greatly reduce the impact to water quality.

Because of climatic conditions in the Arctic region, there would be a number of additional operations specific to the Arctic (e.g., constructing and maintaining ice roads [MMS 2002c] and ice islands). In addition to affecting the turbidity of coastal waters in the Arctic region, construction activities would also produce waste materials. Contaminants would also be released to the coastal waters during every ice breakup from fluids entrained in ice roads and ice islands (Skolnik and Holleyman 2005). Entrained contaminants from vehicle exhaust, grease, antifreeze, oil, and other vehicle-related fluids would pass directly into the sea at each breakup (MMS 2002c). These discharges are not expected to be major; however, they would occur throughout the life of a development area.

Construction of new onshore pipelines (up to 129 km [80 mi] in the Beaufort Sea Planning Area and none in the Chukchi Sea Planning Area) would also affect coastal water quality in the Arctic region. Proper siting of facilities and requirements associated with construction permits would largely mitigate these impacts. The impacts on water quality would range from negligible to minor, depending on site location and construction and mitigation activities.

The OCS service and construction vessel traffic to and from platform sites within the planning area (up to 12 vessel trips per week in the Beaufort Sea Planning Area and up to 15 vessel trips per week in the Chukchi Sea Planning Area) would also affect water quality through the permitted release of operational wastes. Compliance with applicable NPDES permits and USCG regulations would prevent or minimize most impacts on receiving waters.

Marine Waters. Routine operations that could affect marine water quality in the Arctic region include anchoring, mooring, drilling and well completion activities, well testing and cleanup operations, flaring/burning, facility installation and operations, support service activities, decommissioning, and site clearance. Activities such as dredging trenches for pipelines and constructing artificial islands would disturb the seafloor and increase the suspended sediment load in the water column. These suspended sediments have toxicity ranges that are generally described as nontoxic to slightly toxic (National Academy of Sciences 1983). Turbidity and plumes containing sediments would depend on the season, sediment grain size, the rate and duration of discharge within the disturbed areas, and the currents present. This additional suspended sediment load would be temporary, and impacts on water quality would be localized.

The majority of wastes generated during construction and development would consist of drill cuttings and spent muds (MMS 2002c). Drilling muds and cuttings generated when installing exploration and delineation wells would be discharged at the well site. All drilling muds and cuttings associated with development and production wells would be treated and reinjected into the well. Some waste also would be generated during operations from well-workover rigs. Domestic wastewater and produced waters generated by these activities would also be injected into the disposal well. Solid wastes, including scrap metal, would be hauled offsite for disposal at an approved facility. Impacts on water quality from these activities would be negligible.

Turbidity on a smaller scale would also result from retrieving anchors used to control the movement of vessels while dredging and setting pipes or placing platforms. These types of disturbances would not occur if drillships, which use dynamic positioning rather than anchors, were used, a standard procedure in Chukchi Sea exploration.

The OCS service and construction vessel traffic to and from platform sites within the planning area (up to 12 vessel trips per week in the Beaufort Sea Planning Area and up to 15 vessel trips per week in the Chukchi Sea Planning Area) would also affect water quality through the permitted release of operational wastes. Compliance with applicable NPDES permits and USCG regulations would prevent or minimize most impacts on receiving waters.

4.4.3.3.2 Accidents.

Coastal Waters. Accidental releases could affect the quality of coastal water in the Arctic region. The magnitude and severity of impacts would depend on the location of the spill, spill size, type of product spilled, weather conditions, and the water quality and environmental conditions at the time of the spill. Under the proposed action, the number and types of spills assumed to occur in the Arctic region include up to three large spills (i.e., ≥1,000 bbl): up to two spills at a volume of 1,700 bbl from pipelines and up to one spill at a volume of 5,000 bbl from a platform. Between 10 and 35 small spills with volumes between 50 and 999 bbl are assumed to occur and between 50 and 190 very small spills with volumes between 1 and 50 bbl (Table 4.4.2-1).

If a large spill were to occur in enclosed coastal waters or were driven by winds, tides, and currents into a semi-enclosed coastal area, water quality would be adversely affected. With limited wave and current activity in coastal waters, the oil would not be easily dispersed, and weathering could be slower than in the open sea (see discussion in Section 4.4.3.1.2). Under arctic conditions (i.e., cold water and cold air temperatures), weathering processes, such as volatilization, would also be much slower than in warmer climates (MMS 2008b); under calm conditions and cold temperatures in restricted waters, vertical mixing and dissolution would be reduced (MMS 2008b). If the spill were to occur on ice or under ice, oil would be trapped and essentially remain unchanged until breakup occurred and the ice began to melt. The volatile compounds from such a spill would be more likely to freeze into the ice within hours to days rather than dissolve or disperse into the water below the ice. A hydrocarbon plume in the water column underneath the ice could persist with concentrations that exceed ambient standards and background levels for a distance greater than that in the open sea (MMS 2008b). Impacts on coastal waters from a large spill would depend on the season, type and composition of the spill, weather conditions, and size of the spill.

Effects on water quality could persist even longer if oil were to reach coastal wetlands and be deposited in fine sediments, becoming a long-term source of pollution because of remobilization. In such locations, spill cleanup could be necessary for recovery of the affected areas. Shoreline cleanup operations could involve crews working with sorbents, hand tools, and heavy equipment. The magnitude and severity of impacts from such spills would depend on the nature of the coastal area associated with the spill, the spill size and composition, and the water quality and condition of resources affected by the spill.

Cleanup of large spills in the open sea could be hindered by several factors. There could be limited access to oil slicks contained between ice floes during a large part of the year. There could also be reduced oil flow into recovery devices because of increased viscosity and precipitation of wax crystals, as well as decreased oil adhesion to the recovery unit material and a high percentage of free water in the recovered product due to mixing of the oil slick with slash ice and snow (MMS 2008b). Impacts from the spill would again depend on the spill size and composition, weather conditions, and the location of the spill.

Small oil spills (<1,000 bbl) or very small oil spills (<50 bbl) would produce measurable impacts on water quality. Based on the assumption that all small and very small spills do not occur at the same time and place, water quality would rapidly recover without mitigation, due to mixing, dilution, and weathering.

Marine Waters. Under arctic conditions (i.e., cold water and air temperatures), weathering processes would be much slower than in warmer climates (MMS 2008b). Seasonality and the specific spill location would cause variability in effects (e.g., summer versus winter in the Beaufort and Chukchi Seas). If a spill were to occur, oil would be trapped and essentially remain unchanged until breakup occurred and the ice began to melt. The volatile compounds from such a spill would be more likely to freeze into the ice within hours to days rather than dissolve or disperse into the water below the ice. A hydrocarbon plume in the water column underneath the ice could persist with concentrations that are above ambient standards and background levels for a distance that would be five times greater than that in the open sea (MMS 2008b).

Small oil spills (<1,000 bbl) or very small oil spills (<50 bbl) would have measurable impacts on water quality. If it is assumed that all small and very small spills would not occur at the same time and place, water quality would rapidly recover without mitigation because of mixing, dilution, and weathering.

Spill Response and Cleanup. Spill response and cleanup activities in both coastal and marine waters could include, depending on location, use of chemical dispersants, *in situ* burning, use of vessels and skimmers, drilling of a relief well, and beach cleaning and booming (BOEMRE 2011k). Potential impacts to water quality from each of these spill response and cleanup activities are discussed above in Section 4.4.3.1.2. However, cleanup of large spills in the open sea within the Beaufort and Chukchi Seas could be hindered by several factors. There could be limited access to oil slicks contained between ice floes during a large part of the year. There could also be reduced oil flow into recovery devices because of increased viscosity and precipitation of wax crystals, as well as decreased oil adhesion to the recovery unit material and a high percentage of free water in the recovered product due to mixing of the oil slick with slash ice and snow (MMS 2008b). In winter, icebreakers could affect the movement of spilled oil that may be trapped beneath or in the ice (BOEMRE 2011k).

If an oil spill occurred in winter, *in situ* burning would be limited by the lack of open water to collect oil and open water in which to burn it. If burning could occur in winter on a limited scale, sea ice would melt in the immediate vicinity of the burn.

Catastrophic Discharge Event. For the Chukchi Sea Planning Area, a low-probability CDE could have a volume of between 1,400,000 and 2,200,000 bbl (Table 4.4.2-2). For the Beaufort Sea Planning Area, a catastrophic discharge event could have a volume of between 1,700,000 and 3,900,000 bbl (Table 4.4.2-2). A catastrophic discharge event in either coastal or marine waters could present sustained degradation of water quality from hydrocarbon contamination in exceedence of State and Federal water and sediment quality criteria. These effects could be significant depending upon the duration and area impacted by the spill. Additional effects on water quality could occur from response and cleanup vessels, *in situ* burning of oil, dispersant use, discharges and seafloor disturbance from relief well drilling, and activities on shorelines associated with cleanup, booming, beach cleaning, and monitoring.

Impacts from the event would again depend on the spill size and composition, weather conditions, and the location of the spill.

4.4.3.4 Conclusions

Overall coastal and marine water quality impacts due to routine operations and operational discharges under the proposed action would be unavoidable. Compliance with NPDES permit requirements would reduce or prevent most impacts on receiving waters caused by discharges from normal operations. Water quality would recover when discharges ceased because of dilution, settling, and mixing. Impacts on water quality from routine operations associated with the Program are expected to be minor to moderate.

Oil spills could reduce water quality, and these impacts would be unavoidable. In the presence of cold temperatures and ice, cleanup activities could be more difficult than in more temperate environments. The magnitude of the impacts would depend on the specific location affected and the nature and magnitude of the activity/accident. Small spills would be expected to result in short-term, temporary impacts on coastal and marine water quality. A large spill in coastal waters could result in longer term impacts on water quality, but cleanup efforts would reduce the likelihood of permanent impairment. A large spill in marine waters would be expected to have temporary impacts on water quality; however, cleanup efforts and evaporation, dilution, and dispersion would minimize the long-term impacts.

A catastrophic discharge event could present sustained degradation of water quality from hydrocarbon contamination in exceedence of State and Federal water and sediment quality criteria. These effects would be significant depending upon the duration and area impacted by the spill. Impacts from the event would again depend on the spill size and composition, weather conditions, and the location of the spill.

4.4.4 Potential Impacts on Air Quality

4.4.4.1 Gulf of Mexico

In the GOM west of 87.5° W longitude, OCS air emissions are regulated by BOEM according to 30 CFR 250.302-304. BOEM reviews projected air emissions information from an operator submitting a plan for exploration or development activities. If the projected annual emissions exceed a certain threshold, which is determined by the distance from shore, the operator needs to perform a modeling analysis to assess air quality impacts on onshore areas. If the modeled concentrations exceed defined significance levels in an attainment area, which is an area that meets the National Ambient Air Quality Standards (NAAQS), best available control technology would be required on the facility. If the affected area is classified nonattainment, further emission reductions or offsets may be required. Projected contributions to onshore pollutant concentrations are also subject to the same limits that the USEPA applies to the onshore areas under its Prevention of Significant Deterioration (PSD) program (MMS 2007c).

Facilities located east of 87.5° W longitude would be under the USEPA jurisdiction, which regulates air emissions as prescribed in 40 CFR Part 55. For facilities located within 40 km (25 mi) of a State's seaward boundary, the regulations are the same as would be applicable if the emission source were located in the corresponding onshore area and would include State and local requirements for emission controls, emission limitations, offsets, permitting, testing, and monitoring. For facilities located beyond 40 km (25 mi) of a State's seaward boundary, the basic Federal air quality regulations apply, which include the USEPA emission standards for new sources, the PSD regulations, and Title V permits. Both PSD and Title V requirements apply to major sources that, depending on the source type, could potentially emit more than either 100 tpy or 250 tpy of a criteria pollutant. Which threshold applies to a particular source, how the potential emissions are calculated, and what controls are required if the applicable threshold is exceeded are all issues determined in discussions with regulators during the air permit application and approval process (MMS 2007c).

The USEPA has established NAAQS for six criteria pollutants — nitrogen dioxide (NO_2), sulfur dioxide (SO_2), particulate matter (PM; PM_{10}, PM with an aerodynamic diameter of 10 μm or less; and $PM_{2.5}$, PM with an aerodynamic diameter of 2.5 μm or less), carbon monoxide (CO), lead (Pb), and ozone (O_3) — because of their potential adverse effects on human health and welfare. The health and environmental effects of air pollutants have been summarized by the USEPA (USEPA 2011a). Ambient levels of criteria pollutants except Pb can contribute to respiratory illnesses, especially in persons with asthma, children, and the elderly, and PM and CO can also aggravate cardiovascular diseases.

Ozone Formation. O_3 in the atmosphere is formed by photochemical reactions involving primarily nitrogen oxides (NO_x) and volatile organic compounds (VOCs). It is formed most readily in the summer season, with high temperatures, lower wind speeds, intense solar radiation, and an absence of precipitation; high O_3 episodes are typically associated with slow-moving, high-pressure systems characterized by light winds and a shallow boundary layer (NRC 1992). O_3 can irritate the respiratory system, reduce lung function, and aggravate asthma. Repeated exposure to O_3 pollution for several months may cause permanent lung damage. Children, adults who are active outdoors, and people with respiratory problems are the most at risk from high O_3. High levels of O_3 are also accompanied by a mix of organic radicals, which also causes adverse health effects. O_3 interferes with the ability of plants to produce and store food, which makes them more susceptible to disease, insects, other pollutants, competition, and harsh weather. It may also cause damage to the leaves of trees and other plants, thereby affecting the health and appearance of vegetation in cities, National Parks, and recreation areas. O_3 may reduce forest growth and crop yields, potentially affecting species diversity in ecosystems (USEPA 2011a).

Acid Deposition and Visibility. Gaseous pollutants undergo various chemical reactions in the atmosphere to form small particles, which remain airborne for extended periods of time. NO_x compounds react with ammonia and moisture to form ammonium nitrate particles, which contribute to $PM_{2.5}$ concentrations. SO_2 combines with moisture to form tiny sulfate particles, which may also contribute to adverse health effects. In addition, gaseous NO_x and SO_2 can dissolve into cloud water. These acidic chemicals eventually return to the ground in either wet (e.g., rain, snow) or dry (e.g., gases, particles) forms, commonly referred to as acid deposition or acid rain (USEPA 2011b). Dry deposition is equally as important as wet deposition. The deposition often takes place hundreds of kilometers from the source. Acid deposition can damage forests and crops, change the makeup of soil, and may, in some cases, make lakes and streams acidic and unsuitable for fish. Deposition of nitrogen from NO_x emissions also contributes to nitrogen load in water bodies, especially estuaries and near-coastal ecosystems. Acid deposition accelerates the decay of building materials and paints, including irreplaceable monuments, statues, sculptures, and other cultural resources. Particulate matter, including sulfate and nitrate particles and organic aerosols that form part of photochemical smog, significantly reduce atmospheric visibility in areas including National Parks, Monuments, and Wilderness Areas (USEPA 2011b).

In general, the most important source of visibility degradation is from $PM_{2.5}$ in the 0.1 to 1 μm size range, which covers the range of visible light (0.4–0.7 μm) (Malm 1999). These particles are directly emitted into the atmosphere through fuel burning. However, other sources arise through chemical transformation of NO_2, SO_2, and VOCs into nitrates, sulfates, and carbonaceous particles. Existing visibility in the eastern United States, including the GOM States, is impaired due to $PM_{2.5}$ containing primarily sulfates and carbonaceous material. High relative humidity (over 70%) can play an important factor in visibility impairment, especially in the GOM coastal areas, where relative humidity is higher than 70% throughout the year. These particles are generally hygroscopic, and thus the absorption of water by the particulate matter makes them grow to a size that enhances their ability to scatter light and hence aggravates visibility reduction. Over the open waters of the GOM, a study of visibility from platforms off Louisiana revealed that significant reductions in Louisiana coastal and offshore visibility are almost entirely due to transient natural occurrences of fog (Hsu and Blanchard 2005). Episodes of haze are short-lived and affect visibility much less. Offshore haze can result from plume drift generated from coastal sources (MMS 2007c).

4.4.4.1.1 Routine Operations.

Under the proposed action, construction and operation of up to 2,100 exploration and delineation wells, up to 2,600 development and production wells, and up to 12,100 km (7,500 mi) of new pipeline as well as up to 12 new pipeline landfalls, up to 6 new pipe yards, and up to 12 new natural gas processing facilities and the removal of up to 275 platforms with explosives will result in emissions that could affect air quality in the GOM. These activities would generate emissions from stationary sources at the drilling/well sites and from support vessels and aircraft over the 40- to 50-year period of the Program (Table 4.4.1-1). There could be up to 600 vessel trips/wk and 5,500 helicopter trips/wk under the proposed action.

Emissions. The type and relative amounts of air pollutants generated by offshore operations vary according to the phase of activity. There are three principal phases of oil and gas activities operations: exploration, development, and production. Activities affecting air quality include seismic surveys, drilling activities, platform construction and emplacement, pipeline laying and burial operations, platform operations, flaring, fugitive emissions, support vessel and helicopter operations, and evaporation of VOCs during transfers and spills. Principal emissions

TABLE 4.4.4-1 Estimated Highest Annual Air Emissions from OCS Activities in the Gulf of Mexico Planning Areas, Proposed 2012-2017 Leasing Program

	Pollutant (tons/yr)					
Activity	NO_x	SO_x	PM_{10}	$PM_{2.5}$	VOC	CO
Exploration/Delineation Well Drilling	15,359–29,403[a]	1,956–3,745	271–518	267–511	364–696	3,662–7,002
Development/Production Well Drilling	8,190–15,529	1,043–1,978	144–274	142–270	194–368	1,952–3,698
Platform Installation and Removal	540–998	77–142	18–21	18–23	18–23	98–129
Pipeline Installation	3,180–9,939	540–1,688	120–375	120–375	120–375	660–2,063
Production Platforms	11,634–21,887	284–535	108–204	107–202	7,432–13,981	13,031–24,514
Support Vessels	20,943–39,400	2,822–5,309	363–682	363–682	363–682	1,995–3,753
Helicopters	173–325	43–80	34–63	34–63	417–785	2,112–3,973
Tankers Loading	0–326	0–55	0–12	0–12	0–2,456	0–68
Tankers in Transit	0–7,035	0–853	0–107	0–107	0–2,164	0–586
Tankers Unloading	0–326	0–55	0–12	0–12	0–1,162	0–68
Total	60,019–125,167	6,765–14,440	1,058–2,268	1,051–2,257	8,907–22,692	23,510–45,853

[a] The range of values reflects the low and high end of the exploration and development scenarios for the Program.

Source: Herkhof 2011; Wilson et al. 2010.

of concern are the criteria pollutants and their precursors: NO_x, sulfur oxides (SOx),[13] PM_{10} and $PM_{2.5}$, CO, and VOC. Releases of toxic chemicals could be a concern around oil spills and *in situ* burning and especially during accidental releases of hydrogen sulfide (H_2S) at platforms.

Wilson et al. (2010) provided a comprehensive emission inventory of oil and gas activities in the GOM for the year 2008, showing that support vessels and platforms rank first and second, respectively, as NO_x emitters with natural gas engines being the largest source on platforms. Support vessels are the largest SO_x emitters, while the drilling rigs also emit significant SO_x. Albeit small, the primary SO_x sources on platforms are diesel engines used in drilling. The largest sources of PM_{10} are support vessels, drilling rigs, and production platforms. VOCs come mostly from production platforms, where the primary sources are cold vents, followed by fugitive sources. Fugitive sources include oil and gas processing, pump and compressor seals, valves, connectors, and storage tanks. Natural gas engines on platforms account a considerable portion of CO emissions (Wilson et al. 2010).

Air emissions from the proposed action were estimated using the most recently available exploration and development scenario for 2012-2017, as shown in Table 4.4.4-1. These emissions were estimated by BOEM (Herkhof 2011) using emission factors from the *2008 Gulfwide Emission Inventory Study* (Wilson et al. 2010).

In terms of absolute amounts, the largest emissions would be NO_x followed by CO, with lesser amounts of VOC, SO_x, PM_{10}, and $PM_{2.5}$ in order of descending emissions. Under both the high and low scenarios, support vessels would be the largest source of NO_x, SO_x, PM_{10}, and $PM_{2.5}$ and production platforms would be the largest source of VOC and CO. Emissions from the Program would initially be lower in the first few years as exploratory wells were drilled and platforms started producing oil and gas. During the last half of the Program, emissions would decrease as production decreased and some platforms were removed (MMS 2007c).

It is estimated that about 10% of the crude oil produced in deep water in the GOM would be transported to shore via tanker, while in shallow waters about 1% of production would be transported by barge. The transport of crude oil would result in VOC emissions from loading operations and breathing losses during transit. VOC emissions would also occur during unloading and ballasting in port. There would also be emissions of NO_x, SO_2, and PM_{10} from the ships' engines (MMS 2007c).

Impacts on Criteria Pollutants Other Than Ozone. BOEM performed a cumulative air quality modeling analysis of platform emissions in a portion of the GOM in 1992 (MMS 1997b). The area modeled included most of the coastline of Louisiana and extended eastward to include coastal Mississippi and Alabama. Facility emissions were obtained from the emissions inventory used in the GOM air quality study (MMS 1995b). The emission values were multiplied by a factor of 1.4 to account for growth. The modeled onshore annual average NO_2 concentrations were generally somewhat greater than 1 microgram per cubic meter ($\mu g/m^3$). The highest values appeared in the Mississippi River Delta region, where a maximum

[13] Sulfur dioxide (SO_2) belongs to the family of sulfur oxides (SO_x). For emissions, SO_2 accounts for most of SO_x, and thus these are used interchangeably.

concentration of 6 μg/m^3 was calculated, which is 6% of the national standard for NO_2. The highest predicted annual, maximum 24-hr, and maximum 3-hr average SO_2 concentrations were 1.1, 13, and 98 μg/m^3, respectively. These values are 1, 4, and 7% of the NAAQS for the respective averaging periods. Modeling was not performed for PM_{10} or $PM_{2.5}$, but the concentrations would be lower because of lower emission rates. The projected emissions for the proposed action would be lower than the emissions used in the modeling and scattered further offshore; thus, the impacts would be correspondingly lower. Existing concentrations of NO_2, SO_2, PM_{10}, and $PM_{2.5}$ in the GOM coast States are well within the NAAQS, so emissions from the proposed action would not result in any exceedance of the NAAQS.

The highest predicted NO_2 and SO_2 concentrations in the 1992 emissions modeling were well within the maximum allowable PSD Class II increments for those pollutants. Any concentrations resulting from the emissions associated with the proposed action should also be within the PSD Class II increments.

The maximum allowable increase for the annual average NO_2 concentration in the Class I Breton National Wilderness Area (NWA) is 2.5 μg/m^3. The highest predicted annual average NO_2 concentration in Breton from the year 1992 emission sources was 3.6 μg/m^3, which exceeds the Class I increment and indicates that the question of increment consumption at Breton NWA could be of concern (MMS 2007c, 1997b).

The highest predicted SO_2 concentrations in Breton NWA were 0.3, 4.5, and 9.7 μg/m^3 for the annual, maximum 24-hr average, and maximum 3-hr average concentrations, respectively. The maximum allowable concentration increases for PSD Class I areas are 2.0, 5.0, and 25 μg/m^3, respectively. Based on this result, SO_2 concentrations from the proposed action would be within the Class I maximum allowable increases (MMS 1997b, 2007c).

Comparing Impacts to PSD Increments

Several points should be considered when air quality impacts are compared to PSD increments. First, the PSD program applies to individual sources, not programs. Emissions from an individual source such as a platform or set of platforms could differ from the emissions being modeled in a particular study. Second, increment tracking is a cumulative process that sets a maximum allowable increase above a baseline concentration. It is unlikely that a permitting agency would permit a single source to consume all of the increment. Last, PSD applies only to major sources, generally sources with the potential to emit more than 250 tons/yr, except for the 100 tons/yr threshold for 28 source categories. OCS oil and gas production activities are subject to a 250 tons/yr threshold. Regardless of the *actual* emissions, a source's *potential* emissions could exceed the 250 tons/yr threshold. Determining potential emissions and available PSD increment allowances requires consultation with the cognizant regulators.

Because of continuing concern about the combined impact of offshore and onshore emission sources on the PSD Class I increments in Breton NWA, BOEMRE has collected an emission inventory for OCS facilities located within 100 km (62 mi) of the Breton Class I area. A modeling study (2000–2001) to the baseline years (1977 for SO_2 and 1988 for NO_2) revealed that none of the allowable SO_2 or NO_2 increments had been fully consumed (Wheeler et al. 2008). The maximum annual, 24-hr, and 3-hr SO_2 increments consumed with the Breton NWA were –1.07, 1.18, and 1.80 μg/m^3, respectively. A decrease in annual SO_2 concentration resulted from a general decrease in SO_2 emissions from onshore and offshore sources since 1977. The maximum allowable concentration increases for PSD Class I areas are 2.0, 5.0, and 25 μg/m^3, respectively. The maximum annual NO_2 increment consumed within the Breton NWA was 0.10 μg/m^3, for which the maximum allowable NO_2 increment is 2.5 μg/m^3. In addition, the BOEM consults with the U.S. Fish and Wildlife Service (USFWS), the Federal land manager of the Breton NWA area, for plans within 100 km (62 mi) of Breton that exceed a certain emission threshold. Mitigation measures, such as the use of low-sulfur fuel, may be applied (MMS 2007c).

No modeling has been performed for CO. In OCS waters, CO emission sources less than about 7,000 tons/year would not have any significant effect on onshore air quality and are exempt from air quality review under BOEM air quality regulations (MMS 2007c). This is based on air quality modeling that was performed to support the BOEM air quality rules. As shown in Table 4.4.4-1, CO emissions from the proposed action are higher than 7,000 tons/year. However, CO emissions are comparable to NO_2 and SO_2 emissions, and their associated impacts are well within the NAAQS discussed above. In addition, CO standards (40,000 and 10,000 μg/m^3 for 1- and 8-hr averages, respectively) are more than one order of magnitude higher than those for NO_2 and SO_2. Therefore, no significant impacts from CO associated with the proposed action would be anticipated.

Impacts on Ozone. As discussed in MMS (2007c), the impacts from OCS activities on O_3 were evaluated in the GOM air quality study (MMS 1995b). The study focused on the O_3 nonattainment areas in southeast Texas and the Baton Rouge, Louisiana, areas. It was determined through modeling that OCS sources contributed little to onshore O_3 concentrations in either of these areas. At locations where the model predicted 1-hr average O_3 levels above 120 parts per billion (ppb), which was then the NAAQS, the OCS emissions contributed less than 2 ppb to the total concentrations. These contributions occurred in only a small geographic area during any particular episode. At locations where the model predicted O_3 levels were much less than 120 ppb, the highest OCS contributions were about 6–8 ppb. When the modeling was performed after doubling the OCS emissions, the highest OCS contributions at locations where the predicted O_3 levels exceeded the standard was 2–4 ppb.

Again, as noted in MMS (2007c), more recent O_3 modeling was performed using a preliminary GOM-wide emissions inventory for the year 2000 to examine the O_3 impacts with respect to the 1997 8-hr O_3 standard of 80 ppb (effective May 27, 2008, the 8-hr O_3 standard was lowered to 75 ppb). One modeling study focused on the coastal areas of Louisiana extending eastward to Florida (Haney et al. 2004). This study showed that the impacts of OCS emissions on onshore O_3 levels were very small, with the maximum contribution of 1 ppb or less at locations where the standard was exceeded. The other modeling effort dealt with O_3 levels in southeast Texas (Yarwood et al. 2004). The results of this study indicated a maximum contribution of 0.2 ppb or less to areas exceeding the standard.

Due to the complex, nonlinear nature of the photochemical production of ozone in the atmosphere, changing emissions of ozone precursors by a given percentage may not produce a corresponding percentage change in O_3 concentrations. However, the projected emissions from the proposed action would be smaller than the emissions used in the models to ensure that contributions to O_3 levels from actions associated with the proposed action would be smaller than the figures above.

Impacts on Visibility. The application of the VISCREEN visibility screening model (USEPA 1992) to individual OCS facilities has shown that the emissions are not large enough to significantly impair visibility. It is not known to what extent aggregate OCS sources contribute to visibility reductions. However, the individual emission sources from the proposed action are relatively small and scattered over a large area, and it is not expected that they would have a measurable impact on acid deposition or visibility. The impacts on visibility would be negligible (MMS 2007c).

Greenhouse Gas Emissions and Climate Change. Estimates were made of the total greenhouse gas (GHG) emissions of CO_2, CH_4, and N_2O for all projected OCS oil and gas Program activities (Herkhof 2011). Emission estimates for the various activities were largely based on a comprehensive inventory of air emissions from oil and gas activities in the GOM for 2008 (Wilson et al. 2010). Air emissions resulting from the Program were estimated by considering the exploration and development scenarios presented in Table 4.4.4-1. Emissions are given in terms of teragrams (Tg) of CO_2-equivalent, where one Tg is 10^{12} g (10^6 metric tons). This measure takes into account a global warming potential (GWP) factor, which accounts for the relative effectiveness of a gas to contribute to global warming with respect to the same amount CO_2. In these calculations, CH_4 is given a GWP of 21, while N_2O is given a GWP of 310.

Table 4.4.4-2 lists the total calculated emissions of CO_2, CH_4, and N_2O from activities associated with the Program and compare them with current (2009) U.S. greenhouse gas emissions from all sources (USEPA 2011l). The projected CO_2 emissions from the Program are about 0.068–0.14% of all current CO_2 emissions in the United States. The Program CH_4 emissions are about 0.087–0.17% of the current CH_4 emissions in the United States, which is slightly higher than that for CO_2. The projected N_2O emissions from the Program are about 0.009–0.020% of all current N_2O emissions in the United States. If CO_2, CH_4, and N_2O emissions are combined, the Program emissions are about 0.067–0.14% and 0.066–0.13% of the Nationwide total of three GHG emissions and of all GHG emissions, respectively. The estimated total global GHG emissions in 2005 were approximately 38,726 Tg CO_2-equivalent (74 FR 66539). The estimated Program GHG emissions are about 0.011–0.023% of the total global GHG emissions.

As noted in Section 3.3, GHG emissions are one of the causes of climate change. Climate change is a global phenomenon and predicting climate change impacts requires consideration of large scale or even worldwide GHG emissions, not just emissions at a local level. Climate change predictive capability (modeling) lacks the ability to estimate the impact of GHGs from a particular source or sources such as oil and gas activities associated with the Program. What their impact, if any, would be is determined not only by the emissions from the oil and gas activities themselves, but also by the GHG emissions of other sources throughout the world and whether these other emissions are expected to increase or decrease. In addition, since some GHG gases, such as CO_2, may persist in the atmosphere for up to a century, the potential impacts of any source may extend well beyond the active lifetime of the source or program. This

TABLE 4.4.4-2 Projected Greenhouse Gas Emissions from Oil and Gas Activities in the Gulf of Mexico Planning Areas, 2012-2017 Leasing Program

Pollutant	2012-2017 Program ($Tg\ CO_2$-equivalent)[a]	Total 2009 U.S. Emissions from All Sources ($Tg\ CO_2$-equivalent)	2012-2017 Program as Percentage of Total 2009 U.S. Emissions
CO_2	3.75–7.65	5,505.2	0.068–0.39
CH_4	0.59–1.14	686.3	0.087–0.166
N_2O	0.03–0.06	295.6	0.009–0.020
$CO_2 + CH_4 + N_2O$	4.37–8.85	6,487.1	0.067–0.136
All GHG[b]	4.37–8.85	6,633.2[b]	0.066–0.133

[a] One Tg is equal to 10^{12} g, or 10^6 metric tons. The CO_2-equivalent for a gas is derived by multiplying the mass of the gas by the associated GWP, which accounts for the relative effectiveness of a gas to contribute to global warming with respect to the same amount CO_2. In these calculations, CH_4 is given a GWP of 21, while N_2O is given a GWP of 310.

[b] Total U.S. GHG emissions also include hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride emissions. Estimates of emissions from the Program were not made for these compounds, but they are assumed to be very small.

Source: USEPA 2011l; Herkhof 2011.

said, given the small percentage contributions of oil and gas activities in the GOM to global GHG emissions, the potential impact on climate change would probably be small. Section 3.3 provides some baseline considerations for climate change and Section 4.4.3 and Sections 4.4.6 through 4.4-15 discuss potential impacts to specific impact areas.

4.4.4.1.2 Accidents.

Under the proposed action, the number and types of spills assumed to occur in the GOM include up to eight large spills (≥1,000 bbl) from both pipeline and platforms including one tanker spill and between 235 and 470 small spills (<1,000 bbl) over the 40- to 50-year period of the Program (Table 4.4.2-1). Evaporation of oil from these spills and emissions from spill response and cleanup activities including *in situ* burning, if used, have the potential to affect air quality in the GOM.

Spills and *In Situ* Burning. Evaporation of small accidental oil spills would cause small, localized increases in VOCs. Most of the emissions would occur within a few hours of the spill and would decrease after that period. Large spills would result in emissions over a large area and a longer period of time. Hanna and Drivas (1993) modeled the emissions of various hydrocarbon compounds from a large spill. A number of these compounds, including BTEX and hexane, are classified by the USEPA as hazardous air pollutants. The results showed that these compounds evaporate almost completely within a few hours after the spill occurs. Ambient concentrations peak within the first several hours after the spill starts and are reduced by two orders of magnitude after about 12 hr. The heavier compounds take longer to evaporate and may not peak until about 24 hr after spill occurrence. Total ambient VOC concentrations are significant in the immediate vicinity of an oil spill, but concentrations are much reduced after the first day (MMS 2007c). Spreading of the spilled oil and action by winds, waves, and currents would further disperse VOC concentrations to extremely low levels over a relatively larger area. Concentrations of criteria pollutants would remain well within NAAQS (MMS 2008b).

Diesel fuel oil could be spilled either in transit or from accidents involving vehicles, vessels, or equipment. A diesel spill would evaporate faster than a crude oil spill. Ambient hydrocarbon concentrations would be higher than those of a crude oil spill but would persist for a shorter time. Also, because any such spill probably would be smaller than some potential crude oil spills, any air quality effects from a diesel spill likely would be lower than those for other spills (MMS 2008b).

In situ burning of spilled crude or diesel would generate a plume of black smoke and emissions of NO_2, SO_2, CO, PM_{10}, and $PM_{2.5}$ that would temporarily affect air quality, but the effects would be small. Fingas et al. (1995) describe the results of a monitoring program of a burn experiment at sea. The program involved extensive ambient measurements during two experiments in which approximately 300 bbl of crude oil was burned. During the burn, CO, SO_2, and NO_2 were measured only at background levels and were frequently below detection levels. Ambient levels of VOCs were high within about 100 m (328 ft) of the fire, but were significantly lower than those associated with a nonburning spill. It appeared that a major portion of these compounds was consumed in the burn. Effects of *in situ* burning for spilled diesel fuel would be similar to those associated with a crude oil spill (MMS 2008b).

A significant component of the pollution from a fire would be soot. Soot would cling to plants near the fire but would tend to clump and wash off vegetation in subsequent rains. Potential contamination of shoreline and onshore vegetation would be limited, however, because oil and gas activities under the proposed action would be at least 15 km (8 NM) offshore, with the exception of any oil- or gas-transport pipelines (MMS 2008b).

Smoke from burning crude oil would contain PAHs. Benzo(a)pyrene, which often is used as an indicator of the presence of carcinogenic varieties of PAHs, is present in crude oil smoke in very small amounts, but in quantities approximately three times larger than in unburned oil (Evans 1988). Investigators have found that, overall, the oily residue in smoke plumes from crude oil is mutagenic, although not highly so. McGrattan et al. (1995) modeled smoke plumes associated with *in situ* burning. Modeling has shown that the surface concentrations of particulate matter do not exceed the health criterion of 150 $\mu g/m^3$ beyond about 5 km (3 mi) downwind of an *in situ* burn. This result appears to be supported by field experiments conducted off Newfoundland and in Alaska (MMS 2007c). This is quite conservative, as this health standard is based on a 24-hr average concentration rather than a 1-hr average concentration.

Catastrophic Discharge Events. In the GOM, a low-probability CDE event could range in size from 900,000 and 7,200,000 bbl, and have a duration of 30–90 days (Table 4.4.2-2). Evaporation of oil from these spills and emissions from spill response and cleanup activities including *in situ* burning, if used, have the potential to affect air quality in the GOM.

In a catastrophic discharge event, oil may be burned to prevent it from entering sensitive habitats. During an *in situ* burn, the conditions exist (i.e., incomplete hydrocarbon combustion and the presence of chlorides in seawater) such that dioxins and furans could potentially form. (Dioxins and furans are a family of extremely persistent chlorinated compounds that magnify in the food chain, and dioxins are a group of potentially cancer-causing chemicals.) A total of 410 controlled burns (corresponding to about 5% of the total leaked oil) were conducted during the DWH event (Lubchenco 2010). Measurements of dioxins and furans during the DWH event *in situ* burning were made and their emission factors were derived (Aurell and Gullett 2010). The estimated levels of dioxins and furans produced by the *in situ* burns were similar to those from residential woodstove fires and slightly lower than those from forest fires, according to USEPA researchers (Schaum et al. 2010), and thus, concerns about bioaccumulation in seafood were alleviated. The reports found that while small amounts of dioxins were created by the burns, the levels that workers and residents would have been exposed to were below USEPA's levels of concern.

The effects of a catastrophic discharge event on public health and the environment can be classified as short-term and long-term effects. The short-term effects include watery and irritated eyes, skin itching and redness, coughing, and shortness of breath or wheezing.

Although there are relatively few studies on air quality impacts to human health following oil spills, some lessons can be learned from the 1991 Kuwaiti oil field fires and the effects of oil burning during the DWH event. In the Kuwaiti event, 600 oil wells were set on fire. These burnings produced a composite smoke plume of gaseous constituents (e.g., NO_X, SO_X, CO_2, etc.), acid aerosols, VOCs, metal compounds, PAHs, and particulate matter. Military personnel deployed to the Persian Gulf War have reported a variety of symptoms attributed to their exposures, including asthma and bronchitis, but Lange et al. (2002) did not find that exposures to oil fire smoke caused respiratory symptoms among veterans.

There would be some residual air quality impacts after the well is capped or "killed." As most of the oil would have been burned, evaporated, or weathered over time, air quality would return to pre-oil spill conditions. While impacts on air quality are expected to be localized and temporary, adverse effects that may occur from the exposure of humans and wildlife to air pollutants could have long-term consequences (BOEMRE 2011).

Hydrogen Sulfide. An accidental release of H_2S in the atmosphere could present a serious hazard to platform workers and persons in close proximity to a platform. H_2S concentrations of 20 ppm, the OSHA ceiling level that must not be exceeded during any part of the workday, causes irritation to exposed persons within minutes and concentrations of 500 ppm are deadly. All OCS operators involved in production of sour gas or oil that could result in atmospheric H_2S concentrations above 20 ppm are required to file an H_2S Contingency Plan with BOEM. The plan contains measures to prevent serious injury or death to personnel. Under a worst-case scenario of an accidental release at a very large facility with a throughput of 100 million cubic feet of gas per day with high H_2S concentration levels (on the order of 20,000 ppm), near-calm wind, and stable atmospheric conditions, the H_2S levels are predicted to be 500 ppm at about 1 km (0.6 mi) from the facility and 20 ppm at several kilometers from the source (MMS 2001c). Most "sour gas" facilities have H_2S concentrations below 500 ppm, which would result in H_2S levels of 20 ppm that are confined to an area within the dimensions of a typical platform (MMS 2007c).

In the case of an aquatic H_2S release, the gas is soluble in water, so a small gas leak would result in almost complete dissolution into the water column. Larger leaks would result in less dissolution and could result in release into the atmosphere if the surrounding waters reach saturation. Because the oxidation of H_2S in water takes place slowly, there should not be any appreciable zones of hypoxia. H_2S levels can have adverse impacts on mammals, birds, and fish (MMS 2001c).

4.4.4.2 Alaska – Cook Inlet

The OCS facilities located off the coast of Alaska would be under the jurisdiction of the USEPA, which regulates air emissions as prescribed in 40 CFR Part 55. For facilities located within 40 km (25 mi) of a State's seaward boundary, the regulations are the same as would be applicable if the emission source were located in the corresponding onshore area, and would include State and local requirements for emission controls, emission limitations, offsets, permitting, monitoring, testing, and reporting. For facilities located more than 40 km (25 mi) from a State's seaward boundary, the basic Federal air quality regulations apply, including the USEPA emission standards for new sources, PSD regulations, and Title V permits. Both PSD and Title V requirements apply to major sources that, depending on the source type, could potentially emit more than either 100 tons/yr or 250 tons/yr of a criteria pollutant. Which threshold applies to a particular source, how the potential emissions are calculated, and what controls are required if the applicable threshold is exceeded are all issues determined in discussions with regulators during the air permit application and approval process.

The USEPA has established NAAQS for six criteria pollutants — NO_2, SO_2, PM_{10} and $PM_{2.5}$, CO, Pb, and O_3 — because of their potential adverse effects on human health and welfare. The health and environmental effects of air pollutants have been summarized by the USEPA (USEPA 2011a). Ambient levels of criteria pollutants other than Pb can contribute to respiratory illnesses, especially in persons with asthma, children, and the elderly, and PM and CO can also aggravate cardiovascular diseases.

Ozone Formation. O_3 in the atmosphere is formed by photochemical reactions involving primarily NO_x and VOCs. It is formed most readily in the summer season, with high temperatures, lower wind speeds, intense solar radiation, and an absence of precipitation; high-O_3 episodes are typically associated with slow-moving, high-pressure systems characterized by light winds and shallow boundary layers (NRC 1992). However, conditions in Alaska are seldom favorable for significant O_3 formation, primarily due to low ambient temperature. At Kodiak, for example, the highest monthly mean daily maximum of 61.0°F occurs in August, when the highest temperature is 86°F (NCDC 2011a).

Acid Deposition and Visibility. Gaseous pollutants undergo various chemical reactions in the atmosphere to form small particles, which remain airborne for extended periods of time. NO_x compounds react with ammonia and moisture to form ammonium nitrate particles, which contribute to $PM_{2.5}$ concentrations. SO_2 combines with moisture to form tiny sulfate particles, which may also contribute to adverse health effects. In addition, gaseous NO_x and SO_2 can dissolve into cloud water. These acidic chemicals eventually return to the ground in either wet (e.g., rain, snow) or dry (e.g., gases, particles) forms, commonly referred to as acid deposition or acid rain (USEPA 2011b). Dry deposition and wet deposition are equally important. The deposition often takes place hundreds of miles from the source. Acid deposition can damage forests and crops, change the makeup of soil, and in some cases may make lakes and streams acidic and unsuitable for fish. Deposition of nitrogen from NO_x emissions also contributes to nitrogen load in water bodies, especially estuaries and near-coastal ecosystems. Acid deposition accelerates the decay of building materials and paints, including those of irreplaceable monuments, statues, sculptures, and other cultural resources. Particulate matter, including sulfate and nitrate particles and organic aerosols that form part of photochemical smog, significantly reduce atmospheric visibility. Atmospheric pollutants adversely affect visibility in many national parks and monuments, as well as wilderness areas (USEPA 2011b).

The most important source of visibility degradation is from $PM_{2.5}$ in the 0.1- to 1-μm size range, which covers the range of visible light (0.4–0.7 μm) (Malm 1999). These particles are directly emitted into the atmosphere through fuel burning. However, other sources arise through the chemical transformation of NO_2, SO_2, and VOCs into nitrates, sulfates, and carbonaceous particles. Existing visibility in Alaska is generally good because of the absence of large emission sources.

Arctic Haze. Arctic haze is a reduction in visibility that often appears in distinct bands at different heights. It was initially observed during weather reconnaissance flights in the High Arctic. The haze is seasonal, with a peak in the spring, and originates from anthropogenic sources outside the Arctic. The most severe episodes occur when stable high-pressure systems produce clear, calm weather; these episodes can reduce visibility (~30.6 km [~19 mi]) in spite of the otherwise clear weather. Coal burning appears to be the principle source of haze particles. Haze particles consist of sulfate (up to 90%), soot, and sometimes dust, most of which originate in Eurasia and are picked up by the Arctic airmass that moves northward over the North Pole in winter. The cold, dry air in the polar regions allows particles to remain airborne for weeks, thus permitting the contaminants to spread over the Arctic and into North America. Arctic haze reduces visibility, but the levels of sulfur compounds in haze are lower than those found in heavily polluted cities (AMAP 1997).

4.4.4.2.1 Routine Operations. The Cook Inlet OCS experiences open-water conditions throughout the year, except in small northern portions of the planning area from January to March (MMS 2003a).

Under the proposed action, construction and operation of up to 12 exploration and delineation wells, up to 114 development and production wells, up to 241 km (150 mi) of new offshore pipeline, up to 169 km (105 mi) of new onshore pipeline, and up to 1 new pipeline landfall will result in emissions that could affect air quality in Cook Inlet. These activities would generate emissions from stationary sources at the drilling/well sites and from support vessels and aircraft over the 40-year period of the Program (Table 4.4.1-3). There could be up to 3 vessel trips/wk and 3 helicopter trips/wk under the proposed action.

Emissions. The type and relative amounts of air pollutants generated by offshore operations vary according to the phase of activity. There are three principal phases of OCS operations: exploration, development, and production. Activities affecting air quality include seismic surveys; drilling activities; platform construction and emplacement; pipeline laying and burial operations; platform operations; flaring; fugitive emissions; support vessel and helicopter operations; and evaporation of VOCs during transfers and spills. Principal emissions of concern are the criteria pollutants and their precursors: NO_x, SO_2, PM_{10}, and $PM_{2.5}$, CO, and VOCs.

Releases of toxic chemicals could be a concern around oil spills and *in situ* burning and especially during accidental releases of H_2S at platforms. Other sources of pollutants related to OCS operations are accidents such as losses of well control and oil spills. Spill emissions consist primarily of VOCs, while fires and *in situ* burning produce criteria pollutants along with hazardous air pollutants.

Air emissions from the proposed action in the Cook Inlet were estimated using the most recent available exploration and development scenarios for 2012–2017 as shown in Table 4.4.4-3. These emissions were estimated by BOEM (Herkhof 2011) using emission factors from the *2008 Gulfwide Emission Inventory Study* (Wilson et al. 2010). Although the study is specific to the GOM, these factors should be applicable in the Cook Inlet, since many of the same types of sources are involved in oil and gas activities in both areas.

TABLE 4.4.4-3 Estimated Highest Annual Air Emissions from OCS Activities in the Cook Inlet Planning Area, Proposed 2012-2017 Leasing Program

	Pollutant (tons/yr)					
Activity	NO_x	SO_x	PM_{10}	$PM_{2.5}$	VOC	CO
Exploration/Delineation Well Drilling	38–38[a]	8–8	3–3	3–3	7–7	0–0
Development/Production Well Drilling	229–382	46–77	16–27	16–27	41–68	1–2
Platform Installation and Removal	213–213	31–31	5–5	5–5	5–5	28–28
Pipeline Installation	331–663	56–113	13–25	13–25	13–25	69–138
Production Platforms	53–53	1–1	0–0	0–0	34–34	60–60
Support Vessels	96–96	13–13	2–2	2–2	2–2	9–9
Helicopters	1–1	0–0	0–0	0–0	2–2	10–10
Tankers Loading	0–0	0–0	0–0	0–0	0–0	0–0
Tankers in Transit	0–0	0–0	0–0	0–0	0–0	0–0
Tankers Unloading	0–0	0–0	0–0	0–0	0–0	0–0
Total	961–1,445	156–243	39–62	39–62	103–143	177–246

[a] The range of values reflects the low and high end of the exploration and development scenarios for the Program.

Source: Herkhof 2011; Wilson et al. 2010.

Oil and gas activity emissions from the Program for the Cook Inlet are relatively small in comparison to those other planning areas. For all pollutants under both low and high scenarios, Cook Inlet emissions are 4% or less of the GOM emissions. They are up to 12% of Arctic regions emissions. In terms of absolute amount, the main emissions would be NO_x followed by CO, with lesser amounts of SO_x, VOCs, PM_{10} and $PM_{2.5}$ in order of descending emissions. Emissions from the Program would initially be lower in the first few years as exploratory wells were drilled and platforms started producing oil and gas. During the last half of the 40-yr Program, emissions would decrease as production decreased and some platforms were removed (MMS 2007c).

Impacts on Criteria Pollutants Other Than Ozone. Air quality modeling for NO_2, SO_2, and PM_{10} were conducted for a lease sale in the Cook Inlet Planning Area (MMS 2003a). Potential air quality impacts were estimated by using the Offshore and Coastal Dispersion model for both exploratory drilling and a production facility. Potential emission sources were placed so as to maximize potential air quality impacts on the Tuxedni Wilderness Area (WA), which is a PSD Class I area in the Cook Inlet. The highest predicted NO_2 concentration in the Tuxedni WA was 0.27 $\mu g/m^3$, about 11% of PSD Class I maximum allowable increment of 2.5 $\mu g/m^3$. For SO_2, the highest predicted annual average, maximum 24-hr, and maximum 3-hr average concentrations in the Tuxedni WA were 0.02, 0.58, and 2.7 $\mu g/m^3$, respectively, for which PSD Class I incremental limits are 2, 5, and 25 $\mu g/m^3$. For PM_{10}, the highest annual average and 24-hr average concentrations in Tuxedni WA were predicted to be 0.02 and 0.51 $\mu g/m^3$, for which PSD Class I incremental limits are 4 and 8 $\mu g/m^3$. The highest onshore pollutant concentrations were lower than or comparable to those in the Tuxedni WA and thus less than the NAAQS and the PSD Class II incremental limits.

Comparing Impacts to PSD Increments

Several points should be considered when air quality impacts are compared to PSD increments. First, the PSD program applies to individual sources, not programs. Emissions from an individual source such as a platform or set of platforms could differ from the emissions being modeled in a particular study. Second, increment tracking is a cumulative process that sets a maximum allowable increase above a baseline concentration. It is unlikely that a permitting agency would permit a single source to consume the entire increment. Last, PSD applies only to major sources, generally sources with the potential to emit more than 250 tons/yr, except the 100 tons/yr threshold for 28 source categories. OCS oil and gas production activities are subject to a 250 tons/yr threshold. Regardless of the *actual* emissions, a source's potential emissions could exceed the 250 tons/yr threshold. Determining *potential* emissions and available PSD increment allowances require consultation with the cognizant regulators.

Each project in the Program would apply the best available control technology according to USEPA and State regulations, and pollutant concentrations would have to meet the PSD incremental limits. Existing pollutant concentrations in the Cook Inlet are well within the NAAQS (MMS 2003a). The small additional concentrations from the Program would result in levels that are still well within the NAAQS.

Impacts on Ozone. As noted above, conditions in Alaska are seldom favorable for significant O_3 formation because of the low ambient temperature. Precursor emissions NO_x and VOCs are relatively small, and a significant increase in O_3 concentrations onshore is not likely to result from oil and gas activities associated with the proposed action. OCS activities would also be relatively small and separated from each other, diminishing the combined effects from these activities and greatly increasing atmospheric dispersion of pollutants before they reach shore. The proposed activities would not be expected to cause any exceedances of the O_3 standard (MMS 2008b).

Impacts on Visibility. A number of visibility screening runs were performed using the VISCREEN model to evaluate potential effects of oil and gas activities on visibility in the Tuxedni WA (MMS 2003a). For an exploration project located 12 km (7.5 mi) distant from the Tuxedni WA, the model results exceed the screening criteria when the wind blows directly from the facility to the Tuxedni WA, under the worst-case meteorological conditions with a wind speed of 1 m/s (2.2 mph) and stable atmosphere. If the screening criteria are exceeded, it indicates the possibility that a plume generated by the emissions would be visible by an observer within Tuxedni WA. However, it does not provide a measure of any general visibility effects in the area, such as regional haze. It is estimated that this scenario would occur less than 1% of the time. For distances larger than 50 km (31 mi), the screening criteria were not exceeded. Under average meteorological conditions, it is estimated that a plume would not be visible.

Given that oil and gas sources are relatively small and would be scattered over a large area, it is not expected that they would have a measureable impact on visibility. However, a more refined analysis might be needed during the permitting process to more precisely evaluate any effects of oil and gas activities on visibility.

Greenhouse Gas Emissions. Estimates were made of the total GHG emissions of CO_2, CH_4, and N_2O for all projected activities associated with the Program (Herkhof 2011). Emission estimates for the various activities were largely based on a comprehensive inventory of air emissions from oil and gas activities in the GOM for 2008 (Wilson et al. 2010). Air emissions resulting from the Program were estimated by considering the exploration and development scenarios presented in Table 4.4.1-3. Emissions are given in terms of Tg of CO_2-equivalent, where 1 Tg is 10^{12} g (10^6 metric tons). This measure takes into account a GWP factor that accounts for the relative effectiveness of a gas to contribute to global warming with respect to the same amount of CO_2. In these calculations, CH_4 is given a GWP of 21, while N_2O is given a GWP of 310.

Table 4.4.4-4 lists the total calculated emissions of CO_2, CH_4, and N_2O from activities associated with the Program and compares them with current (2009) U.S. greenhouse gas emissions from all sources (USEPA 2011l). The projected CO_2 emissions from the Program are about 0.0025–0.0038% of all current CO_2 emissions in the United States. The Program CH_4 and N_2O emissions are about 0.0004% or less of the current their respective emissions in the United States. If CO_2, CH_4, and N_2O emissions are combined, the Program emissions are about 0.0022–0.0033% and 0.0021–0.0032% of the nationwide total of three GHG emissions and of all GHG emissions, respectively. The estimated total global GHG emissions in 2005 were approximately 38,726 Tg CO_2-equivalent (74 FR 66539). The estimated Program GHG emissions are about 0.00036–0.00055% of the total global GHG emissions.

TABLE 4.4.4-4 Projected Greenhouse Gas Emissions from Oil and Gas Activities in the Cook Inlet Planning Area, 2012-2017 Leasing Program

Pollutant	2012-2017 Program (Tg CO_2-equivalent)[a]	Total 2009 U.S. Emissions from All Sources (Tg CO_2-equivalent)	2012-2017 Program as Percentage of Total 2009 U.S. Emissions
CO_2	0.1363–0.2100	5,505.2	0.00247–0.00382
CH_4	0.0028–0.0028	686.3	0.00041–0.00041
N_2O	0.0006–0.0010	295.6	0.00021–0.00032
$CO_2 + CH_4 + N_2O$	0.1397–0.2138	6,487.1	0.00215–0.00330
All GHG[b]	0.1397–0.2138	6,633.2[b]	0.00211–0.00322

[a] One Tg is equal to 10^{12} g, or 10^6 metric tons. The CO_2-equivalent for a gas is derived by multiplying the mass of the gas by the associated GWP, which accounts for the relative effectiveness of a gas to contribute to global warming with respect to the same amount CO_2. In these calculations, CH_4 is given a GWP of 21, while N_2O is given a GWP of 310.

[b] Total U.S. GHG emissions also include hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride emissions. Estimates of emissions from the Program were not made for these compounds, but they are assumed to be very small.

Source: USEPA 2011l; Herkhof 2011.

As noted in Section 3.3, GHG emissions are one of the causes of climate change. Climate change is a global phenomenon and predicting climate change impacts requires consideration of large-scale or even worldwide GHG emissions, not just emissions at a local level. Climate change predictive capability (modeling) lacks the ability to estimate the impact of GHGs from a particular source or sources such as oil and gas activities associated with the Program. What their impact, if any, would be is determined not only by the emissions from the oil and gas activities themselves, but also by the GHG emissions of other sources throughout the world and whether these other emissions are expected to increase or decrease. In addition, since some GHG gases, such as CO_2, may persist in the atmosphere for up to a century, the potential impacts of any source may extend well beyond the active lifetime of the source or program. This said, given the small percentage contributions of oil and gas activities in Cook Inlet to global GHG emissions, the potential impact on climate change would probably be small. Section 3.3 provides some baseline considerations for climate change and Section 4.4.3 and Sections 4.4.6 through 4.4-15 discuss potential impacts on specific impact areas.

4.4.4.2.2 Accidents. Under the proposed action, the number and types of spills assumed to occur in Cook Inlet include up to one large spill (≥1,000 bbl) from either a pipeline or platform and between 8 and 18 small spills (<1,000 bbl) over the 40-year period of the Program (Table 4.4.2-1). Evaporation of oil from these spills and emissions from spill response and cleanup activities including *in situ* burning, if used, have the potential to affect air quality in Cook Inlet.

Spills and *In Situ* Burning. Small accidental oil spills would cause small, localized increases in concentrations of VOCs because of evaporation of the spill. Most of the emissions would occur within a few hours of the spill and would decrease drastically after that period. Large spills would exhibit similar behavior but would affect a somewhat larger area and cause elevated pollutant concentrations to persist somewhat longer. Hanna and Drivas (1993) modeled the emissions of various hydrocarbon compounds from a large spill. A number of these compounds, including BTEX and hexane, are classified by the USEPA as hazardous air pollutants. Many of these contaminants may be carcinogenic to humans and/or animals. The results showed that these compounds evaporate almost completely within a few hours after the spill occurs. Ambient concentrations peak within the first several hours after the spills starts and are reduced by two orders of magnitude after about 12 hr. The heavier compounds take longer to evaporate and may not peak until about 24 hr after spill occurrence. Total ambient VOC concentrations are significant in the immediate vicinity of an oil spill, but concentrations are much reduced after the first day (MMS 2007c). There is no information about any possible effect from the inhalation of air contaminants by subsistence animals, but this effect would be expected to be much less than any contamination by contact with hazardous compounds in the water. These effects on subsistence are described in Section IV.B.3.k of MMS (2007c).

In situ burning is a potential technique for cleanup and disposal of spilled oil. *In situ* burning of a spill results in emissions of NO_2, SO_2, CO, and PM_{10} and generates a plume of black smoke. Fingas et al. (1995) describes the results of a monitoring program of a burn experiment at sea. The program involved extensive ambient measurements during two experiments in which approximately 300 bbl of crude oil was burned. It found that during the burn, CO, SO_2, and NO_2 were measured only at background levels and were frequently below detection levels. Ambient levels of VOCs were high within about 100 m (328 ft) of the fire but significantly lower than those associated with a nonburning spill. Measured concentrations of PAHs were low. It appeared that a major portion of these compounds was consumed in the burn. The appearance of a black plume from *in situ* burning around a subsistence hunting area could have an adverse effect on subsistence hunting practices because of the creation of a perception that wildlife has been contaminated. Subsistence hunters may avoid areas where such incidents have occurred.

McGrattan et al. (1995) modeled smoke plumes associated with *in situ* burning. The results showed that the surface concentrations of particulate matter did not exceed the health criterion of 150 $\mu g/m^3$ beyond about 5 km (3 mi) downwind of an *in situ* burn. This appears to be supported by field experiments conducted off Newfoundland and in Alaska (MMS 2007c). This is quite conservative because this health standard is based on a 24-hr average concentration rather than a 1-hr average concentration.

Air quality impacts from accidental oil spills in open water during the proposed action would be similar to those described above. However, albeit limited to a small northern area and short duration (January to March), a spill in Cook Inlet during broken ice or melting ice conditions could result in more concentrated emissions over a smaller area than would be the case under open-water conditions because the ice would act to reduce spreading of the oil compared to the spreading of a spill in open water. An oil spill on solid sea ice would spread relatively slowly compared to a spill in open water. The more volatile components of the oil would evaporate rather rapidly, but the heavier compounds would linger on the surface. The effects on air quality would result in more concentrated emissions over a smaller area than would be the case for a spill in open water.

Catastrophic Discharge Event. In the Cook Inlet Planning Area, a low-probability CDE could range in size from 75,000 and 125,000 bbl, with a duration of 50–80 days (Table 4.4.2-2). Evaporation of oil from these spills and emissions from spill response and cleanup activities including *in situ* burning, if used, have the potential to affect air quality in Cook Inlet.

The air impacts of a CDE and any associated *in situ* burning in the Cook Inlet would be similar to those open water impacts discussed in Section 4.4.4.1.2. Potential impacts from a large spill under the ice are discussed in the "Spills and *In Situ* Burning" subsection above.

A CDE in South Central Alaska could emit regulated pollutants into the atmosphere. This may cause major air quality impacts during some phases of the event. The greatest impacts on air quality conditions would occur during the initial explosion of gas and oil and during the spill response and cleanup, particularly if the event occurs during the winter. Impacts could continue for days during the initial event and could continue for months during spill response and clean up. Therefore, while the impacts may be major during these two phases, overall, the emissions from a CDE would be temporary and, over time, air quality in South Central Alaska would return to pre-oil-spill conditions (BOEMRE 2011k).

Hydrogen Sulfide. An accidental release of H_2S at a platform and its associated impacts on platform workers and persons in close proximity to a platform are discussed in detail in Section 4.4.4.1.2 for the GOM. Potential impacts at or around the platform would be similar in the Cook Inlet.

4.4.4.3 Alaska – Arctic

General air emission sources and potential impacts on ambient air quality associated with OCS oil and gas activities are covered in detail in Section 4.4.4.1 for the GOM. Air quality impacts for both the Beaufort and the Chukchi Seas are similar and are discussed together. Differences are noted where appropriate.

The OCS facilities located off Alaska would be under the jurisdiction of the USEPA, which regulates air emissions as prescribed in 40 CFR Part 55. For facilities located within 40 km (25 mi) of a State's seaward boundary, the regulations are the same as would be applicable if the emission source were located in the corresponding onshore area, and would include State and local requirements for emission controls, emission limitations, offsets, permitting, testing, and monitoring. For facilities located more than 40 km (25 mi) from a State's seaward boundary, the basic Federal air quality regulations apply, which include the USEPA emission standards for new sources, the PSD regulations, and Title V permits. Both PSD and Title V requirements apply to major sources that, depending on the source type, could potentially emit more than either 100 tpy or 250 tpy of a criteria pollutant. Which threshold applies to a particular source, how the potential emissions are calculated, and what controls are required if the applicable threshold is exceeded are all issues determined in discussions with regulators during the air permit application and approval process (MMS 2007c).

The USEPA has established NAAQS for six criteria pollutants — NO_2, SO_2, PM_{10} and $PM_{2.5}$, CO, Pb, and O_3 — because of their potential adverse effects on human health and welfare. The health and environmental effects of air pollutants have been summarized by the USEPA (USEPA 2011a). Ambient levels of criteria pollutants other than Pb can contribute to respiratory illnesses, especially in persons with asthma, children, and the elderly, and PM and CO can also aggravate cardiovascular diseases.

Ozone Formation. O_3 in the atmosphere is formed by photochemical reactions involving primarily NO_x and VOCs. It is formed most readily in the summer season, with high temperatures, lower wind speeds, intense solar radiation, and an absence of precipitation; high-O_3 episodes are typically associated with slow-moving, high-pressure systems characterized by light winds and shallow boundary layers (NRC 1992). However, conditions in Alaska are seldom favorable for significant O_3 formation, primarily due to low ambient temperature. At Barrow, for example, the highest monthly mean daily maximum of 45.9°F occurs in July, when the highest temperature is 79°F (NCDC 2011b).

Acid Deposition and Visibility. Gaseous pollutants undergo various chemical reactions in the atmosphere to form small particles, which remain airborne for extended periods of time. NO_x compounds react with ammonia and moisture to form ammonium nitrate particles, which contribute to $PM_{2.5}$ concentrations. SO_2 combines with moisture to form tiny sulfate particles, which may also contribute to adverse health effects. In addition, gaseous NO_x and SO_2 can dissolve into cloud water. These acidic chemicals eventually return to the ground in either wet (e.g., rain, snow) or dry (e.g., gases, particles) forms, commonly referred to as acid deposition or acid rain (USEPA 2011b). Dry deposition is just as important as wet deposition. The deposition often takes place hundreds of miles from the source. Acid deposition can damage forests and crops, change the makeup of soil, and in some cases may make lakes and streams acidic and unsuitable for fish. Deposition of nitrogen from NO_x emissions also contributes to nitrogen load in water bodies, especially estuaries and near-coastal ecosystems. Acid deposition accelerates the decay of building materials and paints, including those of irreplaceable monuments, statues, sculptures, and other cultural resources. Particulate matter, including sulfate and nitrate particles and organic aerosols that form part of photochemical smog, significantly reduce atmospheric visibility. Atmospheric pollutants adversely affect visibility in many of national parks and monuments, and in wilderness areas (USEPA 2011b).

The most important cause of visibility degradation is from $PM_{2.5}$ in the 0.1- to 1-μm size range, which covers the range of visible light (0.4–0.7 μm) (Malm 1999). These particles are directly emitted into the atmosphere through fuel burning. However, other sources arise through chemical transformation of NO_2, SO_2, and VOCs into nitrates, sulfates, and carbonaceous particles. Existing visibility in Alaska is generally good because of the absence of large emission sources. However, the phenomenon of arctic haze, which occurs in Arctic Alaska during the winter and spring, is caused primarily by long-range transport of pollutants from industrial Eurasia (Rahn 1982).

Arctic Haze. Arctic haze is a reduction in visibility that often appears in distinct bands at different heights. It was initially observed during weather reconnaissance flights in the High Arctic. The haze is seasonal, with a peak in the spring, and originates from anthropogenic sources outside the Arctic. The most severe episodes occur when stable high pressure systems produce clear, calm weather and can reduce visibility (~30.6 km [~19 mi]) in spite of the otherwise clear weather. Coal burning appears to be the principle source of haze particles. Haze particles consists of sulfate (up to 90%), soot, and sometimes dust, most of which originate in Eurasia and are picked up by the Arctic airmass that moves northward over the North Pole in winter. The cold, dry air in the polar regions allows particles to remain airborne for weeks, thus permitting the contaminants to spread over the Arctic and into North America. Arctic haze reduces visibility, but the levels of sulfur compounds in haze are lower than those found in heavily polluted cities (AMAP 1997).

4.4.4.3.1 Routine Operations. OCS operations in the Arctic Ocean are unique in a number of ways because of the sea ice that is present much of the year. In waters 5–10 m (16–33 ft) deep, exploratory wells may be drilled from an ice or gravel island (MMS 2003e). Construction of an ice island would need to take place in winter (November–January), and material and personnel would be carried to the site by vehicles operating on an ice road. In water 10–20 m (33–66 ft) deep, movable platforms attached to the seafloor may be used for exploration. Drilling operations from these platforms are usually conducted during open-water season from July through October. Ice islands are not projected for the Chukchi Sea, because activities there would not occur close to shore. In deeper waters, drillships or floating platforms would be used, and drilling would be limited less than 4 months during the summer. Material and supplies would be ferried using barges or supply boats. In addition, icebreakers would operate in the vicinity of the drilling rig and vessels to control incursions of sea ice. Because of the arctic conditions, the pace of development is slower as activities are limited to certain rather narrow time frames. Air emission rates tend to be higher because activities are more concentrated and additional vessels such as icebreakers may be needed. In shallow waters, production may take place from gravel islands, while in deeper waters production facilities would be installed on large gravity-base platforms. As in the case of exploration, a gravel island would be constructed during winter. The modules for production facilities would be installed during the ice-free period using barges, tugboats, and supply vessels (MMS 2007c).

Under the proposed action, construction and operation of up to 36 exploration wells, up to 400 production wells, up to 92 subsea wells, up to 652 km (405 mi) of new offshore pipeline, and up to 129 km (80 mi) of new onshore pipeline will result in emissions that could affect air quality in the Arctic Alaska. These activities would generate emissions from stationary sources at the drilling/well sites and from support vessels and aircraft over the 50-year period of the Program (Table 4.4.1-4). There could be up to 27 vessel trips/wk and 27 helicopter trips/wk under the proposed action.

Emissions. The type and relative amounts of air pollutants generated by offshore operations vary according to the phase of activity. There are three principal phases of OCS operations: exploration, development, and production. Activities affecting air quality include seismic surveys; drilling activities; platform construction and emplacement; pipeline laying and burial operations; platform operations; flaring; fugitive emissions; support vessel and helicopter operations; and evaporation of VOCs during transfers and spills.

Releases of toxic chemicals could be a concern around spills and during *in situ* burning and especially during accidental releases of H_2S at platforms. Other sources of pollutants related to OCS operations are accidents such as losses of well control and oil spills. Spill emissions consist primarily of VOCs, while fires and *in situ* burning produce criteria pollutants along with hazardous air pollutants.

Air emissions from the proposed action for the Beaufort Sea and the Chukchi Sea were estimated by using the most recent available exploration and development scenarios for 2012–2017, as shown in Table 4.4.4-5. These emissions were estimated by BOEM (Herkhof 2011) using emission factors from the *2008 Gulfwide Emission Inventory Study* (Wilson et al. 2010). Although the study is specific to the GOM, these factors should be applicable in the Arctic region, since many of the same types of sources are involved in oil and gas activities in both areas.

In terms of absolute amount, the main emissions would be NO_x, followed by CO, with lesser amounts of VOCs, SO_2, PM_{10}, and $PM_{2.5}$. Tankers in transit are projected to be the largest source of emissions associated with oil and gas activities in the Arctic. However, much of the emissions would be at some distance from the lease areas. For sources located in or near the lease areas, platform installation and removal would be the largest source of NO_x, SO_x, PM_{10}, and $PM_{2.5}$ emissions under the low scenario, while pipeline installation would be the largest source of these pollutants under the high scenario. Production platforms would be the largest source of VOC and CO emissions under both scenarios. Emissions from the Program would initially be lower in the first few years as exploratory wells were drilled and platforms started producing oil and gas. During the last half of the Program, emissions would decrease as production decreased and some platforms were removed (MMS 2007c).

Impacts on Criteria Pollutants Other Than Ozone. Air quality modeling using the Offshore and Coastal Dispersion Model (OCD) has been performed in past studies to assess impacts from planned lease sales in the Beaufort Sea (MMS 1996). The highest predicted onshore annual average NO_2 concentrations were in the range of 0.5–1.5 $\mu g/m^3$, which is well below the PSD Class II maximum allowable increment of 25 $\mu g/m^3$. Concentrations of SO_2 and PM_{10} were not modeled; however, when the results are scaled according to the respective emission rates, the levels would be below the PSD Class II maximum allowable increments.

An examination of the air quality modeling analysis performed for the Northstar facility and proposed Liberty development project in the Beaufort Sea provides a measure of the expected impacts over water near an OCS production facility on a gravel island in the Beaufort Sea. The highest predicted concentrations for NO_2, SO_2, and PM_{10} for the Northstar and Liberty projects occurred within 200 m (656 ft) of the facility boundary and were close to but still lower than PSD Class II maximum allowable increments (MMS 2002c; USACE 1999). The highest onshore concentrations were considerably lower. The combined facility concentrations for Liberty plus background were well within NAAQS (between 2 and 30% of the standards).

TABLE 4.4.4-5 Estimated Highest Annual Air Emissions from OCS Activities in the Arctic (Beaufort and Chukchi Seas) Planning Area, Proposed 2012-2017 Leasing Program

	Pollutant (tons/yr)					
Activity	NO_x	SO_x	PM_{10}	$PM_{2.5}$	VOC	CO
Exploration/Delineation Well Drilling	1,977–1,977[a]	512–512	89–89	82–82	86–86	2–2
Development/Production Well Drilling	535–1,375	108–279	38–97	38–97	96–246	2–6
Platform Installation and Removal	925–1,851	217–435	37–73	34–67	32–64	29–58
Pipeline Installation	398–861	68–146	15–33	15–33	15–33	83–179
Production Platforms	53–106	1–3	0–1	0–1	34–68	60–119
Support Vessels	96–191	13–26	2–3	2–3	2–3	9–18
Helicopters	1–2	0–0	0–0	0–0	2–4	10–19
Tankers Loading (Valdez)	47–158	8–27	2–6	2–6	878–2,955	10–33
Tankers in Transit	6,016–20,253	1,022–3,439	227–764	227–764	1,264–4,256	1,249–4,203
Tankers Unloading (West Coast Port)	47–158	8–27	2–6	2–6	440–1,481	10–33
Total	10,095–26,933	1,957–4,893	411–1,072	401–1,059	2,848–9,194	1,462–4,669

[a] The range of values reflects the low and high end of the exploration and development scenarios for the Program.

Source: Herkhof 2011; Wilson et al. 2010.

Results of OCD modeling for development from a proposed lease sale in the Chukchi Sea indicated that the highest annual average NO_2 concentration was 1.29 μg/m^3, which is about 5% of PSD Class II maximum allowable increment of 25 μg/m^3 (MMS 1991). No modeling was performed for SO_2 and PM_{10}, but concentration should be well within the PSD Class II increments considering that NO_x emissions are an order of magnitude higher than SO_2 and PM_{10} emissions.

These activities in the Arctic Alaska are not anticipated to affect Class I areas in Alaska, which are several hundred miles away.

Comparing Impacts to PSD Increments

Several points should be considered when air quality impacts are compared to PSD increments. First, the PSD program applies to individual sources, not programs. Emissions from an individual source such as a platform or set of platforms could differ from the emissions being modeled in a particular study. Second, increment tracking is a cumulative process that sets a maximum allowable increase above a baseline concentration. It is unlikely that a permitting agency would permit a single source to consume all the increment. Last, PSD applies only to major sources, generally sources with the potential to emit more than 250 tons/yr, other than the 100 tons/yr threshold for 28 source categories. OCS oil and gas production activities are subject to 250 tons/yr threshold. Regardless of the *actual* emissions, a source's *potential* emissions could exceed the 250 tons/yr threshold. Determining potential emissions and available PSD increment allowances requires consultation with the cognizant regulators.

The most significant source of industrial emissions in the Arctic Alaska, the Prudhoe Bay-Kuparuk-Endicott oil-production complex, was the subject of monitoring programs during 1986–1987 and from 1990 through 1996. Five monitoring sites were selected; three were considered subject to maximum air pollutant concentrations, and two were considered more representative of the air quality of the general Prudhoe Bay area. All the values meet Federal and State ambient air quality standards. These results indicate that ambient pollutant concentrations from oil and gas activities, even for sites subject to maximum concentrations, are likely to meet the ambient air quality standards (MMS 2008b).

The Program would result in a rather slow rate of development involving a small number of facilities that would be spread over a wide area. Each project would apply the best available control technology according to USEPA and State regulations, and pollutant concentrations would have to meet the PSD incremental limits. Existing pollutant concentrations in coastal Alaska are well within the NAAQS. The small additional concentrations from the Program would result in levels that are still well within the NAAQS.

Impacts on Ozone. As noted above, conditions in Alaska are seldom favorable for significant O_3 formation. Precursor NO_x and VOC emissions are relatively small, and a significant increase in O_3 concentrations onshore is not likely to result from oil and gas activity scenarios associated with the proposed action. Although sunshine is present in the Beaufort Sea program area most of each day during summer, temperatures remain relatively low. At a number of air-monitoring sites in the Prudhoe Bay and Kuparuk areas, O_3 measurements show that the highest 1-hr maximum O_3 concentrations generally are in the range of 0.04–0.09 ppm. The highest 8-hr average ozone concentrations would be well below the NAAQS of 0.075 ppm. Because the projected O_3 precursor emissions from any of the proposed activities are considerably lower than the existing emissions from the Prudhoe Bay-Kuparuk-Endicott complex, the proposed activities would not be expected to cause any violations of the O_3 standard (MMS 2008b).

Impacts on Visibility. For the proposed Liberty Project in the Beaufort Sea, British Petroleum (Exploration) Alaska (BPXA) ran the VISCREEN model, which calculates the potential impact of a plume of specified emissions for specific transport and dispersion conditions (MMS 2002c). It found noticeable effects on a limited number of days, ones that had the most restrictive meteorological conditions, but no effects at all during average meteorological conditions. This model tends to overestimate impacts, and it is not known to what extent OCS sources contribute to the predicted visibility reductions. The OCS sources are relatively small and would be scattered over a large area. It is not expected that they would have a measureable impact on visibility. Overall, the impacts from the proposed action would be expected to be small or negligible (MMS 2007c).

Greenhouse Gas Emissions. Estimates were made of the total GHG emissions of CO_2, CH_4, and N_2O for all projected activities associated with the Program (Herkhof 2011). Emission estimates for the various activities were largely based on a comprehensive inventory of air emissions from oil and gas activities in the GOM for 2008 (Wilson et al. 2010). Air emissions resulting from the Program were estimated by considering the exploration and development scenarios presented in Table 4.4.1-4. Emissions are given in terms of Tg of CO_2-equivalent, where 1 Tg is 10^{12} g (10^6 metric tons). This measure takes into account a GWP factor, which accounts for the relative effectiveness of a gas to contribute to global warming with respect to the same amount CO_2. In these calculations, CH_4 is given a GWP of 21, while N_2O is given a GWP of 310.

Table 4.4.4-6 lists the total calculated emissions of CO_2, CH_4, and N_2O from activities associated with the Program and compares them with current (2009) U.S. GHG emissions from all sources (USEPA 2011l). The projected CO_2 emissions from the Program are about 0.014–0.038% of all current CO_2 emissions in the United States. Both the projected CH_4 and N_2O emissions from the Program are about 0.002–0.006% of all their current respective emissions in the United States. If CO_2, CH_4, and N_2O emissions are combined, the Program emissions are about 0.013–0.033% and 0.012–0.032% of the Nationwide total of three GHG emissions and of all GHG emissions, respectively. The estimated total global GHG emissions in 2005 were approximately 38,726 Tg CO_2-equivalent (74 FR 66539). The estimated Program GHG emissions are about 0.002–0.006% of the total global GHG emissions.

As noted in Section 3.3, GHG emissions are one of the causes of climate change. Climate change is a global phenomenon and predicting climate change impacts requires consideration of large scale or even worldwide GHG emissions, not just emissions at a local level. Climate change predictive capability (modeling) lacks the ability to estimate the impact of GHGs from a particular source or sources such as oil and gas activities associated with the Program. What their impact, if any, would be is determined not only by the emissions from the oil and gas activities themselves, but also by the GHG emissions of other sources throughout the world and whether these other emissions are expected to increase or decrease. In addition, since some GHG gases, such as CO_2, may persist in the atmosphere for up to a century, the potential impacts of any source may extend well beyond the active lifetime of the source or program. This

TABLE 4.4.4-6 Projected Greenhouse Gas Emissions from Oil and Gas Activities in the Arctic (Beaufort and Chukchi Seas) Planning Area, 2012-2017 Leasing Program

Pollutant	2012-2017 Program (Tg CO_2-equivalent)[a]	Total 2009 U.S. Emissions from All Sources (Tg CO_2-equivalent)	2012-2017 Program as Percentage of Total 2009 U.S. Emissions
CO_2	0.80–2.07	5,505.2	0.014–0.038
CH_4	0.01–0.04	686.3	0.002–0.006
N_2O	0.006–0.019	295.6	0.002–0.006
$CO_2 + CH_4 + N_2O$	0.82–2.14	6,487.1	0.013–0.033
All GHG[b]	0.82–2.14	6,633.2b	0.012–0.032

[a] One Tg is equal to 10^{12} g or 10^6 metric tons. The CO_2-equivalent for a gas is derived by multiplying the mass of the gas by the associated GWP, which accounts for the relative effectiveness of a gas to contribute to global warming with respect to the same amount CO_2. In these calculations, CH_4 is given a GWP of 21, while N2O is given a GWP of 310.

[b] Total U.S. GHG emissions also include hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride emissions. Estimates of emissions from the Program were not made for these compounds, but they are assumed to be very small.

Source: USEPA 2011l; Herkhof 2011.

said, given the small percentage contributions of oil and gas activities in Arctic region to global GHG emissions, the potential impact on climate change would probably be small. Section 3.3 provides some baseline considerations for climate change and Section 4.4.3 and Sections 4.4.6 through 4.4-15 discuss potential impacts to specific impact areas.

4.4.4.3.2 Accidents. Under the proposed action, the number and types of spills assumed to occur in Arctic Alaska include up to 3 large spills (≥1,000 bbl) from pipelines or platforms and between 60 and 225 small spills (<1,000 bbl) over the 50-year period of the Program (Table 4.4.2-1). Evaporation of oil from these spills and emissions from spill response and cleanup activities including *in situ* burning, if used, have the potential to affect air quality in the Arctic Alaska.

Spills and *In Situ* Burning. Small accidental oil spills would cause small, localized increases in concentrations of VOCs because of evaporation of the spill. Most of the emissions would occur within a few hours of the spill and would decrease drastically after that period. Large spills would exhibit similar behavior but would affect a somewhat larger area and cause elevated pollutant concentrations to persist somewhat longer. Hanna and Drivas (1993) modeled the emissions of various hydrocarbon compounds from a large spill. A number of these compounds, including BTEX and hexane, are classified by the USEPA as hazardous air pollutants. Many of these contaminants may be carcinogenic to humans and/or animals. The results showed that these compounds evaporate almost completely within a few hours after the spill occurs. Ambient concentrations peak within the first several hours after the spills starts and are reduced by two orders of magnitude after about 12 hr. The heavier compounds take longer to evaporate and may not peak until about 24 hr after spill occurrence. Total ambient VOC concentrations are significant in the immediate vicinity of an oil spill, but concentrations are much reduced after the first day (MMS 2007c). There is no information about any possible effect from the inhalation of air contaminants by subsistence animals, but this effect would be expected to be much less than any contamination by contact with hazardous compounds in the water. These effects on subsistence are described in Section IV.B.3.k of MMS (2007c).

In situ burning is a potential technique for cleanup and disposal of spilled oil. *In situ* burning of a spill results in emissions of NO_2, SO_2, CO, and PM_{10} and generates a plume of black smoke. Fingas et al. (1995) describes the results of a monitoring program of a burn experiment at sea. The program involved extensive ambient measurements during two experiments in which approximately 300 bbl of crude oil was burned. It found that during the burn, CO, SO_2, and NO_2 were measured only at background levels and were frequently below detection levels. Ambient levels of VOCs were high within about 100 m (328 ft) of the fire, but were significantly lower than those associated with a nonburning spill. Measured concentrations of PAHs were low. It appeared that a major portion of these compounds was consumed in the burn. The appearance of a black plume from *in situ* burning around a subsistence hunting area could have an adverse effect on subsistence hunting practices because of the creation of a perception that wildlife has been contaminated. Subsistence hunters may avoid areas where such incidents have occurred.

McGrattan et al. (1995) modeled smoke plumes associated with *in situ* burning. The results showed that the surface concentrations of particulate matter did not exceed the health criterion of 150 $\mu g/m^3$ beyond about 5 km (3 mi) downwind of an *in situ* burn. This appears to be supported by field experiments conducted off Newfoundland and in Alaska (MMS 2007c). This is quite conservative as this health standard is based on a 24-hr average concentration rather than a 1-hr average concentration.

Air quality impacts from accidental oil spills in open water during the proposed action would be similar to those described above. However, a spill in the Arctic during broken ice or melting ice conditions could result in more concentrated emissions over a smaller area than would be the case under open-water conditions because the ice would act to reduce spreading of the oil compared to the spreading of a spill in open water. An oil spill on solid sea ice would spread relatively slowly compared to a spill in open water. The more volatile components of the oil would evaporate rather rapidly, but the heavier compounds would linger on the surface. The effects on air quality would result in more concentrated emissions over a smaller area than would be the case for a spill in open water.

Catastrophic Discharge Event. In the Arctic, a low-probability CDE could range in size from 1,700,000 and 3,900,000 bbl with a duration of 60–300 days in the Beaufort Planning Area, and from 1,400,000 and 2,100,000 bbl with a duration of 40–75 days in the Chukchi Planning Area (Table 4.4.2-2). Evaporation of oil from these spills and emissions from spill response and cleanup activities including *in situ* burning, if used, have the potential to affect air quality in Arctic Alaska.

The air impacts of a CDE and any associated *in situ* burning in the Arctic would be similar to impacts discussed in Section 4.4.4.1.2. Potential impacts from a large spill under the ice are discussed in the "Spills and *In Situ* Burning" subsection above.

A CDE in Arctic Alaska could emit regulated pollutants into the atmosphere. This may impact local air quality during some phases of the event. The greatest impacts on air quality conditions would occur during the initial explosion of gas and oil and during spill response and clean up, particularly if the event occurs during the winter. Impacts could continue for days during the initial event and could continue for months during spill response and clean up. Therefore, while the impacts may be large during these two phases, overall, the emissions from a CDE would be temporary and, over time, air quality in Arctic Alaska would return to pre-oil-spill conditions (BOEMRE 2011k).

Hydrogen Sulfide. An accidental release of H_2S at a platform and its associated impacts on platform workers and persons in close proximity to a platform are discussed in detail in Section 4.4.4.1.2 for the GOM. Potential impacts at or around the platform would be similar in Arctic Alaska.

4.4.4.4 Conclusions

Routine Program operations in any of the GOM and Alaska Planning Areas would result in levels of NO_2, SO_2, PM_{10}, and CO that are well within NAAQS. The incremental concentrations of NO_2, SO_2, and PM_{10} would be within the maximum allowable PSD increases. Routine Program activities were modeled to contribute less than 1% of the total O_3 concentrations from all OCS oil and gas activities in the GOM, where at some locations, concentrations from all sources (OCS-related and non-OCS sources) exceed standards at times; no exceedance of O_3 standards are expected in the Cook Inlet and Arctic Planning Areas. Therefore, impacts to air quality from routine operations associated with the Program are expected to be minor.

Air quality impacts from large and small accidental oil spills or *in situ* burning would be localized and short-term. Air quality impacts from a large spill (and especially from a CDE) would emit regulated pollutants into the atmosphere. This may cause localized large air quality impacts during some phases of the event. The greatest impacts on air quality conditions would occur during the initial explosion of gas and oil and during the spill response and cleanup, particularly if the spill occurs during the winter. Impacts could continue for days during the initial event and could continue for months during spill response and cleanup. Therefore, while the impacts may be large at times, overall, the emissions from a CDE would be temporary and, over time, air quality would return to pre-oil-spill conditions.

4.4.5 Potential Impacts on the Acoustic Environment

This section identifies impact producing factors and potentially impacted resources (such as marine mammals). Details on impacted resources (such as individual species) are provided in the specific resource sections of Chapter 4.

4.4.5.1 Introduction

The BOEM has screened seismic, deep-tow sonar, electromagnetic survey, geological and geological sampling, remote sensing, and marine magnetic survey activities for potential impacts on marine mammals; sea turtles; fishes; commercial, personal, and recreational fisheries; coastal and marine birds; benthic communities; cultural resources; subsistence uses of natural resources; military uses; and recreational and commercial diving in the GOM (BOEM unpublished), but did not cover other routine operations such as construction, drilling, explosives, and support vessels and aircraft. The study reviewed EAs, EISs, and relevant literature pertinent to OCS activities and identified resources such as marine mammals for impact analysis. A preliminary screening using resource-specific significance criteria based on accepted threshold levels was conducted to identify those G&G seismic survey activities and resources with potential for non-negligible impacts. Various technologies were evaluated for each type of activity, and impacts from air gun noise, sonar noise, vessel traffic, towed streamers, and aircraft traffic were considered. Only seismic surveys were determined to have potential adverse impacts on marine mammals, sea turtles, fishes, and commercial and recreational fisheries. The other survey activities screened were determined to have negligible or no measurable acoustic impacts. These results should also be relevant to the Arctic region and south central Alaska and include potential for impacts to personal-use and subsistence fisheries and taking of marine mammals.

4.4.5.1.1 Routine Operations. Table 4.4.1-1 details impact producing factors for routine activities associated with oil and gas activities and the project phases in which they can occur. Noise associated with offshore OCS oil and gas activities results from exploration activities, construction of onshore and offshore facilities and pipelines involving activities such as pile driving, trenching, earth moving, and building, the operation of fixed structures such as offshore platforms and drilling rigs, maintenance, aircraft and service-vessel traffic including icebreakers, and platform removal, and results in changed ambient noise conditions during those activities.

During exploration, noise is generated by operating air gun arrays, drilling, and support vessels and aircraft. During the development phase, noise is generated by drilling, ship and aircraft traffic, pipeline trenching, platform and other offshore construction, and onshore construction. During production operations, noise is generated by maintenance activities, ship and aircraft traffic, and various production activities and associated equipment such as pumps. During production, air gun–supported deep penetration 4D seismic operations that incorporate changes in reservoirs over time, if used, will also cause noise. Workover rigs also conduct drilling activity during the production phase, albeit with lesser noise levels than original drilling.

Decommissioning noise is generated by explosive and nonexplosive structure removal, and supporting ship and aircraft traffic.

Noise generated from these activities can be transmitted through both air and water and may be extended or transient, and pulsed or constant. Offshore drilling and production involves various activities that produce a composite underwater noise field. As described in Section 3.6, the intensity level and frequency of the noise emissions are highly variable, both between and among the various industry sources. Noise from proposed OCS activities may affect resources. Whether a sound is or is not detected by marine organisms will depend both on the acoustic properties of the source (spectral characteristics, intensity, and transmission patterns) and sensitivity of the hearing system in the marine organism. Anthropogenic noise can cause physical damage to or death of an exposed animal; intense levels can damage hearing, and, if particularly loud or novel, may induce disruptive behavior and cause stress-related responses, such as endocrine responses (MMS 2006a, 2008a).

4.4.5.1.2 Accidents. Accidental events with the potential for affecting ambient noise conditions include oil spills involving transport and support vessels and tankers, loss of well control, and spill response activities. Oils spills can occur both offshore and at coastal facilities and have occurred in coastal waters at shoreline storage, processing, or transport facilities.

Improperly balanced well pressures that result in sudden, uncontrolled releases of fluids from a wellhead or wellbore are referred to as loss of well control. Loss of well control can occur during exploratory drilling, development drilling, production, completion, or workover operations. In the event of a loss of well control, the eruption of gases and fluids may generate significant pressure waves and noise. During a loss of well control, the pressure waves and noise generated by the eruption of gases and fluids might be significant enough to harass or injure marine mammals, depending on the proximity of the animal to the site of the loss of well control (MMS 2006a).

Accident response and support activities, including support aircraft and vessels, involved in mitigating loss of well control and spills affect ambient noise conditions. For smaller spills, response actions (and associated changes in ambient noise) in open water would be expected to be localized and of relatively short duration. In the event of a large spill or a catastrophic spill event covering a greater ocean area and contacting the shore or moving into coastal and inland wetlands, longer term response activities including seismic surveys, skimmers, and other mechanical equipment, would affect ambient noise conditions over a wider area and for a longer time than would response activities for small spills. The nature, magnitude, and duration of noise-related impacts depends on the magnitude, frequency, location, and date of accidents, characteristics of spilled oil, spill-response capabilities and timing, and various meteorological and hydrological factors (MMS 2006a, 2007c). For spills, accident response and cleanup activities, including intentional hazing, would be the primary sources of acoustic impacts.

4.4.5.2 Gulf of Mexico

4.4.5.2.1 Routine Operations. Routine activities that affect ambient noise conditions in some portions of the GOM include seismic surveys, drilling noise, ship and aircraft noise, offshore and onshore construction, operational activities, and decommissioning (see Section 3.6.1 for details on the noise levels and frequencies associated with routine operational activities).

Under the proposed action, seismic surveys would be conducted to identify locations for up to 2,100 exploration wells (Table 4.4.1-1). Noise from these seismic surveys and the associated survey and support vessels would affect the acoustic environment. Air gun noise can be detected up to 100 km (62 mi) from the source, so, under appropriate conditions (see Section 3.6.1.4.4), the affected area can be extensive, but the greatest changes to ambient noise levels would occur at locations closer to the air gun. Effects could include behavioral and physical effects on marine mammals and sea turtles. Impacts of seismic surveys on marine mammals and sea turtles are presented in Sections 4.4.7.1 and 4.4.7.4, respectively. In addition to the noise, the high-pressure pulse and associated particle motion in the near field is a concern for fish. Potential impacts on fish are discussed in Section 4.4.7.3. Commercial and recreational fishing could be affected if behavioral changes in target species (MMS 2007c) occur as a result of exposure to seismic surveys (see Section 4.4.11). These impacts would continue for the duration of the survey, and the affected area would move along with the survey and support vessels. Because these activities would be short term, potential impacts on ecological resources may be equated to incur short-term effects.

Under the proposed action, construction and installation of exploration and delineation wells (up to 2,100), development and production wells (up to 2,600), platforms (up to 450), FPSOs (up to 2), and offshore pipelines (up to 12,000 km [7,500 mi]) will result in increases in noise levels in the vicinity of these construction activities. With the exception of pipeline trenching, construction and installation activities would generate noise from stationary noise sources at the drilling/well sites and from support vessels and aircraft.

Noise from pile driving, construction of offshore platforms and pipelines and noise from the associated support vessels and aircraft would cause noise that would disturb marine mammals (Section 4.4.7.1) and sea turtles (Section 4.4.7.4) in the vicinity of the construction activity and may cause fish to leave the construction area (see Section 4.4.7.3). Pipeline trenching and onshore construction could cause behavioral effects in birds, especially if the noises occur near nesting colonies during nesting periods (see Section 4.4.7.2). Marine species in nearby waters could also be affected. These effects would persist for the duration of the activity and would be strongest at the construction site or along the line of the trenching activity or routes of the vessels or aircraft. Multiple construction projects in the same vicinity could have increased noise impacts.

Additional noise-related impacts could be caused by dredging operations. Noise from dredging generally reaches background levels within 25 km (16 mi), but can extend even farther and thus can affect a fairly wide area.

Under the proposed action, drilling noise during exploration and production would be relatively constant for the duration of the drilling. Drilling noise generally would be less than ambient background levels beyond 30 km (19 mi) from the drill site (see Section 3.6.1.4) and would be strongest near the well. Noise levels would increase if several wells were located in proximity to one another. The principal noise concern in the GOM is the potential to affect marine mammals, sea turtles, and fish (see Sections 4.4.7.1, 4.4.7.4, and 4.4.7.3, respectively).

In addition to drilling noise, machinery on platforms also generates noise during operation. Such noise could be continuous or transient and variable in intensity, depending on the nature and role of the machinery. Underwater noise would be relatively low intensity because the noise sources are on decks well above the surface of the water and because of the small surface area of the legs in contact with the water, but it could affect marine mammals (see Section 3.6.1.4.3).

Under the proposed action, vessel traffic (up to 600 trips per week for up to 45 platforms) and helicopter traffic (up to 5,500 trips per week) will result in increases in noise levels along the traffic routes and at the platforms during construction and operation. Sound generated by these activities will be transient at any one location, may be variable in intensity (MMS 2006a), and may affect marine mammals, sea turtles, and birds (see discussions in Section 4.4.7). Noise from vessel traffic generally reaches background levels within 10 km (6 mi) of the source, but may be detectable at very large distances in deep water. Flights over land would also affect terrestrial mammals (see Section 4.4.7.1). How far sounds travel from vessels is highly variable, depending on environmental conditions and the type of vessel. However, noise would be transient along the traffic path but would recur as long as trips continue. Frequent overflights could produce longer term consequences (MMS 2007c, 2008a).

Noise from decommissioning could result from dismantlement of above-platform structures and the use of underwater explosive or mechanical means to collapse or sever the platform. Marine mammals, sea turtles, and fish could be affected by the noise and shock wave, especially that associated with the use of explosives (see Sections 4.4.6 and 4.4.7). Nonexplosive impacts from dismantling activities and support vessels and aircraft would continue for the duration of the activity and be localized around the facility being decommissioned. Noise and the pressure pulse from explosive detonation would be short term, but the pressure pulse could cause serious impacts on nearby marine mammals (MMS 2007c, 2008a) (also see Section 4.4.7.1). Explosive detonation impacts would be strongest near the detonation site.

4.4.5.2.2 Accidents.

Spills. Under the proposed action, the number and types of spills assumed to occur in the GOM Planning Area include up to 7 large spills (≥1,000 bbl) from both pipeline and platforms, and as many as 470 smaller spills (<1,000 bbl) and up to one tanker spill of up to 3,100 bbl (Table 4.4.2-1). Noise from emergency and spill-response activities and support vessels and aircraft has the potential to disturb marine mammals, sea turtles, fish, and birds. For smaller spills, noise generated from response actions in open water would be expected to be localized and of relatively short duration. In the event of a large spill covering a greater ocean area and contacting the shore or moving into coastal and inland wetlands, longer term response activities, including seismic surveys, skimmers, and other mechanical equipment, over a wider area would be required and associated noise would occur over a wider area. Noise from response equipment and support vessels and aircraft could disturb animals in the vicinity of the response action, temporarily for smaller spills and for longer periods for larger spills (see the biota-specific discussion in Section 4.4.7). Noise along the trajectories of support vessels and aircraft would be transient and localized along the trajectory but would recur for the duration of the spill response. Response activities for onshore spills or offshore spills that reached the land would have similar impacts but would also affect terrestrial species (MMS 2006a, 2007c).

Catastrophic Discharge Event. The PEIS analyzes a CDE that may range in size from 900,000 to 7,200,000 bbl (Table 4.4.2-2). Sources of noise and impacts would be similar to those above for spills. The pressure wave and noise generated from an incident involving a loss of well control could affect marine mammals and could be large enough to harass or disturb them if they were close enough to the site of the event (MMS 2006a). In addition, accident response and support activities, including support aircraft and vessel activity, have the potential to cause noise impacts. These impacts would occur both at the site of the response activity and along the trajectories of support vessels and aircraft. For smaller spills, the noise would be localized and occur throughout the duration of the response activities. Noise along support vessel and aircraft routes would be transient and localized along the route but would recur for the duration of the response. For larger spills and CDEs, the ensonified area would depend on the size of the spill and the extent of the response area. The impacts could cover a larger area, as was the case for the DWH event, and be more sustained over a longer time depending on the volume, location, duration, and weather conditions during the CDE and the response and cleanup activities.

4.4.5.3 Alaska – Cook Inlet

The impact producing factors for noise that may be expected for the Cook Inlet Planning Area under the proposed action include seismic surveys, ship and aircraft traffic, drilling and trenching, offshore construction, and production operations. There would be no onshore new construction involving pipeline landfalls, shore bases, processing facilities, or waste facilities and no platform removals in the Cook Inlet Planning Area under the proposed action (see Table 4.4.1-3).

4.4.5.3.1 Routine Operations. Routine activities that could potentially cause changes in ambient noise levels in Cook Inlet include seismic surveys, drilling noise, ship and aircraft noise, offshore construction, and operational activities. See Section 3.6.1.4 for details on the noise levels and frequencies associated with routine operational activities.

Under the proposed action, seismic surveys would be conducted to identify locations for up to 12 exploration and delineation wells (Table 4.4.1-3). Air gun noise can be detected up to 100 km (62 mi) from the source and beyond under appropriate conditions (see Section 3.6.1.4.4), so the affected area can be extensive, although changes in ambient noise levels would be greatest at locations closest to the air gun. Noise from these seismic surveys and the associated survey and support vessels would alter the acoustic environment and affect ecological resources in the planning area. Effects could include physical and behavioral changes in marine mammals and fish and disturbance of birds. See Section 4.4.7 for discussions of noise impacts on ecological resources of the planning area. Targeted species for commercial, personal-use, subsistence, and recreational fishing could also be affected (MMS 2007c). These impacts would continue for the duration of the survey, and the affected area would move along with the survey and support vessels.

Noise from construction of as many as 3 offshore platforms, up to 114 development and production wells, 241 km (150 mi) of offshore pipeline, and 169 km (105 mi) of onshore pipeline, as well as noise from the associated support vessels and aircraft, could disturb marine mammals (see Section 4.4.7.1) as well as birds (see Section 4.4.7.2) in the vicinity of the construction activity. Construction activity may cause fish to leave the construction area (see Section 4.4.7.3). These effects would persist for the duration of the activity and could persist for weeks after the end of the activity and would be strongest at the construction site or along the line of any required offshore trenching activity. Multiple construction projects occurring simultaneously in the same vicinity or over multiple years would have increased noise impacts. Any effects would persist for the duration of the construction and be strongest near the construction site.

Under the proposed action, pile driving drilling noise during exploration, development, and production would be relatively constant for the duration of the drilling. Drilling noise generally would be less than ambient background levels beyond 30 km (19 mi) from the drill site (see Section 3.6.1.4.3) and would be strongest near the well. Noise levels would increase if several wells were operating simultaneously in close proximity to one another. The noise could have impacts on mammals, fish, and birds in Cook Inlet as discussed in Section 4.4.7. Noise and vessel traffic associated with oil and gas activities in offshore areas adjacent to boundaries of the Lake Clark National Park and Preserve, the Katmai National Park and Preserve, and State wildlife refuges and ranges bordering Cook Inlet could temporarily disturb some wildlife and negatively affect recreational values for park users (Section 4.4.12) (MMS 2007c).

In addition to drilling noise, machinery on platforms generates noise during operation. Such noise could be continuous or transient and variable in intensity depending on the nature and the role of the machinery. Underwater noise would be relatively weak because of the small surface area in contact with the water, but it could affect marine mammals (MMS 2006a). Because there would be no more than three platforms developed as a result of leasing under the Proposed Action Alternative, noise impacts from platform operation are anticipated to localized.

Under the proposed action, vessel traffic (up to three trips per week) and helicopter traffic (up to three trips per week) will result in increases in noise levels along the traffic routes and at platforms during construction and operation. Sound generated by these activities is transient and variable in intensity; it may affect mammals, fish, and birds, as discussed in Section 4.4.7. Noise from vessel traffic generally reaches background levels within 10 km (6 mi) of the source, but may be detectable at very great distances in deep water. Flights over land would also affect terrestrial mammals (see Section 4.4.7.1). The noise would be transient along the traffic path but would recur as long as trips continue. Frequent overflights could produce longer term consequences (MMS 2007c, 2008a).

Although Cook Inlet is generally more than 90% ice free and the Federal waters of Cook Inlet are not seasonally icebound, any icebreaker activity may increase as a result of the proposed action and could result in increased disturbance of marine mammals. However, most exploration activity takes place during the open-water season, minimizing the effects on polar bears (MMS 2008b). Icebreakers operate in support of exploration including seismic survey, construction, and operation activities. Icebreakers do not operate during the open-water season. Icebreaking vessels produce louder, but also more variable, sounds than those associated with other vessels of similar power and size. Icebreaker noise can be substantial out to at least 5 km (3 mi) and may be detectable from more than 50 km (31 mi) away. Icebreaker noise would add to the impacts discussed above for the particular activity they were supporting, but any increases would not occur during the open-water season. Impacts would be transient along the path of the icebreaker and would be strongest near the path.

There is currently no subsistence whaling in Cook inlet, but there is some potential for noise-induced alterations in marine mammal behavior. Local residents have consistently indicated that whales and other marine mammals are very sensitive to noise and that they have been disturbed from their normal patterns of behavior by past seismic and drilling activities (Section 4.4.13). Lease stipulations have minimized such problems in the recent past, so noise and disturbance effects are expected to be effectively mitigated (MMS 2006a). See Sections 4.4.10.2.1 and 4.4.13.2.1 for discussions of noise impacts on land use and subsistence harvests, respectively.

4.4.5.3.2 Accidents.

Spills. Under the proposed action, the number and types of spills assumed to occur in the Cook Inlet Planning Area include up to one large spill (≥1,000 bbl) from either a pipeline or a platform and as many as 18 small (<1,000 bbl) spills (Table 4.4.2-1). Noise from emergency and spill-response activities and support vessels and aircraft has the potential to disturb marine mammals, fish, and birds. For smaller spills, noise generated from response actions in open water would be expected to be localized and of relatively short duration. In the event of a large spill covering a greater ocean area and contacting the shore or moving into coastal and inland wetlands, longer term response activities over a wider area would be required and associated noise would occur over a wider area. Noise from response equipment and activities including seismic surveys, skimmers, and other mechanical equipment and support vessels and aircraft could disturb animals in the vicinity of the response action, temporarily for smaller spills and for longer periods for larger spills and catastrophic discharge events (see biota-specific discussions in Section 4.4.7). Noise along the routes of support vessels and aircraft would be transient and localized along the route but would recur for the duration of the response. Response activities for onshore spills or offshore spills that reached coastal areas would have similar acoustic impacts on nearby marine mammals and birds and affect terrestrial species (see Section 4.4.7).

Catastrophic Discharge Event. The PEIS analyzes a CDE that may range in size from 75,000 to 125,000 bbl (Table 4.4.2-2). Sources of noise and impacts would be similar to those above for spills. The pressure wave and noise generated from an incident involving a loss of well control could affect marine mammals and could be large enough to harass or disturb them if they were close enough to the site of the event (MMS 2006a). In addition, accident response and support activities, including support aircraft and vessel activity, have the potential to cause noise impacts. These impacts would occur both at the site of the response activity and along the routes of support vessels and aircraft. Noise would be localized and occur throughout the duration of the response activities. Noise along support vessel and aircraft routes would be transient and localized along the route but would be recurring for the duration of the response. However, the spill itself and the response and cleanup activities would likely occur over a larger ocean area, could contact larger coastal and inland areas, and take place over a longer time. Thus, the impacts could cover a larger area and be more sustained over a longer time depending on the volume, location, duration, and weather conditions during the CDE and the response and cleanup activities.

4.4.5.4 Alaska – Arctic

The impact-producing factors for noise that may be expected in Arctic Alaska under the proposed action include seismic surveys, ship and aircraft traffic, drilling and trenching, offshore construction, construction of onshore pipeline, and production operations. There would be no onshore construction involving pipeline landfalls or shore bases and no platform removals in Arctic Alaska under the proposed action (see Table 4.4.1-4).

4.4.5.4.1 Routine Operations. Routine activities that will affect ambient noise conditions in the Beaufort Sea and Chukchi Sea Planning Areas include seismic surveys, drilling noise, ship and aircraft noise, icebreaker noise, offshore construction, onshore pipeline construction, and operational activities. See Section 3.6.1.4 for details on the noise levels and frequencies associated with routine operational activities.

Under the proposed action, seismic surveys would be conducted to identify locations for up to 36 exploration wells (16 in the Beaufort Sea Planning area and 20 in the Chukchi Sea Planning Area). Air gun noise can be detected up to 100 km (62 mi) from the source and beyond under appropriate conditions (see Section 3.6.1.4.4), so the affected area can be extensive, although changes in ambient noise levels would be greatest at locations closest to the air gun. Noise from these seismic surveys and the associated survey and support vessels would alter the acoustic environment and affect ecological resources in the planning area. Effects would include physical and behavioral changes and disturbance in marine mammals and fish. Marine and coastal birds could also be affected. See Section 4.4.7 for discussions of noise impacts on ecological resources of the two planning areas. The potential for affecting ecological resources would continue for the duration of the survey activities.

Under the proposed action, construction and installation of exploratory and production wells (up to 36 and 400, respectively), platforms (up to 9), onshore pipelines (up to 129 km

[80 mi]), offshore pipelines (up to 652 km [405 mi]), and subsea wells (up to 92 [up to 10 in the Beaufort Sea Planning Area and up to 81 in the Chukchi Sea Planning Area]) will result in increases in noise levels in the vicinity of these construction activities. With the exception of pipeline trenching, construction and installation activities would generate noise from stationary noise sources at the drilling/well sites and from support vessels and aircraft.

Noise from pile driving, construction of offshore platforms and pipelines, support vessel and aircraft traffic, and gravel placement activities could disturb normal behaviors in marine mammals, birds, and fish in the vicinity of the construction activities (see Section 4.4.7). These effects would persist for the duration of the activity and would be strongest at the construction site(s) or along the line of any required trenching activity. Multiple construction projects occurring simultaneously in the same vicinity or over multiple years would have increased noise impacts.

Construction of up to 129 km (80 mi) of onshore pipeline on areas adjacent to the Beaufort Sea would cause noise that would disturb terrestrial mammals (see Section 4.4.7.1). Impacts would depend on the season and proximity to critical habitat and would persist for the duration of the construction activity. Affected areas would move as the active construction area progressed along the pipeline route. Marine mammals, birds, and fish in nearby waters could be affected. Given that there would be no new pipeline landfalls and no new shore bases constructed, little or no additional onshore construction is anticipated under the proposed action, any noise-related impacts would be limited to relatively few terrestrial mammals and birds. Any effects would persist for the duration of the construction and be strongest near the construction site. Additional noise-related impacts could be caused by gravel excavation activities.

Under the proposed action, drilling noise would be relatively constant during exploration phase drilling and during development and production phase drilling. Drilling noise generally would be less than ambient background levels beyond 30 km (19 mi) from the drill site (see Section 3.6.1.4.3) and strongest near the well. Noise levels would increase if several wells were located in close proximity to one another. The drilling noise could affect marine mammals, birds, and fish (see the biota-specific discussion in Section 4.4.7).

In addition to drilling noise, machinery on platforms generates noise during operation. Such noise could be continuous or transient and variable in intensity depending on the nature and the role of the machinery. Underwater noise would be relatively weak because of the small surface area in contact with the water, but it could affect marine mammals (MMS 2006a).

Under the proposed action, vessel traffic (up to 27 trips per week) and helicopter traffic (up to 27 trips per week) will result in increases in noise levels along the traffic routes and at the platforms during construction and operation. Vessel traffic in Arctic Alaska occurs primarily in the summer (MMS 2007c). Sound generated by these activities is transient and variable in intensity and may affect terrestrial and marine mammals, marine and coastal birds, and fish, as discussed in Section 4.4.7. Noise from vessel traffic generally reaches background levels within 10 km (6 mi) of the source, but may be detectable at very large distances in deep water. Flights over land would also affect terrestrial mammals (see Section 4.4.7.1). The noise would be transient along the traffic path but would recur as long as trips continue. Frequent overflights could produce longer term consequences (MMS 2007c, 2008a).

Icebreaker activity in the Beaufort Sea and Chukchi Sea areas could increase under the proposed action if needed to support exploration, construction, and operation activities. In addition to icebreaking activities when there is ice cover, icebreakers also engage in ice management activities during the summer. Icebreakers do not operate during the open-water season. Icebreaking vessels produce louder, but also more variable, sounds than those associated with other vessels of similar power and size. Icebreaker noise can be substantial out to at least 5 km (3 mi) and may be detectable from more than 50 km (31 mi) away (see Section 3.6). Icebreaker noise would add to the impacts discussed above for the particular activity they were supporting. Impacts would be transient along the path of the icebreaker and would be strongest near the path.

Noise during staging activities for exploration, development, and production would likely occur in areas with existing infrastructure, such as Deadhorse, and cause little direct impact on local native communities. Noise from vessel and aircraft traffic, seismic surveys, and icebreakers could also disturb marine mammals, birds, and fish and thus potentially affect subsistence harvests and resources. Lease stipulations have minimized such problems in the recent past, so noise and disturbance effects are expected to be effectively mitigated (ArcMS 2008).

4.4.5.4.2 Accidents.

Spills. Under the proposed action, the number and types of spills assumed to occur in the Arctic region include up to 3 large spills (≥1,000 bbl) from pipelines and platforms and between 60 and 225 small (<1,000 bbl) spills over the 50-yr period of the Program (Table 4.4.2-1). Noise generated from response actions in open water would be expected to be localized and of relatively short duration. In the event of large spills covering a greater ocean area and contacting the shore or moving into coastal and inland wetlands, longer term response activities over a wider area would be required and the associated noise would occur over a wider area. Noise from response equipment and activities including seismic surveys, skimmers, and other mechanical equipment and support vessels and aircraft could disturb marine mammals, birds, and fish, as well as invertebrate prey species in the vicinity of the response action; the impact would be temporary for smaller spills and of longer duration for larger spills (see biota-specific discussions in Section 4.4.7). Noise along the routes of support vessels and aircraft would be transient and localized but would recur for the duration of the spill response. Response activities for onshore spills or offshore spills that reached the land could have similar impacts but would also affect terrestrial species (MMS 2006a, 2007c).

Catastrophic Discharge Events. In the Arctic Planning Areas, the PEIS analyzes a CDE that may range in size between 1,700,000 and 3,900,000 bbl in the Beaufort Planning Area and a CDE of between 400,000 and 2,100,000 bbl in the Chukchi Planning Area (Table 4.4.2-2). Sources of noise and impacts would be similar to those above for spills. The pressure wave and noise generated from an incident involving a loss of well control would affect marine mammals and could be large enough to harass or disturb them if they were close enough to the site of the event (MMS 2006a). In addition, accident response and support activities, including support aircraft and vessel activity, have the potential to cause noise impacts. These impacts would occur both at the site of the response activity and along the routes of support vessels and aircraft. Noise would be localized and occur throughout the duration of the response activities. Noise along support vessel and aircraft routes would be transient and localized along the route but would recur for the duration of the response. However, the spill itself and the response and cleanup activities would likely occur over a larger ocean area, could contact larger coastal and inland areas, and take place over a longer time. Thus, the impacts could cover a larger area, as was the case for the DWH event, and be more sustained over a longer time depending on the volume, location, duration, and weather conditions during the CDE and the response and cleanup activities.

4.4.5.5 Conclusion

Noise impacts due to routine operations under the proposed action would be unavoidable. Noise could affect terrestrial and marine mammals, fish, and birds primarily through disturbance and disruption of normal activities (see Section 4.4.7). Terrestrial mammals could be similarly affected by onshore construction activities. Noise may also affect the ability of subsistence users and others to gather resources. The magnitude of the impact would vary with the type of resource affected, the timing of the noise-generating activity, the noise footprint, and location of the resource in relationship to the noise-generating activity. In general, the nature and magnitude of impacts from single transient and short-term noises would be different than those associated with continuous, long-term noise. Impacts to ambient noise levels from routine operations associated with the Program are expected to be minor.

Noise from emergency and spill-response activities and activities including seismic surveys, skimmers, and other mechanical equipment and support vessels and aircraft has the potential to disturb marine mammals, fish, and birds. The noise impacts would persist for the duration of the response efforts. Response noise for small spills would be expected to have short-term temporary impacts; response noise for large spills (and especially for CDE-level spills) would have longer term impacts because of the longer duration of spill response activities. As the time over which the response activities continue increases, the chance for permanent noise impacts on some resources (e.g., mammals, birds) may also increase.

4.4.6 Potential Impacts on Marine and Coastal Habitats

4.4.6.1 Coastal and Estuarine Habitats

4.4.6.1.1 Gulf of Mexico (GOM). Coastal and estuarine habitats could be directly or indirectly affected by a number of factors associated with oil and gas activities (Table 4.4.6-1). These factors include vessel traffic, maintenance dredging of navigational canals, construction

TABLE 4.4.6-1 Impacting Factors for Coastal and Estuarine Habitats in the Gulf of Mexico

Oil and Gas Impacting Factors[a]	Habitat Type: Barrier Landforms	Wetlands	Seagrasses
Vessel traffic (all phases)	X	X	X
Navigation channel maintenance dredging (operations)	X	X	X
Pipeline emplacement (construction)	X	X	X
Construction of onshore facilities (construction)		X	X
Expansion of onshore facilities (construction)	X	X	X
Use of existing facilities (operations)	X	X	X
Expansion of ports and docks (construction)	X	X	X
Disposal of OCS-related wastes (all phases)		X	X
Accidental spills (all phases)	X	X	X

[a] X = Potential impacts on the resource attributable to the impacting factor.

and operation of onshore facilities, installation and maintenance of pipelines, expansion of ports and docks, and operation of offshore oil and gas facilities. The potential for impacts would be largely influenced by site-specific factors, such as the habitat types and distribution in the vicinity of oil and gas activities. Many of the activities associated with oil and gas, such as platform construction, would occur in offshore waters, with minimal impacts on coastal habitats other than for potential accidents.

Routine Operations.

Barrier Landforms. The potential effects on coastal barrier islands, beaches, and dunes from routine operations would primarily be associated with indirect effects from maintenance dredging and vessel traffic. Impacts of pipeline landfalls and use or expansion of coastal facilities could also occur.

Maintenance dredging of navigation channels in barrier inlets and bar channels can remove sediments from the longshore sediment drift. Maintained channels intercept and capture sediments, and dredged materials are often discharged to ocean dump sites. Dredging may contribute to the reduction of sediment deposition and affect the stability of downdrift barrier landforms (MMS 2007b). Reductions in sediment supply could subsequently contribute to minor local losses of adjacent downdrift barrier beach habitat, with impacts over a broader area where the sediment supply is low, such as along the Louisiana coastal barrier islands in the Central Planning Area (CPA). However, dredged sediments are used in beach restoration projects where feasible (MMS 2008a). The installation of erosion control structures, such as jetties, for OCS-related facilities built near barrier shorelines may also accumulate sediments and induce erosion of downdrift areas (MMS 2007b). In some locations, the potential exists for dredging to result in the resuspension and transport of oil spilled during the DWH event.

Service vessel traffic to exploration and production wells could contribute to erosion of barrier beaches. Approximately 300 to 600 vessel trips per week would occur in the GOM under the proposed action. Waves generated by service vessels can erode unprotected shorelines and areas that currently experience barrier beach losses from ongoing shoreline degradation, particularly the coastal areas of Louisiana; vessel traffic can contribute to the accelerated erosion of sediments along beaches through increased wave activity. Erosion from vessel activity along unarmored navigation channels has resulted in channel widening in the Western Planning Area (WPA) and CPA and land loss in some areas. However, restoration and stabilization of channel margins have been effective in minimizing channel widening. Wave activity could be minimized by maintaining reduced vessel speeds in the vicinity of barrier islands.

The proposed action would include approximately less than 12 new pipeline landfalls in the GOM region. Impacts on barrier landforms would likely be avoided during pipeline construction by the use of modern construction techniques, such as directional (trenchless) boring, under barrier islands and beaches (MMS 2008a). These construction methods result in minimal impacts on the barrier systems (Wicker et al. 1989). If nonintrusive techniques were not used, impacts on beach and dune communities from ground-disturbing activities during pipeline construction could occur, with the potential for accelerated beach erosion and island breaching.

Up to 12 new natural gas processing facilities and 4 to 6 new pipe yards would be constructed. No new facilities would be expected to be constructed on barrier beaches or associated dunes; however, impacts on other coastal upland habitats would likely occur. Habitat losses would be minimized if facilities were located in previously disturbed areas. Expansion of existing facilities located on barrier beaches or dunes would result in losses of those habitats. The continued use of facilities that have become located in the barrier beach and dune zone because of ongoing shoreline recession may result in accelerated erosion of those habitats.

Wetlands. The potential effects on wetlands from routine operations would primarily be associated with direct impacts from pipeline emplacement and maintenance and navigation channel maintenance dredging, as well as indirect impacts from decreased water quality (such as from disposal of OCS-related wastes), altered hydrology, and vessel traffic. Impacts from ground-disturbing activities during construction or expansion of support facilities, such as processing facilities and pipeline yards, could also occur.

The construction of pipelines through coastal wetlands could result in direct losses of marsh habitat, depending on avoidance of wetlands in pipeline route selection and the emplacement technique used. The use of directional boring under wetlands during pipeline construction would likely avoid impacts, or result in negligible impacts, on wetlands. Trenching for pipeline emplacement would result in direct impacts on marsh habitat from excavation. Long-term reduction in vegetation productivity above and adjacent to the pipeline, including areas backfilled, would likely occur, with potential losses of wetland habitat, depending on factors such as the success of backfilling, time of year, and duration of construction (Turner et al. 1994; MMS 2007b).

Maintenance dredging of navigation channels would contribute to increased flushing and draining of interior marsh areas by tides and storms, which could result in shifts in species composition, habitat deterioration, erosion, and wetland loss (LCWCRTF 1998, 2003). Channels alter the hydrology of coastal marshes by affecting the amount, timing, and pathways of water flow (Day et al. 2000a). Hydrologic alterations can result in changes in salinity and inundation, causing a dieback of marsh vegetation and a subsequent loss of substrate and conversion to open water (LCWCRTF 2001; Day et al. 2000a). Saltwater intrusion into brackish and freshwater wetlands further inland could result in mortality of salt-intolerant species and loss of some wetland types such as cypress swamp, or transition of wetland types such as freshwater marsh to brackish and saltmarsh or open water (MMS 2007b). The deposition of dredged material onto adjacent disposal banks could potentially result in a localized and minor contribution to ongoing impacts of disposal banks, such as preventing the effective draining of some adjacent areas, resulting in higher water levels or more prolonged tidal inundation, or restricting the movement of water, along with sediments and nutrients, into other marsh areas (Day et al. 2000a). Impacts on marsh habitats from navigation channels would be expected to be mitigated by the beneficial use of dredged material (MMS 2008a), through the application of dredged material onto marsh surfaces to increase substrate elevations for marsh restoration or creation. Small areas of marsh would likely be lost during dredging by the occasional inadvertent deposition of dredged material, as well as created by material deposition into shallow water (MMS 2007b).

Service vessel traffic to exploration and production wells would contribute to erosion of marsh habitat. Wetland losses would likely occur along unarmored navigation channels because of the widening that would result from the continued erosion of adjacent marsh substrates due to waves generated by vessel traffic (LCWCRTF 2003). Erosion from vessel activity along navigation channels has resulted in channel widening in the WPA and CPA and land loss in some areas. However, restoration and stabilization of channel margins have been effective in minimizing channel widening. Erosion of wetlands would not occur along armored channels, which are frequently used by OCS-related vessel traffic.

The construction or expansion of facilities near the coastline, including the potential expansion of port facilities, could potentially result in the direct loss of wetlands from the placement of fill material during building construction, as well as the construction of pipelines, access roads, and transmission corridors. However, construction in wetlands is discouraged by State and Federal permitting agencies. Indirect impacts of construction could include habitat fragmentation, altered hydrology from changes in surface drainage patterns or isolation of wetland areas from water sources, conversion to upland communities or open water, sedimentation and turbidity, and introduction of contaminants in stormwater runoff. Resulting changes in affected wetlands could include a reduction in biodiversity and the establishment and predominance of invasive plant species. Impacts on wetlands from construction could be minimized by maintaining buffers around wetlands and by using best management practices for erosion and sedimentation control. Construction in wetlands is managed and regulated by the appropriate State agencies and the USACE. It is assumed that standard mitigation measures would be applied to any construction project associated with the Program.

Impacts on wetlands near constructed facilities might also result from other factors, such as disposal of wastes at upland disposal sites, which could introduce contaminants into wetlands. Contaminants from land storage or disposal sites might migrate into groundwater or could be present in stormwater runoff that could flow into wetlands. Contaminants might also be released to surface water in service vessel discharges, which might affect wetlands. State requirements would be enforced to prevent and address potential occurrences. Impacts on wetlands would be minimized by implementing water quality practices.

Seagrasses. The potential effects on seagrass communities from routine operations would primarily be associated with effects from vessel traffic, pipeline emplacement, and maintenance dredging. Impacts from use or expansion of coastal facilities could also occur.

Coastal seagrass communities might be damaged by vessel traffic outside established traffic routes, which could result in long-term scars on seagrass beds (MMS 2003d). The recovery rate would be greater for larger scars and low-density vegetation. Seagrass communities might also be affected by trenching for pipeline installation, which could bury adjacent seagrasses and deposit lighter sediments onto leaves of more distant seagrasses. Turbidity from pipeline emplacement, maintenance dredging of navigation canals, or vessel traffic might adversely affect seagrass communities by decreasing seagrass cover and productivity, and changing species composition, as a result of reduced light levels (MMS 2007b). It is assumed that the USACE and State agency requirements regarding the mitigation of turbidity impacts on submerged vegetation from pipeline emplacement and maintenance dredging of navigation channels would be followed. Salinity changes resulting from dredging can also result in changes in species composition of seagrass communities. Because activities associated with the Program would be located far from Florida coastal waters, which contain approximately 98.5% of all coastal seagrasses in the U.S. GOM, the Program would be expected to have minimal effects on the overall condition of seagrass communities in the GOM. However, localized impacts on small areas of seagrass could occur in coastal areas west of Florida.

Accidents. The potential effects on coastal and estuarine habitats from accidents would primarily be associated with impacts from spills of oil and other petroleum hydrocarbons, such as fuel oil or diesel fuel, and subsequent cleanup efforts. Large (≥1,000 bbl) and small (<1,000 bbl) oil spills could occur as a result of tanker and barge spills, pipeline spills, or platform spills. Spills from vessels should be minimized by compliance with USCG requirements for spill prevention and control. Section 4.4.2 provides details of spill assumptions. Oil or other spilled materials might be transported to barrier landforms and wetland habitats by currents or tides. The amount of oil deposited on coastal habitats would depend on various factors, such as spill volume, distance from shoreline, ambient conditions, degree of weathering, and effectiveness of response actions. Large spills would potentially result in heavy or widespread deposits of oil.

Beaches could be affected by oil spills, and the direct mortality of biota could result. Spilled oil that reaches barrier beaches might be restricted to beach surfaces, or it could penetrate into subsurface layers. Permeable substrates, generally associated with larger sand grain sizes, and holes created by infauna could increase oil penetration, especially that of light oils and petroleum products (NOAA 2000). Oil may become buried under sediments by wave action. Although beach and foredune areas are often sparsely vegetated, impacts on vegetation might occur if oil was carried to higher elevations by storm waves and tides. Oiled beach sediments could weaken dune and other beach vegetation, resulting in accelerated erosion. Because of the changes in barrier beach and dune profiles as a result of hurricanes, such as Katrina and Rita, habitat between the shoreline and beach ridge may be more vulnerable to impacts of spills (MMS 2008a).

Impacts on coastal marsh vegetation from oil spills could range from a short-term reduction in photosynthesis to extensive mortality and subsequent loss of marsh habitat as a result of substrate erosion and conversion to open water (Hoff 1995; Proffitt 1998). Vegetation that dies back could recover, even following the death of all existing leaves. Long-term impacts could include reduced stem density, biomass, and growth (Proffitt 1998). Mangroves might decrease canopy cover or die over a period of weeks to months (Hensel et al. 2002; Hayes et al. 1992). Other effects of spills could include a change in plant community composition or the displacement of sensitive species by more tolerant species. In locations where soil microbial communities were affected, effects might be long term, and wetland recovery might be slowed. The degree of impacts on wetlands from spills are related to the oil type and degree of weathering, amount of oil, duration of exposure, season, plant species, percentage of plant surface oiled, substrate type, and oil penetration (Hayes et al. 1992; Hoff 1995; Proffitt 1998; Hensel et al. 2002). Higher mortality and poorer recovery of vegetation generally result from spills of lighter petroleum products (such as diesel fuel), heavy deposits of oil, spills during the active growing period of a plant species, contact with sensitive plant species (especially those located in coastal fresh marsh), completely oiled plants, and deep penetration of oil and accumulation in substrates. Most spills in deepwater areas would require an extended period of time to reach a shoreline or marsh and would undergo natural degradation and dispersion, which, in addition to expected containment actions, would reduce potential impacts. Because of the changes in barrier island profiles as a result of hurricanes Katrina, Rita, and Ivan, there is a greater potential for oil spill impacts on coastal marshes (MMS 2008a).

Impacts on seagrass communities would generally be short term, resulting from contact with oil dispersed in the water column, from reduced light and oxygen levels due to the sustained presence of an oil slick in protected areas, or from reduced populations of epiphyte grazers (MMS 2007b). Recovery would generally occur in about 1 yr. Permanent losses of seagrass habitat would not be expected to occur from a spill unless unusually low tides result in direct contact of seagrass leaf surfaces with an oil slick.

Although any residual oil that might remain on barrier beaches following cleanup could be largely removed in highly exposed locations through wave action, oil could remain in the shallow subsurface for extended periods of time. In some locations, oil might become buried by new sand deposition (NOAA 2000). Natural degradation and persistence of oil on beaches are influenced by the type of oil spilled, the amount present, sand grain size, the degree of penetration into the subsurface, the exposure to the weathering action of waves, and sand movement onto and off the shore. Spilled oil might be entirely absent from affected beaches within a year or less, or it might persist for many years (Dahlin et al. 1994; Hayes et al. 1992; Petrae 1995; Irvine 2000). On sheltered beaches, heavy oiling left for long periods could form an asphalt pavement relatively resistant to weathering (Hayes et al. 1992). Spilled oil remaining in wetlands after cleanup degrades naturally by weathering processes and biodegradation caused by microbial communities in the soil. Full recovery of coastal wetlands might occur in less than 1 yr or might require more than 5 yr, depending on site and spill characteristics (Hoff 1995). Oil might degrade very slowly in saturated soils under mangroves; more than 30 yr could be required for mangroves to recover (Hensel et al. 2002). Oil could remain in some coastal substrates for decades, even if it was cleaned from the surface. Heavy deposits of oil in sheltered areas or in the supratidal zone could form asphalt pavements resistant to degradation (Hoff 1995).

Spill cleanup operations might adversely affect barrier beaches and dunes if large volumes of contaminated substrates were removed. Such removal could affect beach stability, resulting in accelerated shoreline erosion, especially in areas of sand deficit, such as along the Louisiana coastline in the CPA. However, sand removal is generally minimized during spill cleanup (MMS 2007b). Foot traffic during cleanup might mix surface oil into the subsurface, where it might persist for a longer time. Spill cleanup actions might damage coastal wetlands through trampling of vegetation, incorporation of oil deeper into substrates, increased erosion, and inadvertent removal of plants or sediments, all of which could have long-term effects (Hoff 1995; Proffitt 1998; NOAA 2000). These actions could result in plant mortality and delay or prevent recovery. In locations where spill cleanup would include the excavation and removal of contaminated soils and biota, increased erosion and lowered substrate elevation could result in marsh loss by conversion to open water, unless new sediments were applied. Effective low-impact cleanup actions could include bioremediation, low-pressure flushing, or use of chemical cleaners (Mendelssohn and Lin 2003; Hoff 1995; Proffitt 1998).

Catastrophic Discharge Event. The PEIS analyzes a CDE with an assumed volume of 0.9–7.2 million bbl (Table 4.4.2-2). The amount of oil deposited on coastal habitats would depend on various factors, such as spill volume, distance from shoreline, ambient conditions, degree of weathering, and effectiveness of response actions. A CDE would potentially result in heavy or widespread deposits of oil and would have a greater likelihood for extensive areas of shoreline affected and heavy deposits of oil in multiple locations. For example, the DWH event affected more than 1,046 km (650 mi) of the GOM coastal habitat, from the Mississippi River Delta to the Florida panhandle. More than 209 km (130 mi) of coastal habitat were moderately to heavily oiled, including a substantial number of Louisiana beaches (see Section 3.7.1.1.5).

4.4.6.1.2 Alaska Region – Cook Inlet.

Routine Operations. The potential effects on coastal habitats from routine operations would primarily be associated with direct impacts from ground-disturbing activities during pipeline construction as well as indirect impacts from service vessels and the operation of existing facilities (see Table 4.4.6-2).

Up to one new pipeline landfall would be constructed in the Cook Inlet Planning Area. Pipeline installation would include trench excavation through intertidal and shallow subtidal areas. Installation could directly disturb tidal marshes, beaches, rocky shores, or other coastal habitats, depending on the location of the landfall. A few acres of habitat would likely be altered at each landfall site, and some intertidal and shallow subtidal organisms would be displaced (MMS 2003b). Intertidal and shallow subtidal vegetation could be indirectly impacted by excavation for pipeline installation. Areas adjacent to the trench may be covered by excavated sediments, and organisms could be affected by sedimentation and turbidity associated with the

TABLE 4.4.6-2 Impacting Factors for Coastal and Estuarine Habitats in the Alaska Region – Cook Inlet

	Habitat Type		
Oil and Gas Impacting Factors[a]	Cook Inlet Coastal Habitats	Arctic Barrier Landforms	Arctic Wetlands
Vessel traffic (all phases)	X	X	X
Construction of onshore pipelines (construction)	X		X
Use of existing facilities (operations)	X		X
Disposal of OCS-related wastes (all phases)	X		X
Accidental spills (all phases)	X	X	X

[a] X = Potential impacts on the resource attributable to the impacting factor.

disturbance of bottom sediments during trench excavation and backfilling. Impacts could be reduced by implementing measures to restrict the dispersal of sediments.

Approximately 80–169 km (50–105 mi) of new onshore pipeline would be constructed. Pipelines would deliver oil to existing refineries in Nikiski and natural gas to transmission facilities in the Kenai area, both on the eastern side of Cook Inlet. Indirect effects could include habitat fragmentation, reduced infiltration and increased surface runoff from soil compaction on the construction site, altered hydrology including increased or reduced inundation or saturation of substrates, sedimentation and turbidity, deposition of fugitive dust, and introduction of contaminants in stormwater runoff. Impacts to local streams could affect coastal wetlands. Impacts could result in changes in plant community structure, reduction in plant biodiversity, and the establishment and dominance of invasive plant species. However, activities that may potentially impact wetlands are regulated by State agencies and the USACE. Standard mitigation measures would be applied to any construction project associated with these activities. For example, construction-related impacts could be minimized by maintaining buffers around wetlands and implementing best management practices for erosion and sediment control. Although wetlands along the pipeline route could be affected by construction, impacts could be reduced if pipelines were located in existing utility or transportation system rights-of-way, when possible, and if natural drainage patterns were maintained. Indirect impacts to coastal habitats from sedimentation originating along the pipeline route could be reduced by minimizing crossings of anadromous fish streams and consolidating pipeline crossings with other utility and road crossings.

Construction of a pipeline gravel service road, haul road, and access roads would replace habitat with unvegetated surfaces or result in altered habitat having few species in common with nearby undisturbed habitats. Habitat may also be disturbed by the establishment of work camps. Resulting changes in affected wetlands could include a reduction in biodiversity, replacement of one wetland type for another (such as by dewatering or ponding), conversion to upland communities, or conversion of vegetated wetlands to open water.

No new shore bases, processing facilities, or waste disposal facilities would be constructed. Existing shore bases, gas processing facilities, and waste disposal facilities would be used for all new oil and gas activities in the planning area. Operation of existing facilities could have local indirect effects on wetland vegetation from exhaust emissions or atmospheric releases from processing facilities. Contaminants could be introduced into wetlands from the use of existing waste storage or disposal sites, if contaminants migrate into groundwater or enter stormwater that flows into wetlands. Service vessels would make one to three trips per week for each of the one to three new platforms in the planning area. Discharges from service vessels that support drilling platforms may contain materials that adversely affect coastal wetlands or other intertidal or shallow subtidal habitats. Wetland impacts could be avoided or minimized by implementing practices that eliminate or minimize impacts on water quality.

Accidents. The potential impacts on coastal habitats from accidents would primarily be associated with impacts from spills of oil or other petroleum hydrocarbons, such as fuel oil or diesel fuel, and the methods used for spill cleanup. This analysis assumes 1 large spill of 4,600 bbl from a pipeline or 1,500 bbl from a platform, as well as 2 smaller spills (>50–1,000 bbl) and 10 spills up to 50 bbl. Currents and tides within Cook Inlet could transport oil or other materials to coastal habitats from drilling platforms, pipeline leaks, or vessel accidents. The Cook Inlet Planning Area is unlike any other OCS Planning Area in that it is almost entirely surrounded by coastal habitat. Therefore, there is a very high likelihood that spills in the planning area would make contact with coastal habitats. Because of the patterns of Cook Inlet surface currents, habitats along the western shoreline of the inlet and along Shelikof Strait would have the greatest likelihood of contact from spills within the planning area, while the eastern shoreline would have a lower potential for contamination from spills (MMS 2003a). Extensive winter ice can develop along the western shores of Cook Inlet, and epibiota are seasonally removed by ice scour. Along the Shelikof Strait mainland, intertidal communities are affected by glacier ice melt and are subject to turbidity and freshwater stresses (McCammon et al. 2002).

Intertidal habitats would be highly vulnerable to spills that reach the coastline, and repeated influxes of oil may contaminate intertidal surfaces with each subsequent tidal cycle. Because of the wide tidal range (more than 9 m [30 ft] in some portions of upper Cook Inlet, north of the planning area), extensive areas of shoreline habitat may be affected by a spill, especially soft bottom habitats (sands and muds), which typically have a relatively flat topography. Shallow subtidal habitats could be affected by oil that slumps from intertidal areas and accumulates below the low-tide line.

Vulnerable intertidal habitats sensitive to disturbance from oil spills extend around most of lower Cook Inlet (MMS 2003a). Highly sensitive shoreline habitats include marshes, sheltered tidal flats, and sheltered rocky shores (NOAA 1994). The vulnerability of intertidal habitats is generally rated as highest for vegetated wetlands and semipermeable substrates, such as mud, that are sheltered from wave energy and strong tidal currents. Oil contacting these habitats is less likely to be removed by waves. Cleanup activities are very difficult to conduct on soft mud substrates, such as on tidal flats (NOAA 1994, 2000).

Direct mortality of biota could result from spilled oil contacting intertidal habitats. Oil readily adheres to marsh vegetation (NOAA 1994, 2000; Hayse et al. 1992), and effects may range from a short-term reduction in photosynthesis to extensive vegetation injury or mortality. Many invertebrates are sensitive to oil exposure. Studies of the *Exxon Valdez* oil spill provide valuable information on oil spill effects and recovery. Following the *Exxon Valdez* oil spill, the abundance of many species of algae and invertebrates were reduced at affected sites (NOAA 1997; Peterson 2000; *Exxon Valdez* Oil Spill Trustee Council 2003). In particular, the abundance and reproductive potential of *Fucus gardneri*, a common and important brown alga species, was reduced in oiled areas and remained unstable at some locations for extended periods (*Exxon Valdez* Oil Spill Trustee Council 2003, 2010a). Although adult *Fucus* appear to have some resistance to oil toxicity, earlier life stages appear to be much more sensitive (NOAA 1998). In shallow subtidal habitats, impacts were less severe, although kelp, eelgrass, and many invertebrates were adversely affected (Peterson 2000).

Spilled oil that contacts intertidal habitats can cause changes in community structure and dynamics. Toxic compounds in oil can selectively remove the more sensitive organisms, such as echinoderms and some crustaceans, while organic enrichment from oil can stimulate the growth and abundance of opportunistic infaunal invertebrates, such as some polychaetes and oligochaetes (McCammon et al. 2002). Some opportunistic species, such as species of barnacle, oligochaetes, and filamentous brown algae, colonized affected shorelines following the *Exxon Valdez* oil spill and cleanup (Peterson 2000; *Exxon Valdez* Oil Spill Trustee Council 2003). Indirect effects also included the spread of *Fucus gardneri* onto lower shoreline areas in some regions, which inhibited the return of red algae (Peterson 2000). The reduction of predators or herbivores can also result in changes in lower trophic levels for extended periods. The adverse effects of oil on intertidal organisms, such as macroalgae, clams, and mussels, can last for more than a decade (MMS 2003e; *Exxon Valdez* Oil Spill Trustee Council 2003).

Extended periods of time may be required for intertidal communities to fully recover from an oil spill. The degree of effects and length of recovery depend on a number of factors such as the type of oil, extent of biota exposure, substrate type, degree of sediment contamination, time of year, and species sensitivity (NOAA 1998; Hayse et al. 1992; Hoff 1995). Although the most acutely toxic components of crude oil are rapidly lost through weathering, the more persistent components have been associated with long-term pathologies such as carcenogenicity (NOAA 1997). Full recovery of wetlands including invertebrate communities may require more than 10 years (Hoff 1995). Studies indicate that full recolonization of sheltered rocky shorelines in Cook Inlet may require 5–10 years (Highsmith et al. 2001). Although studies in Prince William Sound indicate that some organisms can recover quickly, recovery in some intertidal and shallow subtidal habitats takes more than a decade (Peterson 2000; *Exxon Valdez* Oil Spill Trustee Council 2003). More than 20 years after the *Exxon Valdez* oil spill, intertidal communities were considered to be recovering, but had not yet fully recovered from the effects of the spill (*Exxon Valdez* Oil Spill Trustee Council 2010a).

Spilled oil may penetrate into subsurface layers or may remain on the surface. Oil can remain in intertidal sediments and organisms for more than a decade and may remain a long-term source of exposure (NOAA 1997; MMS 2003e; Short et al. 2004; *Exxon Valdez* Oil Spill Trustee Council 2003). Lingering oil, in some areas only slightly weathered, persists in intertidal beach substrates at a number of locations more than 20 years after the *Exxon Valdez* oil spill (*Exxon Valdez* Oil Spill Trustee Council 2009b, 2010a,b). Coarse-grained sand beaches are more conducive to subsurface penetration than fine-grained sands (NOAA 2000), and subsequent deposition of sand may bury oil deposits. Natural removal of subsurface oil from gravel beaches is greatly reduced by surface armoring of boulders, as observed in Prince William Sound (NOAA 1997). Although oil is not likely to adhere to the surface of mudflats, oil may be deposited if concentrations are high; penetration of the surface is unlikely except for entering burrows or crevices (NOAA 2000).

Cleanup activities may also adversely affect intertidal habitats and biota, as occurred following the *Exxon Valdez* oil spill (NOAA 1997; McCammon et al. 2002; *Exxon Valdez* Oil Spill Trustee Council 2003). The removal of organisms from affected surfaces and washing out of fine particles from substrates likely inhibited and slowed the recovery of intertidal communities in some areas. Trampling of vegetation and other biota during cleanup activities as well as working oil deeper into sediments from foot traffic and equipment can also delay recovery from oil spills. Extensive vessel traffic during cleanup operations may increase turbidity and adversely affect organisms, such as eelgrass, in shallow subtidal communities (*Exxon Valdez* Oil Spill Trustee Council 2003).

Catastrophic Discharge Event. For the Cook Inlet Planning Area, the PEIS analyzes a CDE with an assumed volume of 75,000–125,000 bbl (Table 4.4.2-2). Currents and tides within Cook Inlet could transport oil, and there is a very high likelihood that spills in the planning area would make contact with coastal habitats. A CDE would potentially result in heavy or widespread deposits of oil and would have a greater likelihood for extensive areas of shoreline affected and heavy deposits of oil in multiple locations. The degree of effects and length of recovery depend on a number of factors such as the type of oil, extent of biota exposure, substrate type, degree of sediment contamination, time of year, and species sensitivity. More than 20 years after the *Exxon Valdez* oil spill, intertidal communities were considered to be recovering, but had not yet fully recovered from the effects of the spill (*Exxon Valdez* Oil Spill Trustee Council 2010a).

4.4.6.1.3 Alaska – Arctic.

Routine Operations.

Coastal Barrier Beaches. The potential effects on coastal barrier beaches from routine operations would primarily be associated with direct impacts from ground-disturbing activities during pipeline construction and indirect effects from vessel traffic.

No new pipeline landfalls would be constructed in the Arctic region. However, 16–129 km (10–80 mi) of new onshore pipeline would be constructed for the Beaufort Sea, connecting to existing infrastructure on the Arctic Coastal Plain (ACP). Pipeline construction may affect sand beaches and dunes on the margins of lakes and rivers on the ACP, and erosion of sand beaches and dunes adjacent to pipelines could be promoted. Stabilization of dune margins could be difficult, and establishment of vegetation cover might be slow, possibly resulting in prolonged losses of dune habitat near pipeline routes.

No new shore bases, processing facilities, or waste disposal facilities would be constructed in the Arctic region. Existing shore bases, gas processing facilities, and waste disposal facilities would be used for all new oil and gas activities in the region. Operation of existing facilities could have local indirect effects on vegetation from exhaust emissions or atmospheric releases from processing facilities.

Arctic coastal habitats are exposed to strong wave and sea ice action, and the shoreline is generally unstable and prone to erosion (MMS 2002c; Viereck et al. 1992; Macdonald 1977). Service vessel traffic to exploration and production wells and barge traffic in support of shore bases could contribute to erosion along barrier beaches. Under the proposed action, up to three vessel trips per week would be made to each of the up to five new platforms along the Chukchi Sea and up to four along the Beaufort Sea. Increases in wave activity from vessel traffic could contribute to the removal of sediments along barrier beaches. Wave activity could be minimized by maintaining reduced vessel speeds in the vicinity of barrier islands.

Wetlands. The potential effects on wetlands from routine operations would primarily be associated with direct impacts from ground-disturbing activities during construction of pipelines and roads, as well as the indirect impacts from decreased water and air quality, altered hydrology, and facility maintenance. Wetland losses could result in the localized reduction or loss of wetland functions, such as fish and wildlife habitat, attenuation of flooding and shoreline erosion, and removal of substances that reduce water quality. Avoidance of wetlands during route selection for pipelines or roads might be difficult on the ACP because of the high density of wetlands. Activities that would potentially affect wetlands are regulated by State agencies and the USACE. Standard measures would help mitigate construction-related impacts.

Although no new pipeline landfalls would be constructed in the Arctic region, 16–129 km (10–80 mi) of pipeline would be constructed onshore to transport oil from the Beaufort Sea to existing North Slope pipelines. With a 46-m (150-ft) wide construction ROW, approximately 73–584 ha (180–1,443 ac) of land would be disturbed. A number of wetland types, including wet or moist tundra habitat, lakes, ponds, or marshes (including those occurring within lakes and ponds), could be affected by pipeline construction. Construction of a pipeline gravel workpad (service roadway), haul road, and access roads would replace wetland habitat with unvegetated surfaces or result in upland habitat having few species in common with nearby undisturbed habitats. Because of the high density of wetlands on the coastal plain, wetland habitat expected to constitute a large proportion of the disturbed area would likely be lost, as occurred during the construction of the TAPS (Pamplin 1979; BLM 2002). Construction of buried pipeline segments would affect similar amounts of wetland habitat as a workpad. However, construction of aboveground pipeline segments without a workpad would result in the loss of only small areas of wetland habitat at the locations of the vertical support members. Wetland areas may also be disturbed by the establishment of work camps. Additional impacts of construction could include altered hydrology from changes in surface drainage patterns or isolation of wetland areas from water sources, such as from blocking natural surface flows. Changes in the moisture regime, natural drainage patterns, or snow-drift patterns in adjacent areas would likely result in thermokarst, with resulting changes in the species composition of plant communities (NRC 2003a). Wetland impacts associated with degraded water quality could include sedimentation and turbidity and introduction of contaminants in stormwater runoff. Resulting changes in affected wetlands could include a reduction in biodiversity, replacement of one wetland type for another (such as by dewatering or ponding), conversion to upland communities, or conversion of vegetated wetlands to open water. Wetlands adjacent to a gravel workpad would be indirectly affected by deposition of airborne dust. Additional wetland habitat may be lost through thermokarst associated with new impoundments and heavy dust accumulations (BLM 2002).

Deposition of fugitive dust can affect plant communities and alter wetland characteristics, primarily by reducing canopy cover and altering species composition (Auerbach et al. 1997; Everett 1980; Walker and Everett 1987). Impacts may include reduced growth and density of vegetation and changes in community composition to more tolerant species. Reductions in plant cover can reduce the insulation of the ground surface, leading to thawing of the underlying ice-rich permafrost (NRC 2003a). Nonvascular species, primarily mosses and lichens, are highly sensitive. The reduction or loss of sphagnum mosses, which are important components of many plant communities on the ACP, can occur in acidic tundra habitat, especially within 10 m (33 ft) of a road (Walker et al. 1987a), potentially contributing to thermokarst. Deposition of dust on snowdrifts along roads promotes earlier melting. Roads and construction/excavation equipment can also provide a means for the introduction and spread of non-native plants and noxious weeds.

The construction of access roads and transmission corridors would likely result in the direct loss of wetlands from the placement of fill material during construction. Additional wetland habitat could be disturbed by other forms of infrastructure such as employee camps, airstrips, and power stations. The construction of these facilities could permanently eliminate wetland habitat within the immediate footprints of the facilities. While this wetland loss would be long term, the areas disturbed represent an extremely small portion of habitat that occurs on the ACP adjacent to the Arctic region. Impacts on wetlands from construction could be minimized by maintaining buffers around lakes and ponds and by using best management practices for erosion and sedimentation control.

The impacts of road construction on the North Slope are often reduced by the restriction of construction activities to the winter months when the ground is frozen and the use of ice roads rather than gravel roads. Although ice roads avoid the permanent loss of habitat associated with gravel roads, they may affect some vegetation communities. Effects may result from delayed melting in spring, damage to plants, plant mortality, and removal of dead material from the canopy (Walker et al. 1987a). Tundra communities generally recover from such effects, however, within several years (MMS 2002c, 2003e). Drier communities, elevated microsites, and tussock tundra are more affected (Pullman et al. 2003), while moist or wet meadow communities are little affected (Payne et al. 2003).

Large amounts of gravel may be required for permanent road construction. On the North Slope, gravel is often extracted from the floodplains of large rivers (Pamplin 1979; BLM 2002). The excavation of gravel from these material sites and the creation of stockpile areas may affect wetland communities on river floodplains. Wetland areas may be modified by gravel excavation and other mining operations that alter stream channels. Revegetation of the affected area is expected to be relatively rapid, within a few years.

Additional factors, such as reduced air quality, might also affect wetlands because of activities associated with pipeline or platform construction. Exhaust emissions, such as from construction equipment or pump stations, or fugitive dust generated from exposed soils or roadways could have adverse effects on nearby wetland communities.

Existing shore bases, gas processing facilities, and waste disposal facilities would be used for all new oil and gas activities in the region. Operation of existing facilities could have local indirect effects on vegetation from exhaust emissions or atmospheric releases from processing facilities. Contaminants could be introduced into wetlands from the use of existing land storage or disposal sites, if contaminants migrate into groundwater or enter stormwater that flows into wetlands. Contaminants might also be released to surface waters in service vessel discharges, and might subsequently affect wetlands. Impacts on wetlands could be minimized by the implementation of air and water quality practices.

Accidents.

Coastal Barrier Beaches. The potential effects on coastal barrier beaches and dunes from accidents would primarily be associated with impacts from spills of oil and other petroleum hydrocarbons, such as fuel oil or diesel fuel, and subsequent cleanup efforts. Oil or other spilled materials might be transported to barrier island beaches, coastal beaches, or lagoon beaches by currents or tides. Contamination of beaches from platform spills, pipeline spills, or vessel spills could occur. Because platforms in the Chukchi Sea would be at least 40 km (25 mi) from the coastline, platform spills there would have a lower potential for contacting beaches and dunes than spills nearer the coast in the Beaufort Sea, and the point of contact may be a greater distance down the coastline due to longshore currents. Greater weathering of the lighter, more acutely toxic components of crude oil may therefore also occur prior to contact with the coastline. Beach habitat could be affected by oil spills, and the direct mortality of biota could result. Although beach and foredune areas are often sparsely vegetated, impacts on vegetation might occur if oil were carried to higher elevations by storm waves and tides.

Spilled oil that becomes stranded on beaches might occur only on the surface, or it could penetrate into subsurface layers. Permeable substrates, generally associated with larger sand grain sizes, and holes created by infauna could increase oil penetration, especially that of light oils and petroleum products. Penetration into coarse-grained sand beaches may be up to 25 cm (0.8 ft) (NOAA 1994, 2000). Light oils may penetrate peat shores; however, peat resists penetration by heavy oils (NOAA 2000).

Although any residual oil that could remain following cleanup might be largely removed in highly exposed locations through wave action, oil could remain in the shallow subsurface for extended periods of time. In some locations, oil might become buried by new sand or gravel deposition. Natural degradation and persistence of oil on beaches are influenced by the type of oil spilled, amount present, sand grain size, degree of penetration into the subsurface, exposure to weathering action of waves, and sand movement onto and off shore. Although petroleum-degrading microbial communities are present, biodegradation along arctic coastlines would likely be slow (Prince et al. 2002; Braddock et al. 2003; Braddock et al. 2004) and is limited to only a few months per year. Spilled oil might persist for many years, with continued effects on infauna and potential recovery of infaunal communities. On sheltered beaches, heavy oiling left for long periods could form an asphalt pavement relatively resistant to weathering (Hayes et al. 1992). Lagoon shorelines include low-energy beaches where spilled oil would likely persist for many years. Spilled oil may persist for extended periods on peat shores; however, if cleaned up, it would be expected to persist for less than a decade (Owens and Michel 2003).

Spill cleanup operations might adversely affect beaches and dunes, if the removal of contaminated substrates affects beach stability and results in accelerated shoreline erosion. Vehicular and foot traffic during cleanup could mix surface oil into the subsurface, where it would likely persist for a longer time. Manual cleanup rather than use of heavy equipment would minimize the amount of substrate removed.

Catastrophic Discharge Event. The PEIS analyzes a CDE in the Beaufort Sea of 1.7–3.9 million bbl, and in the Chukchi Sea of 1.4–2.2 million bbl. Oil might be transported to barrier island beaches, coastal beaches, or lagoon beaches by currents or tides, even from a discharge in the Chukchi Sea; however, the point of contact may be a greater distance down the coastline due to longshore currents. Greater weathering of the lighter, more acutely toxic components of crude oil may therefore also occur prior to contact with the coastline. A CDE would potentially result in heavy or widespread deposits of oil and would have a greater likelihood for extensive areas of shoreline affected and heavy deposits of oil in multiple locations. Natural degradation and persistence of oil on beaches are influenced by the amount present, sand grain size, degree of penetration into the subsurface, exposure to weathering action of waves, and sand movement onto and off shore. Spilled oil might persist for many years, with continued effects on infauna and potential recovery of infaunal communities.

Wetlands. The potential effects on wetlands from accidents would primarily be associated with impacts from spills of oil and other petroleum hydrocarbons, such as fuel oil or diesel fuel, and subsequent cleanup efforts. Oil or other spilled materials might be transported from offshore areas to coastal wetlands by currents or tides, and may result from spills involving platforms, pipelines, or service vessels. Because platforms in the Chukchi Sea would be at least 40 km (25 mi) from the coastline, platform spills there would have a lower potential for contacting coastal wetlands than spills nearer the coast in the Beaufort Sea, and the point of contact may be a greater distance down the coastline due to longshore currents. Greater weathering of the lighter, more acutely toxic components of crude oil may therefore also occur prior to contact with the coastline. The potential for impacts on marshes, estuaries, and low-lying tundra would depend on wind and wave conditions, because the rates of abrasion and dispersal of stranded oil by littoral processes are generally low, due to the small tidal range along the arctic coast. Oil may be deposited at higher elevations of marshes, tundra, and river deltas by spring tides or storm surges and would be expected to persist for long periods due to the low rates of dispersion and degradation.

Freshwater wetlands on the ACP could be affected by spills from onshore pipelines. Oil spilled on the ACP could potentially flow into a nearby stream. Vegetation along the path of the spill would be injured or killed, including wetland vegetation along the stream. Oil reaching the arctic coastline may persist for extended periods of time and slow or reduce vegetation recovery. Wetlands in river deltas and estuaries could be affected by oil spilled in upstream areas.

Impacts on wetlands from oil spills could result in extensive injury or mortality of vegetation and invertebrates in or on the substrate. Other effects of spills could include a change in plant community composition or the displacement of sensitive species by more tolerant species. Impacts on soil microbial communities might result in long-term wetland effects, and wetland recovery would likely be slowed. Various factors influence the extent of impacts on wetlands. Impacts would depend on site-specific factors at the location and time of the spill. The degree of impacts is related to the oil type and degree of weathering, the quantity of the spill (lightly or heavily oiled substrates), duration of exposure, season, plant species, percentage of plant surface oiled, substrate type, soil moisture level, and oil penetration into the soil (Hayes et al. 1992; Hoff 1995; NOAA 1994). Higher mortality and poorer recovery of vegetation generally result from spills of lighter petroleum products (such as diesel fuel), heavy deposits of oil, spills during the growing season, contact with sensitive plant species, completely oiled plants, and deep penetration of oil and accumulation in substrates. Oil that reaches the root system would result in high levels of mortality. Vegetation regrowth and recovery are generally better where oil spills occur in flooded areas or on saturated soils, than on unsaturated soils (BLM 2002). Coastal wetlands in sheltered areas, such as bays and lagoons, which are not exposed to strong water circulation or wave activity, would be expected to retain oil longer with longer-lasting effects on biota (Culbertson et al. 2008).

Oil spills on ice or snow in winter would likely be easily cleaned up with little oil remaining; however, spills during other times may be difficult to clean up, and considerable amounts of oil may remain. Following cleanup, the spilled oil remaining degrades naturally by weathering and biodegradation by soil microbial communities. However, biodegradation would likely be slow due to generally cool temperatures and a short growing season. Full recovery of wetlands, including invertebrate communities, might require more than 10 years depending on site and spill characteristics (Hoff 1995; Culbertson et al. 2008). Oil could remain in some wetland substrates for decades, even if it was cleaned from the surface. Heavy deposits of oil in sheltered areas of coastal wetlands or in the supratidal zone could form asphalt pavements resistant to degradation (Hoff 1995; Culbertson et al. 2008).

Spill cleanup actions might damage wetlands through trampling of vegetation, incorporation of oil deeper into substrates, increased erosion, and inadvertent removal of plants or sediments, all of which could have long-term effects (NOAA 1994, 2000; Hoff 1995). These actions could result in plant mortality and delay or prevent recovery. Complete recovery of coastal wetlands disturbed by cleanup activities could take several decades. Effective low-impact cleanup actions could include bioremediation, low-pressure flushing, or use of chemical cleaners.

The NOAA Environmental Sensitivity Index (ESI) shoreline classification system classifies coastal habitats on a scale of 1 to 10, according to habitat sensitivity to spilled oil,

oil-spill retention, and difficulty of cleanup (NOAA 1994). Habitats with high ESI values are given a higher priority for protection. The ESI shoreline classification for the Beaufort and Chukchi Sea coasts includes habitats with high values, such as inundated lowland tundra or salt/brackish-water marshes, both ranked 10 (MMS 2002d, Owens and Michel 2003).

Catastrophic Discharge Event. The PEIS analyzes a CDE in the Beaufort Sea of 1.7–3.9 million bbl, and in the Chukchi Sea of 1.4–2.2 million bbl. Oil or other spilled materials might be transported from offshore areas to coastal wetlands by currents or tides, even from a discharge in the Chukchi Sea; however, the point of contact may be a greater distance down the coastline due to longshore currents. Greater weathering of the lighter, more acutely toxic components of crude oil may therefore also occur prior to contact with the coastline. A CDE would potentially result in heavy or widespread deposits of oil and would have a greater likelihood for extensive areas of shoreline affected and heavy deposits of oil in multiple locations. The potential for impacts on marshes, estuaries, and low-lying tundra would depend on wind and wave conditions. The degree of impacts is related to the degree of weathering, whether substrates are lightly or heavily oiled, duration of exposure, season, plant species, percentage of plant surface oiled, substrate type, soil moisture level, and oil penetration into the soil.

4.4.6.1.4 Conclusion. Routine Program activities in the GOM, Cook Inlet, and the Arctic would result in minor to moderate localized impacts. Although routine operations in the GOM could have impacts on coastal barrier beaches and dunes, primarily as a result of pipeline construction, maintenance dredging of inlets and channels, and vessel traffic, modern methods of pipeline construction could result in minimal beach erosion. Studies have shown few effects of pipeline landfalls and navigation channels on barrier beach stability.

Routine operations in the GOM could have direct impacts on wetlands as a result of direct losses of habitat from construction activities, pipeline landfalls, and channel dredging, and indirect impacts as a result of altered hydrology caused by channel dredging. Construction impacts, while unavoidable, would be mitigated by State and Federal regulations governing construction in wetland areas. Spills could potentially affect both the surface and subsurface of beach and dune substrates in the GOM. Oiled beach sediments could weaken dune and other beach vegetation, resulting in accelerated erosion. Oil spills could have direct impacts on wetlands by weakening and killing vegetation. Weakened wetland vegetation could lead to long-term or permanent loss of wetland areas, particularly in an already stressed environment such as the Mississippi River deltaic plain. Cleanup operations themselves could also affect wetlands.

Routine operations in Cook Inlet could affect coastal habitats as a result of vessel traffic, as well as infrastructure maintenance and repair activities. Direct loss of habitat could occur as a result of damaging habitats during maintenance. Direct losses would be minimized through existing Federal and State environmental review and permitting procedures that would attempt to mitigate impacts through appropriate requirements. Secondary impacts on wetlands could occur from water and air quality degradation. Because the Cook Inlet Planning Area is almost entirely surrounded by coastal habitat, it is likely that a large spill would contact these habitats. Habitats along the western shoreline have the greatest likelihood of contact based on surface currents in the inlet. Spills could result in changes in community structure and direct loss of habitat.

Routine operations in the Arctic could affect coastal habitats as a result of pipeline construction, gravel mining on floodplains (for pipeline workpads and offshore islands), vessel traffic, and infrastructure maintenance and repair activities. These activities could result in direct loss of habitat by replacing habitat with infrastructure and by damaging habitats during maintenance. These direct losses would be minimized through existing Federal and State environmental review and permitting procedures that would attempt to mitigate impacts through appropriate siting and construction requirements. Secondary impacts on wetlands could occur from water and air quality degradation, ice roads, fugitive dust, and altered drainage caused by pipelines and roads.

A catastrophic discharge event with an assumed volume of 0.9–7.2 million bbl in the GOM would be associated with a loss of well control; a 75,000–125,000 bbl CDE in Cook Inlet would be associated with a loss of well control or pipeline break; a 1.7–3.9 million bbl CDE in the Beaufort Sea or a 1.4–2.1 million bbl CDE in the Chukchi Sea would be associated with a loss of well control. Oil or other spilled materials might be transported from offshore areas to coastal wetlands by currents or tides. The amount of oil deposited on coastal habitats would depend on various factors, such as spill volume, distance from shoreline, ambient conditions, degree of weathering, and effectiveness of response actions. A catastrophic discharge event would potentially result in heavy or widespread deposits of oil and would have a greater likelihood for extensive areas of shoreline affected and heavy deposits of oil in multiple locations. The degree of effects and length of recovery depend on a number of factors such as the type of oil, extent of biota exposure, substrate type, degree of sediment contamination, time of year, and species sensitivity.

4.4.6.2 Marine Benthic Habitats

4.4.6.2.1 Gulf of Mexico.

Soft Sediments.

Routine Operations.

<u>Exploration and Site Development.</u> Impacting factors for the exploration and site development phase are shown in Table 4.4.6-3. The vast majority of marine benthic habitat affected by the Program would be soft sediments. Drilling wells would temporarily reduce habitat quality by generating temporary turbidity and sedimentation for some distance around the disturbed area. It is estimated that 1,000 to 2,100 exploration and delineation wells and 1,300 to 2,600 development and production wells will be drilled in the WPA and CPA. Drilling can occur from fixed platforms, floating platforms, or drillships. The installation of floating or fixed platforms would disturb soft sediment habitat where the legs or mooring structures (anchors and

TABLE 4.4.6-3 Impacting Factors by Phase and Potential Effects on Marine Benthic Habitat in the CPA and WPA of the GOM

Disturbance	Potential Effects[a]
Exploration and Site Development	
Seismic surveys	Noise; localized anchoring disturbance
Anchoring and mooring of platforms, drillships, and seismic survey vessels	Sediment scour; temporary turbidity and sedimentation; localized alteration in sediment grain size and biogeochemical functions
Drilling and production platform placement	Noise; temporary sediment resuspension and turbidity; loss of natural habitat creation of artificial reef
Drilling	Noise; small habitat loss; local alteration of sediment characteristics; temporary turbidity and sedimentation in surrounding areas
Miscellaneous discharges (deck washing; sanitary waste; vessel releases of bilge and ballast water)	Sediment contamination
Solid wastes	Sediment contamination
Discharge of drilling muds/cuttings	Sediment and water column contamination; alteration in sediment granulometry and biogeochemical functions
Pipeline trenching and placement	Noise; long-term loss and degradation of existing benthic habitat; temporary sediment resuspension and turbidity; substrate for growth
Production	
Scour from anchors and the movement of pipelines and mooring structures	Chronic, long-term disturbance of bottom sediments; turbidity
Platform production	Noise; loss of natural habitat creation of artificial reef
Produced water discharge	Sediment contamination
Miscellaneous discharges	Sediment contamination
Solid wastes and debris	Sediment contamination
Decommissioning	
Miscellaneous discharge	Sediment contamination
Solid wastes and debris	Sediment contamination
Platform removal	Explosive noise; temporary turbidity and disturbance of bottom sediments

[a] Colors indicate impact level: white = negligible; blue = minor; yellow = moderate; red = major.

chains) encountered the seabed and where subsea equipment (such as reentry collars and blowout preventers) was installed. Chronic local bottom disturbance would result from subsequent movements of anchors and mooring lines associated with floating production platforms and support vessels. The actual area of seafloor affected by anchoring operations would depend upon water depth, currents, size of the vessels and anchors, and length of anchor chain. The amount of bottom affected by anchored structures would increase with water depth because of the use of larger anchors and longer anchor chains. Anchor scars were detected in a radial pattern up to 3 km (2 mi) from a well located on the GOM continental slope (Continental Shelf Associates, Inc. 2006). Drilling vessels would use either anchors or dynamic positioning to maintain station. Drilling vessels using dynamic positioning systems rather than anchors would not generate mooring impacts on the seafloor. Exploratory well platforms can be fixed or floating.

Under the proposed action, it is estimated that 200 to 450 new production platforms will be constructed, which is expected to disturb 150 to 2,500 ha (370 to 6,178 ac) of seafloor. Ninety-five percent of these new platforms will be located in water depths less than 200 m (656 ft). In deep water, floating platforms (including those associated with a FPSO system) requiring mooring structures will typically be used, while platforms in more shallow water would likely have legs and not require mooring. Impacts from fixed and floating production platforms would be similar to those described above for the exploration phase.

Under the proposed action, it is estimated that 3,862 to 12,070 km (2,400 to 7,500 mi) of new pipeline would be placed in the CPA and WPA, resulting in disturbance to 2,000 to 11,500 ha (4,942 to 28,417 ac) of seafloor. Up to two FPSO systems could potentially be used in deep water, which would reduce the need for pipelines. In water depths less than 60 m (197 ft), pipelines must be buried; benthic organisms within the trenched corridor could be killed or injured and organisms to either side of the pipeline could be buried by sediments. Pipelines placed on the sediment surface would permanently replace the existing soft sediments with man-made substrate that sessile invertebrates may colonize over time. Vessel anchoring during pipeline placement would also disturb soft sediment. Anchor and mooring impacts from pipeline placement vessels would be eliminated if dynamic positioning systems rather than anchors were used during pipeline placement. The recovery period for soft sediment benthic habitat disturbed by pipeline placement would depend on factors such as water depth, sediment type, and community composition. Disturbed sediments with a greater proportion of sand to mud may fill in with fine silty material, which would alter grain size and potentially inhibit the colonization by species that existed prior to the disturbance.

During the exploration and development phase, drill cuttings and drilling muds (including synthetic drilling fluids adhering to the cuttings) could contaminate and alter the grain size of sediments immediately around the wellhead and below the discharge area. Drilling wastes are regulated by the USEPA under NPDES permits and can be discharged into the ocean only if they meet USEPA toxicity and discharge rate requirements. These requirements greatly reduce the potential for sediment contamination. Drill cuttings and muds rapidly reach the sediment surface. Therefore, the discharged drilling muds and cuttings could be deposited in highly concentrated thick layers if deposited in shallow water or near the sediment surface. In the case of near-surface discharge in deep water, drilling muds would spread out in a thin veneer over a wide area. Settled muds could cause smothering of organisms, changes in sediment characteristics and biogeochemical functions, and the loss of food resources in the immediate area. The biodegradable synthetic drilling fluids attached to the drilling waste may deplete oxygen (Trannum et al. 2010) and therefore may create local sediment anoxia.

Studies at multiple sites on the Louisiana continental shelf and slope provide the most relevant information on the potential ecological effects of drilling and drilling mud discharges on soft sediment habitat. These studies found drill cuttings were detectable up to 1 km (0.6 mi) from the well site, depending on whether cuttings were discharged near the water surface or near the bottom (Continental Shelf Associates Inc. 2004, 2006). Concentrations of barium, hydrocarbons, and synthetic drilling fluids in the sediment were patchily distributed within the sampling radius (up to 500 m [1,640 ft] from the well) but, overall, were higher than at the control sites (Continental Shelf Associates Inc. 2004, 2006). Several other alterations in habitat were also detected, including anoxic bottom patches, elevated metal concentrations, coarser grain size (all typically less than 300 m [984 ft] from well), and anchor scars (up to 3 km [1.9 mi] from well). Within 250 m (820 ft) of the well, sediment toxicity to certain invertebrates based on bioassays was also reported at several sites, and metrics of invertebrate community health were lower and more variable (Continental Shelf Associates Inc. 2004). However, a greater abundance of certain species of mieofauna, macrofauna, and fish compared to controls was also detected, potentially because of the organic enrichment of sediments near the well (Continental Shelf Associates Inc. 2006). The spatial extent of the biological, physical, and chemical effects cannot be precisely determined, but drilling discharges, hydrocarbons, and sediment toxicity all dropped off rapidly with distance from the well (Continental Shelf Associates Inc. 2004, 2006). Habitat recovery time is also unknown, but evidence for biological, physical, and chemical recovery was detected after 1 yr, so full recovery may occur over several years as sediment contaminants are biodegraded and buried by natural deposition and bioturbation (Continental Shelf Associates Inc. 2004, 2006).

Miscellaneous discharges (deck washing, sanitary waste, and vessel discharge) also have the potential to disturb soft sediment habitats. Miscellaneous discharges could contaminate sediments if discharged in relatively shallow water. However, contaminants in surface discharges would most likely be diluted to negligible concentrations before reaching the sediment, especially for platforms located in deep water. Many vessel and platform wastes are disposed of on land, and those that are discharged at sea must meet USEPA and/or USCG regulatory requirements that limit their environmental effects.

Noise from seismic surveys and drilling could kill or injure organisms close enough to the noise source and reduce habitat suitability because some species would avoid the area. The severity and duration of noise would vary with site and development scenario, but overall the impacts would be temporary and localized with overall minimal effects on soft sediment habitat. See Section 4.4.7 for detailed discussions of the effects of noise and different categories of biota.

Overall, site development and exploration represents a moderate, but localized, long-term disturbance, with the severity of the impacts generally decreasing dramatically with distance from the well site.

Production. Production activities that could affect soft sediment habitat are shown in Table 4.4.6-3 and include operational noise, miscellaneous discharges, bottom disturbance from the movement of anchors and mooring structures, and the releases of process water. In addition, the platform would replace existing featureless soft sediments and serve as an artificial reef. The potential impacts of miscellaneous discharges would continue on from the exploration and development phase and are described above. Impacts on soft sediment habitats from vessel and operational noise are expected to be negligible, but long term, with the impacts lasting the duration of the production phase.

Chronic bottom disturbance from the movement of anchors and chains associated with platforms and support vessels would affect soft sediment habitats as described above for the exploration and site development phase. Pipelines in water less than 60 m (197 ft) must be buried, which would reduce the potential for pipeline movement. However, pipelines could become unearthed or moved following severe storms. These disturbances would be long term and chronic and cause scour, turbidity, and sedimentation of soft sediment habitats.

The platforms and pipelines would also create novel hard substrate, and the area on and immediately around the platform would have habitat functions and biological communities very different from these in the preconstruction period. Algae and sessile invertebrates would attach to the platform and would in turn attract reef-oriented organisms. The ecological function and value of artificial reef habitat are controversial as some species may benefit while others do not. In addition, sediment grain size and the biogeochemical processes around the platform could be altered by the flux of biogenic material from the platform to the seafloor. For example, an increase in shell material and organic matter would likely result along with a transition to benthic species adapted to these conditions (Montagna et al. 2002). The replacement of soft sediment with artificial reef would exist only during the production phase, unless the platform was permitted to remain in place after decommissioning. In deep sea soft sediment, communities may form on mooring structures, but colonization would likely be slow, and mooring structures would be completely removed during decommissioning, so impacts, if any, would be temporary.

Produced water is a normal product of oil and gas extraction that contains contaminants such as polycyclic aromatic hydrocarbons (PAHs) and heavy metals and therefore represents a potential source of contamination to benthic habitats. Before being discharged into the ocean, produced water is typically treated and must meet NPDES requirements regarding discharge rate, contaminant concentration, and toxicity, thereby reducing the potential for sediment contamination. In addition, contaminants in produced water would be rapidly diluted with distance from the discharge point and are expected to reach sediments only in biologically negligible concentrations. A major study of produced water discharges across the northern GOM indicated that despite the large volume discharged, the contribution of produced water to bottom water hypoxia is minimal when compared to riverine inputs (Bierman et al. 2007). Overall, produced water did not make a significant contribution to the hypoxic zone (Rabalais 2005).

The results of the GOM Offshore Monitoring Experiment funded by BOEM provide a good summary of the long-term changes to soft sediment habitats resulting from oil and gas development (Kennicutt et al. 1995). For the study, stations at 30–50, 100, 200, 500, and 3,000 m (98–164, 328, 656, 1,640, and 9,842 ft) distances from petroleum wells were sampled in a radial pattern surrounding the platforms. Elevated sediment concentrations of sand, organic matter, hydrocarbons, and metals were generally restricted to sediments less than 200 m (656 ft) from the platforms. PAH levels in sediments were well below levels considered to be toxic to invertebrates, and no significant hydrocarbon bioaccumulation was observed in megafaunal invertebrates near platforms. However, metal levels in invertebrate tissues were higher at the study sites (Kennicutt et al. 1995). The physical and chemical changes to sediments near the platforms were enough to alter the soft sediment communities, but the effects were restricted to within 200 m (656 ft) of the platforms. Overall, the authors concluded that oil and gas development and production resulted in moderate, highly localized changes to soft sediment habitat (Montagna and Harper 1996).

Decommissioning. Miscellaneous discharges and solid waste releases discussed above would continue during the decommissioning phase (Table 4.4.6-3). Platform and mooring structure removal activities could result in increased turbidity, temporary suspension of bottom sediments, and explosive shock-wave impacts. Impacts from decommissioning will vary with platform removal scenario, which ranges from complete to partial removal. The impacts from the explosive removals of the platforms would be attenuated by the movement of the shock wave through the seabed, because the charges typically would be set at 5 m (16 ft) below the seafloor surface. Under the proposed action, it is assumed that a total of 150 to 275 platforms would be removed using explosives. A small area would be disturbed, compared with total seafloor area in the entire GOM. In addition, because soft-bottom benthic habitats are typically recolonized relatively quickly following disturbances, benthic communities in disturbed areas would be expected to recover over a period of months to years without mitigation. If the platform is toppled and left in place, the remains would serve as hard bottom habitat that would permanently replace the existing soft sediment habitat. Artificial reefs provide habitat to fish, algae, and invertebrates; however, their ecological and population effects are controversial. Overall, impacts on soft sediment resources from decommissioning activities are expected to be negligible.

Accidents. Accidental hydrocarbon releases in marine habitat can occur at the surface from tankers or platforms or at the seafloor from the wellhead or pipelines. Natural gas would quickly rise above the sediment surface, which would minimize its impacts on benthic habitat. Natural gas is also less persistent in the environment than oil. Evidence from the DWH event indicates that methane gas released from the well was rapidly broken down by bacterial action with little oxygen drawdown (Camilli et al. 2010; Kessler et al. 2011). Consequently, the remainder of the discussion focuses on oil spills. It is assumed that up to 8 large spills (≥1,000 bbl), up to 70 spills between 50 and 999 bbl, and up to 400 smaller spills between 1 and 50 bbl could occur during the lease period under the proposed action (Table 4.4.2-1). Modeling indicates that oil spilled at the surface could mix to a depth of 20 m (66 ft) at highly diluted concentrations (MMS 2008a). Therefore, most surface spills would likely reach the sediment at biologically negligible concentrations. Most subsea spills would be minor, and the hydrocarbon concentrations would typically be diluted to background levels within a few hundred meters to a few kilometers of the spill site. The soft sediment habitat would recover without mitigation because of natural breakdown of the oil, sediment movement by currents, and reworking by benthic fauna.

Oil spill-response activities such as burning, skimming, and chemical release (e.g., dispersants or coagulants) could affect benthic habitat and biota. Skimming and burning could kill pelagic live stages of benthic biota. The chemicals used during a spill response are toxic, but there is controversy about whether the combination of oil and dispersant is more toxic than oil alone (NRC 2005b; Fingas 2008; Holland-Bartels and Kolak 2011). The use of dispersant would likely reduce oiling of nearshore benthic habitat, but may increase the exposure of subtidal benthic habitat and biota to toxic fractions of oil (NRC 2005b). In shallow water, the presence of, and noise generated by, oil spill-response equipment and support vessels could temporarily disturb benthic habitat in the vicinity of the response action, potentially reducing habitat use or disturbing migration. As with the spill itself, the location and time of the year the cleanup occurs would be an important determinant of impacts on benthic habitat and biota.

Catastrophic Discharge Event. The PEIS analyzes a CDE up to 7.2 million bbl (Table 4.4.2-2). Lethal or sublethal concentrations of hydrocarbons or mixtures of hydrocarbon and dispersant (if used) could accumulate in soft sediments, reducing habitat function. The magnitude of the impact depends primarily on the location of the well, the volume released, and the speed at which the well is capped. Typically oil rises from the seafloor to the surface, forming a surface slick. However, a subsurface plume capable of traveling long distances could form if dispersants are used or if the well releases a mixture of oil and gas. However, even in the case of a subsurface plume, most oil would stay above the sediment. Sediment contamination could occur from the deposition of oiled sediment and organic matter (dead plankton and organic flocculants) falling from the water column. Such deposition is expected to decrease significantly with distance from the well.

Benthic habitat would probably recover more quickly from a shallow-water spill than from a deepwater spill because of the greater microbial activity and potential for sediment resuspension in shallow water, which would facilitate the breakdown of hydrocarbons. Because of the widespread presence of soft-bottom habitats on the continental shelf and slope and the tendency of oil to stay suspended above the sediment, it is anticipated that impacts from oil spills would affect only a very small proportion of such habitat within the GOM. Oiled sediments would eventually recover their habitat value as hydrocarbons broke down or were buried by natural processes, and communities would soon recover through larval recruitment from adjacent areas. However, recovery time would vary with local conditions and the degree of oiling. Overall, impacts on soft sediment habitat from accidents could be moderate and potentially long term, but no permanent degradation of soft sediment habitat is expected to result from accidental spills.

Warm Water Coral Reefs and Hard-Bottom Habitat.

Routine Operations. BOEM has several protections in place to minimize and mitigate the adverse effects of oil and gas exploration and development on coral reefs and hard-bottom habitat. It is assumed that these current protections will also be implemented during this Program. The mitigations as described in the Topographic Features Stipulation and NTL No. 2009-G39 (available at http://www.gomr.boemre.gov/homepg/regulate/regs/ntls/2009NTLs/09-G39.pdf) create avoidance and mitigation requirements for biologically sensitive hard bottom areas and topographic features in waters 300 m (984 ft) or less.

Four hard bottom or reef habitats are designated for the various protections: (1) banks offshore of Texas and Louisiana (including the Flower Garden Banks National Marine Sanctuary [FGBNMS]), (2) the Pinnacle Trend off the Louisiana-Alabama coast, (3) seagrass and low-relief live-bottom areas primarily located in the CPA and Eastern Planning Area (EPA), and (4) potentially sensitive biological features of moderate to high relief that are not protected by (1) and (2). These protections are explained in greater detail below.

Exploration and Site Development. *Topographic features (banks)*. Because FGBNMS is a national sanctuary, no oil and gas exploration or site development would be allowed there. To protect other hard-bottom topographic features, BOEM instituted a Topographic Features Stipulation that established No Activity Zones prohibiting structures, drilling rigs, pipelines, and anchoring around 22 underwater topographic features out to a specified isobaths (typically 85 m [279 ft]) (Table 4.4.6-3). The continuation of this same practice is assumed here. To limit impacts from drilling discharges, the stipulation also requires all drilling muds and cuttings be shunted to within 10 m (33 ft) of the seafloor at distances ranging from 1 to 6.4 km (0.6 to 4 mi) away from topographic features depending on their nature and biological sensitivity. This shunting protects biota by confining the effluent to a level deeper than that of the living components of a high-relief topographic feature. For low-relief banks in the WPA, shunting drilling effluents is not required because it would put the potentially harmful drilling muds and cuttings in the same water depth range as the topographic features. In addition, NTL No. 2009-G39 prohibits bottom-disturbing activities, including the use of anchors, chains, cables, and wire ropes within 152 m (500 ft) of a No Activity Zone without first consulting NOAA. Maps of the protected banks in the WPA and CPA are available at http://www.gomr.mms.gov/homepg/lsesale/topo_features_package.pdf.

Ninety five percent of the 200 to 450 anticipated new production platforms would be located in water depths less than 200 m (656 ft), which is within the depth range at which coral reefs and live-bottom features are found. Turbidity and sedimentation from bottom disturbance and the discharge of drilling wastes can adversely affect coral in multiple ways, including mortality, decreased growth, and loss of xoozanthelle (Thompson et al. 1980; Nugues and Roberts 2003; Fabricius 2005). The protections described above would minimize the impacts from direct bottom disturbance and sediment resuspension to designated banks from anchoring, drilling, platform placement, and pipeline trenching and placement. It is possible but not likely that turbidity would affect hard-bottom habitat if bottom disturbance occurred near the boundary of a No Activity Zone. The shunting requirements should minimize the adverse effects of discharged drilling muds and cuttings, although low-relief banks in more shallow water may be adversely affected to some degree. The topographic feature stipulations have been very effective in protecting the communities associated with topographic features. For example, despite the proximity of oil and gas development activities, long-term monitoring studies do not indicate any significant detrimental impact on the coral reefs of the FGBNMS (Gittings 1998).

Pinnacle trend. The Live-Bottom/Pinnacle Trend Stipulation, which currently applies to certain blocks in the CPA and EPA, requires a biological interpretation of bathymetric and geophysical surveys to determine the distribution of pinnacle features before any bottom-disturbing activities can occur. Also, NTL No. 2009-G39 currently requires consultation with NOAA before any bottom-disturbing activities (including those caused by pipelines, anchors, chains, cables, or wire ropes) planned within 30 m (100 ft) bottoms/pinnacles with vertical relief of 2.4 m (8 ft) or more. There are no specific measures requiring drilling muds and cuttings to be discharged near the seafloor, because modeling studies suggest that the discharge would be transported over the pinnacles (Continental Shelf Associates, Inc. and Texas A&M 2001). Limitations on drilling mud discharges required by NPDES permit and the fact that the pinnacle trend area is subject to high levels of natural turbidity and sedimentation should limit impacts on pinnacle features. If it is determined that the live-bottoms might be adversely affected by the proposed activity, BOEM can further require economically, environmentally, and technically feasible measures to protect the pinnacle area. These measures may include, but are not limited to, the relocation of operations and monitoring to assess the impact of the activity on the live-bottoms. See the BOEM Web site at http://www.gomr.mms.gov/homepg/regulate/environ/topoblocks.pdf for the list and http://www.gomr.mms.gov/homepg/regulate/environ/topomap.pdf for the map of the identified pinnacle trend features.

Continued implementation of the Live-Bottom/Pinnacle Trend Stipulations and the requirements in NTL No. 2009-G39 would minimize bottom disturbance within 30 m (100 ft) of the majority of known pinnacle features. Because of these protections, direct effects such as benthic habitat disturbance from drilling, platform placement, trenching, and placement of pipelines would be minimal. However, if these activities occurred in the vicinity of the pinnacles, then sedimentation and turbidity could kill or inhibit respiration, filter feeding, and photosynthesis by hard-bottom biota. Because of the lower vertical relief pinnacles, the effects of turbidity and sedimentation could be greater in their vicinity. In addition, noise from seismic surveys, construction, and drilling could injure, kill, or cause avoidance behavior in organisms within a certain distance from the noise source. Noise disturbance would be temporary and the community would recover if the initial impact did not result in major injury or mortality to organisms associated with a pinnacle trend.

Impacts from drilling discharges would be reduced by compliance with the Pinnacle Trend/Live-Bottom Stipulation, NPDES permit restrictions that limit the amounts and types of drilling discharges and the depth at which the pinnacles are located. However, studies in the pinnacle region indicated that discharges of drilling muds may reach background levels within 1,500 m (4,921 ft) of the discharge point (Shinn et al. 1993). Therefore, pinnacles could be affected by discharges occurring at the surface and outside of the 30-m (98-ft) buffer required by NTL-2009-G39. As described above, increased turbidity and sediment deposition from discharges of muds and cuttings in the vicinity of pinnacles may reduce habitat quality and ecological function. However, biota associated with live-bottom/pinnacle features are usually adapted to life in somewhat turbid conditions and are often observed coated with a sediment veneer (Continental Shelf Associates, Inc. and Texas A&M 2001). The existing bottom currents would also prevent the accumulation of large amounts of mud and cuttings. Documentation of an exploratory well adjacent to hard-bottoms in the pinnacle trend at a depth of 103 m (338 ft), 15 months after drilling, showed cuttings and other debris covering an area of approximately 0.6 ha (1.5 ac) (Shinn et al. 1993), but the hard-bottom feature was still found to support a diverse community, including gorgonians, sponges, ahermatypic stony corals, and antipatharians. If turbidity and sediment deposition did result in extensive damage, existing studies suggest that recovery could take years (Continental Shelf Associates, Inc. and Texas A&M 2001).

Pinnacles not detected may be subject to direct damage from construction activities and discharges during site exploration and development. Previously undiscovered pinnacle features are also protected by the Potentially Sensitive Biological Features component of NTL No. 2009-G39. To minimize impacts on unmapped pinnacle features, the BOEM also supports investigations through its Environmental Studies Program to locate hard- and live-bottom features and to understand their ecologies (Continental Shelf Associates, Inc. and Texas A&M University 2001). The BOEM updates regulations and mitigations based on the data from these studies and from the biological interpretations of geophysical surveys, which reduces the risk of accidental damage.

Live-bottom (low-relief) features (CPA and EPA) and potentially sensitive biological features. NTL No. 2009-G39 and the Live-Bottom (Low-Relief) Stipulation pertains to seagrass communities and low-relief hard-bottom reef within the GOM EPA blocks in water depths of 100 m (328 ft) or less and portions of Pensacola Area Blocks and Destin Dome Area Blocks in the CPA. NTL No. 2009-G39 also covers potentially sensitive biological features, which are features of moderate to high relief (about 2.4 m [8 ft] or higher) that provide habitat but are not protected by a biological lease stipulation.

NTL No. 2009-G39 requires that no bottom-disturbing activities (including drilling, platform placement, or the use of anchors, chains, cables, or wire ropes) may cause impacts on live-bottoms (low-relief features) or potentially sensitive biological communities. It is also required that any exploration or development activity planned within 30 m (100 ft) of either must be reviewed by BOEM. If it is determined that these habitats might be adversely affected by the proposed activity, then BOEM will require measures that may include, but are not limited to, relocation of operations, shunting of all drilling fluids and cuttings to avoid live-bottom areas, and monitoring to assess the adequacy of any mitigating measures. For further information on the live-bottom (low-relief) area stipulation and the protections for potentially sensitive biological features in the GOM, see NTL No. 2009-G39.

Overall, the protections in NTL No. 2009-G39 should minimize the potential for direct disturbance to coral reefs and live-bottom habitat. However, sediment disturbance and the discharge of drilling muds and cuttings in nearby areas could result in turbidity and sedimentation around these features that could kill or inhibit respiration, filter feeding, and photosynthesis by hard-bottom biota. Because of their generally shallow depth, low-relief habitats are particularly vulnerable to turbidity and sedimentation. In addition, low-relief live-bottom areas and potentially sensitive biological features not detected would be subject to direct mechanical damage from site exploration and development activities. Thus, appropriately siting discharge locations in pre-disturbance mitigation plans would be critical in minimizing the effects of bottom disturbance and discharges. NTL No. 2009-G39 states that the developer must provide a map showing the activity, structures, and maximum area of disturbance in relation to the feature. Such mapping would minimize impacts on these habitats and minimize the chance of disturbing as-yet-unmapped features.

Overall, impacts on coral reef and live-bottom habitat from exploration and site development activities should be minimized by existing protections. However, low-relief or small, isolated, unmapped live-bottom habitat could be affected by direct mechanical damage and turbidity and sedimentation. Given the frequent natural bottom disturbance that occurs in the GOM shelf, coral reef and live-bottom communities should be resistant to some extent to the adverse physiological impacts from periodic sedimentation. Live-bottom and coral reef habitat should recover, if they are adversely affected by exploration and site development activities. Recovery could be short term to long term depending on the extent and nature of the impact, species affected, and the suitability for recolonization of the habitat affected.

Production. Impacts on hard-bottom and coral reef habitat during the production phase could result from miscellaneous discharges, the movement of vessel anchors and mooring structures, produced water discharge, and the creation of artificial reef habitat (Table 4.4.6-3). Turbidity and sedimentation generated by chronic movement of anchors could affect coral reefs and hard-bottom habitat if they were located close enough to the disturbance. Impacts on coral and hard-bottom habitat from bottom disturbance would be minimized by existing mitigation measures.

Ninety-five percent of the 200 to 450 anticipated new production platforms would be located on the continental shelf. Algae and sessile invertebrates would rapidly colonize the platform and pipelines and would also attract mobile reef-oriented organisms. Thus, platforms would provide new hard-bottom habitat for a variety of species. However, oil and gas production platforms have been implicated in promoting the establishment of new species through natural range expansion or by providing suitable habitat for introduced exotic species (Sammarco et al. 2004; Page et al. 2006; Hickerson et al. 2008). Introduced species could displace native species and in doing so alter the ecological function of existing hard-bottom and coral habitat. For example, oil and gas platforms may have expedited the establishment of several exotic species on the FGBNMS including sergeant majors (*Abudefduf saxatilis*), yellowtail snapper (*Ocyurus chrysurus*), and orange cup coral (*Tubastraea coccinea*) (Hickerson et al. 2008). It is likely that these species would have spread even without the platforms, although the platforms may have expedited the process. If floating platforms with moorings are used, organisms could colonize mooring structures. Thus the overall benthic footprint may be small depending on the design. Also, in deep sea areas, most platforms and mooring structures would likely be completely removed during decommissioning, so impacts, if any, would be temporary.

Produced water discharges could introduce petroleum hydrocarbons and metals into hard-bottom habitat. However, impacts would be minimized by discharge and toxicity limitations imposed by NPDES permits, as well as restrictions that prevent the placement of oil and gas platforms in the immediate vicinity of these habitats. In addition, the depth of many of the coral reef and hard-bottom habitats, the prevailing current speeds, and the offsets of the discharges from these habitats would substantially dilute produced waters before they could come in contact with sensitive biological communities. As a result, the impact of produced water discharges is expected to be minor.

Decommissioning. Coral reefs are not likely to be affected by platform removal because of existing stipulations. Hard-bottom habitat could be adversely affected by explosive platform removal (estimated 150 to 275), which could cause turbidity and sedimentation in nearby hard-bottom habitat. Deposition of suspended sediments could smother and kill the filter-feeding sessile animals that inhabit much of the hard-bottom habitat. Explosive impacts on large topographic features covered by the No Activity Zone Stipulations would be minimized because of their distance from the seafloor and the existing stipulations precluding the placement of structures on or near these communities. However, hard-bottom features located closer to production platforms may be more susceptible to damage. In the event that live-bottom areas were affected during removal of existing platforms, recovery times would vary with damage and species.

Pipelines on the surface of the seafloor that are left in place would continue to provide hard substrate of structure-oriented organisms. In addition, many of the decommissioned platforms will be converted into artificial reefs. By acting as stepping stones across the GOM, oil platforms have been implicated in the introduction of a non-native coral species (*Tubastraea coccinea*) and fishes such as sergeant majors (*Abudefduf saxatilis*) and yellowtail snapper (*Ocyurus chrysurus*) into the FGB (Hickerson et al. 2008).

Accidents. Accidental spills in the CPA and WPA could affect hard-bottom and coral reef habitat from south Texas to the west Florida shelf in the EPA. Accidental hydrocarbon releases in marine habitat can occur at the surface or at the seafloor. Natural gas would quickly rise above the sediment surface, which would minimize its impacts on benthic habitat, although natural gas could temporarily reduce the habitat quality of high-relief benthic features. Natural gas is also less persistent in the environment than oil. Evidence from the DWH event indicates that methane gas released from the well was rapidly broken down by bacterial action with little oxygen drawdown (Camilli et al. 2010; Kessler et al. 2011). Consequently, the remainder of the discussion focuses on oil spills.

It is assumed that up to 8 large spills (≥1,000 bbl), up to 70 spills between 50 and 999 bbl, and up to 400 smaller spills between 1 and <50 bbl could occur during the lease period under the proposed action (Table 4.4.2-1). Most spills would be small and occur at the surface from the platform or vessels or at the seafloor from pipeline leaks. Oil from surface spills can sometimes penetrate the water column to documented depths of 20 m (66 ft) or more, which is within the depth range of the crests of some coral reefs and topographic features including the FGBNMS. However, at these depths, the concentrations of the various chemical components of spilled oil are typically several orders of magnitude lower than those demonstrated to have an effect on marine organisms (MMS 2008a). Therefore, it is likely that only low concentrations of oil from surface spills would reach the sensitive benthic habitats (MMS 2008a). Small subsurface spills could rise and come into contact with corals and hard-bottom habitat. Offshore banks are less likely to be affected because of the No Activity Zone stipulation that would create a large buffer between the banks and oil and gas development and production activities. A buffer of only 30 m (98 ft) applies to most hard-bottom areas and therefore low-relief, hard-bottoms could be contacted by small subsurface oil spills. However, because rapid dilution would occur as spilled oil was transported by currents and rose toward the water surface, subsurface oil spills would likely have to come into contact with a topographic feature almost immediately to have detrimental effects on the associated community. Consequently, the risk of a most accidental oil spills to these communities is relatively small.

Catastrophic Discharge Event. The PEIS analyzes a CDE up to 7.2 million bbl (Table 4.4.2-2). A CDE oil spill from a pipeline rupture, a loss of well control, or a tanker associated with a FPSO system could degrade coral reef and hard-bottom habitat if it came into contact with large quantities of oil as it moved through the water column. Hydrocarbons have been shown to have lethal and sublethal (reproduction, larval settlement, photosynthesis, and feeding) effects on corals, although no effects on corals following oil spills are also frequently reported (Loya and Rinkevich 1980; Bak 1987; Guzman et al. 1991; Dodge et al. 1995; Haapkyla et al. 2007). Water currents moving around the banks would tend to carry oil around the banks rather than directly over the features, thereby lessening the severity of the impact

(Rezak et al. 1983). Corals have the capacity to recover quickly from hydrocarbon exposure. For example, Knap et al. (1985) found that when *Diploria strigosa*, a common massive brain coral at the Flower Garden Banks, was dosed with oil, it rapidly exhibited sublethal effects but also recovered quickly. However, larval stages of coral are far more sensitive than adults. Therefore, the impact magnitude of a spill is partly dependent on whether the spill occurs during a period of coral spawning.

If dispersants were used or if oil released from the wellhead had a high ratio of gas, a subsurface hydrocarbon plume covering a large area could form, which would increase the potential for contact with hard-bottom and coral reef habitat. The effect of chemically dispersed oil on corals is equivocal, with some studies finding large effects of oil and dispersant mixtures on corals and others finding only minor effects (Dodge et al. 1984; Wyers et al. 1986; Epstein et al. 2000; Haapkvla et al. 2007; Shafir et al. 2007). If used, dispersants may slow the natural breakdown of oil, resulting in persistent toxicity. In most cases, effects on sensitive biota would be sublethal, with recovery occurring within months to a few years (MMS 2002a). For lethal exposures, the community would likely recover once the area had been cleared of oil, although full recovery could take many years (Haapkvla et al. 2007). Consequently, it is anticipated that impacts of lethal concentrations of oil reaching coral reef or hard-bottom habitat would be long term but temporary.

Deepwater Corals and Chemosynthetic Communities.

Routine Operations.

<u>Exploration and Site Development.</u> In the GOM, both deepwater coral and chemosynthetic communities are currently protected under NTL No. 2009-G40 (available at http://www.gomr.boemre.gov/homepg/regulate/regs/netls/2009NTLs/09-G40.pdf), which covers all high-density deepwater communities (HDDC) in depths 300 m (984 ft) or greater. Impacts on deepwater corals and chemosynthetic communities (HDDC) from exploration and site development could potentially occur during platform and pipeline placement, the discharge of drilling muds and cuttings, and miscellaneous discharges (Table 4.4.6-3). NTL No. 2009-G40 (MMS 2010b) currently prohibits the discharge of drilling muds and cuttings within 610 m (2,000 ft) of HDDC. In addition, NTL No. 2009-G40 requires that all proposed seafloor disturbances (including those caused by anchors, anchor chains, wire ropes, seafloor template installation, and pipeline construction) must be maintained at a distance of at least 76 m (250 ft) from HDDC habitat. In addition, any seafloor disturbances planned within 152 m (500 ft) of a high-density deepwater coral community must be reviewed and approved by BOEM, and the developer must demonstrate that the communities will not be adversely affected by exploration or site development. It is assumed that BOEM will continue to require and implement these measures at the lease sale phase. While these requirements and procedures are believed to be effective in identifying and avoiding most HDDC, it is possible that some unmapped or lower density communities could be mechanically damaged. In addition, despite the 76-m (250-ft) buffer, turbidity and sedimentation created by ground-disturbing activities could contact HDDC habitats. Although data are limited, studies in the GOM indicate that *Lophelia* corals are generally tolerant of turbidity and sedimentation, but at high enough levels suspended sediments can have lethal and sublethal effects (Brooke et al. 2009). Sediment could clog filtering organs,

thereby inhibiting food intake and increasing metabolic costs associated with sediment removal. Chronic bottom disturbance by drilling platform moorings could be particularly large in the deep ocean depending on the technology employed. Impacts from pipeline placement barges could be minimized by the use of dynamic positioning when possible. An FPSO system may be employed for deepwater wells. Under the FPSO system, oil would be transported from the well to a surface vessel and ultimately to shore. By eliminating the need for pipelines, an FPSO system would greatly reduce bottom disturbance and the chance for disturbing HDDC.

It is estimated that less than 1% of the deepwater GOM is occupied by features or areas that could support HDDC (NTL No. 2009-G40). HDDC are spread throughout the deep areas of the northern GOM (Figure 3.7.2-2 and Figure 3.7.2-3), which makes it unlikely that the damage to small areas of the bottom would threaten this resource as a whole. The BOEM Environmental Studies Program funds research to locate and understand the ecology of chemosynthetic communities. The BOEM updates regulations and mitigations based on the data from studies and from the biological interpretations of geophysical surveys, and this reduces the risk of accidental damage. If affected by exploration and site development activities, HDDC could be repopulated from nearby undisturbed areas, although the rate of recovery could be slow or nonexistent, particularly for chemosynthetic communities (MacDonald 2000). Recent studies have shown that chemosynthetic communities can be dynamic and that changes in species composition and colonization rates can operate on the order of years to decades (Lessard-Pilon et al. 2010). This suggests chemosynthetic communities could begin recovery relatively quickly if adversely affected by oil and gas activities, although full recovery would take much longer.

Miscellaneous discharges would occur at the surface and are not expected to reach HDDC. HDDC communities are also not likely to be buried or stressed by drilling muds and cuttings because NTL No. 2009-G40 (MMS 2010b) prohibits their discharge within 610 m (2,000 ft) of HDDC. Also, drilling muds and cutting would typically be discharged at the surface, and the depth of most HDDC communities make it unlikely that drilling muds and cuttings would be deposited in thick layers capable of adversely affecting these habitats.

Overall, impacts on HDDC from exploration and site development activities are expected to be minimal because of the provisions in place to protect HDDC and the review required for all drilling plans in water deeper than 300 m (984 ft). The likelihood of the undetected communities is greatly reduced through continuing improvements in the use of remote sensing data and groundtruthing. However, small and unmapped HDDC may be completely or partially destroyed by bottom-disturbing activities. In such cases, recovery would likely be long term, although permanent loss of the affected feature is also possible.

<u>Production.</u> Impacts on HDDC from routine operations could result from production platform placement; operational noise; miscellaneous discharges; the movement of anchors and chains, and the releases of process water (Table 4.4.6-3). In addition, the platform, pipelines, and mooring structure will create new artificial reef habitat. A general discussion of these impacts can be found in the soft sediments section above.

Impacts from bottom disturbing activities would be similar to those discussed above in the exploration and site development phase. The direct effects of production noise, platform placement, and anchor and chain damage on HDDC would be minimized by the 76-m (250-ft) buffer required between HDDC and ground-disturbing activities, although turbidity plumes resulting from those activities could reach HDDC. Impacts from produced water discharge should also be minimal, given the NPDES requirements and the distance of HDDC from the surface where produced water will likely be discharged. Cold water coral species may colonize the well, pipeline, and platform structures relatively quickly (Gass and Roberts 2005), although growth in the GOM appears to be slower than in other areas (Brooke and Young 2009). Over time, petroleum structures may become an artificial reef functioning in a manner similar to existing coral habitat. Colonization could benefit cold water corals by increasing suitable habitat and improving gene flow among populations (Macreadie et al. 2011). The artificial reef would only exist during the production phase, except in the cases where pipelines remain on the seabed and if tension leg platform templates are allowed to remain on the seabed. There is also possible decommissioning options including leaving portions of deepwater platforms in place.

There is evidence from California that oil and gas extraction reduces the natural release of hydrocarbons that support deep-sea chemosynthetic communities (Quigley et al. 1999). However, there is no evidence for this in the GOM. More research may be needed, but oil and gas operations are not likely to remove enough hydrocarbons to affect seep communities, given the volume of the overall resource. Unlike chemosynthetic communities, *Lophelia* corals do not depend on hydrocarbon seepage to meet their metabolic requirements (Becker et al. 2009) and presumably would not be affected.

Overall, impacts on HDDC from routine operations are expected to be minimal. However, small and unmapped HDDC may suffer major impacts.

Decommissioning. Explosive platform removals would not occur because floating platforms would be used in the deep sea. The removal of anchors and chains could affect nearby HDDC by suspending sediments in the water column as described above. Restrictions that prevent oil and gas extraction activities on or near HDDC would reduce the impacts of sediment disturbance. In the event that HDDC were affected during removal of existing platforms, recovery times would vary with the species affected and the extent and nature of the damage. Cold water corals are likely to recover much more rapidly than chemosynthetic communities. Overall, the effects of decommissioning on HDDC should be negligible.

Accidents. It is assumed that up to 8 large spills (≥1,000 bbl), up to 70 spills between 50 and 999 bbl, and up to 400 smaller spills between 1 and <50 bbl could occur during the lease period under the proposed action (Table 4.4.2-1). Most accidental spills would be small releases at the surface that are not expected to reach waters deep enough to contact HDDC. Much of the impact magnitude depends on the location of the spill, the direction of bottom currents, and the amount of oil released. The impact of a small pipeline leak would also be reduced by the requirement that pipelines be located 76 m (250 ft) away from HDDC habitats. Much of the impact magnitude depends on the location of the spill, the direction of bottom currents, and the amount of oil released. Oil from accidental releases would be dispersed by currents, rapidly broken down by natural chemical and microbial processes, and would rise in the water column, thereby limiting the extent of HDDC habitat that would be affected by any given spill.

Catastrophic Discharge Event. The PEIS analyzes a CDE up to 7.2 million bbl (Table 4.4.2-2). A CDE resulting from pipeline ruptures, tanker spills, and a loss of well control would cause high turbidity and sedimentation and the potential release of large quantities of oil. A loss of well control or pipeline rupture in deep water would be particularly difficult to repair, given the tremendous depth. Although petroleum hydrocarbons serve as a nutrient source for symbiotic microorganisms associated with chemosynthetic communities, hydrocarbon toxicity and the partial or complete destruction of the habitat could occur if a large concentration of oil were to contact chemosynthetic communities. Similarly, oil covering deepwater corals could kill all or part of the community or cause sublethal physiological and reproductive effects. Oil typically rises to the surface over the release site. However, if dispersants are used in the subsurface or if the released oil has a significant fraction of gas, a subsurface plume may form that would increase the potential for contact with a HDDC habitat. A subsurface plume 200 m (656 ft) high and 2 km (1.2 mi) wide was found at a 1,000 m (3,280 ft depth for a distance of 35 km (22 mi) from the DWH site (Camilli et al. 2010). Whether there is a synergistic toxicity from dispersants and oil mixtures for chemosynthetic communities or deepwater corals is not known. There is evidence that oil released from the DWH event was mixed with dispersant (Kujawinski et al. 2011) and may have killed deepwater corals located 11 km (7 mi) from the well (see http://www.boemre.gov/ooc/press/2010/press1104a.htm). Certain organismal components of chemosynthetic HDDC are slow-growing, and if damaged, recovery would be long term (potentially hundreds of years), if they recover at all. Recent studies have shown that seep communities can be dynamic and that changes in species composition and colonization rates can operate on the order of years to decades (Lessard-Pilon et al. 2010). This suggests chemosynthetic communities could begin recovery relatively quickly if adversely affected by oil and gas activities, although full recovery would take much longer.

4.4.6.2.2 Alaska – Cook Inlet.

Routine Operations.

Exploration and Site Development. Impacting factors for the exploration and site development phase are shown in Table 4.4.6-4. Noise from seismic surveys and drilling could kill or injure organisms close enough to the noise source and reduce habitat suitability, because some species would avoid the area. The severity and duration of noise would vary with site and development scenario, but overall the impacts would be temporary and localized with overall minimal effects on benthic habitat. See Section 4.4.7 for detailed discussions of the effects of noise on different categories of biota.

Drilling exploratory wells would temporarily reduce habitat quality by generating turbidity and sedimentation for some distance around the disturbed area. It is estimated that 4 to 12 exploration wells and 42 to 114 production wells will be drilled in the Cook Inlet Planning Area. Exploration would use jack-up rigs and gravity rigs in water up to 46 m (150 ft), while

TABLE 4.4.6-4 Impacting Factors by Phase and Potential Effects on Marine Benthic Habitat in the Cook Inlet Planning Area

Impacting Factor	Potential Effects[a]
Exploration and Site Development	
Seismic surveys	Noise; localized anchoring disturbance
Anchoring and mooring of platforms, drillships, and seismic survey vessels	Sediment scour; temporary turbidity and sedimentation; localized alteration in sediment grain size and biogeochemical functions
Drilling and production platform placement	Noise; temporary sediment resuspension and turbidity; loss of natural habitat creation of artificial reef;
Drilling	Noise; small habitat loss; local alteration of sediment characteristics; temporary turbidity and sedimentation in surrounding areas
Miscellaneous discharges (deck washing, sanitary waste, vessel discharges)	Sediment contamination
Solid wastes	Sediment contamination
Discharge of drilling muds/cuttings	Sediment and water column contamination; alteration in sediment granulometry and biogeochemical functions
Pipeline trenching and placement	Noise; long-term loss and degradation of existing benthic habitat; temporary sediment resuspension and turbidity
Production	
Scour from anchors and the movement of pipelines and mooring structures	Chronic long-term disturbance of bottom sediments; turbidity
Platform production	Noise; loss of natural habitat creation of artificial reef
Produced water	Sediment contamination
Miscellaneous discharges	Sediment contamination
Solid wastes and debris	Sediment contamination
Decommissioning	
Miscellaneous discharge	Sediment contamination
Solid wastes and debris	Sediment contamination
Platform removal	Temporary turbidity and disturbance of bottom sediments

[a] Colors indicate impact level: white = negligible; blue = minor; yellow = moderate; red = major.

drilling ships or semisubmersible or floating drilling rigs would be used in deeper water. One to three production platforms may be installed under the proposed action. Production operations will most likely be carried out from fixed platforms. The installation of floating or fixed platforms would eliminate soft sediment where the legs or mooring structures (anchors and chains) encountered the seabed and where subsea equipment (such as reentry collars and blowout preventers) was installed. Chronic local bottom disturbance could result from subsequent movements of anchors and mooring lines associated with floating drilling platforms and support vessels. Because these types of drilling rigs affect only small areas of the bottom, the disturbance to benthic habitat would be minor.

Under the proposed action, it is estimated that 80 to 241 km (50 to 150 mi) of offshore pipeline may be placed in the Cook Inlet Planning Area, resulting in disturbance of up to 210 ha (519 ac) of seafloor in Cook Inlet. Pipelines would be trenched or installed and anchored on the sediment surface, which would temporarily disturb a large area of benthic habitat by generating turbidity and sedimentation. Placing the pipeline on the sediment surface would result in permanent loss of soft sediment habitat. Vessel anchoring during pipeline placement would also disturb soft sediment. It is anticipated that pipeline placement would displace benthic communities and temporarily alter grain size in areas of the seafloor with soft sediments. Cook Inlet waters are naturally high in suspended sediments, and analyses conducted for pipeline construction for previous lease sales indicated that turbidity from pipeline construction was expected to be within the natural range of turbidities for Cook Inlet (MMS 2003a).

It is assumed that drilling muds and cutting would be discharged into Cook Inlet for exploration wells only. Drilling wastes from development and production wells would be reinjected into the wells. Drill cuttings and drilling muds (including synthetic drilling fluids adhering to the cuttings) could contaminate and alter the sediments immediately around the wellhead and below the area where drilling wastes are discharged. Drill cuttings and muds rapidly reach the sediment surface and could be deposited in highly concentrated thick layers if deposited in shallow water or near the sediment surface. In the case of near-surface discharge in deep water, drilling muds would spread out in a thin veneer over a wide area. Settled muds could cause smothering of organisms, local hypoxia, changes in sediment characteristics and biogeochemical functions, and the loss of food resources in the immediate area. Although such releases could result in temporary impacts, the amount of discharge would be small compared to the more than 44 million tons of suspended sediment carried annually into Cook Inlet by runoff from area rivers (Brabets et al. 1999). The currents in lower Cook Inlet are likely strong enough to prevent the accumulation of muds and cuttings on the bottom; therefore, benthic habitats affected by drilling discharges would recover their natural grain size. In addition, the discharge of these drilling wastes is regulated by the USEPA under NPDES permits and can be discharged into the ocean only if they meet USEPA toxicity and discharge rate requirements. These requirements greatly reduce the potential for sediment contamination. A study of sediment quality in depositional areas of Shelikof Strait and Cook Inlet in 1997–1998 found that the concentrations of metals and polyaromatic hydrocarbons in sediments (1) posed no significant risk to benthic biota or fish and (2) were not linked to oil and gas development in upper Cook Inlet (MMS 2001a). Consequently, degradation of benthic habitat in Cook Inlet from drilling waste is not expected.

Other miscellaneous discharges (deck washing, sanitary waste, and vessel discharge) also have the potential to degrade benthic habitats. Miscellaneous discharges could contaminate sediments if discharged in relatively shallow water. However, considering the high flow rate of Cook Inlet, contaminants in surface discharges would most likely be diluted to negligible concentrations before reaching the sediment (MMS 2003a). Many vessel and platform wastes are disposed of on land, and those that are discharge at sea must meet USEPA and/or USCG regulatory requirements that limit their environmental effects.

Overall, activities conducted during the exploration and site development phase are expected to have minor to moderate effects on benthic habitat. Recovery of benthic habitat could range from short term to long term.

Production. Production activities that could affect soft sediment habitat are shown in Table 4.4.6-4 and include operational noise; miscellaneous discharges; bottom disturbance from the movement of anchors and mooring structures, and releases of process water. In addition, the platform would replace existing featureless soft sediments and serve as an artificial reef. The potential impacts of miscellaneous discharges would continue on from the exploration and development phase and are described above. Impacts on soft sediment habitats from vessel and operational noise are expected to be negligible but long term, with the impacts lasting the duration of the production phase.

Chronic bottom disturbance from the movement of anchors and chains associated with support vessels would affect soft sediment habitats as described above for the exploration and site development phase. Production platforms will most likely be fixed structures, but benthic disturbance from the movement of mooring anchors is possible if floating production platforms are used. The movement of pipelines following severe storms could be a long-term chronic disturbance to benthic habitat causing scour, turbidity, and sedimentation of soft sediment habitats. However, pipelines would either be anchored securely or trenched which would minimize the potential for bottom disturbance.

The platform structure would also create novel hard substrate, and the area on and immediately around the platform may have very different habitat functions and biological communities compared to the preconstruction period. Algae and sessile invertebrates could attach to the platform and in turn attract reef-oriented organisms. Sediments grain size, benthic communities, and biogeochemical processes in sediments around the platform could be altered by the flux of biogenic material (e.g., organic matter and shell material) from the platform to the seafloor.

Produced water can contain hydrocarbons, salts, and metals at levels toxic to marine organisms. Before being discharged into the ocean, produced water is typically treated and must meet NPDES requirements regarding discharge rate, contaminant concentration, and toxicity, thereby reducing the potential for sediment contamination. Under the proposed action, it is assumed that all produced waters would be treated and reinjected into the disposal well. Therefore, no impacts on pelagic habitat are expected to result from produced water.

Overall, activities conducted during the production phase are expected to have minor effects on benthic habitat on a regional scale. Platforms would alter benthic habitat on a local scale.

Decommissioning. Platform removal activities would result in loss of the platforms reef function, bottom disturbance, and a temporary increase in turbidity and sedimentation (Table 4.4.6-4). Over time, most sediments will recover their normal physical characteristics, ecological functions, and biological communities. No explosives would be used during platform removal. Pipelines installed and anchored on the seafloor would be capped and left in place, although there is the potential for chronic sediment disturbance from pipeline movement.

Overall, impacts on benthic habitat associated with removal of platforms are expected to be negligible.

Accidents. It is assumed that 1 to 3 small spills between 50 and 999 bbl and 7 to 15 smaller spills between 1 and <50 bbl, and large spills (≥1,000 bbl) could occur under the proposed action (Table 4.4.2-1). Much of the impact magnitude depends on the location of the spill, the direction of bottom currents, and the amount of oil released. Oil from accidental releases would be dispersed by currents, rapidly broken down by natural chemical and microbial processes, and would rise in the water column, thereby limiting the extent of benthic habitat that would be affected by any given spill. A few of these spills might be large enough and persist long enough to drift to shore where they could contaminate benthic habitat. However, it is anticipated that only a small amount of shoreline would be affected by these spills and they would not, therefore, present a substantial risk to the overall resource. The benthic habitat would recover without mitigation because of natural breakdown of the oil, sediment movement by currents, and reworking by benthic fauna.

Oil spill-response activities such as burning, skimming, and chemical release (e.g., dispersants or coagulants) could affect benthic habitat and biota. Skimming and burning could kill pelagic live stages of benthic biota. The chemicals used during a spill response are toxic, but there is controversy about whether the combination of oil and dispersant is more toxic than oil alone (NRC 2005b; Fingas 2008; Holland-Bartels and Kolak 2011). The use of dispersant would likely reduce oiling of nearshore benthic habitat but may increase the exposure of subtidal benthic habitat and biota to toxic fractions of oil (NRC 2005b). In shallow water, the presence of, and noise generated by, oil spill-response equipment and support vessels could temporarily disturb benthic habitat in the vicinity of the response action, potentially reducing habitat use or disturbing migration. As with the spill itself, the location and time of the year the cleanup occurs would be an important determinant of impacts to benthic habitat and biota.

Catastrophic Discharge Event. The PEIS analyzes a CDE of 75,000 to 125,000 bbl. In the case of a CDE, the likelihood of oil contacting shoreline benthic habitat and biota is relatively high because the Cook Inlet Planning Area is located within a confined estuary. Oil reaching intertidal benthic habitat would likely be drawn below the sediment surface by capillary action. Subsurface oil is more persistent because it is spread throughout a matrix of sediment types and is less subject to physical weathering from sunlight and wave action (Taylor and Reimer 2008). Decades after the *Exxon Valdez* spill, highly weathered, asphalt-like or tar deposits may still be present beneath the surface of intertidal sediments of Prince William Sound, especially in the intertidal zone of low-energy, protected, unexposed bays and beaches with boulder/cobble or pebble/gravel sediments (Short et al. 2007; Taylor and Reimer 2008; *Exxon Valdez* Oil Spill Trustee Council 2010c). NOAA reported that 97 metric tons (tonnes) (107 tons) of oil may still be present in subsurface sediments in discontinuous patches, although this is only a small fraction of the >20,000 metric tons of oil initially deposited on beaches. After a initial rapid decline of 68% per year during 1991–1992, the oil is currently decreasing in concentration at a rate of 0–4% per year (NOAA 2010d; Short et al. 2007). Overall, studies of the *Exxon*

Valdez spill indicate that a catastrophic spill could result in long-term degradation of benthic habitat and sublethal effects on benthic biota. As of 2010, intertidal sediments and communities are considered to still be recovering from the *Exxon Valdez* spill (*Exxon Valdez* Oil Spill Trustee Council 2010c).

Following the *Exxon Valdez* oil spill in 1989, highly elevated hydrocarbon concentrations in intertidal sediments were found at heavily oiled sites followed by an apparent migration of the oil into the shallow subtidal zone in 1991 (Wolfe et al. 1993). Oil in the intertidal and subtidal zones can affect not only lower trophic-level organisms but also higher trophic-level organisms, such as marine and coastal birds (Section 4.4.7.2.2) and fish (Section 4.4.7.3.2; Peterson et al. 2003). However, subtidal sediment may be less likely to suffer long-term contamination because oil tends to float and natural weathering, bottom scour, and depositional processes would reduce the oil concentration in the sediment. Biological impacts on subtidal biota are also typically short term (Lee and Page 1997). Oiled subtidal sediments were detected shortly after the *Exxon Valdez* spill, but not in follow-up studies conducted in 2001, and subtidal sediment concentrations of oil are much lower than concentrations in intertidal sediments (Lee and Page 1997). Subtidal habitat and communities are considered to be very likely recovered by the *Exxon Valdez* Oil Spill Trustee Council (2010c).

Broken ice occurs in the northern and western portions of lower Cook Inlet during fall and winter. If an open water spill were to occur at this time, the ice would contain the oil somewhat and reduce spreading and contacting intertidal benthic habitat. However, oil cleanup is also more difficult in broken ice conditions. Oil from spills occurring in the winter may be trapped under ice, resulting in localized, persistent degradation of habitat quality and ecosystem function.

4.4.6.2.3 Alaska – Arctic.

Routine Operations.

Exploration and Site Development. Impacting factors for the exploration and site development phase relevant to seafloor habitat are shown in Table 4.4.6-5. It is assumed that oil and gas development activity would be restricted to waters less than 91 m (300 ft). Exploration drilling would employ gravel islands or mobile platforms in waters between 6 to 18 m (20 and 60 ft) in depth and drillships in deeper water. Production operations will be conducted from subsea wells, gravel islands, or gravity-based platforms in water less than 12 m (40 ft) in depth, and from larger gravity-based platforms in deeper waters. It is assumed that as many as 92 subsea production wells and 9 artificial islands could be constructed during the lease period with a footprint of approximately 1.5 ha (4 ac) per platform or island. Under the proposed action, it is estimated that 89 to 652 km (55 to 405 mi) of new offshore pipeline would be placed in the Beaufort and Chukchi Sea Planning Areas, resulting in disturbance to 77 to 567 ha (190 to 1,402 ac) of seafloor.

Drilling, platform and pipeline placement, and construction and maintenance of artificial islands have the potential to reduce benthic habitat quality by disturbing the seafloor and

TABLE 4.4.6-5 Impacting Factors by Phase and Potential Effects on Marine Benthic Habitat in the Beaufort and Chukchi Sea Planning Areas

Impacting Factor	Potential Effects[a]
Exploration and Site Development	
Vessel traffic	Noise
Seismic surveys	Noise; localized anchoring disturbance
Anchoring and mooring of platforms, drillships, and seismic survey vessels	Sediment scour; temporary turbidity and sedimentation; localized alteration in sediment grain size and biogeochemical functions
Drilling and subsea well and production platform placement (including artificial islands)	Noise; temporary sediment resuspension and turbidity; loss of natural habitat creation of artificial reef; loss of benthic habitat due to artificial islands
Drilling	Noise; small habitat loss; local alteration of sediment characteristics; temporary turbidity and sedimentation in surrounding areas
Miscellaneous discharges (deck washing; sanitary waste, vessel discharges)	Sediment contamination
Solid wastes	Sediment contamination
Discharges of drilling muds/cuttings	Sediment and water column contamination; alteration in sediment grain size and biogeochemical functions
Pipeline trenching and placement	Noise; long-term loss and degradation of existing benthic habitat; temporary sediment resuspension and turbidity
Production	
Scour from anchors and the movement of pipelines and mooring structures	Chronic, long-term disturbance of bottom sediments; turbidity
Platform production	Noise; loss of natural habitat creation of artificial reef
Produced water	Sediment contamination
Miscellaneous discharges	Sediment contamination
Solid wastes and debris	Sediment contamination
Decommissioning	
Miscellaneous discharge	Sediment contamination
Solid wastes and debris	Sediment contamination
Platform removal	Temporary turbidity and disturbance of bottom sediments

[a] Colors indicate impact level: white = negligible; blue = minor; yellow = moderate; red = major.

generating noise, turbidity, and sedimentation for some distance around the disturbed area and potentially adversely affecting benthic biota. Such activities could reduce benthic habitat quality by displacing benthic organisms and interrupting the movement and dispersal of species of all life stages. Chronic bottom disturbance would result from movements of anchors associated with floating drilling vessels and support vessels. The installation of platforms would eliminate soft sediment where the platform and mooring structures (anchors and chains) encountered the seabed and where subsea equipment (such as reentry collars and blowout preventers) was installed and depending on location, habitat loss for benthic feeders could be important. The area of burial around constructed islands could increase over time because of erosion from storm action and ice gouging on island slopes. The construction of subsea wells and gravel islands would eliminate soft sediment habitat, but the total bottom area that could be disturbed would be relatively small compared to the overall area of benthic habitat available in the Beaufort and Chukchi Sea Planning Areas.

Pipelines would be buried in waters less than 50 m (156 ft) to prevent damage from ice gouges, and pipelines in deeper water would be installed and anchored on the seafloor. Pipelines installed and anchored on the seafloor would replace natural soft sediment habitat with hard-bottoms, which would alter species composition and biogeochemical habitat function. For buried pipelines, benthic organisms within the trenched corridor would be killed or injured, and organisms to either side of the pipeline would be buried by sediments. Disturbed sediments with a greater proportion of sand to mud may fill in with fine, silty material that would alter grain size and potentially inhibit the colonization by species that existed prior to the disturbance. The recovery period for soft sediment benthic habitat affected by bottom disturbance would depend on factors such as water depth, sediment type, and community composition. In the Arctic, the benthic community in these areas experiences a naturally high amount of disturbances from ice gouging, strudel scour, and severe storms, and hyposaline and highly turbid conditions occur naturally during spring breakup. Therefore, seafloor biota in the Beaufort and Chukchi Seas may be adapted to such conditions. Turbidity plumes from construction activities under the proposed action would be temporary and disturbed areas would probably be recolonized within a few years (Woodward-Clyde Consultants 1996), although recovery could take more than a decade (Conlan and Kvitek 2005).

Increased water turbidity and sedimentation from ground-disturbing activities discussed above could directly affect kelp growth by burying kelps and other organisms, altering the optical properties of the water column, and limiting photosynthesis (Maffione 2000; Dunton et al. 2009). It is estimated that kelp contributes 50–56% of annual productivity in the Boulder Patch and is an important source of organic matter that supports various members of the epilithic community (Dunton 1984). Overall, measurements have indicated natural inputs of suspended sediment from runoff and erosion are large relative to any anthropogenic inputs of sediment (Trefry et al. 2004). Therefore, unless activities are located in the immediate vicinity of the Boulder Patch, the proposed action is not expected to substantially increase turbidity or sedimentation on the Boulder Patch. Planning and permitting procedures and requirements will likely be sufficient to avoid such occurrences. Under current regulations, proposed development near the Boulder Patch area requires detailed surveys to identify the boundaries of the Boulder Patch habitat, and the expected levels of impacts from proposed activities must be identified, which will likely be sufficient to minimize impacts from pipeline construction within the Boulder Patch area. However, the construction of offshore pipelines could affect kelp habitat area outside of the Boulder Patch. Recovery would be slow if kelp communities were mechanically damaged by drilling or anchor and chain scour. It is estimated that recovery of kelp growth in areas trenched for pipeline construction could occur within a decade in some cases or could be much longer depending on the proportion of hard substrate exposed after pipeline construction was completed (Konar 2006). Although habitat loss may be minor when compared to the large size of the Arctic Planning Areas, even small habitat loss can be significant to specific populations depending on where it occurs. Overall, moderate but temporary impacts on seafloor habitat are expected to result from pipeline placement.

It is assumed that drilling muds and cutting would be discharged into the Beaufort and Chukchi Sea Planning Areas for exploration wells only. Drilling wastes from development and production wells would be reinjected into the wells. Drill cuttings and drilling muds (including synthetic drilling fluids adhering to the cuttings) could contaminate and alter the grain size of sediments immediately around the wellhead and below the area where these drilling wastes are discharged. Drill cuttings and muds rapidly reach the sediment surface and could be deposited in highly concentrated thick layers if deposited in shallow water or near the sediment surface. In the case of near-surface discharge in deep water, drilling muds would spread out in a thin veneer over a wide area. Settled muds could cause smothering of organisms, local hypoxia, changes in sediment characteristics and biogeochemical functions, and the loss of food resources in the immediate area. Arctic sediments are constantly changing in grain size (Neff & Associates LLC 2010) due to natural disturbances. Thus, after they reach the sediment, discharged muds and cuttings are likely over time to be redistributed over a broad area. Although such releases could result in temporary, localized increases in sediment load and deposition, this amount of discharge would be small compared to the more than 6.35 million tons of suspended sediment carried annually into the Beaufort Sea alone by runoff from area rivers (Neff and Associates LLC 2010). In addition, drilling muds or cuttings that are discharged into the ocean are regulated by the USEPA under NPDES permits and can be discharged into the ocean only if they meet USEPA toxicity and discharge rate requirements. These requirements greatly reduce the potential for sediment contamination. Discharges of drilling wastes in the vicinity of the Steffansson Sound Boulder Patch are regulated under NPDES Permit Number AKG280000. Consequently, there should be minimal impacts on Boulder Patch habitat from drilling wastes. Therefore, the impacts from drilling waste discharges are expected to be minor.

Miscellaneous discharges (deck washing, sanitary waste, and vessel discharge) also have the potential to degrade seafloor habitats. Miscellaneous discharges could contaminate sediments if discharged in relatively shallow water. However, many vessel and platform wastes are disposed of on land, and those that are discharged at sea must meet USEPA and/or USCG regulatory requirements that limit their environmental effects. In addition, stratification of the water column prevents diffusion of chemicals to bottom layers in many areas.

Noise from seismic surveys and drilling could kill or injure organisms close enough to the noise source and reduce habitat suitability as some species would avoid the area. The severity and duration of noise would vary with site and development scenarios, but the impacts would be temporary and localized with overall minimal effects on soft sediment habitat. See Section 4.4.7 for detailed discussions of the effects of noise on different categories of biota.

Overall, activities conducted during the exploration and site development phase are expected to have minor to moderate effects on seafloor habitat on a planning area scale. Recovery of seafloor habitat could range from short-term (months) to long-term (decades).

Production. Production activities that could affect soft sediment habitat are shown in Table 4.4.6-5. The potential impacts of miscellaneous discharges would continue on from the exploration and development phase and are described above. Impacts on soft sediment habitats from vessel and operational noise are expected to be negligible but long term, with the impacts lasting the duration of the production phase. Chronic bottom disturbance from the movement of anchors and chains associated with support vessels would affect soft sediment habitats as described above for the exploration and site development phase. These disturbances would be long term and chronic and cause scour, turbidity, and sedimentation of soft sediment habitats.

Platforms and gravel islands would provide additional habitat for marine plants and animals (e.g., kelp and mussels) that require a hard substrate. Therefore, the overall probable effect of platform placement and island construction would be to alter local species composition. In addition, sediment grain size and biogeochemical processes around the platform would be altered by the flux of biogenic material (shell and organic matter) from the platform to the seafloor. Data from other hard-bottom habitats suggest colonization would be slow and seasonal ice cover may restrict colonization to short-lived opportunistic species. Any artificial reef function the platform does serve would exist only during the production phase, so impacts, if any, would be temporary but lasting decades. However, gravel islands would remain in place. The islands may eventually erode and form a subsea gravel bed that would provide habitat to species attracted to hard substrate.

Produced water is a normal product of oil and gas extraction that contains contaminants such as polycyclic aromatic hydrocarbons and heavy metals and therefore represents a potential source of contamination to benthic habitats. It is assumed that all produced water will be disposed of onshore or reinjected into the well rather than discharged into the ocean. If produced water is discharged into the ocean, it is typically treated and must meet NPDES requirements regarding discharge rate, contaminant concentration, and toxicity, thereby reducing the potential for sediment contamination. Consequently, no impacts from the discharge of produced water are expected.

The results of the Arctic Nearshore Impacts Monitoring in the Development Area study funded by BOEM provide a good summary of the long-term changes to benthic habitats resulting from oil and gas production in the Arctic (Neff and Associates LLC 2010). No relationship between the location of oil and gas production and the concentration of metals and hydrocarbons in sediment and marine animals was detected. The study concluded that metals and PAHs in Beaufort Sea sediments were primarily derived from sediments delivered by rivers, not oil and gas activities. Overall, activities conducted during the production phase are expected to have minor effects on benthic habitat.

Decommissioning. Miscellaneous and solid waste releases discussed above would continue during the decommissioning phase (Table 4.4.6-5). Platform and mooring structure removal activities would result in bottom disturbance and a temporary increase in turbidity and sedimentation. No platforms are expected to be removed using explosives. Over time, sediments will recover their normal physical characteristics, ecological functions, and biological communities. Overall, activities conducted during the decommissioning phase are expected to have negligible effects on benthic habitat.

Accidents. It is assumed that large spills (≥1,000 bbl), up to 35 small spills (50 to 999 bbl), and up to 190 smaller spills (>1 and <50 bbl) could occur during the lease period under the proposed action (Table 4.4.2-2). Much of the impact magnitude depends on the location of the spill, the direction of bottom currents, and the amount of oil released. Oil from accidental releases would rise in the water column, thereby limiting the extent of benthic habitat that would be affected by any given spill. Oil from most small surface spills is likely to reach the sediment only at biologically negligible concentrations. Most subsea spills would be minor, and the hydrocarbon concentrations would typically be diluted to background levels within a few hundred meters to a few kilometers of the spill site. Large spills would affect a wider area of benthic habitat and potentially persist in the sediment for an extended period. Benthic habitat would recover without mitigation because of natural breakdown of the oil, sediment movement by currents, and reworking by benthic fauna.

Oil spill-response activities such as burning, skimming, and chemical release (e.g., dispersants or coagulants) could affect benthic habitat and biota. Skimming and burning could kill pelagic live stages of benthic biota. The chemicals used during a spill response are toxic, but there is controversy about whether the combination of oil and dispersant is more toxic than oil alone (NRC 2005b; Fingas 2008; Holland-Bartels and Kolak 2011). The use of dispersant would likely reduce oiling of nearshore benthic habitat, but may increase the exposure of subtidal benthic habitat and biota to toxic fractions of oil (NRC 2005b). In shallow water, the presence of, and noise generated by, oil spill-response equipment and support vessels could temporarily disturb benthic habitat in the vicinity of the response action, potentially reducing habitat use or disturbing migration. As with the spill itself, the location and time of the year the cleanup occurs would be an important determinant of impacts on benthic habitat and biota.

Catastrophic Discharge Event. This PEIS analyzes a CDE up to 2.2 million bbl in the Chukchi Sea Planning Area and up to 3.9 million bbl in the Beaufort Sea Planning Area (Table 4.4.2-2) that could result in lethal or sublethal concentrations of hydrocarbons or mixtures of hydrocarbons and dispersants (if used), which could accumulate in soft sediments, reducing habitat function. The magnitude of the impact depends primarily on the location of the well, the volume released, and the speed at which the well was capped. Most oil released in a surface or seafloor spill would float above the sediment, but sediment contamination could occur from the deposition of oiled sediment and organic matter (dead plankton and organic flocculants) falling from the water column. In addition, oil could reach the shoreline and contaminate coastal benthic habitat (see Sections 4.4.6.1.3 and 4.4.6.2.2 for a detailed discussion of the impacts of oil spills on coastal habitat). The soft sediment habitat would recover without mitigation because of natural breakdown of the oil, sediment movement by currents, and reworking by benthic fauna. However, the cold temperatures of the Arctic may allow hydrocarbons to persist in the sediments longer than in temperate areas. Overall, impacts on soft sediments from catastrophic releases could be major and potentially long-term.

The magnitude of impacts on the Boulder Patch from an oil spill would depend on the location and severity of the spill. Oil spills contacting the Stefansson Sound Boulder Patch community could cause both lethal and sublethal effects on marine plants and invertebrates. Sublethal effects occur at lower concentrations and include reduced growth and/or fecundity, increased physiological stress, and behavioral changes. *Laminaria solidungula*, found in the Stefansson Sound Boulder Patch, has not been studied directly, but other Laminaria species from the Canadian Beaufort Sea showed marked physiological impairment when exposed to oils of several types and concentrations (Hsiao et al. 1978; Shiels et al. 1973). Photosynthesis would probably be reduced by the floating oil because of reduced light penetration, and if the floating oil persisted long enough, it could affect growth and reproduction of the kelp. Benthic animal communities have also been shown to have major shifts in species composition following exposure to oil (Dean and Jewett 2001). Impacts on kelp habitat from an oil spill could be long term, but are not expected to be permanent. *Laminaria* beds oiled by the *Exxon Valdez* spill recovered within 10 years (Dean and Jewett 2001).

If the spill were to occur during winter, cleanup would be much more difficult because sea ice would limit access to the spill (reviewed in Holland-Bartels and Kolak 2011). Oil cleanup response plans and technologies for ice-covered spills are still evolving, and the efficacy of many proposed spill countermeasures is as yet unknown (Holland-Bartels and Kolak 2011). If the spill were to occur under ice, oil would be trapped and essentially remain unchanged until breakup occurred and the ice began to melt. Oil could float or freeze within the ice, which would limit the potential for oil to reach deeper subtidal seafloor habitat. However, oil transported under ice to nearshore areas would remain unweathered and could degrade intertidal and shallow subtidal benthic habitat throughout the winter and after the ice thaws. The effects on primary and secondary biological productivity could be severe as well, because of loss of epontic and ice-associated fish assemblages due to oil toxicity. Oil under landfast ice would be more easily accessed and cleaned, which could reduce the duration and severity of impacts.

4.4.6.2.4 Conclusion. Routine Program activities conducted during the exploration, development, and production phases could result in moderate impacts on benthic habitat in the GOM, Cook Inlet, and Beaufort and Chukchi Sea Planning Areas. The primary impacts would be on soft sediments from ground disturbance during drilling and pipeline and platform placement as well as the discharge of drilling muds and cuttings and produced water. Existing mitigation measures, if applied, should ameliorate most direct impacts on sensitive benthic marine habitats, including soft sediments, hard-bottoms, coral reefs, and HDDC in the GOM and Boulder Patch communities in the Beaufort and Chukchi Seas. However, in some cases activities that generate noise, turbidity, and sedimentation may affect sensitive habitats depending on their proximity to these activities. In addition, unmapped sensitive benthic habitats not covered by the stipulations may be damaged or destroyed. If sensitive benthic live-bottom and associated biota were damaged or killed, the impacts could be long term or permanent because living benthic habitats are slow-growing and have highly specific habitat requirements. Overall, moderate, temporary, and localized impacts, primarily on soft sediment benthic habitats, are expected to result from routine exploration, site development, and production activities.

Small hydrocarbon spills are not likely to result in the degradation of benthic marine habitat because spills at the surface would likely reach the benthic marine habitats only in low concentrations. However, large or CDE spills from a loss of well control and pipeline ruptures would physically disturb the seafloor around the spill site, and a subsurface plume extending a large distance from the spill could form if dispersants are used or if the oil released is mixed with gas. The impact of accidental releases of oil depends on several factors such as the size, duration, timing, and location of the spill, and the nature of the benthic habitat contacted by the oil. The season in which the spill occurs is especially important in Alaskan waters due to heavy seasonal ice cover that could hinder cleanup efforts. In the unlikely event that a CDE occurred, sensitive benthic habitats could suffer long-term loss of ecological function because of both hydrocarbon toxicity and the subsequent cleanup activities. Hydrocarbons could persist at sublethal concentrations in sediments for decades, and sensitive habitats (i.e., kelp beds, intertidal zones; live-bottom and coral reef) damaged by a spill would likely recover slowly and possibly not recover at all. However, hydrocarbons would be broken down by natural processes, and most benthic habitats are likely to eventually recover. Many sensitive benthic habitats are widely scattered; therefore, individual spills would be unlikely to threaten the resource as a whole.

4.4.6.3 Marine Pelagic Habitats

4.4.6.3.1 Gulf of Mexico.

Water Column.

Routine Operations.

Exploration and Site Development. See Section 4.4.3.1.1 for a general discussion of the impacts of exploration and site development on water quality. During the exploration and site development phase, pelagic habitat would be affected by platform and pipeline placement, drilling activity, seismic surveys, platform lighting, and aircraft and vessel traffic, and miscellaneous vessel and platform discharges (Table 4.4.6-6). Noise impacts would be greatest near the source and would temporarily reduce habitat quality (i.e., induce physiological stress, injury, or behavioral changes) for certain species whose noise tolerance is below that of the noise level generated by the exploration and development activities. See Section 4.4.7 for detailed discussions of the effects of noise on different categories of biota. Construction lighting would alter the pelagic light regime of a small area and would attract phototaxic organisms to the platform. Studies in the northern GOM suggest that platform lighting could enhance phytoplankton productivity around the platform, potentially increase prey availability, and improve the visual foraging environment for fishes (Keenan et al. 2007).

Bottom water quality would be temporarily affected by turbidity from sediment disturbance during drilling, platform placement, and pipeline trenching and placement. Turbidity from bottom-disturbing activities could kill zooplankton, although the population-level effects would be negligible. Photosynthetic productivity of phytoplankton that specialize in near-bottom habitats may be reduced if the turbidity plume reduced solar irradiance at depth. However, the turbidity plume would be temporary, and phytoplankton populations have rapid replacement times (Behrenfeld et al. 2006). Therefore no permanent impacts on phytoplankton populations are anticipated. FPSO systems could potentially be used in deep water, which would reduce the need for pipeline placement and greatly reduce water quality impacts.

The discharge of drilling muds and cuttings can occur near the water's surface or the seafloor. Releases at the seafloor would affect bottom waters in ways similar to those of bottom-disturbing activities, resulting in a temporary reduction in water quality. Surface discharge of drilling muds and cuttings would create a turbidity plume that would diminish within some

TABLE 4.4.6-6 Impacting Factors by Phase and Potential Effects on Marine Pelagic Habitat in the CPA and WPA of the GOM

Impacting Factor	Disturbance[a]
Exploration and Site Development	
Vessel traffic	Noise
Seismic surveys	Noise [blue]
Miscellaneous discharges (deck washing, sanitary waste, bilge and ballast water)	Degraded water quality
Drilling and discharge of drilling muds/cuttings	Noise; degraded water quality [blue]
Pipeline trenching	Noise; turbidity [blue]
Drilling platform placement	Noise; turbidity [blue]
Offshore lighting	Alteration of light field
Production	
Production platform placement	Noise; turbidity [blue]
Production	Noise
Produced water discharge	Degraded water quality [blue]
Miscellaneous discharges (deck washing, sanitary waste)	Degraded water quality
Offshore lighting	Alteration of light field
Decommissioning	
Miscellaneous discharges (deck washing, sanitary waste, bilge and ballast water)	Degraded water quality
Explosive platform removal	Noise, turbidity [blue]
Offshore lighting	Alteration of light field

[a] Colors indicate impact level: white = negligible; blue = minor; yellow = moderate; red = major.

distance from the release point. The turbidity plume could smother or stress small zooplankton and reduce phytoplankton productivity by decreasing the depth and intensity of light penetration. While synthetic drilling fluids are not discharged directly, they do enter the pelagic environment by adhering to drilling cuttings (Neff et al. 2000). These cuttings tend to aggregate and settle rapidly to the sea floor. This tendency for aggregation increases the higher the concentration of adhered synthetic fluid. The rapid settling of the cuttings reduces their dispersion in the water column and water column turbidity (Neff et al. 2000). In addition, synthetic drilling fluids have low toxicity (Neff et al. 2000). Consequently, the release of such cuttings and associated synthetic drilling fluids should result in minor, short-term, and relatively localized impacts. Similarly, in well-mixed ocean waters, water-based drilling muds and cuttings are diluted by 100-fold within 10 m (33 ft) of the discharge and by 1000-fold at a distance of about 100 m (330 ft) from the platform (Neff 2005). These estimates are for well-mixed water, and therefore the size of the turbidity field will vary with hydrology. The generally rapid dilution would limit the degradation of pelagic habitat to a localized area, and impacts on pelagic habitat would be minor. Degradation of pelagic habitat would also be limited by NPDES permits regulating the discharge of drill cuttings in a way that reduced impacts on water quality (Neff et al. 2000; Neff 2005).

Pelagic habitat would be affected minimally and temporarily by miscellaneous discharges (deck drainage, sanitary and domestic waste, bilge and ballast water) during site development. Such releases would be minor in quantity, would be rapidly diluted, and would likely have only negligible impacts on pelagic habitat. In addition, many vessel and platform wastes are disposed of on land, and those that are discharged at sea must meet USEPA and/or USCG regulatory requirements that limit their environmental effects.

<u>Production.</u> Impacts from offshore lighting, miscellaneous discharges, and bottom disturbance from the movement of platform and support vessel anchors and chains will also exist in the production phase and are described above. In addition, production noise and produced water discharge could affect pelagic habitat quality (Table 4.4.6-6). Production noise is not expected to appreciably degrade habitat quality, as production platforms are known to have high biological abundance and diversity. Impacts on pelagic habitat from produced water should be minor because produced water is treated before being discharged and must meet NPDES permitting guidelines regarding discharge rate and toxicity. Produced water is high in organic matter and has the potential to generate local hypoxia (Rabalais 2005). However, a major study of produced water discharges across the northern GOM indicated that despite the large volume discharged, the contribution of produced water to bottom water hypoxia is minimal when compared to riverine inputs, and produced water did not make a significant contribution to the hypoxic zone in the GOM (Rabalais 2005; Bierman et al. 2007).

Algae and sessile invertebrates would rapidly colonize the platform and would in turn attract mobile reef-oriented organisms. Thus, the platform structure would serve as a novel artificial reef in formerly open water habitat. The platform would function in a manner similar to existing reefs, banks, and topographic features and may increase zooplankton densities around the platform. A floating platform would extend from the surface to some depth below the waterline, potentially creating a floating reef habitat that would attract organisms to adjacent surface waters. The artificial reef would only exist during the production phase, unless the platform was permitted to remain in place after decommissioning. In deep sea areas, the platform and mooring structures would likely be completely removed during decommissioning, so impacts from bottom disturbance would be temporary.

<u>Decommissioning.</u> Impacts from vessel noise, platform lighting, and miscellaneous discharges are discussed above and would continue throughout the decommissioning phase (Table 4.4.6-6). In addition, bottom disturbance during platform removal (potentially including the use of explosives) would temporarily disturb pelagic habitat by increasing noise and turbidity for some length of the water column (see individual sections on marine biota for discussions of the impacts of explosive platform removal). These impacts would temporarily degrade habitat quality, but conditions would return to normal as suspended sediments dispersed and resettled, and the long-term impacts to pelagic habitat would be negligible.

Accidents. Accidental hydrocarbon releases can occur at the surface or at the seafloor. Natural gas would tend to rise in the water column and could degrade habitat quality in a large portion of the water column. However, natural gas is also less persistent in the environment than oil. Evidence from the DWH event indicates that methane gas released from the well was rapidly broken down by bacterial action with little oxygen drawdown (Camilli et al. 2010;

Kessler et al. 2011). Consequently, the remainder of the discussion focuses on oil spills. It is assumed that large spills (≥1,000 bbl), up to 70 spills between 50 and 999 bbl and 400 smaller spills between 1 and 50 bbl could occur during the lease period under the proposed action (Table 4.2.2-1). Impacts on pelagic habitat from accidental oil spills could result from surface releases from platforms or vessels or from seafloor releases from pipelines and the wellhead. Modeling indicates that oil spilled at the surface could mix to a depth of 20 m (66 ft) at highly diluted concentrations (MMS 2008a). Accidental oil releases from pipeline leakage would degrade bottom water quality at local scales, but would be broken down over time through natural processes, and the long-term effects on pelagic habitat and biota would be minor. Large spills would degrade pelagic habitat quality over a wider area and potentially reduce the habitat value and ecosystem function in the areas affected. Eventually, the oil would be broken down by natural processes, and pelagic habitat would recover. See Section 4.4.3.2.1 for a further discussion of the effects of oil spills on water quality in the GOM.

Oil spill-response activities such as burning, skimming, and chemical release (e.g., dispersants or coagulants) could affect pelagic habitat and biota. Burning would kill pelagic biota in the burn area, and skimming would remove aquatic organisms from the water column or trap them in oiled water. The chemicals used during a spill response are toxic, but there is controversy about whether the combination of oil and dispersant is more toxic than oil alone (NRC 2005b; Fingas 2008; Holland-Bartels and Kolak 2011). The use of dispersant would likely increase the areal extent of oil dispersion and the exposure of pelagic biota to oil. The presence of, and noise generated by, oil spill-response equipment and support vessels could temporarily disturb pelagic habitat in the vicinity of the response action, potentially reducing habitat use or disturbing migration. As with the spill itself, the location and time of the year the cleanup occurs would be an important determinant of impacts on pelagic habitat and biota.

Catastrophic Discharge Event. The PEIS analyzes a CDE up to 7.2 million bbl (Table 4.4.2-2). Pelagic organisms could be exposed to lethal or sublethal concentrations of hydrocarbons or mixtures of hydrocarbons and dispersants (if used). The extent and magnitude of the impact depend primarily on the location of the well, the volume of oil released, and the season in which the spill occurs. Typically oil rises from the seafloor to the sea surface forming a surface slick. However, a subsurface plume capable of traveling long distances could form if dispersants are used or if the well releases a mixture of oil and gas. In the case of the DWH event, hydrocarbons were detected as far as 56 km (35 mi) northeast and southwest of the well (Camilli et al. 2010; Haddad and Murawski 2010). The DWH event also changed pelagic microbial communities. Menthanotropic and oil-eating bacteria were greatly increased following the DWH event (Camilli et al. 2010; Kessler et al. 2011). However, the increase in microbial biomass did not result in significant oxygen depletion, even in deep water. The hydrocarbons appeared to be assimilated by bacteria and transferred up through the zooplankton food web (Graham et al. 2010).

These studies suggest the GOM has a tremendous natural capacity to assimilate accidental oil spills, and pelagic habitats would eventually recover their ecological function as hydrocarbons broke down. However, recovery time would vary with local conditions and the degree of oiling. For example, the shallow pelagic habitats would probably recover more quickly than deepwater pelagic habitats because of the greater physical and biological activity in shallow water. Overall, impacts on pelagic habitats from a CDE could be negligible to moderate and potentially short term to long term, but no permanent degradation of pelagic habitats is expected to result.

Sargassum.

Routine Operations.

Exploration and Site Development. *Sargassum* could be affected by several activities during the exploration and site development phase of OCS oil and gas development including vessel traffic, miscellaneous discharge, and drilling waste discharge. Drilling muds and cuttings are typically discharged near surface waters and could come into contact with *Sargassum* mats. Turbidity generated by the discharge could reduce photosynthesis in *Sargassum* and cause physiological stress on associated animal communities. The cuttings should settle to the bottom within 1,000 m (3,280 ft) of the release point (Continental Shelf Associates, Inc. 2006), so the contact should be minimal. NPDES permit requirements regulating the toxicity and amount of drilling wastes discharged would also limit the potential for impacts on *Sargassum*. Miscellaneous discharges (deck drainage, sanitary and domestic waste, bilge and ballast water) are not expected to affect *Sargassum* because the releases would be minor in quantity and would be rapidly diluted. Service vessels and drilling ships could damage *Sargassum* mats with their propeller or by entraining *Sargassum* in their cooling water intake. The effects on individual *Sargassum* mats and the associated communities could be complete or partial loss of the *Sargassum*. Given the small area affected relative to the size of known *Sargassum* habitat, vessel traffic is not expected to measurably reduce the biomass or productivity of *Sargassum* in the northern GOM.

Sargassum appears to originate in the northwestern GOM, and little new oil and gas development is expected to occur in this region. Given the small overall area of seafloor affected by new oil and gas development, and the new spring production of *Sargassum* that occurs in the GOM (Gower and King 2008), no detectable population level effects on *Sargassum* are anticipated.

Production. Miscellaneous discharges and vessel traffic will continue through the production phase, but they are not expected to affect *Sargassum* for the reasons described above. Contaminants in produced water discharged from the platform could affect *Sargassum* and associated biota. However, produced water is treated before discharge and must meet NPDES permitting guidelines. Consequently, impacts on *Sargassum* should be negligible. Other production activities would primarily affect subsurface habitat and are not anticipated to affect *Sargassum*.

Decommissioning. Miscellaneous discharges and vessel traffic will continue through the decommissioning phase, but they are not expected to affect *Sargassum* for the reasons described above. Platform removal activities would primarily affect subsurface communities, and while they are not anticipated to affect adult *Sargassum*, they could affect sediment-dwelling germlings. However, decommissioning impacts will be highly localized over a relatively small area.

Accidents. Spills could occur at the surface or at the seafloor. Surface spills as well as seafloor spills that rise to the surface could contact *Sargassum*, potentially resulting in complete or partial mortality of the *Sargassum* mat and lethal or sublethal effects to associated biota. Surface slicks would pose a potential threat to *Sargassum* communities until dilution and natural chemical, physical, and biological processes reduced the toxicity of the oil. Upon release, hydrocarbons would be rapidly diluted and broken down by natural processes, which would limit the potential for contact with and toxicity to Sargassum communities. The warm waters of the GOM are particularly conducive to rapid chemical and microbial breakdown of hydrocarbons.

Catastrophic Discharge Event. The effects from a CDE would depend on the location of the particular spill and on various environmental factors, including water depth, currents, and wave action. Seafloor releases could reach *Sargassum* in surface waters if the spill occurred in shallow water or if dispersants were used or the oil released was well mixed with gas. A CDE could affect a large portion of the *Sargassum* population if the spill occurred in an area of high *Sargassum* density or if toxic concentrations of oil were spread over a large area of surface water. Surprisingly little is known about the lifecycle of *Sargassum*. *Sargassum* is generally only present in the WPA and CPA in spring through early fall, and recent data suggest *Sargassum* originates in the northwest GOM and is exported from the GOM by ocean currents (Gower and King 1998). Therefore, the potential for impacts on *Sargassum* are highly dependent on when the spill occurs. *Sargassum* reproduces every year, so it is expected that the population will recover if affected by an oil spill.

4.4.6.3.2 Alaska – Cook Inlet.

Routine Operations.

Exploration and Site Development. See the Section 4.4.3.2.1 for a general discussion of the impacts of exploration and site development on water quality. During the exploration and site development phase, pelagic habitat would be affected by platform and pipeline placement, drilling activity, seismic surveys, platform lighting, and aircraft and vessel traffic (Table 4.4.6-7). Noise impacts would be greatest near the source and would temporarily reduce habitat quality for certain species. Construction lighting would alter the pelagic light regime of a small area and would attract phototaxic organisms to the platform.

Bottom water quality would be temporarily affected by turbidity from sediment disturbance during drilling, platform placement, and pipeline placement. Turbidity from bottom-disturbing activities could kill phytoplankton, although the population-level effects would be negligible. Photosynthetic productivity of phytoplankton that specialize in near-bottom habitats may be reduced if the turbidity plume reduced solar irradiance at depth. The turbidity plume would be temporary, and the effects on pelagic habitat are expected to be short term and minor.

It is assumed that drilling muds and cutting would be discharged into Cook Inlet for exploration wells only. Drilling wastes from development and production wells would be reinjected into the wells. The discharge of drilling muds and cuttings can occur near the water's surface or the seafloor, and both would create a turbidity plume that would diminish within some

TABLE 4.4.6-7 Impacting Factors by Phase and Potential Effects on Marine Pelagic Habitat in the Cook Inlet Planning Area

Impacting Factor	Disturbance[a]
Exploration and Site Development	
Vessel traffic	Noise
Seismic surveys	Noise
Miscellaneous discharges (deck washing, sanitary waste, bilge and ballast water)	Degraded water quality
Drilling and discharge of drilling muds/cuttings	Noise; degraded water quality
Pipeline trenching	Noise; turbidity
Drilling platform placement	Noise; turbidity
Offshore lighting	Alteration of light field
Production	
Production platform placement	Noise; turbidity
Production	Noise
Produced water discharge	Degraded water quality
Miscellaneous discharges (deck washing, sanitary waste)	Degraded water quality
Offshore lighting	Alteration of light field
Decommissioning	
Miscellaneous discharges (deck washing, sanitary waste, bilge and ballast water)	Degraded water quality
Platform removal	Noise, turbidity
Offshore lighting	Alteration of light field

[a] Colors indicate impact level: white = negligible; blue = minor; yellow = moderate; red = major.

distance from the release point. The turbidity plume could smother or stress small zooplankton and reduce phytoplankton productivity by decreasing the depth and intensity of light penetration. In well-mixed ocean waters, water-based drilling muds and cuttings are diluted by 100-fold within 10 m (33 ft) of the discharge and by 1,000-fold at a distance of about 100 m (330 ft) from the platform (Neff 2005). These estimates are for well-mixed water, and therefore the size of the turbidity field will vary with hydrology. Because the waters of Cook Inlet generally are vertically well mixed with a relatively large tidal range, dilution of drilling discharges would be expected to occur rapidly. Drilling wastes that are discharged are regulated by the USEPA under NPDES permits and must meet the toxicity, water quality, and discharge rate standards set by the permits, thereby reducing impacts on water quality (Neff et al. 2000; Neff 2005). Although such releases could result in temporary, localized increases in sediment load and deposition, this amount of sediment is small compared to the more than 40 million tons of suspended sediment carried annually into Cook Inlet by runoff from area rivers (Brabets et al. 1999). For all these reasons, long-term impacts from drilling waste discharges are expected to be minor.

Pelagic habitat would be affected minimally and temporarily by miscellaneous discharges (deck drainage, sanitary and domestic waste, bilge and ballast water) during site development. Such releases would be minor in quantity and would be rapidly diluted and are expected to have only negligible impacts on pelagic habitat. In addition, many vessel and platform wastes are disposed of on land, and those that are discharged at sea must meet USEPA and/or USCG regulatory requirements that limit their environmental effects.

Overall, activities conducted during the exploration and site development phase are expected to have minor effects on pelagic habitat.

Production. Impacts from offshore lighting, miscellaneous discharges, and bottom disturbance from the movement of support vessel anchors and chains will also exist in the production phase and are described above. In addition, production noise and produced water discharge could impact pelagic habitat quality (Table 4.4.6-7). Production noise is expected to have negligible impacts on habitat quality, because production platforms are known to have high biological abundance and diversity (Stanley and Wilson 2000). Impacts on pelagic habitat from produced water should be negligible because it is assumed that all produced water will be reinjected into the well. Overall, activities conducted during the production phase are expected to have negligible effects on pelagic habitat.

Decommissioning. Impacts from vessel noise, platform lighting, and miscellaneous discharges are discussed above and would continue throughout the decommissioning phase. In addition, bottom disturbance during platform removal would temporarily disturb pelagic habitat by increasing noise and turbidity for some length of the water column. These impacts would temporarily degrade habitat quality, but conditions would return to normal as suspended sediments dispersed and resettled. The use of explosives to remove platforms is not expected. Overall, activities conducted during the decommissioning phase are expected to have minor effects on pelagic habitat.

Accidents. Impacts on pelagic habitat from accidental oil spills could result from surface releases from platforms or vessels or from seafloor releases from pipelines and the wellhead. Spills could vary in size. It is assumed that 1 large spill (≥1,000 bbl), 1 to 3 small spills between 50 and 999 bbl and 7 to 15 smaller spills between 1 and 50 bbl could occur under the proposed action (Table 4.4.2-1). Such releases would reduce the habitat value and ecosystem function of pelagic habitat at local scales. Most spills would be small and the overall impacts on pelagic habitat resources will be minor and short term, given the natural dilution and breakdown of hydrocarbons. Large spills would degrade pelagic habitat quality over a wider area and potentially reduce the habitat value and ecosystem function in the areas affected. Eventually, the oil would be broken down by natural processes, and pelagic habitat would recover. Overall, impacts on pelagic habitat from accidental hydrocarbon spills could be negligible to moderate, and impacts could be short term to long term, but no permanent degradation of pelagic habitat is expected. See Section 4.4.3.2.2 for a further discussion of the effects of oil spills on water quality in Cook Inlet.

Oil spill-response activities such as burning, skimming, and chemical release (e.g., dispersants or coagulants) could affect pelagic habitat and biota. Burning would kill pelagic biota in the burn area, and skimming would remove aquatic organisms from the water column or trap them in oiled water. The chemicals used during a spill response are toxic, but there is controversy about whether the combination of oil and dispersant is more toxic than oil alone (NRC 2005b; Fingas 2008; Holland-Bartels and Kolak 2011). The use of dispersant would likely increase the areal extent of oil dispersion and the exposure of pelagic biota to oil. The presence of, and noise generated by, oil spill-response equipment and support vessels could temporarily disturb pelagic habitat in the vicinity of the response action, potentially reducing habitat use or disturbing migration. As with the spill itself, the location and time of the year the cleanup occurs would be an important determinant of impacts to pelagic habitat and biota.

Catastrophic Discharge Event. The PEIS analyzes a CDE of 75,000 to 125,000 bbl (Table 4.4.2-2). Oil from a CDE (Table 4.4.2-2) would form a surface slick and kill, injure, or displace pelagic biota over a large area of Cook Inlet. The extent and magnitude of the impact depend primarily on the time of year, the location of the well, the volume released, and the speed at which the well was capped. Most oil released would be rapidly diluted and broken down in the water column by physical and biological processes, so pelagic habitats would eventually recover their habitat value. Studies of water quality after the *Exxon Valdez* spill indicated that the hydrocarbon concentrations were highest in the first two months after the spill, but were well below the State of Alaska's water quality standard (Neff and Stubbenfield 1995). PAH concentrations in the water column of the sound reached background concentrations by 5 to 6 months after the spill. Toxicity tests also indicated no lethal or sublethal toxicity to pelagic phytoplankton, invertebrates, or larval fish test organisms due to exposure to water from Prince William Sound (Neff and Stubbenfield 1995). Within 1 yr of the *Exxon Valdez* spill, PAH concentrations generally declined to background levels (Boehm et al. 2007). However, in heavily oiled areas, toxic fractions of oil trapped in intertidal sediments can be periodically resuspended into the water column, where they are available to filter-feeding biota (Boehm et al. 2007). However, data from the *Exxon Valdez* spill suggest resuspended oil represented a contamination threat for biota less than 1 to 2 yr, with the highest PAH concentrations in intertidal waters (Boehm et al. 2007).

Broken ice occurs in the northern and western portions of lower Cook Inlet during fall and winter. If an open water spill were to occur at this time, the ice would contain the oil somewhat and reduce spreading. However, oil cleanup is also made more difficult in broken ice conditions. Oil from spills occurring in winter would likely freeze in ice where it could be transported hundreds of kilometers. If the spilled oil became frozen in the ice, cleanup would not be possible and the unweathered oil would be released into pelagic habitat as the ice melted. However, oil frozen into shorefast ice could be recovered using terrestrial cleanup methods, assuming the ice was stable and thick enough to support the cleanup activities.

4.4.6.3.3 Alaska – Arctic.

Routine Operations.

Exploration and Site Development. See Section 4.4.3.3.1 for a general discussion of the impacts of exploration and site development on water quality. During the exploration and site development phase, pelagic habitat would be affected by multiple activities (Table 4.4.6-8). Noise impacts would be greatest near the source and would temporarily reduce habitat quality for certain species. (See Section 4.4.7 for detailed discussions of the effects of noise on different

TABLE 4.4.6-8 Impacting Factors by Phase and Potential Effects on Marine Pelagic Habitat in the Beaufort and Chukchi Sea Planning Areas

Impacting Factor	Disturbance
Exploration and Site Development	
Vessel traffic	Noise; air emissions
Seismic surveys	Noise
Miscellaneous discharges (deck washing, sanitary waste, bilge and ballast water)	Degraded water quality
Drilling and discharge of drilling muds/cuttings	Noise; degraded water quality
Pipeline trenching	Noise; turbidity
Drilling and subsea well an platform placement	Noise; turbidity
Offshore lighting	Alteration of light field
Production	
Production platform placement	Noise; turbidity
Production	Noise
Produced water discharge	Degraded water quality
Miscellaneous discharges (deck washing, sanitary waste)	Degraded water quality
Offshore lighting	Alteration of light field
Decommissioning	
Miscellaneous discharges (deck washing, sanitary waste, bilge and ballast water)	Degraded water quality
Platform removal	Noise, turbidity
Offshore lighting	Alteration of light field

[a] Colors indicate impact level: white = negligible; blue = minor; yellow = moderate; red = major.

categories of biota.) Construction lighting would alter the pelagic light regime of a small area and would attract phototaxic organisms to the platform.

Bottom water quality would be temporarily affected by turbidity from sediment disturbance during drilling, placement of subsea wells, platforms and pipelines, and the construction of artificial islands. In addition to lethal or sublethal impacts to benthic organisms (Section 4.4.7.5), turbidity from bottom-disturbing activities could kill plankton, although the population-level effects would be negligible. Photosynthetic productivity of phytoplankton that specialize in near-bottom habitats may be reduced if the turbidity plume reduced solar irradiance at depth. However, the turbidity plume would be temporary, and the effects on pelagic habitat are expected to be short term and minor.

It is assumed that drilling muds and cuttings would be discharged into the Beaufort and Chukchi Sea Planning Areas for exploration wells only. Drilling wastes from development and production wells would be reinjected into the wells. The discharge of drilling muds and cuttings can occur near the water's surface or the seafloor, and both would create a turbidity plume that would diminish within some distance from the release point. The turbidity plume could smother or stress small zooplankton and reduce phytoplankton productivity by decreasing the depth and intensity of light penetration. In well-mixed ocean waters, water-based drilling muds and cuttings are diluted by 100-fold within 10 m (33 ft) of the discharge and by 1,000-fold at a distance of about 100 m (330 ft) from the platform (Neff 2005). These estimates are for well-mixed water, and therefore the size of the turbidity field will vary with hydrology. Although the release of drilling muds and cuttings could result in temporary, localized impacts, the amount of material released is small compared to the more than 6.35 million tons of suspended sediment carried annually into the Beaufort Sea alone by runoff from area rivers (Neff and Associates LLC 2010). In addition, the drilling wastes that are discharged are regulated by the USEPA under NPDES permits and must not exceed the toxicity, water quality, and discharge rate standards set by the permits. These requirements greatly reduce the potential for sediment alteration and contamination.

Pelagic habitat would be affected minimally and temporarily by miscellaneous discharges (deck drainage, sanitary and domestic waste, bilge and ballast water) during site development. Such releases would be minor in quantity and rapidly diluted and are expected to have negligible impacts on pelagic habitat. In addition, many vessel and platform wastes are disposed of on land, and those that are discharged at sea must meet USEPA and/or USCG regulatory requirements that limit their environmental effects.

Overall, activities conducted during the exploration and site development phase are expected to have minor effects on pelagic habitat.

Production. See Section 4.4.3.3.1 for a general discussion of the impacts of exploration and site development on water quality. Impacts from offshore lighting, miscellaneous discharges, and bottom disturbance from support vessel anchors and chains will also exist in the production phase and are described above. In addition, production noise and produced water discharge could impact pelagic habitat quality (Table 4.4.6-8). Recent analyses indicate that the discharge of produced water into the Chukchi Sea could result in elevated PAH concentrations in shallow water areas or in the winter (MMS 2007a). However, impacts on pelagic habitat from produced water should be minor because it is assumed that all produced water will be reinjected into the well.

Overall, activities conducted during the production phase are expected to have negligible effects on pelagic habitat.

Decommissioning. Impacts from vessel noise, platform lighting, and miscellaneous discharges are discussed above and would continue throughout the decommissioning phase. In addition, bottom disturbance during platform removal would temporarily disturb pelagic habitat by increasing noise and turbidity for some length of the water column. In addition, gravel islands would be left in place where they would wash away and introduce fine sediments into the water column over time. These impacts would temporarily degrade habitat quality, but conditions would return to normal as suspended sediments dispersed and resettled. Overall, only negligible impacts on pelagic habitat are expected to result from decommissioning activities.

Accidents. See Section 4.4.3.3.2 for a detailed discussion of the effects of oil spills on water quality in the Beaufort and Chukchi Sea Planning Areas. Accidental oil spills could result from surface releases from platforms or vessels or from seafloor releases from pipelines and the wellhead. It is assumed that up to 3 large oil spills (≥1,000 bbl) up to 35 small spills (50 to 999 bbl) and up to 190 smaller spills (>1 and <50 bbl) could occur during the lease period under the proposed action (Table 4.4.2-1). Small releases would degrade bottom water quality, but the overall contaminant impacts on pelagic habitat resources will be minor and short term, given the localized nature of a small release and the natural dilution and breakdown of hydrocarbons. Large spills would degrade pelagic habitat quality over a wider area and potentially reduce the habitat value and ecosystem function in the areas affected. Eventually, the oil would be transported from the area as well as broken down by natural processes. Oil is not expected to persist in marine pelagic habitat for an extended period (Section 4.4.3.3).

Spills in open water could be contained and much of the oil removed by standard oil spill-response methods. Oil spill-response activities such as burning, skimming, and chemical release (e.g., dispersants or coagulants) could affect pelagic habitat and biota. Burning would kill pelagic biota in the burn area, and skimming would remove aquatic organisms from the water column or trap them in oiled water. The chemicals used during a spill response are toxic, but there is controversy about whether the combination of oil and dispersant is more toxic than oil alone (NRC 2005b; Fingas 2008; Holland-Bartels and Kolak 2011). The use of dispersant would likely increase the areal extent of oil dispersion and the exposure of pelagic biota to oil. The presence of, and noise generated by, oil spill-response equipment and support vessels could temporarily disturb pelagic habitat in the vicinity of the response action, potentially reducing habitat use or disturbing migration. As with the spill itself, the location and time of the year the cleanup occurs would be an important determinant of impacts on pelagic habitat and biota.

If the spill were to occur under ice or during winter, cleanup would be much more difficult because sea ice would limit access to the spill (reviewed in Holland-Bartels and Kolak 2011). For spills affecting areas of broken ice, the ice would contain the oil somewhat and reduce spreading. However, cleanup is also more difficult in broken ice conditions. Oil cleanup response plans and technologies for ice-covered areas are still evolving, and the efficacy of many proposed spill countermeasures is as yet unknown (Holland-Bartels and Kolak 2011). The oil could freeze into the ice where it could be transported hundreds of kilometers. Oil under ice or frozen in ice would undergo little weathering (Holland-Bartels and Kolak 2011) and could therefore degrade pelagic habitat for an extended period of time, with the extent of the impacts increasing with the size of the oiled area. Sea ice habitat could be degraded or lost if contact with oil spills results in lethal or sublethal effects on biota growing beneath the ice (e.g., fish, invertebrates, and algae). Overall, moderate and potentially long-term degradation of pelagic habitat could result from accidental spills occurring under ice or frozen in ice.

Catastrophic Discharge Event. The PEIS analyzes a CDE of up to 2.2 million bbl in the Chukchi Sea Planning Area and 3.9 million bbl in the Beaufort Sea Planning Area. A CDE may affect pelagic habitats (Table 4.4.2-2). The extent and magnitude of the impact depend primarily on the time of year, the location of the well, the volume released, and the speed at which the well was capped. Typically oil rises from the seafloor to the surface, forming a surface slick capable of traveling greater than 50 km (31 mi) (MMS 2007a). Pelagic organisms could be exposed to lethal or sublethal concentrations of hydrocarbons or mixtures of hydrocarbons and dispersants (if used). Pelagic habitats would eventually recover their habitat value as hydrocarbons broke down and were diluted. Recovery time would vary with local conditions and the degree of oiling. Overall, impacts on pelagic habitat from accidental hydrocarbon spills in open water could range from negligible to moderate, and impacts could be short term to long term, but no permanent degradation of pelagic habitat is expected.

4.4.6.3.4 Conclusion. Impacts on pelagic habitat in the GOM, Cook Inlet, and Beaufort and Chukchi Sea Planning Areas could occur during the exploration through decommissioning phases. In all Planning Areas, most impacts would be negligible to minor for routine Program activities and would range from short term for the exploration, site development, and decommissioning phases to long term for those impacts occurring throughout the production phase. Impacts would primarily occur from turbidity generated by bottom-disturbing activities. Temporary reduction in habitat quality could also result from the discharge of produced water and drilling muds and cuttings. Overall, no permanent degradation of pelagic habitat is anticipated to result from routine OCS activities because of the nature of the impacts and the small area potentially affected compared to the total area available.

Most accidental oil spills would be small and result in only negligible, localized impacts on pelagic habitat. However, large or CDE spills could potentially reduce habitat quality over potentially much broader areas. The effects from oil spills would depend on the size, timing, duration, and location of the spill and on various environmental factors. Pelagic habitat in nearshore areas would likely have the greatest potential for long-term contamination. Unique pelagic habitat and associated biota such as *Sargassum* mats in the GOM and sea ice in the Arctic could also be affected by oil spills. Contact with spilled oil could completely or partially kill *Sargassum* and cause lethal or sublethal effects to associated biota.

In the Alaskan planning areas, oil could become trapped under sea ice for an extended period, where it would remain relatively unweathered and capable of being transported large distances. Oil under ice or frozen in ice could therefore degrade pelagic habitat for an extended period of time with the extent of the impacts increasing with the size of the oiled area; the largest area affected would occur with a CDE-level spill. Sea ice habitat could be degraded or lost if contact with oil spills results in lethal or sublethal effects on biota growing beneath the ice. In all pelagic habitats, hydrocarbons would be diluted and broken down by natural processes, and pelagic habitat would eventually recover its ecological functions.

4.4.6.4 Essential Fish Habitat

4.4.6.4.1 Gulf of Mexico. As described in Section 3.7.4.1, most of the coastal and marine waters of the GOM are considered EFH for life stages of one or more managed species, and any oil and gas development activity that degrades coastal or marine benthic and pelagic environments would affect EFH. Also, several offshore banks are considered HAPC

(Section 3.7.4.1). EFH consists of benthic and water column habitats in marine coastal areas. The potential effects of exploration, site development, and production activities on these habitats are discussed in individual sections including coastal and estuarine habitats (Sections 4.6.1.1), marine benthic habitats (Section 4.4.6.2.1), and the marine water column (Section 4.4.6.3.1). Impacts on fish and fisheries from the Program are discussed in Sections 4.4.7.3.1 and 4.4.1.1.1.

Routine Operations.

Exploration and Site Development. During the exploration and site development phase, impacts on EFH could occur as a result of drilling and drilling waste discharge, seismic surveys, and the placement of drilling units, production platforms, and pipelines. Noise from drilling, construction, and seismic surveys would temporarily disturb EFH and potentially kill, injure, or displace managed species. See Section 4.4.7.3.1 for a discussion of the impacts of noise on fish. It is anticipated that behavioral and distributional responses to such acoustic stimuli would be small and that these temporary effects would not persist for more than several hours after acoustic surveys are ended. All the noise associated with these activities would be temporary and affect a small area; therefore, it is expected to result in only negligible to minor impacts on EFH and managed species in the northern GOM.

The vast majority of marine EFH affected by the Program would be soft sediments. The estimated bottom habitat that may be directly disturbed by new pipeline and platform installation ranges from 2,150 to 14,000 ha (5,313 to 34,594 ac) over the entire GOM. Pipelines placed on the sediment surface would eliminate natural soft sediment EFH. Sediment-disturbing activities would result in increased turbidity, which would lower the water quality of EFH in small areas for a limited time. Although mobile, adult managed species are not likely to be directly affected by bottom disturbance, bottom-disturbing activities could injure, displace, or kill early life stages of managed species or bury the benthic prey of managed species. Bottom disturbance would affect a small area relative to the size of the GOM, and no population-level effects on managed species are expected. Also, FPSO systems could potentially be used in deep water, and would reduce the need for pipelines.

The potential for bottom-disturbing activities to affect sensitive marine EFH such as hard-bottoms, deepwater corals, and chemosynthetic communities would be reduced by stipulations requiring buffers between these features and bottom-disturbing activities (Section 4.4.6.2.1). Up to two FPSO systems may be employed for deepwater wells. Under the FPSO system, oil would be transported from the well to a surface vessel and ultimately to shore. By eliminating the need for pipelines, an FPSO system would greatly reduce bottom disturbance and the chance for disturbing deepwater corals and chemosynthetic communities. Topographic features classified as HAPC are also protected by the Topographic Features stipulation, which prohibits direct bottom disturbance or the deposition of drilling muds and cuttings in areas containing such habitat. Therefore, HAPC should be minimally affected by exploration and site development activities.

Coastal EFH could be affected by the estimated 0 to 12 new pipeline landfalls that are anticipated under the proposed action. Routing the pipelines through the most sensitive coastal EFH (i.e., mangroves and seagrass) is not likely to be permitted, but saltmarsh wetlands may be permanently lost due to construction activity. The overall area of coastal EFH affected by oil and gas activities would be minor, and impacts are not expected to permanently reduce the EFH available to managed species or result in population-level impacts on managed species.

A total of up to 4,700 exploration and production wells will be drilled in the WPA and CPA under the proposed action. The subsequent discharges of drilling cuttings and muds would alter the grain size distribution and chemical characteristics of sediments immediately surrounding the drill sites and for some distance around the wells (typically less than 1 km [3,281 ft]), depending on the depth at which the material is discharged (Kennicutt et al. 1994; Continental Shelf Associates, Inc. 2004, 2006). The deposited material could alter benthic habitat for EFH prey species and potentially affect spawning sites, which are often chosen on the basis of sediment grain size. Elevated sediment metal and PAH concentrations near the well (<500 m [1,640 ft]) would also likely result from drilling discharge, but with the exception of some metals, elevated tissue concentrations of contaminants have not been found in demersal fish or their benthic invertebrate food sources sampled around platforms in the GOM (Kennicutt et al. 1994; Continental Shelf Associates, Inc. 2004, 2006).

It is expected that the overall impacts of exploration and site development activities on marine EFH would be moderate, and impacts are not expected to permanently reduce the EFH available to managed species or result in population-level impacts on managed species. Recovery rates of EFH habitat and benthic food resources could range from short term to long term depending on the spatial and temporal scope of the disturbance.

Production. The primary production activities that could affect EFH include chronic bottom disturbance from the movement of platform mooring structures and the discharge of produced water. Bottom disturbance represents chronic, long-term, but moderate and localized impacts on marine EFH. NPDES permits would limit the potential for produced water discharges to contaminate sediment and water column EFH. Fish and invertebrates collected near platforms in the GOM do not appear to bioaccumulate the common contaminants in produced water such as radionuclides, metals, and hydrocarbons and do not exceed the USEPA-specified tissue concentrations considered to be harmful (Continental Shelf Associates, Inc. 1997).

After new platforms have been established, sessile fouling organisms would colonize the underwater portions of the structures, which would attract managed reef species such as snapper, grouper, and some coastal migratory pelagics. Over time, this could change the spawning, breeding, and feeding patterns of some managed fish. The effects of artificial reefs on fish populations are controversial (Section 4.4.7.3.1), as the reefs may benefit some species and adversely affect others. The benefit or detriment of artificial reefs as habitat depends on how fisheries on the reef are managed and on the individual life histories and habitat requirements of the species present (Bohnsack 1989; Macreadie et al. 2011). Unless platforms are permitted to remain, the reef function of the platforms would last only through the production phase.

It is expected that the effects of production activities on marine EFH would be minor, and impacts are not expected to permanently reduce the EFH available to managed species or result in population-level impacts on managed species.

Decommissioning. During decommissioning and structure removal, both explosive and nonexplosive methods may be used to sever conductors and pilings. With the exception of some water quality concerns, nonexplosive removals (e.g., abrasive, mechanical, or diver cutters) have little impact on the fish resources. With explosive removal, impacts on managed species range from disturbance and habitat loss to injury and death. From 150 to 275 explosive platform removals are expected, and most would occur in relatively shallow water. Floating platforms would not require explosive removals, although the seafloor would be temporarily disturbed by the removal of platform mooring structures. Removing structures would also remove the associated fouling communities that serve as prey for managed fish species, thereby forcing these species to relocate to other foraging areas. Pipelines would typically be left in place. Pipelines on the sediment surface could periodically move, resulting in chronic bottom disturbance to soft sediment EFH. Pipelines not buried, in both shallow and deepwater, would provide hard substrate and habitat. Overall, it is expected that the effects of decommissioning activities on marine EFH would be minor, and impacts are not expected to permanently reduce the EFH available to managed species or result in population-level impacts on managed species.

Accidents. Small accidental hydrocarbon releases occurring in surface or near-bottom offshore habitats would temporarily degrade EFH in the vicinity of the release, but are not likely to reach large-scale sensitive marine EFH such as hard-bottom EFH (Section 4.4.6.2.1). Large spills (≥1,000 bbl) have the potential to degrade EFH over a wider area that potentially reduce the habitat value and ecosystem function in the areas affected. Impacts would be greatest if oil from the spill were to contact sensitive marine habitat such as seagrass beds and wetlands. However, in most cases, the area affected would likely be small compared to the overall resources and eventually the oil would be transported from the area as well as broken down by natural processes.

Catastrophic Discharge Event. The PEIS analyzes a CDE up to 7.2 million bbl (Table 4.4.2-2). However, much of the hydrocarbon would likely be consumed relatively quickly by bacteria (Camilli et al. 2010; Kessler et al. 2011). The potential for oil from an accidental release to reach marine HAPC at lethal concentrations would be reduced by the Topographic Features Stipulation prohibiting oil and gas development near these features. However, topographic features as well as unique deepwater communities could be partly or completely destroyed if contacted by a large quantity of oil. Oil from surface and subsurface spills contacting nearshore EFH has the greatest potential to degrade EFH such as intertidal and estuarine habitats with emergent and submerged vegetation, sand and mud flats, and shell and oyster reefs. These areas provide food and rearing substrate for a variety of federally managed juvenile fish and shellfish. Most nearshore spills would be small so they are not likely to degrade a large fraction of EFH because the hydrocarbons would be rapidly metabolized and diluted. However, moderate and long-term but temporary degradation of EFH could occur if a catastrophic coastal area was oiled following a large offshore spill. In most cases, the coastal habitat would recover as the hydrocarbons were metabolized or buried, but marsh grasses currently stressed by subsidence may not recover.

A catastrophic spill occurring offshore could affect all life stages of federally managed species and their food sources. Managed species could be affected by the spill directly due to lethal or sublethal toxicity or indirectly by long-term reduction in food resources and juvenile and reproductive habitat. Adult life stages will likely avoid heavily oiled areas, although sublethal exposures are possible (Roth and Baltz 2009). Early life stages of managed species may be most vulnerable to hydrocarbon spills, which could trap and kill planktonic eggs and larvae in the affected area. Mortality to pelagic eggs and larvae contacting the oil could be particularly high in the case of a catastrophic spill at the surface that spreads over a wide area. In addition to the size of the spill, the location of the spill and the season in which the spill occurred would be important determinants of the impact magnitude. For example, catastrophic spills occurring during recruitment periods or spills that oil critical spawning areas could result in temporary population-level impacts on managed fish and invertebrates. Also, managed species currently in serious population decline, such as sharks and bluefin tuna, may experience population-level impacts if the spill were to kill a significant number of eggs and larvae in a given year. For example, the HAPC for bluefin tuna extends from the 100 m (328 ft) isobath and could also be affected by oil spills, and population-level impacts to Bluefin tuna could result from catastrophic spills (Teo et al. 2007; Atlantic Bluefin Tuna Status Review Team 2011). The effects of a CDE on such managed species could be major.

Wave and wind action, weathering, and biological degradation would dissipate oil in the surface water, and suitable habitat condition would eventually return. The period of time needed to reestablish appropriate habitat conditions following a spill would depend upon the characteristics of the individual spill and would be related to many factors, including the EFH resource affected, the location of the spill, the nature of transporting currents, the magnitude of the spill, and the chemical characteristics of the spilled oil. With the exception of sensitive habitats such as corals and chemosynthetic communities, EFH affected by oil spills is expected to fully recover within a few years. Sensitive habitats with slow-growing biota may take longer to recover or may not recover at all. Overall, accidental large spills could have negligible to moderate effects on marine EFH. The effects for a CDE could be more severe depending on the volume, duration, and persistence.

4.4.6.4.2 Alaska – Cook Inlet. The Cook Inlet Planning Area contains EFH for a variety of fish and invertebrate species that can be broadly categorized into three groups based upon the relevant Fishery Management Plans (FMPs): Gulf of Alaska groundfish, Alaska salmon, and Alaska weathervane scallop. As identified in the FMPs, the EFH includes bottom and water-column habitat in streams, lakes, ponds, wetlands, and marine and coastal waters. Consequently, activities that degrade these aquatic habitats could adversely affect EFH for one or more species. For the purposes of this analysis, potential impacts on EFH resources in the Cook Inlet Planning Area and adjacent waters are generally addressed. EFH in Cook Inlet potentially affected by exploration, site development, and production activities are discussed in detail in individual sections including coastal and estuarine (Sections 4.4.6.1.2) and marine benthic habitats (Section 4.4.6.2.2) and the marine water column (Section 4.4.6.3.2). Impacts on Cook Inlet fish and fisheries from the Program are discussed in (Sections 4.4.7.3.2 and 4.4.11.2). Because of the connection with adjacent marine areas, this evaluation also considers the potential for effects on fish populations in the overall Gulf of Alaska.

Routine Operations.

Exploration and Site Development. During the exploration and site development phase, the primary impacts on EFH could occur as a result of drilling and drilling waste discharge, seismic surveys, and the placement of drilling units, production platforms, and pipelines. Each seismic survey would be completed within weeks. While it is anticipated that there would be no permanent population-level effects on managed species in Cook Inlet or the Gulf of Alaska from seismic surveys, individual fishes, especially egg and larval life stages in close proximity (1 to 5 m [3 to 16 ft]) to air gun arrays (Dalen and Knutsen 1986; Holliday et al. 1987; Turnpenny and Nedwell 1984), could suffer mortality or injury, and adult fishes located farther from the noise could exhibit short-term avoidance and behavioral alteration. The migration of managed salmon could also be temporarily disrupted. Additional sources of noise from drilling, construction of platforms and pipelines, and boat traffic could also temporarily disturb or displace individual fish. All the noise associated with these activities would be temporary and is expected to result only in minor impacts on EFH and managed species in Cook Inlet.

The vast majority of marine EFH affected by the Program would be soft sediments. It is anticipated that 1.5 to 4.5 ha (4 to 11 ac) of seafloor habitat in the Cook Inlet Planning Area could be affected by platform construction under the proposed action. It is also estimated that 80 to 241 km (50 to 150 mi) of new pipelines would be installed offshore. Pipelines could be trenched or installed and anchored on the sediment surface. Placing the pipeline on the sediment surface could result in permanent loss of soft sediment EFH. Ground-disturbing activities would result in increased turbidity, which would lower the water quality of EFH in small areas for a limited amount of time. Although adult managed fish are not likely to be killed or injured during bottom disturbance, bottom-disturbing activities could injure, displace, or kill early life stages of managed species or bury the benthic prey of managed species. Scallops have less mobility than fish and may be killed, injured, or displaced by bottom disturbance. The migration of managed salmon could also be temporarily disrupted by bottom disturbance.

Pipeline construction in nearshore subtidal habitats could damage marine plant EFH by mechanically removing the plants or smothering them through sedimentation. Areas containing high densities of aquatic vegetation are typically avoided during construction activities due to a lease stipulation calling for protection of important or unique biological populations or habitats. Pipeline crossings of streams could affect EFH for several life stages of anadromous salmon, including eggs, larvae, juveniles, and adults. The Alaska Department of Fish and Game (ADF&G) reviews plans for construction activities for potential impacts on salmon and other fish species and requires permits to be issued before stream pipeline crossings can be installed. Therefore, it is anticipated that impacts on anadromous salmon from freshwater pipeline crossings would be minimized through appropriate permitting and management actions once site-specific assessments are conducted.

It is anticipated that 4 to 12 exploration and delineation wells and 42 to 114 production wells will be drilled in Cook Inlet under the proposed action. It is assumed that drilling muds and cuttings from the exploration and delineation wells would be discharged into Cook Inlet and could temporarily affect benthic and water-column EFH resources. While the toxicity of those cuttings is expected to be low and within permitted levels, the drilling wastes that are discharged would temporarily increase turbidity and sediment deposition, and small numbers of managed species could be temporarily displaced. In the mixing area near the discharge site, eggs and larvae of managed groundfish and scallops could be killed or injured. Settlement of discharged cuttings on the seafloor could smother some prey species and change substrate composition in the area where the cuttings settle. However, the discharge of all drilling muds and cuttings would be subject to NPDES permitting requirements that would greatly reduce the impacts on EFH and managed species.

Overall, exploration and site development activities are expected to result in moderate impacts on EFH and managed species. Recovery of EFH habitat and benthic food resources could range from short term to long term.

Production. The primary production activities that could affect EFH include bottom disturbance from anchors and the discharge of produced water. Bottom disturbance represents a chronic, long-term but moderate and localized impact on EFH. It is assumed that all produced water would be disposed of by injection into permitted disposal wells. Therefore, the effects of produced water discharges on sediment and water-column EFH are expected to be minimal.

After new platforms have been established, sessile fouling organisms would colonize the underwater portions of the structures, and they would attract prey for unmanaged species as well as managed species such as rockfish. Over time, this could change the spawning, breeding, and feeding patterns of some managed fish.

Overall, production activities are expected to result in minor impacts on EFH and managed species.

Decommissioning. During decommissioning and structure removal, only nonexplosive methods would be used to sever conductors and pilings. Nonexplosive removals (e.g., abrasive, mechanical, or diver cutters) are expected to have little impact on EFH resources and managed species (Section 4.4.7.3.2). Many platforms would be floating, and the seafloor would be temporarily disturbed by the removal of platform mooring structures. Removing structures would also remove the associated biological communities that serve as prey for managed fish species, thereby forcing these species to relocate to other foraging areas. Overall, decommissioning activities are expected to result in negligible impacts on EFH and managed species.

Accidents. Most accidental hydrocarbon releases in the Cook Inlet Planning Area would be small and would result in only negligible effects on EFH and managed species, while larger releases could have a greater adverse impact on EFH and various life stages of managed species depending upon the timing, location, and magnitude of an oil spill. Impacts from spills would be greatest if a large spill occurred during a reproductive period or contacted a location important for spawning or growth such as intertidal and nearshore subtidal habitats. Small releases would degrade bottom water quality, but the overall contaminant impacts on pelagic habitat resources will be minor and short-term, given the localized nature of a small release and the natural dilution and breakdown of hydrocarbons. Large spills have the potential to degrade EFH over a wider area than small spills and could potentially reduce the habitat value and ecosystem function in the areas affected. Eventually, the oil would be transported from the area as well as broken down by natural processes.

The period of time needed to reestablish appropriate EFH conditions following a spill would depend upon the characteristics of the individual spill and many factors, including the location of the spill, the nature of transporting currents, the magnitude of the spill, and the chemical characteristics of the spilled oil. For example, while most of the waters within the Cook Inlet Planning Area remain open throughout the winter, currents could transport oil under ice to surrounding areas. Oil spilled under ice is more difficult to locate and clean than surface spills. As evidenced by effects of the *Exxon Valdez* oil spill, recovery of some EFH resources could occur within less than a year, while shoreline resources could continue to be affected at some level for 10 yr or more (*Exxon Valdez* Oil Spill Trustee Council 2009a). Wave and wind action, weathering, and biological degradation would dissipate spilled oil in the surface water, and water-column EFH resources would likely recover most quickly. Sediments could recover much more slowly. Following the *Exxon Valdez* oil spill, contamination persisted in some freshwater benthic habitats for at least 4 yr (Murphy et al. 1999) and oil contaminating intertidal sediments continued to reduce survival of eggs for anadromous salmon for a number of years after the spill (Peterson et al. 2003). Similarly, intertidal sediments and benthic communities are still listed as recovering (*Exxon Valdez* Oil Spill Trustee Council 2010c). Like EFH, managed species would eventually recover from catastrophic spills, although the recovery could take many years. The *Exxon Valdez* Oil Spill Trustee Council evaluated the status of several managed species following the *Exxon Valdez* spill, including sockeye salmon, pink salmon, and rockfish. The salmon were listed as recovered within a decade after the spill and rockfish as very likely recovered (*Exxon Valdez* Oil Spill Trustee Council 2010c).

Overall, accidental hydrocarbon releases could have negligible to moderate effects on EFH largely depending on the size of spill, location, environmental factors, and uniqueness of the affected EFH.

Catastrophic Discharge Event. The PEIS analyzes a CDE of 75,000 to 125,000 bbl (Table 4.4.2-2). Deeper subtidal sediment EFH may be less affected because hydrocarbons would tend to float over the sediments. The potential for severe impacts from accidents would be greatest from oil washed inshore into wetlands, intertidal zones, and shorelines where spilled oil could contaminate nearshore habitat and associated prey species. Spilled oil could also kill kelp and other marine plants that provide food and nursery habitat for managed salmon and groundfish. Spilled oil concentrated along the coastline at the mouths of streams or rivers may disrupt migration patterns for some species, such as eulachon or salmon, by causing fish to avoid contaminated areas. In some cases, toxic fractions (e.g., PAHs) of spilled oil could also reach freshwater areas where salmon eggs are deposited in stream bottoms. PAHs in the parts-per-billion range can cause sublethal impacts on developing fishes (MMS 2007a). Depending on the timing and severity of an oil spill, adult anadromous fish migrating from marine waters to freshwater to spawn and juveniles migrating seaward from freshwater could be harmed by high concentrations of hydrocarbons. Large, mobile adult managed species in Cook Inlet would likely avoid hydrocarbon spills by temporarily moving to other areas. However, small obligate benthic species as well as pelagic eggs and larvae of some managed species and organisms that serve as their prey may be unable to avoid the oil.

4.4.6.4.3 Alaska – Arctic. There are two FMPs designating EFH in the Beaufort/Chukchi Planning Areas: one for Alaska salmon and one for arctic fishes (NPFMC and NMFS 1990; NPFMC 2009). Activities that degrade these aquatic habitats could adversely affect EFH for one or more species. For the purposes of this analysis, potential impacts on EFH resources in the Beaufort/Chukchi Planning Area and adjacent waters are generally addressed. EFH in the Beaufort and Chukchi Seas potentially affected by exploration, site development, and production activities are discussed in detail in individual sections including coastal and estuarine (Sections 4.4.6.13) and marine benthic habitats (Section 4.4.6.2.3) and the marine water column (Section 4.4.6.3.3). Impacts on Beaufort/Chukchi Planning Area fish and fisheries from the Program are discussed in Section 4.4.7.3.3 and Section 4.4.11.3.

Routine Operations.

Exploration and Site Development. During the exploration and site development phase, impacts on EFH could occur as a result of drilling and drilling waste discharge, seismic surveys, the placement of subsea drilling units, production platforms, pipelines, and construction of artificial islands. While it is anticipated that there would be no permanent population-level effects on fishes in the Beaufort/Chukchi Planning Area from seismic surveys, individual fishes, especially egg and larval life stages, in close proximity (1 to 5 m [3 to 16 ft]) to air gun arrays could suffer mortality or injury, and juvenile and adult fishes located farther away could exhibit temporary behavioral alteration including spawning/migratory behavior (Dalen and Knutsen 1986; Holliday et al. 1987; Turnpenny and Nedwell 1994). Additional sources of noise from activities such as drilling, platform and pipeline placement, and boat traffic could also temporarily disturb or displace individual fish. All the noise associated with these activities would be temporary and affect a small area and therefore is expected to result in only minor impacts on EFH and managed species in the Beaufort/Chukchi Planning Area.

The vast majority of marine EFH affected by the Program would be soft sediments on the continental shelf in less than 91 m (300 ft) of water. Under the proposed action, up to 13.5 ha (33 ac) of seafloor habitat could be permanently covered by up to 9 artificial islands, and as much as 567 ha (1,401 ac) of seafloor habitat could be disturbed by pipeline placement. Pipelines located in water less than 50 m (165 ft) would be trenched to avoid damage from ice scour. In addition, up to 92 subsea production wells could be constructed. The construction of artificial islands and the placement of pipelines on the sediment surface would alter existing seafloor EFH and the associated communities. Sediment-disturbing activities would increase turbidity, which would lower the water quality of EFH in small areas for a limited amount of time, typically causing fish to leave the areas until water quality improves. The migration of managed salmon could also be temporarily disrupted by bottom disturbance, although salmon are relatively uncommon in the Beaufort and Chukchi Seas. Although adult managed species are less likely to be killed or injured during bottom disturbance, bottom-disturbing activities could injure, displace, or kill early life stages of managed species or bury the benthic prey of managed species. However, the sediments would eventually settle out and would not experience permanent effects. Pipeline trenching and island construction could damage marine plants associated with EFH by mechanically removing the plants or smothering them through sedimentation. Marine vegetation is concentrated in relatively few areas within the Beaufort Sea and Chukchi Sea Planning Areas (e.g., the Stefansson Sound Boulder Patch Community), and impacts on such areas are typically minimized during construction activities by stipulations protecting sensitive biological habitats.

It is assumed that drilling muds and cuttings from the exploration and delineation wells would be discharged into the Beaufort and Chukchi Seas. The discharges of drilling fluids and cuttings could temporarily affect some EFH resources. While the toxicity of those cuttings is expected to be low and within permitted levels, the drilling wastes that are discharged would temporarily increase turbidity and sediment deposition, and a small number of managed species could be temporarily displaced. In the mixing area near the discharge site, eggs and larvae of managed arctic fishes could be killed or injured. Settlement of discharged cuttings on the seafloor could smother some prey species and change substrate composition in the area where the cuttings settle. However, the discharge of all drilling muds and cuttings would be subject to NPDES permitting requirements that would greatly reduce the impacts on EFH and managed species.

Gravel island and ice road construction may affect freshwater EFH depending on the location and timing of the activities. Gravel for island construction is mined from river bars, and water for construction of ice roads is pumped from local rivers and lakes to desired areas to build a rigid surface. Removal of gravel and water could increase turbidity and reduce the water quality of EFH in affected rivers. The ADF&G requires reviews of such activities for potential impacts on salmon and other fish species and requires permits to be issued before gravel mining and water withdrawals can be initiated.

Overall, the impacts of exploration and site development activities on EFH and managed species are expected to be moderate.

Production. The primary production activities that could affect EFH include bottom disturbance from anchors and the discharge of produced water. Bottom disturbance represents chronic, long-term, but moderate and localized impacts on EFH. Pipelines not buried would be anchored in place which would minimize their movement and potential to disturb sediment EFH. It is assumed that all produced water would be disposed of by injection into permitted disposal wells. Therefore, the effects of produced water discharges on sediment and water-column EFH are expected to be minimal. Platform and island construction will introduce floating or benthic hard substrate that may attract managed species and their prey. Over time, this could change the spawning, breeding, and feeding patterns of some managed fish.

Chronic discharges of contaminants in ice roads would occur during every breakup from fluids entrained in the roads. Entrained contaminants from vehicle exhaust, grease, antifreeze, oil, and other vehicle-related fluids could potentially affect EFH. These discharges are not expected to be major; however, they would exist over the life of the field.

Overall the impacts of production activities on EFH and managed species are expected to be minor.

Decommissioning. Bottom disturbance during platform removal would temporarily disturb EFH by increasing noise and turbidity for some length of the water column. During decommissioning and structure removal, only nonexplosive methods would be used to sever conductors and pilings. Nonexplosive removals (e.g., abrasive, mechanical, or diver cutters) are expected to have little impact on EFH resources and managed species (Section 4.4.7.3.2). These impacts would temporarily degrade EFH quality and potentially kill or injure managed species, but conditions would return to normal as suspended sediments dispersed and resettled, and the long-term impacts on EFH would be negligible. Removing structures would also remove the associated fouling communities that serve as prey for managed fish species, thereby forcing these species to relocate to other foraging areas. Gravel islands would be left in place where they would wash away and introduce fine sediments into the water column over an extended period of time.

Overall, only negligible impacts on EFH are expected to result from decommissioning activities.

Accidents. Most accidental hydrocarbon releases in the Beaufort and Chukchi Planning Areas would be small. Small releases would degrade bottom water quality, but the overall contaminant impacts on pelagic habitat resources will be minor and short-term, given the localized nature of a small release and the natural dilution and breakdown of hydrocarbons. Large spills would degrade EFH over a wider area than small spills and potentially reduce the habitat value and ecosystem function in the areas affected. Impacts from spills would be greatest if a large spill occurred during a reproductive period or contacted a location important for spawning or growth such as intertidal and nearshore subtidal habitats. Eventually, the oil would be transported from the area as well as broken down by natural processes.

Toxic fractions of oil in the parts-per-billion range can cause sublethal impacts on developing fishes (MMS 2007a). Depending on the timing and severity of an oil spill, adult anadromous fish migrating from marine waters to fresh water to spawn and juveniles migrating seaward from freshwater could be harmed by high concentrations of hydrocarbons. Most adult managed species in the Beaufort and Chukchi Seas are highly mobile and would likely avoid oil spills by temporarily moving to other areas. However, small obligate benthic species and egg and larval life stages of managed species as well as planktonic organisms that serve as their prey may be unable to avoid hydrocarbon spills. In addition, oil reaching the intertidal zone can persist in the sediments and cause sublethal impacts on fish eggs and larvae for multiple years (Peterson et al. 2003).

Wave and wind action, weathering, and biological degradation by microbes would dissipate oil in the surface water, and EFH would be reestablished after some period of time. The period of time needed to reestablish appropriate EFH conditions following a spill would depend upon the characteristics of the individual spill and would be related to many factors, including the habitat affected, the location of the spill, the nature of transporting currents, the magnitude of the spill, and the chemical characteristics of the spilled oil. Studies following the *Exxon Valdez* spill found that water column EFH recovered in less than 1 to 2 years (Boehm et al. 2007). Subtidal habitat and communities are considered to be very likely recovered by the *Exxon Valdez* Oil Spill Trustee Council (2010c), but as of 2010, intertidal sediments and communities are considered to still be recovering from the *Exxon Valdez* spill (*Exxon Valdez* Oil Spill Trustee Council 2010c). Impacts to kelp habitat from an oil spill could be long-term, but are not expected to be permanent. Laminaria beds oiled by the *Exxon Valdez* spill recovered within 10 years (Dean and Jewett 2001). Overall, accidental oil spill could have negligible to moderate effects on EFH largely depending on the size of the spill, its location, environmental factors, and the uniqueness of the affected EFH.

Catastrophic Discharge Event. The PEIS analyzes a CDE up to 2.2 million bbl in the Chukchi Sea Planning Area and up to 3.9 million bbl in the Beaufort Sea Planning Area. Deeper subtidal sediment EFH may be less affected because hydrocarbons would tend to float over the sediments. The potential for severe impacts from accidents would be greatest if large quantities of oil from catastrophic spills washed inshore into wetlands, intertidal zones, and shorelines where spilled oil could contaminate nearshore EFH and associated prey species. Spilled oil reaching wetland habitat could kill vegetation and associated invertebrates and small fish that are prey species for managed species. Deeper subtidal sediment EFH may be less affected because hydrocarbons would tend to float over the sediments. Similar effects are expected to those described above, but managed species that suffer large losses of early life stages or that are currently in decline could suffer population-level effects from catastrophic oil spills. A single catastrophic spill could cause long-term declines of managed species that rely on shallow coastal, intertidal, and freshwater areas. Spilled oil could smother kelp and other marine plants, reducing habitat and substrate for potential prey of managed species. Oil spilled under ice is more difficult to locate and remove than surface spills. Since weathering would be greatly reduced by ice cover, managed species with mobility could continue to be harmed or killed as they drift into the trapped oil. In addition, the sea ice that provides habitat for managed species such as juvenile arctic cod could be uninhabitable.

4.4.6.4.4 Conclusion. Most impacts on EFH from oil and gas exploration and production activities would likely result from bottom disturbance and the creation of artificial reefs by production platforms. The magnitude of impacts on sensitive marine and coastal EFH would be limited by specific lease stipulations and site-specific analyses conducted for particular lease sales. Managed species, particularly egg and larval stages, could be killed, injured, or displaced from the immediate vicinity of oil and gas activities. No more than moderate impacts on EFH are expected to result from routine Program activities and no population-level impacts on managed species are expected. Recovery of EFH habitat and benthic food resources from oil and gas activities would range from short term to long term.

The severity of effects of accidental hydrocarbon spills on EFH would depend on the size of the spill, its location, environmental factors, and the uniqueness of the affected EFH. While most accidents would be small and would have relatively small impacts on EFH, large or CDE-level spills that reach coastal EFH could have more persistent impacts and could require remediation. A single CDE spill could cause long-term declines of managed species that rely on shallow coastal, intertidal, and freshwater areas. Adult managed species would probably not be greatly affected by a hydrocarbon spill in open water areas, but small obligate benthic species, eggs, larvae, and some managed species and their prey could experience lethal and sublethal effects from contact with hydrocarbons. In Alaskan waters, spills occurring under ice could result in long-term degradation of EFH and managed species because of the cleanup difficulties; largest impacts would be incurred with a CDE-level spill. Managed species that suffer large losses of early life stages or that are currently in decline could suffer population-level effects from catastrophic oil spills.

4.4.7 Potential Impacts on Marine and Coastal Fauna

4.4.7.1 Mammals

This section addresses the potential impacts to both marine mammals and terrestrial mammals in context of each program area. It should be noted that both NMFS and FWS have statutory and regulatory mandates under the ESA and MMPA for mammals. Under the MMPA (16 USC 1371; 50 CFR Subpart 1), the taking of marine mammals without a permit or exemption is prohibited. The term "take" under the MMPA means "to harass, hunt, capture, kill or collect, or attempt to harass, hunt, capture, kill or collect." The MMPA has defined takes by "harassment" in two ways: (1) level A harassment is "any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild," and (2) level B harassment is "any act of pursuit, torment, or annoyance, which has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering but which does not have the potential to injure a marine mammal or marine mammal stock in the wild." In 30 CFR 250 Subpart B, BOEM requires operators of Federal oil and gas leases to meet the requirements of ESA and MMPA. The regulations outline the environmental, monitoring, and mitigation information that operators must submit with proposed plans for exploration, development, and production.

4.4.7.1.1 Gulf of Mexico.

Marine Mammals. There are 29 species of marine mammals, including six endangered whale species and the endangered West Indian manatee, that may occur in the northern GOM (Section 3.4.4.2.1), and which therefore could be affected by normal operations associated with the proposed action.

Routine Operations. As part of the proposed action, 1,000 to 2,100 exploration and delineation wells and 1,300 to 2,600 development and production wells are projected to be drilled, while 200 to 450 new platforms and up to 2 FPSOs are projected to be used. Additional activities planned as part of the proposed action include 3,862 to 12,070 km (2,400 to 7,500 mi) of new pipeline (Table 4.4.1-1). Although a specific scenario for geophysical operations has not been prepared, exploratory and on-lease seismic surveys are expected to result from the Program. Table 4.4.7-1 illustrates how each of the impacting factors associated with OCS oil and gas development may affect marine mammals and their habitats, while Figure 4.4.7-1 presents a conceptual model of potential impacting factors for marine mammals from oil- and gas-related activities (including accidental oil spills).

TABLE 4.4.7-1 Impact Factor Data Matrix for Marine Mammals[a]

Resource Receptor Category Potentially Affected	O&G Impacting Factor								
		Noise							
	Collisions with Support Vessels	Seismic Exploration	Construction, Operation, and Decommissioning	Presence of Support Vessels	Onshore Construction and Operation	Offshore Infrastructure Construction, Operation, Decommissioning	Produced Water, Drill Cuttings and Mud	Solid Wastes and Debris	Accidental Oil Spills
Individuals (adults and juveniles)	Injury from ship strikes	Injury; disruption of normal behavior	Disruption of normal behavior	Disruption of normal behavior	Physical disturbance or reduced habitat quality associated with noise and/or human presence	Physical disturbance or reduced habitat quality associated with noise and/or human presence	Toxicity	Ingestion and/or entanglement	Fouling, toxicity
Onshore Habitats (e.g., haul-out sites and rookeries)	–	–	–	–	Physical disturbance or loss; reduced habitat quality	–	–	–	Physical habitat loss; reduced quality
Offshore Habitats (e.g., calving grounds, foraging areas, or wintering grounds)	–	–	–	–	–	Temporary habitat disturbance during construction; possible long-term increase in habitat	Reduced habitat quality	–	Physical habitat loss; reduced quality
Migration	Displacement or impediment	Displacement or impediment	Displacement or impediment	Displacement or impediment	Displacement or impediment for terrestrial movements (e.g., polar bears)	Displacement or impediment	–	–	Displacement or impediment

[a] A dash indicates that no impact is anticipated.

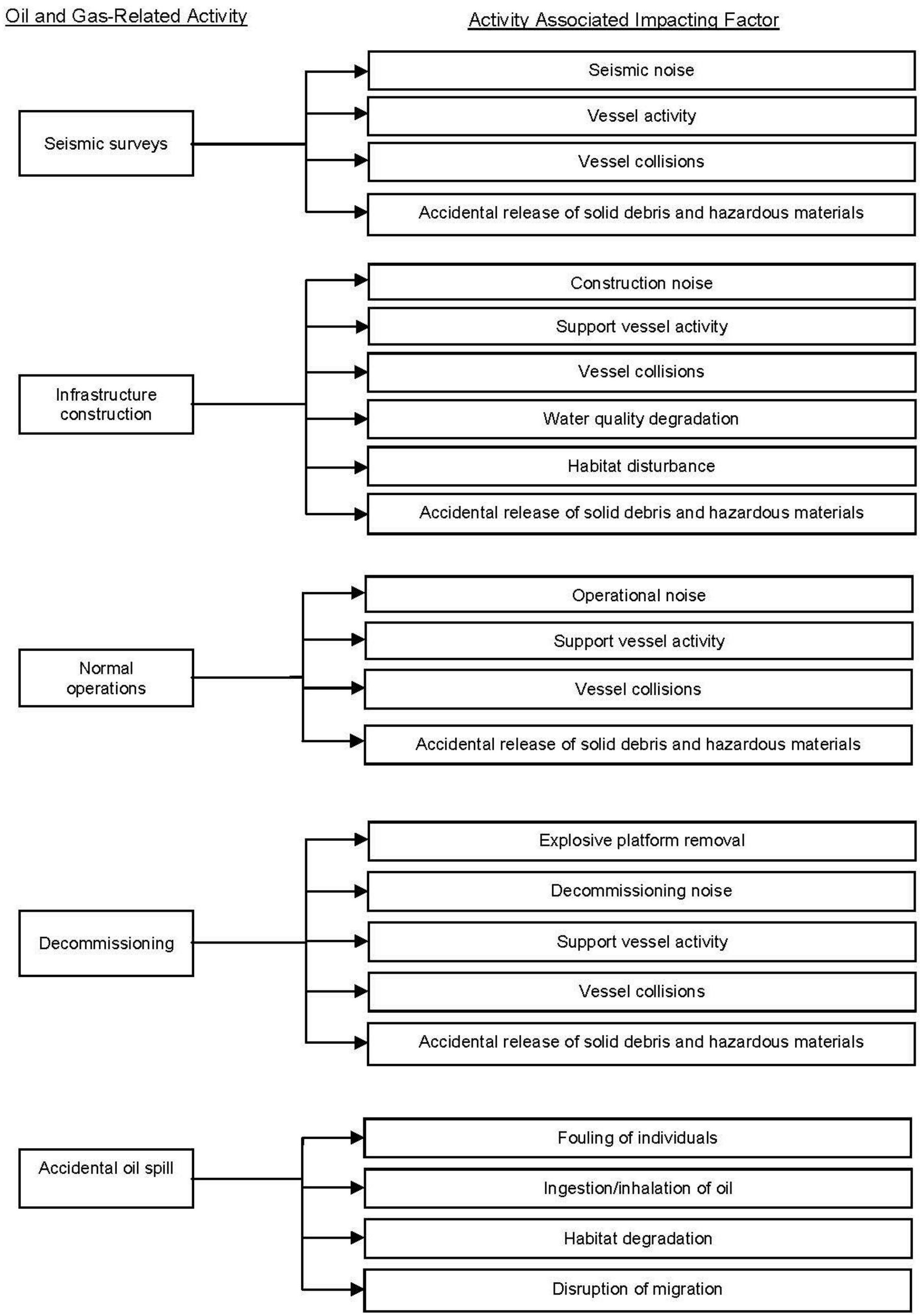

FIGURE 4.4.7-1 Conceptual Model for Anticipated Impacting Factors for Marine Mammals

Because of differences in the distribution and ecology of marine mammal species, routine operations under the proposed action would not equally affect marine mammal species. All of the mysticetes (baleen whales), except for the Bryde's whale, are considered extralimital or rare in the northern GOM (Würsig et al. 2000). Because of their rarity, it is unlikely that individuals of these species would be present where OCS-related activities would occur, and thus they would not be affected by routine operations of the proposed action. Although the Bryde's whale is the most frequently sighted mysticete whale, it is uncommon. While the Bryde's whale is present throughout the year, it occurs primarily in the Eastern Planning Area (Davis et al. 2000; Würsig et al. 2000; MMS 2004a). Waring et al. (2010) estimate a population size of 15 individuals. Thus, it would not be expected to be affected to any great extent by routine operations under the proposed action.

In contrast to the mysticetes, many of the odontocetes (toothed whales) are considered relatively common in the GOM OCS (Davis et al. 2000; MMS 2004a). Thus, there is a greater potential that some individuals of these species to occur in areas where OCS-related activities occur and to be affected during routine operations. The only odontocete listed as endangered is the sperm whale, which is the most common large whale in the GOM. Sperm whales occur year-round in all deepwater areas of the U.S. GOM, with a well-documented aggregation consistently found in the shelf-edge waters around the 305-m (1,000-ft) depth contour south of the Mississippi River Delta (Davis et al. 2000; MMS 2004a). Thus, this species may encounter OCS-related activities occurring within the northern GOM, especially in deepwater areas of the Central Planning Area.

Although manatees appear to prefer nearshore habitats, there are rare observations around structures at offshore sites. Negligible impacts on the West Indian manatee are anticipated because the 2012-2017 proposed action does not include routine operations in most of the Eastern Planning Area. The potential for impacts on manatees would occur in nearshore habitats where interactions with OCS-related activities (i.e., vessel traffic) exist. Service vessel impacts would mainly occur in the Central and Western Planning Areas where manatees occasionally occur.

The following analysis presents an overview of impacts on marine mammals from the following routine operations: (1) seismic surveys, (2) construction of offshore facilities and pipelines, (3) operations of offshore facilities and drilling rigs, (4) discharges and waste generation, (5) service vessel and helicopter traffic, and (6) decommissioning.

<u>Seismic Surveys.</u> Sections 4.4.1.1 and 4.4.5.1.1 provide descriptions of seismic survey technologies, energy outputs, operations, and general acoustic impacts. The type of O&G activities presently occurring in the GOM include:

- Seismic surveys (includes high-resolution site surveys and various types of seismic exploration and development surveys, including narrow azimuth, multi azimuth and wide azimuth);

- Side-scan sonar surveys;

- Electromagnetic surveys;

- Geological and geochemical sampling; and

- Remote sensing (including gravity, gravity gradiometry, and magnetic surveys).

Marine mammals produce and use sound to communicate as well as to orient, locate and capture prey, and to detect and avoid predators (Hofman 2004; Southall et al. 2007). A panel of experts in acoustic research from behavioral, physiological, and physical disciplines generated a report, *Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations* (Southall et al. 2007), which summarized existing acoustic and marine mammal data and made recommendations for regulatory criteria and research. Noise generated by seismic surveys may have physical and/or behavioral effects on marine mammals, such as (1) permanent or temporary hearing loss, discomfort, and injury; (2) masking of important sound signals; and (3) behavioral responses such as fright, avoidance, and changes in physical or vocal behavior (Richardson et al. 1995; Davis et al. 1998b; Gordon et al. 1998; Nowacek et al. 2004, 2007). Seismic surveys may also indirectly impact marine mammals by altering prey availability (Gordon et al. 2003, 2004).

Southall et al. (2007) synthesized the understanding of underwater and aerial hearing in some marine mammal groups and recommended some acoustic criteria. A precautionary approach was used to derive frequency-specific marine mammal weighting functions; the marine mammal hearing groups are broken down into five categories: (1) low-frequency cetaceans, which are the mysticetes, have an estimated lower and upper frequency range of 7 to 22 kHz; (2) mid-frequency species are estimated to have lower and upper frequency limits of hearing at approximately 150 Hz and 160 kHz, respectively; (3) high-frequency cetaceans have an estimated functional hearing between approximately 200 and 180 kHz; (4) pinnipeds in air have an estimated functional hearing between 75 and 30 kHz; and (5) pinnipeds in water have an estimated functional hearing between 75 and 75 kHz.

Almost all impacts of seismic surveys have been inferred or assumed by implication rather than observed. There have been no documented instances of deaths, physical injuries, or auditory (physiological) effects on marine mammals from seismic surveys. Behavioral responses have been observed but the biological importance of such behavioral responses (to the individual animals and populations involved) has not been determined.

The types of potential effects can be broken down into non-auditory injury, auditory effects, behavioral effects, and masking. Nowacek et al. (2007), Richardson et al. (1995), and Southall et al. (2007) have reviewed the effects of anthropogenic sound on marine mammals and are incorporated by reference.

Permanent loss of hearing in a marine mammal (i.e., permanent threshold shift [PTS]) is defined as the deterioration of hearing due to prolonged or repeated exposure to sounds that accelerate the normal process of gradual hearing loss (Kryter 1985), or the permanent hearing damage due to brief exposure to extremely high sound levels (Richardson et al. 1995). PTS results in a permanent elevation in hearing threshold — an unrecoverable reduction in hearing sensitivity (Southall et al. 2007) and this is considered level A harassment under the MMPA. Noise may cause a temporary threshold shift (TTS), a temporary and reversible loss of hearing that may last for minutes to hours. Animals suffering from TTS over longer time periods, such as hours or days, may be considered to have a change in a biologically significant behavior, because they could be prevented from detecting sounds that are biologically relevant, including communication sounds, sounds of prey, or sounds of predators. TTS is considered level B harassment under the MMPA. To date, for level B harassment, NMFS uses the 160-decibel (dB) root-mean squared (rms) isopleth to indicate where level B harassment begins for acoustic impulse sounds, such as seismic surveying. Also, NMFS' policy has been to use the 180-dB rms isopleth where on-set level A harassment from acoustic sources potentially begins for cetaceans (whales, dolphins and porpoises) and 190-dB rms isopleth for pinnipeds (seals, sea lions).

For the purpose of analysis, it is assumed that operators will implement survey and monitoring mitigation (e.g., ramp-up, marine mammal observers, speed restrictions, exclusion zones) currently required in the GOM to minimize or avoid impacts of seismic on marine mammals with an emphasis on prevention of injury (auditory and non-auditory). Assuming the implementation of these mitigations, the potential for injury is minimized. There remains a greater potential for behavioral effects; therefore, the following discussion focuses on the potential behavioral changes resulting from exposure to seismic operations. More detailed discussions of impacts to marine mammals from seismic surveys in the GOM can be found in MMS (2004).

Non-Auditory Injury. Non-auditory injury could include direct acoustic impact on tissue, indirect acoustic impact on tissue surrounding a structure, acoustically mediated bubble growth within tissues from supersaturated dissolved nitrogen gas, or resonance. However, resonances are not anticipated given that the resonance frequencies of marine mammal lungs are generally below that of the G&G seismic survey source signal (Nowacek et al. 2007; Zimmer and Tyack 2007).

Auditory Effects (PTS and TTS). The hearing of marine mammals varies based on individuals, thresholds of the species, location in relation to the sound source, frequency discrimination, and the motivation of an individual to change behaviors due to the sound (Richardson et al. 1995). PTS results in a permanent elevation in hearing threshold — an unrecoverable reduction in hearing sensitivity (Southall et al. 2007). TTS is defined as a temporary and reversible loss of hearing that may last for minutes to hours. The duration of TTS depends on a variety of factors including intensity and duration of the stimulus. Therefore, animals suffering from TTS over longer time periods, may be considered to have a change in a biologically significant behavior, as they could be prevented from detecting sounds that are biologically relevant, including communication sounds, sounds of prey, or sounds of predators.

Behavioral Effects. A number of studies have documented behavioral effects in response to seismic surveys, primarily for marine mammals (Richardson et al. 1995, Southall et al. 2007). The Bryde's whale is the only mysticete species occurring regularly in the GOM. As discussed in Southall et al. (2007), the expected frequencies of best hearing sensitivity in mysticetes and maximal air gun output at source may overlap. Given that no direct audiograms of mysticetes have been obtained, it is impossible to define what level of sound above hearing threshold may cause behavioral effects, which would be expected to be variable, complicated, and dependent upon more than just the received sound level. For this reason, observations at sea have concentrated on relating received sound levels to observed behavioral changes (Malme et al. 1983, 1984, 1985, 1986, 1988; Reeves et al. 1984; Richardson et al. 1986; Ljungblad et al. 1988; McDonald et al. 1993; Richardson and Malme 1993; Richardson 1998; McCauley et al. 2000a, b).

Auditory thresholds of adult sperm whales have not been obtained. Ridgeway and Carder (2001) studied the vocalizations of a neonate sperm whale which led them to believe that they are sensitive to a wide range of frequencies. This was also hypothesized by Bowles et al. (1994). Sperm whales are a highly vocal species under natural conditions (i.e., they click almost continuously during dives). Jochens et al. 2008 synthesized the findings of the Sperm Whale Seismic Study (SWSS) in the GOM. They stated that it does not appear that sperm whales in the SWSS study area showed any horizontal avoidance to controlled exposure of seismic air gun sounds. The data analysis suggested that, for at least some individuals, it is more likely that some decrease in foraging effort may occur during exposure to full-array air gun firing as compared to the post-exposure condition. Sperm whales are most likely acoustically aware of their environment and can exhibit behavioral reactions in a number of ways, including interruption of vocal activity and foraging. However, there are insufficient data to assign thresholds for acoustic disturbance to sperm whales. Sperm whales are also deep divers, spending relatively little time at the surface while feeding. Therefore, they may be less likely to receive any surface shielding afforded by refractive effects caused by near surface hydrographic conditions, which can sometimes occur. As air gun arrays are generally configured to produce a maximum, low frequency energy lobe directly downwards toward the seabed, sperm whales may enter a region of increased ensonification.

Dwarf and pygmy sperm whales are also deep-diving and use echolocation clicks in the sonic and low ultrasonic frequency range (Willis and Baird 1998). Few audiograms have been obtained for pygmy sperm whales, dwarf sperm whales, or beaked whales (Cook et al. 2006; Finneran et al. 2009; Ridgway and Carder 2001), so there still are insufficient data to determine avoidance thresholds. Like sperm whales, they may be sensitive to a wide range of sound frequencies, including those produced by air gun arrays. Similarly, beaked whales are also deep divers, use echolocation clicks to find their prey, and have been shown to be susceptible to acoustic disturbance (Frantzis 1998; Balcomb and Claridge 2001). Since they have similar deep-diving habits and relatively widespread distributions in the GOM, this may warrant concern for dwarf and pygmy sperm whales and beaked whales.

Delphinids include dolphins, killer whales, and pilot whales. Several studies have been conducted documenting the effects of seismic operations on delphinid species. Finneran et al. (2000a) discuss a behavioral response study measuring masked underwater hearing thresholds in bottlenose dolphin and beluga whale, before and after exposure to seismic pulses from a watergun. Ridgway et al. (1997) showed that captive delphinids produced behavioral reactions at levels at least 10 dB below those that induced TTS. Soto et al. (2006) and Van Parijs and Corkeron (2001) showed vessel presence is sufficient to change behavior in some species and situations.

Dolphin species are generally mid- to high-frequency hearing specialists (Southall et al. 2007). While air guns are primarily low frequency (<200 Hz), they are considered broadband and therefore there is energy at higher frequencies. These energies encompass the entire audio frequency range of 20 Hz to 20 kHz (Goold and Fish 1998), and extend well into the ultrasonic range up to 50 kHz (Sodal 1999). This high-frequency energy must be taken into account when considering seismic interactions with Delphinids. The high-frequency components of air gun emissions are of sufficient level to exceed the dolphin auditory threshold curve at these low frequencies, even after spreading loss (Goold and Fish 1998).

Some studies, such as Wakefield (2001), have shown that vocal behaviors of common dolphins may be altered by air guns. Stone (1996, 1997a, b, 1998) reported that common dolphins, white beaked dolphins, and white sided dolphins were sighted in the vicinity of seismic surveys less often when the guns were firing than when they were not firing. However, some marine mammals are known to continue calling in the presence of seismic pulses. Their calls can be heard between the seismic pulses (e.g., Richardson et al. 1986; McDonald et al. 1995; Greene et al. 1999; Nieukirk et al. 2004; Smultea et al. 2004). Although Delphinids specialize in hearing ranges generally outside of the majority of seismic survey impulse sounds, there is still the potential for sounds from these surveys to fall within the acoustic sensitivity of toothed whales and for behavioral responses to seismic noise to occur.

Masking. Auditory masking occurs when a sound signal that is of importance to a marine mammal (e.g., communication calls, echolocation, environmental sound cues) is rendered undetectable due to the high noise-to-signal ratio in a frequency band relevant to a marine mammal's hearing range. In other words, noise can cause the masking of sounds that marine mammals need to hear to in order to function effectively (Erbe et al. 1999). If sounds used by the marine mammals are masked to the point where they cannot provide the individual with needed information, critical natural behaviors could be disrupted and harm could result (Erbe and Farmer 1998).

In the case of seismic surveys, where potential masking noise takes a pulsed form with a low duty cycle (~10%, or 1 s of active sound for every 10 s of ambient noise) (MMS 2004), the effect of masking is likely to be low relative to continuous sounds such as ship noise. Some marine mammals are known to continue calling in the presence of seismic pulses. Their calls can be heard between the seismic pulses (e.g., Richardson et al. 1986; McDonald et al. 1995; Greene et al. 1999; Nieukirk et al. 2004; Smultea et al. 2004). Bowles et al. (1994) reported that sperm whales ceased calling when exposed to pulses from a very distant seismic ship, while other studies reported that sperm whales continued calling in the presence of seismic pulses (Madsen et al. 2002; Tyack et al. 2003; Smultea et al. 2004; Holst et al. 2006; Jochens et al. 2006).

Some marine mammals are known to increase the source levels of their calls in the presence of elevated sound levels, or to shift their peak frequencies in response to strong sound signals (Dahlheim 1987; Au 1993; review in Richardson et al. 1995;Lesage et al. 1999; Terhune 1999; Nieukirk et al. 2005; Parks et al. 2007). However, these studies tested other anthropogenic sounds, not seismic pulses, and it is not known if air guns would elicit this same response. If so, these adaptations would all reduce the importance of masking.

Construction of Offshore Facilities and Pipelines. Figure 4.4.7-2 presents a conceptual model for potential effects of infrastructure construction on marine mammals. Construction and trenching activities may affect habitat use for the short or long-term. Marine mammals are mobile and able to avoid areas where construction or trenching is occurring so they are less likely to be injured or killed but their behavior may be altered. Noise and human activity associated with the construction of offshore facilities and pipelines (e.g., pile driving, vessel presence) could disturb marine mammals that may be present in the vicinity of the construction activity. Construction activities could disturb normal behaviors (e.g., feeding, social interactions), mask calls from conspecifics, disrupt echolocation capabilities, temporarily affect localized air/water quality and mask sounds generated by predators. Depending on the size of the project, at any single location, offshore construction and trenching activities would be of relatively short duration since the majority of construction activities would occur on land. The length of time necessary for offshore construction depends on what is being constructed, the water depth, procurement activities, the climatic conditions to install the platform could be considered. It also depends on if the construction project is a fixed platform, semi-submersible platform, or jack-up drilling platform and each one could take approximately 1 to 2 months to set up, depending on the contractor. In addition, running a pipeline likely would not take more than 2–3 weeks.

Animals may leave the vicinity of a constructions area. Some known locations for the endangered sperm whale includes, but is not limited to, the continental slope waters off the Mississippi River Delta in the Central Planning Area (Jochens 2007; Davis et al. 2000; MMS 2004a). Portions of the GOM that would be disturbed by the construction of new wells and pipelines would be largely limited to the immediate footprint of the new structure and its surroundings. Animals would be expected to locate to other suitable habitat nearby. Some permanent displacement may occur, but would be largely limited to the local environment surrounding individual wells or areas with well aggregations, and thus would not be expected to affect overall habitat availability or cetacean access.

Currently in the northern GOM, the West Indian manatee is the only marine mammal that has a federally designated critical habitat, and this habitat is limited to specific coastal and inland marine and freshwater areas in peninsular Florida (west, southeast, and northeast Florida). As pipeline landfalls and land-based facilities associated with the proposed action would not be located in Florida, no impacts to West Indian manatee critical habitat would occur.

Under the proposed action, only a few individuals or small groups of marine mammals would be temporarily disturbed behaviorally by routine construction of offshore facilities, and disturbance of these individuals, given their localized nature, would not be expected to result in population-level effects. Any impacts on marine mammals incurred from structure placement or trenching would be short term and localized to the construction area and immediate surroundings, and therefore unlikely to cause more than minor impacts to marine mammals. Onshore construction and operation activities are unlikely to impact cetacean and sirenian populations. Overall, the impacts associated with construction of offshore facilities and pipelines are unlikely to have significant adverse effects on the size and recovery of any marine mammals species or population in the GOM. It is assumed that BOEM will continue to implement GOM

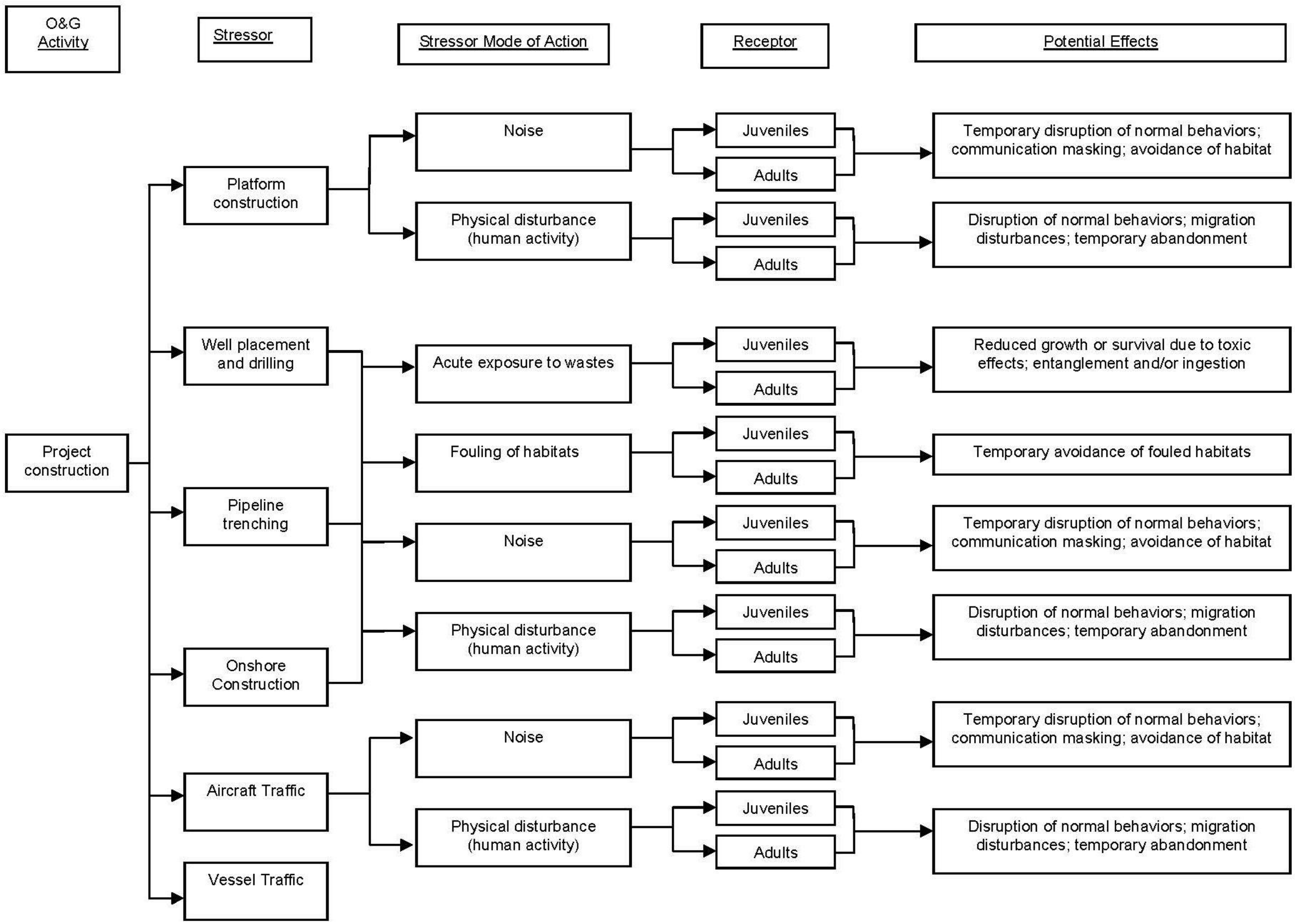

FIGURE 4.4.7-2 Conceptual Model for Potential Effects of Infrastructure Construction on Marine Mammals

guidelines currently in place to reduce impacts to marine mammals such as vessel strike avoidance measures and marine debris awareness.

<u>Operations of Offshore Facilities and Drilling Rigs.</u> Noise from drilling could be intermittent, sudden, and at times could be high intensity as operations take place. Sound from a fixed, ongoing source like an operating drillship is continuous. However, the distinction between transient and continuous sounds is not absolute on a drillship, as generators and pumps operate essentially continuously; however, there are occasional transient bangs and clangs from various impacts during operations (Richardson et al. 1995). Estimated frequencies from drilling by semisubmersible vessels are broadband from 80 to 4,000 Hz, with an estimated source level of 154 dB re 1 μPa at 1 m. Tones of 60 Hz had source levels of 149 dB, 181 Hz was 137 dB, and 301 Hz was 136 dB (Greene 1986). The potential effects that water-transmitted noise have on marine mammals include disturbance (subtle changes in behavior, interruption of previous activities, or short- or long-term displacement), masking of sounds (calls from conspecifics, reverberations from own calls, and other natural sounds such as surf or predators), physiological stress, and hearing impairment. Individual marine mammals exposed to recurring disturbance could be negatively affected. Malme et al. (1986) observed the behavior of feeding gray whales in the Bering Sea during four experimental playbacks of drilling sounds (50–315 Hz; 21-minute overall duration and 10% duty cycle; source levels of 156–162 dB re: 1 μPa-m). In two cases for received levels 100–110 dB re: 1 μPa, there was no observed behavioral reaction. Avoidance behavior was observed in two cases where received levels were 110–120 dB re: 1 μPa. These source levels are all below NMFS's current 160-dB level B harassment threshold under the MMPA.

The source levels from drilling are relatively low (154 dB and below, as cited by Greene [1986] in Richardson et al. [1995]), below the level B (behavioral) harassment threshold of 160 dB (set by NMFS). According to Southall et al. (2007), for behavioral responses to nonpulses (such as drill noise), data indicate considerable variability in received levels associated with behavioral responses. Contextual variables (such as novelty of the sound to the marine mammal and operation features of the sound source) appear to have been at least as important as exposure level in predicting response type and magnitude. While there is some data from the Arctic on baleen whales, there is little data on the behavioral responses of marine mammals in the GOM from the sound of drilling. Southall et al. (2007) summarized the existing research, stating that the probability of avoidance and other behavioral effects increases when received levels increase from 120 to 160 dB. Marine mammals may exhibit some avoidance behaviors, but their behavioral or physiological responses to noise associated with the proposed action, however, are unlikely to have population-level impacts to marine mammals in the northern GOM.

<u>Discharges and Waste Generation.</u> Table 4.4.1-1 presents information on drilling fluids, drill cuttings, and produced waters discharged offshore as a result of the proposed action. Produced water, drilling muds, and drill cuttings are discharged into offshore marine waters in compliance with applicable regulations and permits. Compliance with regulations and permits will limit the exposure of marine mammals to waste discharges. The discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by the BOEM

(30 CFR 250.40) and the USCG (International Convention for the Prevention of Pollution from Ships [MARPOL], Annex V, P.L. 100-220 [101 Statute 1458]).

Most operational discharges are diluted and dispersed when released in offshore areas and are considered to have sublethal effects (NRC 1983; API 1989; Kennicutt 1995; Kennicutt et al. 1996). Any potential impacts from drilling fluids would be indirect, either as a result of impacts to prey species or possibly through ingestion via the food chain (Neff et al. 1989). However, marine mammals are generally not considered good bioaccumulators of petroleum compounds from eating contaminated prey due to rapid metabolism and excretion rates (Neff 1990). As such, impacts from discharges related to the proposed action would not be expected to result in long term impacts to marine mammals because these compounds would not assimilated.

Many types of plastic materials end up as solid waste during drilling and production operations. Some of this material is accidentally lost overboard where cetaceans could consume it or become entangled in it. The incidental ingestion of marine debris and entanglement could adversely affect marine mammals. Industry has made good progress in debris management on vessels and offshore structures in the last several years. It is assumed that BOEM will continue to require implementation of current trash and debris elimination guidelines that appreciably reduce the likelihood of marine mammals encountering marine debris from the proposed action. Thus, impacts to marine mammals from entanglement in or ingestion of OCS-related trash and debris under the proposed action would be negligible to minor.

<u>Service Vessel and Helicopter Traffic.</u> There may be 300 to 600 vessel and 2,000 to 5,500 helicopter trips per week under the proposed action (Table 4.4.1-1). Figure 4.4.7-3 presents a conceptual model for the potential effect of vessel traffic on marine mammals. Vessel traffic could occur during seismic exploration, drilling and platform construction, platform operation, and platform decommissioning.

Ship strikes are a concern for marine mammals. There have been documented reports of cetaceans being struck by ships in the oceans throughout the world (Laist et al. 2001; Jensen and Silber 2004; Glass et al. 2008), although none to date in the GOM as a result of offshore oil/gas operations. Analyses by Vanderlaan and Taggart (2007) provides evidence that as vessel speeds fall below 15 knots (27.75 km/hr or 17.25 mph), there is a substantial decrease in the probability of a vessel strike to prove lethal to a large whale. Collisions with vessels greater than 80 m (260 ft) in length are usually either lethal or result in severe injuries (Laist et al. 2001). In addition, a majority of ship strikes seemed to occur over or near the continental shelf. Collisions with vessels can cause major wounds on marine mammals and/or be fatal. Debilitating injuries may have negative effects on a population through impairment of reproductive output (MMS 2003e). Cetaceans are more likely to be struck by vessels if they are young or sick, slow swimmers, distracted by feeding or mating activities, habituated to vessels, or congregated in an area for feeding or breeding (Dolman et al. 2006). Vessel strikes in inland waterways are a major cause of death in the manatee population. Because this species is rare in these planning areas, encounters with OCS-related vessels in these areas would be unlikely.

Deep-diving whales, such as the sperm whale, may be more vulnerable to vessel strikes given the longer surface period required to recover from extended deep dives. NMFS has determined that vessel strikes are a "discountable" concern for sperm whales when vessel avoidance measures are implemented (USDOC, NMFS 2007b); it is assumed for the purpose of this analysis that BOEM will continue to requirement operator implementation of such avoidance criteria and speed limitations.

It is possible that noise produced from vessels and, to a lesser extent helicopters, can cause disturbance, masking of sounds, and physiological stress. The dominant source of noise from vessels is from the propeller operation, and the intensity of this noise is largely related to ship size and speed. Vessel noise from activities resulting from the proposed action will produce low levels of noise, generally in the 150- to 170-dB re 1 µPa-m at frequencies below 1,000 Hz. Vessel noise is transitory and generally does not propagate at great distances from the vessel.

The noise and the shadow from helicopter overflights, take-offs, and landings can cause a startle response and can interrupt whales and dolphins while resting, feeding, breeding, or migrating (Richardson et al. 1995). The Federal Aviation Administration's Advisory Circular 91-36D (September 17, 2004) encourages pilots to maintain higher than minimum altitudes over noise-sensitive areas. Guidelines and regulations put in place by NOAA Fisheries under the authority of the Marine Mammal Protection Act include provisions specifying that helicopter pilots maintain an altitude of 305 m (1,000 ft) within 91 m (300 ft) of marine mammals. Helicopter occurrences would be temporary and pass within seconds. Marine mammals are not expected to be adversely affected by routine helicopter traffic operating at prescribed altitudes.

<u>Decommissioning</u>**.** Under the proposed action, 150 to 275 platforms may be removed with explosives from the northern GOM. Figure 4.4.7-4 presents a conceptual model for potential impacts of decommissioning on marine mammals.

BOEM published a programmatic EA on decommissioning operations (MMS 2005) that, in part, addresses the potential impacts of explosive- and nonexplosive-severance activities on OCS resources, particularly upon marine mammals and sea turtles. Pursuant to 30 CFR 250 Subpart Q, operators must obtain a permit from BOEM before beginning any platform removal or well-severance activities. The NMFS has issued regulations (50 CFR Part 216) under the MMPA for "Taking Marine Mammals Incidental to the Explosive Removal of Offshore Structures in the Gulf of Mexico," and operators are required to obtain a Letter of Authorization from NMFS in accordance with these regulatory conditions. This analysis assumes the continued implementation of current BOEM guidelines on decommissioning which specify limits on the type and size of explosives that can be used and the times when detonations can occur; require explosives to be placed at a minimum depth of 15 m (49 ft) below the sediment surface; and require a monitoring plan that uses qualified observers to monitor the detonation area for protected species, including all marine mammals, prior to and after each detonation. The detection of a marine mammal (or other applicable biota) within the blast zone would, without exception, would delay explosive detonation. Thus, explosive platform removals conducted under the proposed action and complying with BOEM guidelines would not be expected to adversely affect marine mammals in the GOM.

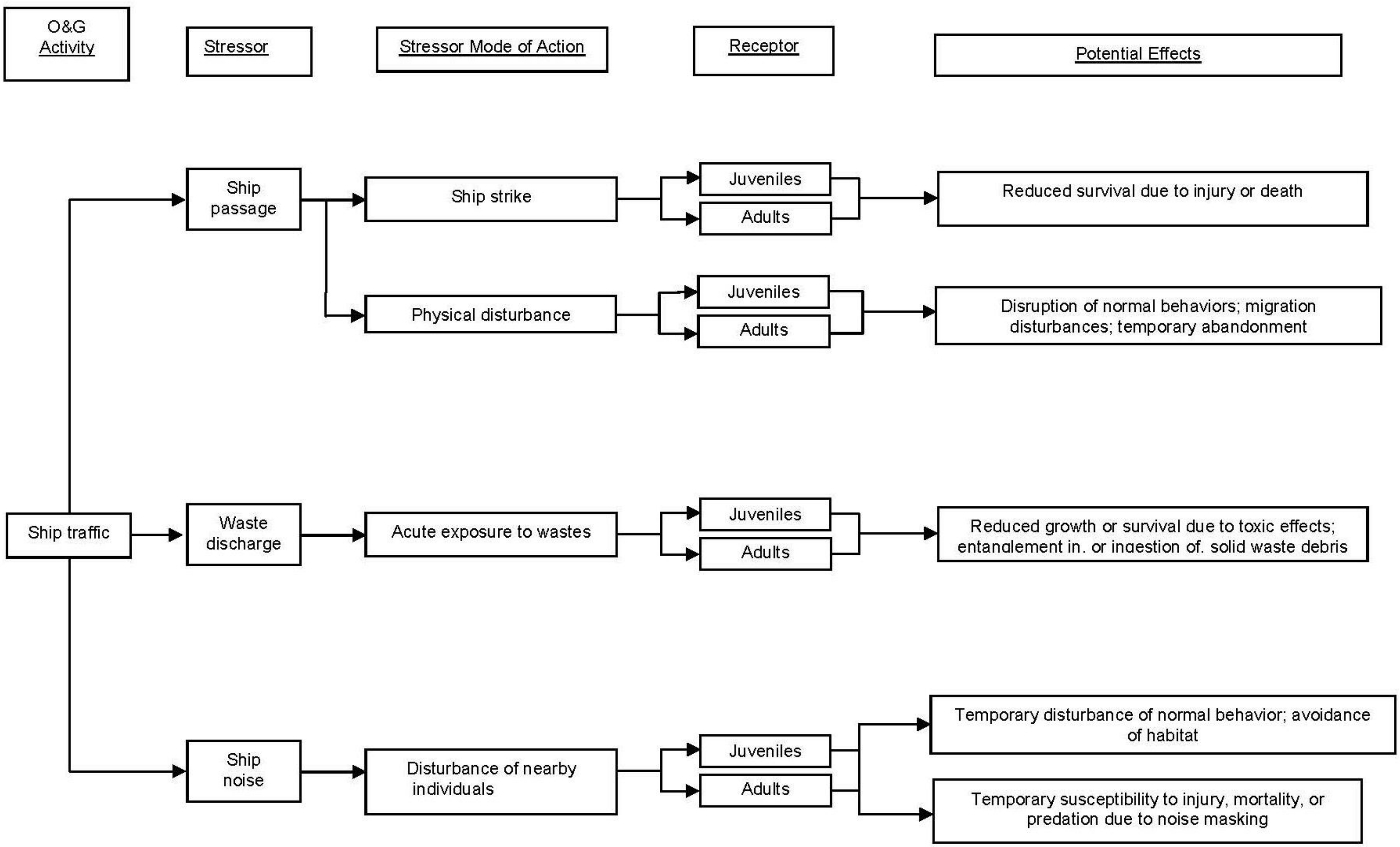

FIGURE 4.4.7-3 Conceptual Model for Potential Effects of Vessel Traffic on Marine Mammals

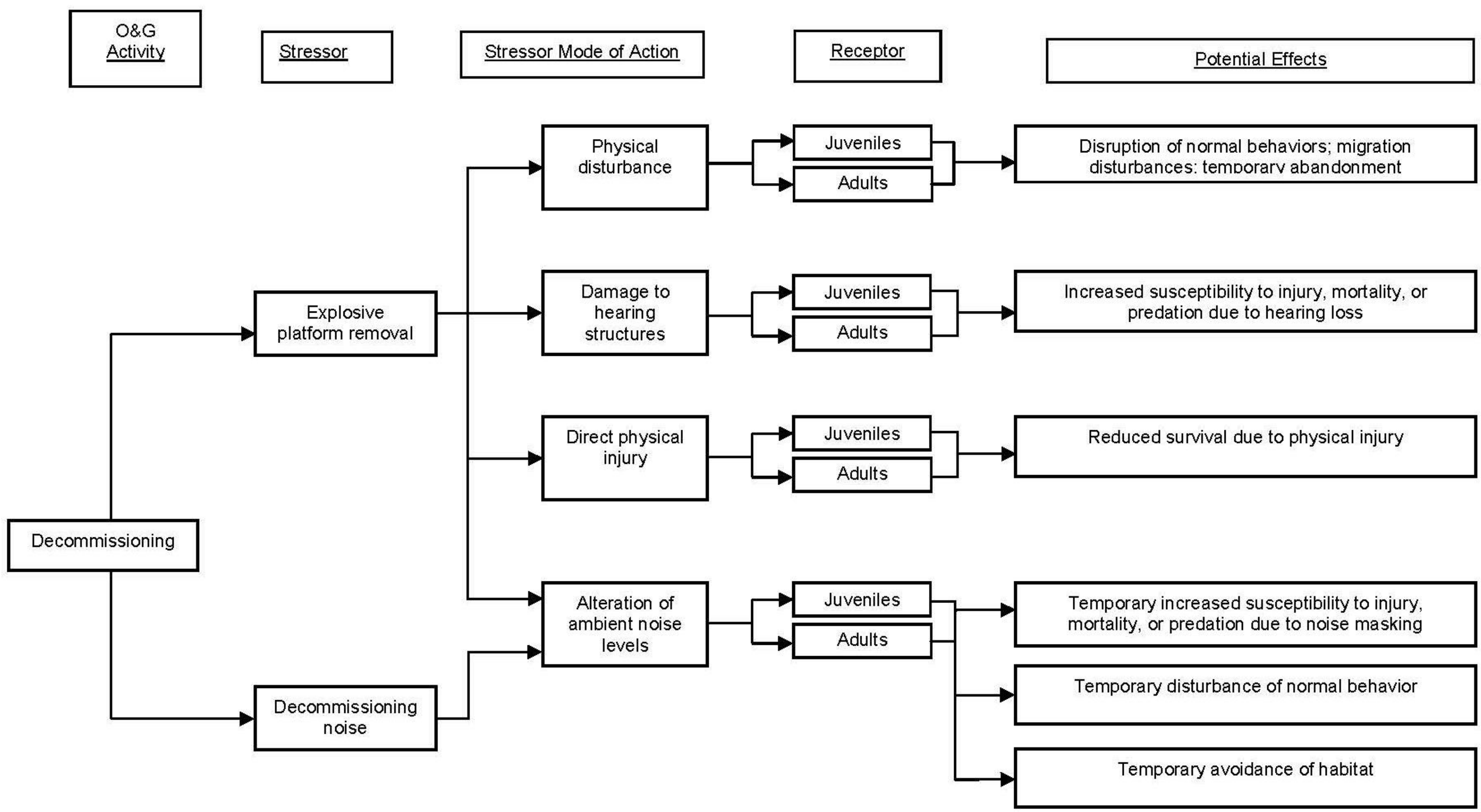

FIGURE 4.4.7-4 Conceptual Model for Potential Effects of Decommissioning on Marine Mammals

Accidents. Potential effects on marine mammal species may occur from accidental activities associated with the proposed action and may be direct or indirect. Accidental oil spills could occur in the GOM under the proposed action (Section 4.4.2.1). Tables 4.4.2-1 and 4.4.2-2 presents the oil spill assumptions for the purpose of analyzing the proposed action, while Figure 4.4.7-5 presents a conceptual model for potential effects of oil spills on marine mammals.

The major potential impact-producing factors include accidental blowouts, platform and pipeline oil spills, and spill-response activities. Impacts (i.e., acute vs. chronic impacts) depend on the magnitude, frequency, location, and date of accidents; characteristics of spilled oil; spill-response capabilities and timing; and various meteorological and hydrological factors. Impacts could include decreased health, reproductive fitness, and longevity; and increased vulnerability to disease). Spilled oil can cause soft tissue irritation, fouling of baleen plates, respiratory stress from inhalation of toxic fumes, food reduction or contamination, direct ingestion of oil and/or tar, and temporary displacement from preferred habitats (St. Aubin and Lounsbury 1990; Geraci and St. Aubin 1990). The long-term impacts to marine mammal populations are poorly understood but could include decreased survival and lowered reproductive success. Impacts from dispersants are unknown but may be irritants to tissues and sensitive membranes (NRC 2005). Chronic or acute exposure may result in harassment, harm, or mortality to marine mammals. In some cases, marine mammals made no apparent attempt to avoid spilled oil in some cases (Smultea and Würsig 1995); however, marine mammals have been observed apparently detecting and avoiding slicks in other reports (Geraci and St. Aubin 1990).

Impacts on marine mammals from smaller accidental events may adversely affect individual marine mammals in the spill area, but are unlikely to rise to the level of population effects (or significance) given the size and scope of such spills. Assuming that all small spills would not occur at the same time and place, water quality would rapidly recover and therefore would not have significant effects on marine mammals or their prey species. The potential effects associated with a large spill may be more adverse than a smaller accidental spill and could potentially contribute to longer-lasting effects. The long-term impacts to marine mammal populations could include decreased survival and lowered reproductive success. For example, the oil from an oil spill can adversely affect cetaceans by causing soft tissue irritation, fouling of baleen plates, respiratory stress from inhalation of toxic fumes, food reduction or contamination, direct ingestion of oil and/or tar, and temporary displacement from preferred habitats. However, the range of toxicity and degree of sensitivity to oil hydrocarbons and the effects of cleanup activities on cetaceans are not fully understood. Similarly, impacts to marine mammals from dispersants are not fully understood, but may be irritants to tissues and sensitive membranes (NRC 2005). One assumption concerning the use of dispersants is that the chemical dispersion of oil will considerably reduce the impacts to marine mammals, primarily by reducing their exposure to petroleum hydrocarbons (French-McCay 2004; NRC 2005). However, the impacts to marine mammals from chemical dispersants could include nonlethal injury (e.g., tissue irritation, inhalation), long-term exposure through bioaccumulation, and potential shifts in distribution from some habitats.

Catastrophic Discharge Event. The PEIS analyzes a CDE up to 7.2 million bbl (Table 4.4.2-2). If a CDE occurs, there is greater potential for more severe effects compared to the risk of effects from a large oil spill. A CDE would result in sustained degradation of water

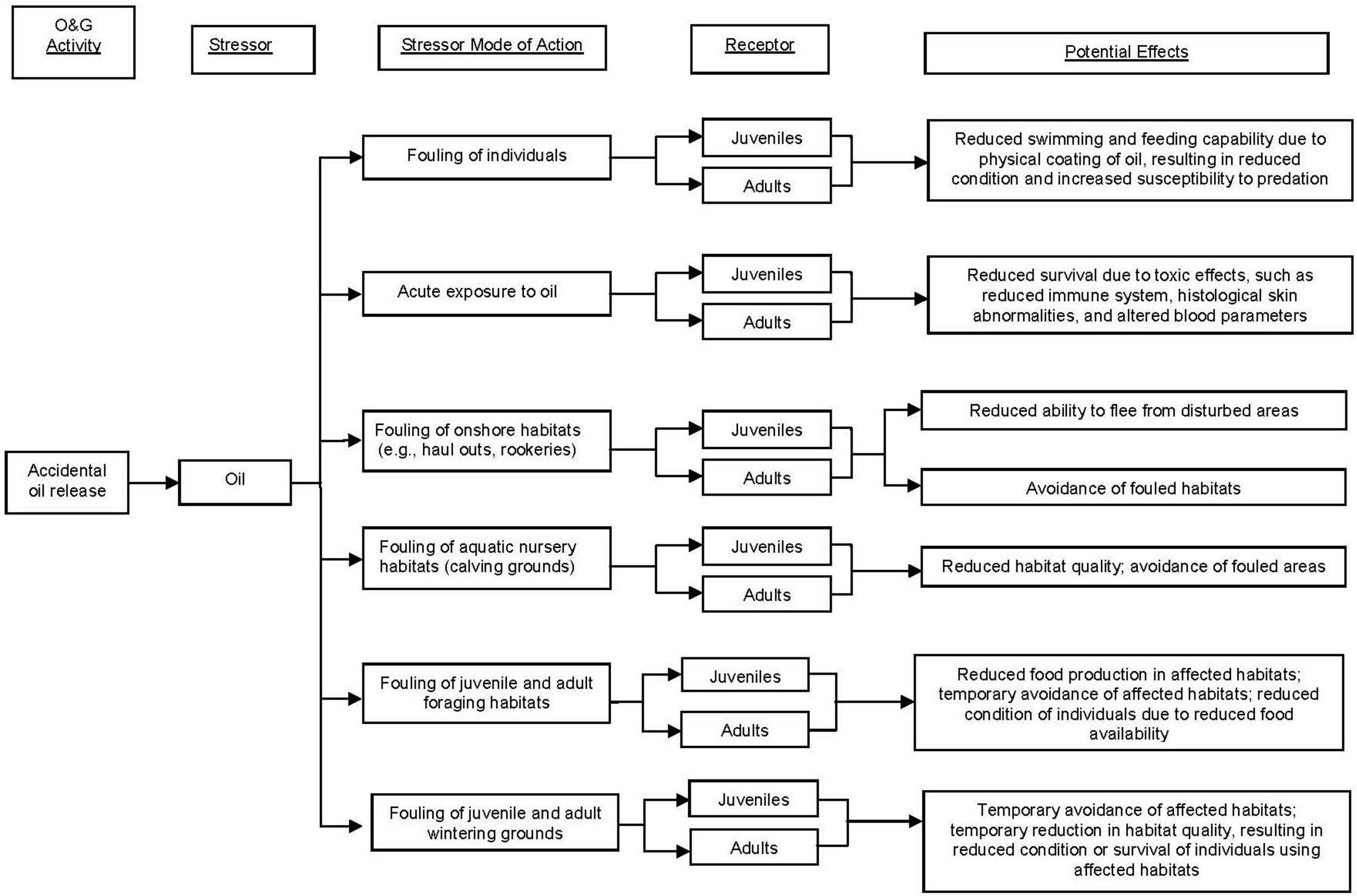

FIGURE 4.4.7-5 Conceptual Model for Potential Effects of Oil Spills on Marine Mammals

quality and, to a lesser extent, air quality that would impact marine mammals from direct contact, inhalation, and ingestion (either directly or indirectly through the consumption of oiled forage or prey species). These effects would be significant, causing a multitude of acute and chronic effects. Additional effects on marine mammals would occur from water and air quality degradation associated with response and cleanup vessels, *in situ* burning of oil, dispersant use, discharges and seafloor disturbances from relief well drilling, and activities on shorelines associated with cleanup, booming, beach cleaning, and monitoring. A CDE has the potential to increase the area and duration of an oil spill, thereby increasing the potential for population-level effects, or at a minimum, an increase in the number of individuals killed. For example, following the DWH event, dead marine mammals collected from April 30, 2010, through April 12, 2011, included 142 bottlenose dolphins, 3 spinner dolphins, and 2 each of *Kogia* spp., melon-headed whales, and sperm whales (NMFS 2011b).

Terrestrial Mammals. The terrestrial mammals considered in this section are those species listed as endangered under the ESA that may be affected by routine OCS operations or accidents under the proposed action. These include the Alabama, Choctawhatchee, Perdido Key, and St. Andrew beach mice (subspecies of the old-field mouse) and the Florida salt marsh vole (Section 3.8.1.1.2).

Routine Operations**.** The endangered beach mice subspecies inhabit mature coastal barrier sand dunes on the Alabama and northwest Florida coasts; the Florida salt marsh vole inhabits salt marsh habitats and is known from two locations (Waccasassa Bay in Levy County, Florida, and the Lower Suwannee National Wildlife Refuge), in southeastern Dixie and northwestern Levy Counties, Florida; Figure 3.8.1-1). Under the proposed action, no new OCS-related facilities or activities would occur in close proximity to the known habitats for these species; therefore, routine operations would not affect any of the species.

Accidents. Three types of oil residues on or near beach environments are particularly challenging or potentially damaging to the environment if removed (OSAT 2011):

- Supratidal buried oil — oil residue typically buried below the 15-cm (6-in.) surface cleaning depth near sensitive habitats, removal of which would damage these sensitive habitats and affect protected species;

- Small surface residual balls — oil residue left behind after beaches are cleaned (removal would involve sieving sand so finely that it could remove material used for habitat by organisms, thus altering the natural condition of the beach; and

- Surf zone submerged oil mats — submerged oil mats in nearshore surf zone in troughs between sand bars.

In the event of an accidental offshore or coastal oil spill, the four beach mice subspecies and the vole species could be affected by oil washing up on their beach habitats, and by subsequent spill containment and cleanup activities. Individuals coming in direct contact with spilled oil may experience skin, ear, eye, throat, and mucous membrane irritations. Oiling of fur may affect thermoregulation. Individuals inhaling petroleum vapors may aggravate linings of the respiratory system and in extreme cases may result in asphyxiation. Oil may be ingested through contaminated food or during cleaning of oiled fur. Exposure to oil via inhalation or ingestion may lead to a variety of lethal and sublethal effects, including lung, liver, and kidney damage. Beach mice could be exposed to small surface residual balls via ingestion of residual oil in soil and by exposure in their burrows (OSAT 2011).

In addition to affecting individuals, an oil spill may also affect the habitats of these small mammals. Oil contacting their habitats could result in a reduced food supply (oiled vegetation), reduced physical habitat quality (oiled sands), and fouling of nests and burrows. The fouling of nests and burrows may also lead to a temporary displacement from or permanent abandonment of these habitats. Depending on the persistence of the oil in these habitats and the effectiveness of spill cleanup, long-term reductions in overall habitat quality and quantity may be possible.

An accidental spill fairly close to shore would have the potential to contact beaches adjacent to beach mouse habitat, particularly if a spill were to occur nearshore or within inshore waterways. However, beach mice are generally restricted to interior dune habitats, which would not be expected to come in contact with spilled oil unless the accident occurred during a period of high storm surge. In contrast, habitats of the Florida salt marsh vole may be more vulnerable to an oil spill because of their being connected to coastal waters. However, the location of this species and its habitat on the western Florida coast are far removed from those portions of the GOM OCS where exploration and development might occur under the proposed action.

If an oil spill occurs and contacts a coastal area associated with these species, oil spill response activities, including beach cleanup activities and vehicular and pedestrian traffic, could result in habitat degradation. However, cleanup activities would be designed and conducted in consultation with the USFWS and other appropriate stakeholders so that the potential for impacts on these species and their habitats would be minimized or avoided.

Large-scale oiling of beach mice or vole habitats could result in extinctions, and if not properly regulated, oil spill-response and cleanup activities could have a significant impact on the species and their habitats. Vehicle traffic and activity associated with oil spill cleanup can trample or bury nests and burrows or cause displacement from preferred habitat (MMS 2008b). If disturbance results in the temporary abandonment of young by adults, survival of young may be reduced (MMS 2007d).

The probabilities of large oil spills (≥1,000 bbl) resulting from the proposed action occurring and contacting beach mouse or Florida salt marsh vole habitat within 3 to 30 days from a spill in various locations in the WPA, CPA, and far western EPA is ≤5%. In most instances, the probabilities were 0% to 1% (MMS 2004a). Direct contact with spilled oil that has washed ashore can cause skin and eye irritation, asphyxiation from inhalation of fumes, oil ingestion, and reduction or contamination of food sources. A slick cannot wash over the fore dunes unless carried by a heavy storm swell. High seas would be necessary to cause a spill slick to landfall and affect beach mice, Florida salt marsh voles, or their habitats. However, erosion with high seas during storms is likely to do more damage to rodent habitat than oiling.

Protective measures required under the ESA should prevent any oil spill-response and cleanup activities from having more than minor impacts on beach mice, the Florida salt marsh vole, and their habitats (MMS 2003e).

Catastrophic Discharge Event. The PEIS analyzes a CDE up to 7.2 million bbl (Table 4.4.2-2). If a CDE occurs, there is greater potential for more severe effects compared to the risk of effects from a large oil spill. A CDE would potentially result in sustained degradation of water quality, shoreline terrestrial habitats, and, to a lesser extent, air quality that could impact terrestrial mammals from direct contact, inhalation, and ingestion (either directly or indirectly through the consumption of oiled forage or prey species). These effects could be significant, causing a multitude of acute and chronic effects. Additional effects on terrestrial mammals would occur from land and air quality degradation associated with response and cleanup vessels, *in situ* burning of oil, dispersant use, and activities on shorelines associated with cleanup, booming, beach cleaning, and monitoring. A CDE has the potential to alter terrestrial mammal habitats and populations, and, could foreseeably contribute to population-level effects on one or more of the beach mice subspecies and/or the Florida salt marsh vole. The potential for these impacts would be more probable if the catastrophic discharge event occurs coincident with a severe storm event (e.g., a hurricane).

4.4.7.1.2 Alaska – Cook Inlet.

Marine Mammals. There are 18 species of marine mammals that occur in south Alaskan waters and that may either occur in or near (such as the Gulf of Alaska, Kenai Peninsula, and Kodiak Archipelago) the Cook Inlet Planning Area (Section 3.8.1.2.1; Table 3.8.1-2). Nine of these species or species stocks are threatened or endangered under the ESA. These species include the North Pacific right, sei, blue, fin, humpback, sperm, and beluga whales; the Steller sea lion; and the sea otter. The non-listed species commonly occur in portions in or near the Cook Inlet Planning Area (MMS 2003e). Marine mammals may be exposed to OCS-related oil and gas exploration, development, and operations that could occur under the proposed action.

Routine Operations. As part of the proposed action, a maximum of 4 to 12 exploration and delineation wells and 42 to 114 development and production wells will be drilled and 1 to 3 new platforms are projected to be used. Additional activities planned as part of the proposed action include 40 to 241 km (25 to 150 mi) of new offshore pipeline. No onshore facilities or pipelines are proposed under the proposed action (Section 4.4.1.2). Table 4.4.7-1 (Section 4.4.7.1) illustrates how each of the impacting factors associated with OCS oil and gas development may affect marine mammals and their habitats, while Figure 4.4.7-1 (Section 4.4.7.1) presents a conceptual model of potential impacting factors for marine mammals from oil- and gas-related activities (including accidental oil spills). The following text presents an overview of potential impacts to marine mammals in and near Cook Inlet from the following routine operations (seismic surveys, construction of offshore facilities and pipelines, operations of offshore facilities and drilling rigs, discharges and waste generation, service vessel and helicopter traffic, and decommissioning) and from accidents.

Seismic Surveys. Section 4.4.7.1 provides a detailed discussion of the issues surrounding anthropogenic noise. In Cook Inlet, noise generated by seismic surveys may have physical and/or behavioral effects on marine mammals, such as (1) permanent or temporary hearing loss, discomfort, and injury; (2) masking of important sound signals; and (3) behavioral responses such as fright, avoidance, and changes in physical or vocal behavior (Richardson et al. 1995; R.A. Davis et al. 1998b; Gordon et al. 1998; Nowacek et al. 2004, 2007). Seismic surveys may also indirectly impact marine mammals by altering prey availability (Gordon et al. 2003, 2004).

Non-Auditory Injury. Direct acoustic impact on tissue, indirect acoustic impact on tissue surrounding a structure, and acoustically mediated bubble growth within tissues from supersaturated dissolved nitrogen gas (if source intense and animals within short distance to source: Nowacek et al. 2007; Zimmer and Tyack 2007); resonance (although not anticipated given resonance frequencies of marine mammal lungs are generally below that of the G&G seismic survey source signal).

Auditory Injury (Temporary or Permanent Hearing Loss). The hearing of marine mammals varies based on individuals, absolute threshold of the species, masking, localization, frequency discrimination, and the motivation to be sensitive to a sound (Richardson et al. 1995). As stated previously, Southall et al. (2007) described the frequency sensitivity in five functional hearing. Similarly, the previous discussion in Section 4.4.7.1 on permanent and temporary loss of hearing in a marine mammal (i.e., PTS, TTS) is incorporated.

Masking. In the case of seismic surveys in Cook Inlet, , the effect of masking is likely to be low relative to continuous sounds such as ship noise. In addition, a few cetaceans are known to increase the source levels of their calls in the presence of elevated sound levels, or to shift their peak frequencies in response to strong sound signals (Dahlheim 1987; Au 1993; review in Richardson et al. 1995; Lesage et al. 1999; Terhune 1999; Nieukirk et al. 2005; Parks et al. 2007). These studies involved exposure to other types of anthropogenic sounds, not seismic pulses, and it is not known whether these types of responses ever occur upon exposure to seismic sounds. If so, these adaptations, along with directional hearing and preadaptation to tolerate some masking by natural sounds (Richardson et al. 1995), would all reduce the importance of masking.

Behavioral Change. As described in Section 4.4.7.1, a number of studies have documented behavioral effects in response to seismic surveys, primarily for mysticetes (Richardson et al. 1995), given their possible overlap between the expected frequencies of best hearing sensitivity (low threshold) in mysticetes and maximal air gun output at source. Given that no direct audiograms of mysticetes have been obtained, it is impossible to define what level of sound above hearing threshold may cause behavioral effects, which could be expected to be variable, complicated and dependent upon more than just the received sound level. For this reason, observations at sea have concentrated on relating received sound levels to observed behavioral changes.

Beluga whales are mid-frequency hearing specialists. The Southall et al. (2007) data review discussed the Finneran et al. (2002b) experiment using a seismic watergun which produced a single acoustic pulse. They conducted this test on one beluga and one bottlenose dolphin. Based on Finneran et al. (2002), for belugas exposed to a single pulse, TTS-onset occurred with unweighted peak levels of 224 dB re: 1 μPa (peak) and 186 dB re: 1 μPa2-s. The latter is equivalent to a weighted (M- weighting for mid-frequency marine mammals) SEL exposure of 183 dB re: 1 μPa2-s as some of the energy in the pulse was at low frequencies to which the beluga is less sensitive. Adding 6 dB to the former (224 dB) values, Southall et al. (2007) estimates the pressure criterion for injury for mid-frequency cetaceans is 230 dB re: 1 μPa (peak).

Southall et al. (2007) also went on to discuss pinnipeds, which include 16 species and subspecies of sea lions and fur seals (otariids), 23 species and subspecies of true seals (phocids), and two subspecies of walrus (odobenids). They produce a variety of social signals, most occurring at relatively low frequencies but lack the highly specialized active biosonar systems of toothed cetaceans. Because of they are active both in and out of water, pinnipeds communicate acoustically in air and water, have significantly different hearing capabilities in the air versus water, and may be subject to both aerial and underwater noise exposure (Schusterman 1981; Kastak & Schusterman 1998, 1999 in Southall et al. 2007). Therefore, pinnipeds have two different hearing criteria. However, since seismic surveys are less likely to affect pinnipeds, such as Steller sea lions, in air, the in-water criteria is discussed here. It is also acknowledged that there are "among species differences in the exposure conditions that elicited TTS under water" (Southall et al. 2007). Steller sea lion hearing has not specifically been studied but for the purposes of this analysis, it is assumed that their hearing is comparable to that of California sea lions. Comparative analyses of the combined underwater pinniped data (Kastak et al. 2005) indicated that, in the harbor seal, a TTS of *ca*. 6 dB occurred with 25-min exposure to 2.5 kHz OBN with SPL of 152 dB re: 1 μPa (SEL: 183 dB re: 1 μPa2-s). Under the same test conditions, a California sea lion showed TTS-onset at 174 dB re: 1 μPa (SEL: 206 dB re: 1 μPa2-s), and a northern elephant seal experienced TTS-onset at 172 dB re: 1 μPa (SEL: 204 dB re: 1 μPa2-s). Data on underwater TTS-onset in pinnipeds exposed to pulses are limited to a single study. Finneran et al. (2003) exposed two California sea lions to single underwater pulses from an arc-gap transducer. They found no measurable TTS following exposures up to 183 dB re: 1 μPa (peak-to-peak) (SEL: 163 dB re: 1 μPa2-s).

The Southall et al. (2007) criteria do not cover sea otter due to a lack of key hearing data. Further, there is little information on the effects of noise associated with oil and gas exploration on sea otters. Their production and use of sound underwater has not been studied. Airborne sounds are diverse and include high-pitched screams, whines, whistles, deep-throated growls, cooing, chuckles, and snarls (Kenyon 1981). Mothers and their pups communicate by calling, and both call to one another if separated. Most of the sounds in these mother-pup communications are 3-5 Hertz, but there are higher harmonics. Sandegren, Chu, and Vandervere (1973) recorded these calls from a distance of 50 meters in air. It is not known how far sea otters can hear these sounds. Available data do not indicate that sea otters are likely to be seriously impacted by seismic exploration. Riedman (1983, 1984) reported no evident disturbance reactions by sea otters in California coastal waters in response to noise from a full-scale array of air guns (67 L) and a single air gun. No disturbance was noted either when the operating seismic ship passed as close as 1.85 and 0.9 kilometers to sea otters. Sea otters continued to feed, groom, interact with pups, rest, and to engage in other normal behaviors. Riedman (1983, 1984) reported there was also no apparent reaction to the single air gun. Riedman (1983) cautioned that there are no data for the reactions of sea otters more than 400 meters offshore. Riedman (1983, 1984) reported no evidence of changes in behavior of sea otters during underwater playbacks of drillship, semisubmersible, and production platform sound. Most of the animals studied were 400 or more meters from the source of the sound. Foraging otters continued to dive and feed.

Whales and other marine mammals sometimes continue with important behaviors even in the presence of noise. Some marine mammals may be motivated by feeding opportunities to the extent that they subject themselves to increased noise levels. For example, Native hunters reported to Huntington (2000) that beluga whales often ignore the approach of hunters when feeding, but at other times will attempt to avoid boats of hunters. There is a potential for effects from geophysical survey operations on marine mammals found in Cook Inlet from non-auditory or auditory effects, including PTS, but this is expected to be negligible. Local effects could result to endangered species near noise and other disturbance caused by exploration. For example, in specific areas, particularly near the Barren Islands, these disturbances could affect the haulouts and behavior of Steller sea lions; cause local, short-term effects on the feeding of mysticetes; and locally affect some Cook Inlet beluga whales. Behavior of sea otters could be affected and some displacement of sea otters could occur near areas of activity. Although small numbers of individuals could be affected, regional population or migrant populations of non-endangered marine mammals would experience a negligible effect from disturbance and habitat alteration. The potential for injury is greatly lessened through effective implementation of assumed mitigation. Mitigation that is often implemented to reduce impacts includes use of marine mammal observers, survey vessel speed reductions, and establishment of exclusion zones.

<u>Construction and Operation of Offshore Platforms and Pipelines.</u> Figure 4.4.7-2 (Section 4.4.7.1.1) presents a conceptual model for potential effects of infrastructure construction on marine mammals. Under the proposed action, up to 1 to 3 offshore platforms and 40 to 241 km (25 to 150 mi) of offshore pipeline could be constructed in the Cook Inlet Planning Area (Table 4.4.1-3).

If exploration leads to development and production, impacts likely could occur from the following:

- Noise from construction of pipelines and production facilities;

- Routine and recurring traffic associated with crew and supply activities;

- Domestic wastewaters generated at the offshore facility (the scenario assumes on-platform disposal wells will reinject drilling fluids, muds, cuttings, and produced waters generated from production wells. Discharges and Wastes are described further below.);

- Trash and debris from production activities;

- Gaseous emissions from production facilities, both onshore and offshore, and from transportation vessels and aircraft; and

- Physical placement, presence, and removal of offshore production facilities, including platforms and pipelines to onshore common carrier pipelines.

Noise generated by industrial activities can come from a variety of sources, such as transportation, general machinery use, construction, and human activity. Noise, whether carried through the air or under water, may cause some species to alter their feeding routines, movement, and reproductive cycles. For cetaceans, effects from noise and disturbance associated with development would be much the same as discussed for exploration. The most likely impacts could be the disturbance of sea otters and Steller sea lions that are hauled out and the displacement of females and pups that occur near regions of focused activity. These effects are expected to be extremely local and have no population-level impacts on sea otters or Steller sea lions.

Construction may also cause an alteration in habitat and water quality for marine mammals. However, the activities associated with construction are not likely to significantly affect water quality. Construction activities would increase the turbidity in the water column along segments of the 40-km (25-mi) corridors for up to a few months, but no significant water quality degradation could occur. Further, construction activities could affect benthic organisms and fish (prey species) in the immediate vicinity. Organisms in soft substrates (bivalves and polychaetes) could be adversely affected; however, platforms would add a hard substrate to the marine environment, providing additional habitat for marine plants and animals (for example, kelp and mussels) that require a hard substrate. Therefore, the overall effect of platform and pipeline installation could be to alter species diversity in a small area. Construction activities may disturb pelagic and demersal finfishes and shellfishes, potentially displacing them from preferred habitat, as turbidity, vibrations, and noise from construction increases. Positive effects may accrue because following construction, offshore structures provide refugia to some species and their prey. Any disturbance or displacement should be localized and short term (hours to days to months), limited to only the time of construction and shortly thereafter. Effects are expected to be limited to negligible numbers of individuals in the immediate vicinity of construction activities.

The landfall of a pipeline would avoid sensitive aquatic habitat. The route for the pipeline would be sited inland from shorelines and beaches, and pipeline crossings of anadromous fish streams would be minimized and consolidated with other utility and road crossings of such streams. Pipelines would be buried wherever possible and sited in existing rights-of-way for other utilities or transportation systems wherever possible, such as that provided by the Sterling Highway. The pipelines would be designed, constructed, and maintained to minimize risk to fish habitats from a spill, pipeline break, or other construction activity. Habitat alteration due to pipeline laying and platform construction are expected to be localized and should not cause significant impacts to mobile species.

The immediate response of disturbed individuals or groups could be to leave or avoid the construction areas. This displacement or avoidance could be short or long term in duration, depending on the duration of the construction activity. Because relatively few individuals would be expected to be affected by the limited amount of construction and few new facilities that would be operating, the construction and operation of new offshore facilities would not be expected to result in population-level effects to affected marine mammals.

Facilities to be constructed and operated under the proposed action may occur in or near beluga whale critical habitat area 2 (76 FR 20180). Construction and operation of offshore platforms and pipelines are expected to have negligible impact to beluga habitat and would not be expected to affect movement of belugas within Cook Inlet. However, if activities were to occur in or near the beluga whale critical habitat, ESA consultation would occur to ensure the protection of the species and their habitat.

Critical habitat designation for the Steller sea lion (50 CFR 226.202) includes a 0.9-km (3,000-ft) radius no-entry zone around designated rookeries within the Cook Inlet Planning Area, as well as a 37-km (20-NM or 23-mi) aquatic avoidance zone around all major rookeries and haulouts. Additional restrictions (50 CFR 223.202) associated with Steller sea lion critical habitat include a 5.5-km (3-NM or 3.4-mi) radius vessel approach zone around listed rookeries, and 1.9-km a (1-NM or 1.2-mi) minimum distance for vessel passing near rookery sites (50 CFR 223.202). Compliance with these critical habitat designations, restrictions, and buffer zones could greatly reduce the likelihood of exposure of Steller sea lion rookeries and haulouts to OCS activities that could occur in the Cook Inlet Planning Area.

<u>Discharges and Wastes.</u> Table 4.4.1-3 presents information on drilling fluids, drill cuttings, and produced waters discharged offshore as a result of the proposed action. Figure 4.4.7-3 (Section 4.4.7.1.1) presents a conceptual model for potential effects of operational waste discharges on marine mammals. Produced water, drilling muds, and drill cuttings are discharged into offshore marine waters in compliance with applicable regulations and permits. Compliance with regulations and permits will limit the exposure of marine mammals to waste discharges.

Up to 500 bbl of drill fluids and 600 tons of drill cuttings will be discharged at each exploration and delineation well (Table 4.4.1-3). Heavier components of these muds and cuttings (such as rock) would settle to the bottom, while lighter components could increase turbidity around the drill site. While this increased turbidity could cause marine mammals to avoid the area, any increase in suspended solids associated with the discharge of drilling wastes would be rapidly diluted and dispersed, and thus not be expected to adversely affect marine mammals in the area. Drilling fluids and cuttings associated with development and production wells would be treated and disposed of in the wells; therefore, negligible impacts to marine mammals from these wastes are expected.

The OCS-related vessels supporting exploration activities and the construction and operation of offshore platforms and pipelines will generate waste fluids (such as bilge water) which may be discharged to the surface water. Such discharges, if allowed, would be regulated under applicable NPDES permits. Sanitary and domestic wastes would be processed through shipboard waste treatment facilities before being discharged overboard, and deck drainage would also be processed aboard ship to remove oil before being discharged. Because of the low level of expected vessel traffic, relatively small volumes of operational wastes would be discharged, and these would be rapidly diluted and dispersed. Thus, permitted waste discharges from OCS construction and service vessels are expected to have negligible impacts on marine mammals.

Solid debris can adversely impact marine mammals through ingestion or entanglement (Marine Mammal Commission 2003). Mammals that ingest debris, such as plastics, may experience intestinal blockage, which in turn may lead to starvation, while toxic substances present in the ingested materials (especially in plastics) could lead to a variety of lethal and sublethal toxic effects. Entanglement in plastic debris can result in reduced mobility, starvation, exhaustion, drowning, and constriction of, and subsequent damage to, limbs caused by tightening of the entangling material. The discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by the BOEM (30 CFR 250.40) and the USCG (International Convention for the Prevention of Pollution from Ships [MARPOL], Annex V, P.L. 100-220 [101 Statute 1458]). Thus, impacts to marine mammals from entanglement in or ingestion of OCS-related trash and debris under the proposed action are expected to be negligible to minor.

Drilling fluids and produced waters are not anticipated to be discharged during production. The hydrodynamic processes in the Cook Inlet suggest the water column generally is well mixed, and dilution would reduce the concentration of the substances in the discharges. Degradation processes also act to continuously reduce the concentrations of many substances deliberately or accidentally released into the environment. We do not expect the discharge of drilling muds and cuttings and other discharges associated with exploration drilling to have any effect on the overall quality of Cook Inlet water. Within a distance of between 100 and 200 m (328 and 656 ft) from the discharge point, the turbidity caused by suspended-particulate matter in the discharged muds and cuttings would dilute to levels that are less than the chronic criteria (100–1,000 parts per million) and within the range associated with the variability of naturally occurring suspended particulate matter concentrations. Mixing in the water column would reduce the toxicity of the drilling muds that already fall into the "practically nontoxic" category to levels that would not be harmful to organisms in the water column. In general, the amounts of additives in the other discharges are likely to be relatively small (from 4 to 400 or 800 liters/month and diluted with seawater several hundred to several thousand times before being discharged into the receiving waters. The potential effects in any of the areas where there are permitted discharges would last for about 3–4 months for each exploration well drilled.

<u>Vessel and Aircraft Traffic.</u> There may be up to 9 surface vessels and 9 helicopter trips per week under the proposed action (Table 4.4.1-3). Figure 4.4.7-4 (Section 4.4.7.4) presents a conceptual model for potential effect of vessel traffic on marine mammals. Vessel traffic could occur during seismic exploration, drilling and platform construction, platform operation, and platform decommissioning. Generally, marine mammals may be affected by direct collisions with vessels or by visual and noise disturbances.

In addition to possible collision-related injuries and/or mortalities, cetaceans and pinnipeds in the vicinity of an OCS-related vessel may be disturbed by the presence of vessels and helicopters and the noise they generate. Noises emitted by shipping vessels are expected to range between 140 dB re 1 μPa for smaller vessels to 198 dB re 1 μPa for larger tankers and cargo ships (Heathershaw et al. 2001; Erbe 2002; Hildebrand 2004). Helicopters flying at 150 m (492 ft) altitude are expected to emit noises received at ground level of approximately 80 to 86 dB re 20 μPa (Born et al. 1999). Reactions of cetaceans, including both odontocetes and mysticetes, may include apparent indifference, cessation of vocalizations or feeding activity, increases in vocal behavior, and evasive behavior (e.g., turns, diving, etc.) (Richardson et al. 1995; Nowacek and Wells 2001; Buckstaff 2004; Doyle et al. 2008). Noise from service vessels may also mask cetacean sound reception (MMS 2003e). Disturbed individuals would be expected to cease their normal behaviors and likely move away from the vessel. Following passage of the vessel, affected individuals may return and resume normal behaviors.

Cetaceans, such as humpback whales, near the Barren Islands and the southern portions of the Cook Inlet also could be negatively affected by vessel transport and construction activities. However, this area has a high volume of fishing- and tourism-related vessel traffic in the summer months when the whales are present. The incremental addition of noise from two vessels per day associated with the proposed action is unlikely to add significantly to this existing noise.

Based on their distributions, humpbacks are more vulnerable to aircraft noise than fin whales. Shallenberger (1978) reported that some humpbacks were disturbed by overflights at 305 m (1,000 ft), whereas others showed no response at 152 m (500 ft). As with the response to air gun noise, pods varied in their response. Humpbacks in large groups showed little or no response but some adult-only groups exhibited avoidance (Herman et al. 1980). Other authors report no response (for example, Friedl and Thompson, 1981). Due to concerns about the impacts of helicopters in Hawaiian waters, helicopters are prohibited from approaching within a slant range of 1,000 ft, or 305 m, from humpbacks (National Marine Fisheries Service 1987).

Belugas could be disturbed by noise and disturbance from exploration and development-related aircraft, especially helicopters. Belugas reacted to aircraft flying at 150–200 m (492–656 ft) by diving for longer periods, reducing surfacing time and sometimes swam away (see references cited in Richardson et al. 1995). They did not respond to aircraft at 500 m (1,640 ft). Richardson et al. (1991) found variable reactions to turbine helicopters and fixed wing aircraft in offshore waters near Alaska. Some individuals exhibited no discernible response even when the aircraft was within 100–200 m (328–656 ft), whereas other individuals dove abruptly, looked upward, or turned sharply in response to aircraft at altitudes up to 460 m (1,510 ft). In shallow summering areas, belugas sometimes respond to aircraft by diving or swimming away (Finley et al. 1982; Gales 1982; Caron and Smith 1990).

Vessel traffic may disturb pinnipeds and sea otters (which are discussed further below) in the water and hauled out on ice or terrestrial habitats. For example, when approached too closely or disturbed too often, harbor seals are known to abandon their favorite haul-out sites or their pups (Kinkhart et al. 2008). Hauled out pinnipeds may exhibit behavioral reactions to the physical disturbance of an approaching vessel or aircraft by exhibiting startle reactions, slipping into the water. In recognition of their vulnerability to loud and startling noises, Steller sea lion critical habitat has been defined to include a terrestrial zone that extends 914 m (3,000 ft) landward from the baseline or base point of each Steller sea lion major rookery or major haulout and an air zone that extends 914 m (3,000 ft) above the terrestrial zone, as measured at sea level around them. Assuming aircraft flying to any platforms maintain sufficient distances from these rookeries, based on recognition of this critical habitat, it not likely this form of disturbance would have a major impact on Steller sea lions. However, given observations by Withrow et al. (1985) cited above, it is possible that sea lions could be negatively affected by oil- and gas-activity-related helicopters (and possibly by other noise) operating at further distances. Under the proposed scenario, one to two helicopter trips per day would be made to oil and gas operations from Kenai or other sites along the western Kenai Peninsula shore. In most of the proposed Cook Inlet multiple-sale area, these flights would not require transit over any terrestrial components of Steller sea lion critical habitat and adverse effects could easily be avoided. The greatest potential for such disturbance could come from helicopters transiting to blocks on the far side of the Barren Islands if flights originated on the Kenai Peninsula and stayed, as geography permits, near land until crossing of the entrances of Cook Inlet was required to reach drill (or production) sites on the far sides of the Barren Islands.

Major rookeries in and near the Cook Inlet include Outer Island, Sugarloaf Island, Marmot Island, Chirikof Island, and Chowiet Island. There are several major haulouts in and near the Cook Inlet, 20-NM aquatic zones, and an aquatic foraging area in Shelikof Strait. All of these are part of Steller sea lion critical habitat. Support-vessel traffic would be unlikely to adversely affect these habitats as long as operators avoided transiting near to the rookeries or haulouts or deliberately approaching sea lions in the water. Critical habitat of Steller sea lions is unlikely to be impacted by exploration activities. As noted above, terrestrial zones are legally protected from activities degrading them by disturbance. Shelikof Strait was designated as critical habitat because of its proximity to major rookeries and important haulouts, its use by foraging sea lions and its value as an area of high forage-fish production. Any adverse impacts of oil and gas development that adversely affect the production and availability of prey to Steller sea lions in this and other critical habitat could adversely modify the habitat. Aircraft restrictions associated with Steller sea lion critical habitat protection (50 CFR 223.202; 50 CFR 226.202) could further reduce the likelihood of helicopter flights impacting designated rookery sites for this listed species. Careful planning of flight paths to avoid rookeries and haulouts of other pinnipeds could further reduce or eliminate the potential for disturbing animals in these habitats.

Boat traffic associated with OCS oil and gas exploration activity could disturb sea otters in specific areas. In summer, these impacts are likely to be insignificant compared to the quantity of fishing, tourism, shipping, and other boat traffic in the region. In winter, boat traffic in a remote region could have local impacts on distribution of females and pups. While male sea otters sometimes habituate to heavy boat traffic, female sea otters, particularly those with pups, are sensitive to disturbance. Garshelis and Garshelis (1984) reported that sea otters in Prince William Sound avoided waters with frequent boat traffic but reoccupy these areas when boats are less frequent. Rotterman and Monnett (2002) concluded that disturbance after the *Exxon Valdez* oil spill was sufficient to keep sea otters from feeding habitat in certain bays in oiled areas of Prince William Sound. Udevitz et al. (1995) reported that about 15% of sea otters along boat survey transects are not detected because they move away from the approaching boat. Boat traffic could disturb resting patterns of sea otters. Sea otters in Alaska haul out regularly. Sea otters that are hauled out will often move into the water with the approach of a boat. Garrott, Eberhardt, and Burn (1993) reported that sea otters on shore would move into the water with approach of a single small motorboat moving parallel to and 100 m (328 ft) from shore.

As previously discussed, the FAA Advisory Circular 91-36D (FAA 2004) encourages pilots to maintain higher than minimum altitudes over noise-sensitive areas. Also, guidelines and regulations issued by NMFS under the authority of the MMPA include provisions specifying helicopter pilots to maintain an altitude of 305 m (1,000 ft) within 91 m (300 ft) of marine mammals (MMS 2007d). Helicopter operations would only be expected to occur below specified minimums during inclement weather. In MMS (2007d), it was concluded that this could occur for about 10% of helicopter operations. Because of the low level of vessel and aircraft traffic that could occur under the proposed action, potential impacts to marine mammals from this traffic would likely be limited to a few individuals, be largely short-term in nature, and not result in population-level effects.

<u>Decommissioning.</u> Under the proposed action, no platforms will be removed with explosives from the Cook Inlet Planning Area. Therefore, potential impacts of decommissioning on marine mammals, as summarized in Figure 4.4.7-4 (Section 4.4.7.1.1), will not occur.

Accidents. Accidental oil spills could occur in Cook Inlet under the proposed action (Section 4.4.2). Table 4.4.2-1 presents the oil spill assumptions for the proposed action, while Figure 4.4.7-5 (Section 4.4.7.1.1) presents a conceptual model for potential effects of oil spills on marine mammals. Small oil spills (≤1,000 bbl) break-up and dissipate within hours to a day (MMS 2009a). Larger spills, particularly those that continue to flow fresh hydrocarbons into waters for extended periods (i.e., days, weeks, or months), pose an increased likelihood of impacting marine mammal populations (MMS 2008b). While the numbers have been steadily decreasing since the 1970s, operational discharges such as tank washing with seawater, oil content in ballast water, and fuel oil sludge are among the sources of small oil spills from tankers (Jernelöv 2010). Large oil spills from tankers have decreased significantly in recent years (modern tankers have double hulls and are sectioned to prevent losing the ship's entire cargo and sea lanes have been established) while spills from ageing, ill-maintained or sabotaged pipelines have increased.

Characteristics of impacts (i.e., acute vs. chronic impacts) depend on the magnitude, frequency, location, and date of accidents; characteristics of spilled oil; spill-response capabilities and timing; and various meteorological and hydrological factors. Chronic or acute exposure may result in harassment, harm, or mortality to marine mammals. Studies have shown varying results. Marine mammals made no apparent attempt to avoid spilled oil in some cases (Smultea and Würsig 1995); however, marine mammals have been observed apparently detecting and avoiding slicks in other reports (Geraci and St. Aubin 1990). Since there are reports of oiled marine mammals exposure to hydrocarbons persisting in the sea following the dispersal of an oil slick may result in sublethal impacts (e.g., decreased health, reproductive fitness, and longevity; and increased vulnerability to disease) to marine mammals.

Small and large spills occurring in the Cook Inlet Planning Area are not expected to affect the listed blue, sei, sperm, or North Pacific right whales, as these species occur only infrequently, if at all, within the area (MMS 2003e). However, it is important to note that any impacts to individuals of species already in decline (listed species) that affect their survival or reproductive capacity could result in population-level impacts. The endangered fin and humpback whales, as well as the minke and killer whales, which do occur within the planning area, could be affected by accidental spills occurring in or reaching the Shelikof Strait. Gray whales migrating past Cook Inlet could be exposed to accidental spills occurring near the Kennedy and Stevenson entrances to Cook Inlet. Accidental spills in the Cook Inlet Planning Area could also expose smaller cetacean species (such as Dall's porpoise) and pinnipeds foraging in open marine waters. Because of the small number and mostly small size of potential spills that could occur under the proposed action, exposures of these species to spilled oil would be temporary and likely affect only a few individuals (MMS 2003e).

Oil spills could have serious impacts on pinnipeds during periods when they are concentrated at rookeries (typically, late spring, summer, and early fall). At such times, spills and/or spill response operations have the potential to disturb hundreds of pinnipeds. If a spill contaminates a rookery, a significant population decline could occur (Calkins et al. 1994). Sea otters, sea lions, and harbor seals had elevated hydrocarbon levels in areas contaminated by the *Exxon Valdez* oil spill, but only sea otters and harbor seals showed population declines associated with the spill (Loughlin et al. 1996).

Spills occurring in or reaching coastal areas, especially sheltered coastal habitats such as bays and estuaries, pose the greatest risk to marine mammals. These spills may be more likely to affect species such as the sea otter and the Steller sea lion that use coastal habitats for pupping, foraging, and resting. A large spill contacting an active pinniped rookery site could result in population-level effects for some species, while spills in nearshore areas could result in the direct oiling of large numbers of pinnipeds and sea otters, and adversely affect local populations of some of these species (primarily the sea otter and fur seals), while sublethal effects may be incurred by all individuals ingesting or inhaling spilled oil.

An estimated 3,905 sea otters were killed by the *Exxon Valdez* oil spill (EVOS), and sea otter abundance in some oiled areas remains under pre-spill estimates, suggesting that sea otters have not fully recovered (USFWS 2008). Oiling and ingestion of oil-contaminated shellfish may have affected reproduction and caused a variety of long-term sublethal effects (Fair and Becker 2000). The recovery of sea otters may be constrained by residual spill effects resulting from elevated mortality and emigration (Bodkin et al. 2002). According to Frost and Lowry (1994), initially following the *Exxon Valdez* oil spill in Prince William Sound, Alaska (Frost et al. 1994a, b; Lowry et al. 1994; Spraker et al. 1994), it was claimed an estimated 300+ harbor seals died as a result of crude oil exposure. Subsequent investigations revealed that there were no significant quantities of oil in the tissues (liver, blubber, kidney and skeletal muscles) of harbor seals exposed to the *Exxon Valdez* spill (Bence and Burns 1995), and that the cause of the decreasing trend in harbor seal numbers since the spill (4.6% per year) is complicated because seal populations were declining prior to the spill (Frost et al. 1999). A further analysis of harbor seal population trends and movements in Prince William Sound concluded harbor seals moved away from some oiled haul-outs during the Exxon Valdez spill (Hoover-Miller et al. 2001) and that the original estimate of 300 or more harbor seal mortalities may have been overstated. St. Aubin (1990) found that the greatest effect of a spill was on young seals in cold water and that no mortalities were reported after a well blowout near Sable Island in 1984.

As discussed in Section 4.4.7.1.1, oil spill response activities may affect marine mammals through exposure to spill response chemicals (e.g., dispersants or coagulants) and through behavioral disturbance during cleanup and restoration operations. The chemicals used during a spill response are toxic, but are considered much less so than the constituents of spilled oil (Wells 1989), although there is little information regarding their potential effects on marine mammals. The presence of, and noise generated by, oil spill response equipment and support vessels could temporarily disturb marine mammals in the vicinity of the response action, with affected individuals likely leaving the area. While such displacement may affect only a small number of animals, cleanup operations disturbing adults in pup-rearing areas may decrease pup survival and result in population-level effects. While some smaller animals can be collected and examined closely, impacts on whales from oil spills are difficult to assess because large numbers of most of the species cannot be easily captured, examined, weighed, sampled, or monitored closely for extended periods of time. Some authors have attempted to link beached carcasses with spill effects, particularly gray whales. Large numbers of gray whale carcasses were discovered previously in other parts of the range (see examples in Loughlin 1994). During the oil spill off Santa Barbara in 1969, an estimated 80,000 bbl of oil may have entered the marine environment. Gray whales were beginning their annual migration north during the spill. Whales were observed migrating northward through the slick. Several dead whales were observed and carcasses recovered, including six gray whales. Brownell (1971, as reported by Geraci 1990) acknowledged that these whales totaled more than the usual number of gray whales and dolphins stranding annually on California shores, and concluded that increased survey efforts had led to the higher counts. Several of the whales examined were thought to have died from natural causes, and one may have been harpooned. No evidence of oil contamination was found on any of the whales examined. The Battelle Memorial Institute concluded the whales were either able to avoid the oil, or were unaffected when in contact with it. Similarly, extensive beached carcass surveys made after the EVOS revealed a number of gray whales. The number of carcasses found was the result of such an atypical survey effort and were comparable to gray whale strandings along the pacific coast, well south of the EVOS area.

Catastrophic Discharge Event. If a catastrophic discharge event occurs, there is greater potential for more severe effects compared to the risk of effects from a large oil spill. A catastrophic discharge event would result in sustained degradation of water quality and, to a lesser extent, air quality that would impact marine mammals from direct contact, inhalation, and ingestion (either directly or indirectly through the consumption of oiled forage or prey species). These effects would be significant, causing a multitude of acute and chronic effects. Additional effects on marine mammals would occur from water and air quality degradation associated with response and cleanup vessels, *in situ* burning of oil, dispersant use, discharges and seafloor disturbances from relief well drilling, and activities on shorelines associated with cleanup, booming, beach cleaning, and monitoring. A catastrophic discharge event has the potential to increase the area and duration of an oil spill, thereby increasing the potential for population-level effects, or at a minimum, an increase in the number of individuals killed. A catastrophic discharge event in Cook Inlet would potentially impact marine mammals throughout much of south central Alaska and has the potential to increase the area and duration of an oil spill, thereby increasing the potential for population-level effects, or at a minimum, an increase in the number of individuals killed. For example, one resident killer whale pod (AB Pod) and one transient killer whale population (AT1 Group) suffered losses of 33 and 41%, respectively, in the year following the *Exxon Valdez* oil spill. Sixteen years after the spill, the resident pod had not returned to pre-spill numbers, while the transient population lost nine members following the spill and continued to decline to the point that it is listed as depleted under the MMPA (Matkin et al. 2008). Additionally, sea otters and harbor seals showed population declines associated with the spill (Loughlin et al. 1996). An estimated 3,905 sea otters were killed by the *Exxon Valdez* oil spill and sea otter abundance in some oiled areas remains under pre-spill estimates, suggesting that sea otters have not fully recovered (USFWS 2008). An estimated 302 harbor seals were killed by the *Exxon Valdez* oil spill, probably due to the inhalation of toxic fumes (Frost and Lowry 1994). Contraction of the Cook Inlet beluga whale population northward into the upper portions of the inlet makes the population more vulnerable to a catastrophic discharge event (NMFS 2008).

Terrestrial Mammals. There are approximately 40 species of terrestrial mammal that occur in southern Alaska. Among these, 10 species may regularly use mainland and island habitats adjacent to or near the Cook Inlet Planning Area (Section 3.8.1.2.2), and thus could be affected by OCS-related activities.

Routine Operations. Under the proposed action, up to 80 km (50 mi) of new onshore pipeline would be installed along Cook Inlet, which could result in up to 364 ha (900 ac) of soil disturbance. The area disturbed represents an extremely small portion of terrestrial wildlife habitat that occurs inshore of the Cook Inlet Planning Area. Wildlife are expected to avoid the area where construction of new pipeline is occurring. Few additional impacts, other than those that might occur from helicopter overflights, would occur on terrestrial mammals. Helicopter traffic could disturb wildlife near the existing onshore facilities and pipelines or along the overland portions of flight paths between the existing onshore facilities and new offshore platforms. The aircraft effects on wildlife vary by species, habitat type, and the wildlife activity occurring at the time of the overflight. During overflights, some wildlife will cease their normal behaviors until the aircraft has passed and then resume their normal activity; others may flee the area, while some species may become habituated and experience no disturbance (Harting 1987). Aircraft overflights would be relatively infrequent (no more than three flights per week per offshore platform). Thus, no long-term, population-level effects are expected from aircraft overflights associated with routine operations.

Accidents. An offshore oil spill that contaminates beaches and shorelines could affect terrestrial mammals, such as the Sitka black-tailed deer, brown bear, and river otter, that forage in intertidal habitats (*Exxon Valdez* Oil Spill Trustees 1992). An onshore oil spill could similarly affect terrestrial animals, such as American black bear or moose that may forage in the area of the onshore pipeline. Spills contacting high-use areas, such as coastal habitats along Shelikof Strait heavily used by brown bears, could locally affect a relatively large number of animals (MMS 2003e). The impacts on wildlife from an oil spill would depend on such factors as the time of year and volume of the spill, type and extent of habitat affected, and home range or density of the wildlife species. The potential effects on wildlife from oil spills could occur from direct contamination of individual animals, contamination of habitats, and contamination of food resources (ADNR 1999). Acute (short-term) effects usually occur from direct oiling of animals, while chronic (long-term) effects generally result from such factors as accumulation of contaminants from food items and environmental media (e.g., sediments).

Terrestrial mammals directly contaminated by an accidental release could inhale volatile organics and/or ingest oil while grooming contaminated fur (MMS 1996b). Exposure may also occur through the consumption of contaminated foods. The moose and opportunistic omnivores, such as brown and American black bears, may experience a greater potential of exposure than many other wildlife species.

Staging and support activities for a large spill cleanup could temporarily displace terrestrial mammals not only from the contaminated habitats but also from nearby uncontaminated habitats. Depending on the effectiveness of the cleanup activities, chronic oil exposure may continue for years in some habitats.

Catastrophic Discharge Event. The PEIS analyzes a CDE of 75 to 125 thousand bbl (Table 4.4.2-2). If a CDE occurs, there is greater potential for more severe effects compared to the risk of effects from a large oil spill. A catastrophic discharge event would result in sustained degradation of water quality, shoreline terrestrial habitats, and, to a lesser extent, air quality that could impact terrestrial mammals from direct contact, inhalation, and ingestion (either directly or indirectly through the consumption of oiled forage or prey species). These effects could be significant, causing a multitude of acute and chronic effects. Additional effects on terrestrial mammals would occur from land and air quality degradation associated with response and cleanup vessels, *in situ* burning of oil, dispersant use, and activities on shorelines associated with cleanup, booming, beach cleaning, and monitoring. A CDE has the potential to alter terrestrial mammal habitats and populations. However, only minor impacts to terrestrial mammals were observed from the *Exxon Valdez* oil spill. No Sitka black-tailed deer were found whose death could be attributed to the *Exxon Valdez* oil spill. However, some deer that fed on kelp in the intertidal areas had slightly elevated concentrations of petroleum hydrocarbons in their tissues (*Exxon Valdez* Oil Spill Trustees 1992). Several river otter carcasses were found following the *Exxon Valdez* oil spill. Analysis showed that they accumulated petroleum hydrocarbons. Also, home ranges in oiled areas were twice that of unoiled areas, suggesting that increased foraging was required to find sufficient food resources. Body lengths, weights, and dietary diversity were also lower in oiled areas (*Exxon Valdez* Oil Spill Trustees 1992). Lewis et al. (1991) examined the impacts of the *Exxon Valdez* oil spill on Katmai National Park coastal brown bears. Of the 27 bears captured, 4 had been exposed to crude oil. Bears were also observed with oil on their fur, consuming oiled carcasses, and presumably feeding on razor clams in the intertidal area. One yearling bear was found dead with high concentrations of aromatic hydrocarbons in its bile. Crude oil elements were also found in the fecal samples of the bear's mother. However, no population-level impacts on the bears of Katmai were indicated.

4.4.7.1.3 Alaska – Arctic.

Marine Mammals. There are 14 resident or seasonal species of marine mammals in the Arctic region, including 8 species of cetaceans, 5 species of pinnipeds, and 1 fissiped species (Table 3.8.1-4; Section 3.8.1.3.1). All of the species occur in the Chukchi Sea; the Pacific walrus and the bearded and ribbon seals also occur in the western portions of the Beaufort Sea, while the ringed and spotted seals, bowhead and beluga whales, and polar bear occur throughout both seas (Section 3.8.1.3.1). The endangered fin and humpback whales are only occasional transients in the southern portion of the Chukchi Sea during summer. The endangered bowhead whale migrates through the Chukchi and Beaufort Seas between its wintering grounds in the Bering Sea and its summering grounds primarily in the Canadian portion of the Beaufort Sea (Figure 3.8.1-4; Section 3.8.1.3.1). However, some individuals remain in the Alaska portion of the Beaufort Sea and in the Chukchi Sea during summer. Thus, the bowhead whale has the greatest potential of the endangered whale species to occur in areas where OCS-related activities are occurring and be affected by normal operations or oil spills. The potential for this would be most probable during the bowhead whale's spring and fall migrations that generally occur from March through June and September through November, respectively (Hill and DeMaster 1998).

There are at least 9 species of seasonal or resident cetaceans- bowhead, fin, humpback, minke, gray, beluga, and killer whales; harbor porpoise (Suydam and George, 1992) occur with rare or observational accounts of narwhals. Bearded seals occur throughout the Beaufort Sea and into the Canadian High Arctic and Greenland. There are more seasonal residents (3,150) than year-long resident bearded seals, but some seals remain in the Beaufort year-round. Spotted seals have small haul-outs east to the Colville River Delta and historically to Prudhoe Bay. Spotted seals are rare past Harrison Bay and are not known to occur throughout the Beaufort Sea. Gray whales occur primarily nearshore and are occasionally found as far east as the Canadian Beaufort Sea. The continental shelf in the Beaufort is much narrower than in the Chukchi, and therefore it can support fewer gray whales. Humpback whales have been observed nearshore in the Chukchi Sea and as far east as the Western Beaufort Sea. Observations of fin whales have occurred in the southern and east central Chukchi Sea. Observations of a few individuals have been more consistent over the last five years during the open water period.

Routine Operations. Table 4.4.7-1 (Section 4.4.7.1) illustrates how each of the impacting factors associated with OCS oil and gas development may affect marine mammals and their habitats, while Figure 4.4.7-1 (Section 4.4.7.1) presents a conceptual model of potential impacting factors for marine mammals from oil and gas-related activities (including accidental oil spills). The following text presents an overview of potential impacts to marine mammals in and near the Beaufort and Chukchi Sea Planning Areas from the following routine operations (seismic surveys, construction of offshore facilities and pipelines, operations of offshore facilities and drilling rigs, discharges and waste generation, service vessel and helicopter traffic, and decommissioning) and from accidents.

Seismic Surveys. During offshore exploration, seismic surveys conducted in offshore areas and in lagoon systems could affect marine mammals. Seismic surveys generally occur during the ice-free periods, normally from July to October (NMFS 2001b). In the Beaufort Sea, there are also on-ice seismic surveys, which may impact ice seals and polar bear. Noise generated by seismic surveys may have physical and/or behavioral effects on marine mammals, such as hearing loss, discomfort, and injury; masking of important natural sound signals, including communications among individual whales; behavioral responses such as flight, avoidance, displacement of migration route, and changes in physical or vocal behavior (Richardson et al. 1995; Davis et al. 1998; Gordon et al. 1998; MMS 2003e). It has not been possible to predict the type or magnitude of responses to such surveys (and other oil and gas activities) nor to evaluate the potential effects on populations (NRC 2003a). However, there is no evidence to suggest that routine seismic surveys may result in population-level effects for any of the marine mammal species. There have been no documented instances of deaths, physical injuries, or physiological effects on marine mammals from seismic surveys (MMS 2004c).

Cudahy and Ellison (2002) indicated that tissue damage from exposure to underwater low frequency sound will occur at a damage threshold on the order of 180 to 190 dB or higher. The onset of level A harassment impacts per the MMPA (i.e., the potential to injure a marine mammals or marine mammal stock) for cetaceans and walrus is 180 dB re 1 μPa (rms) RL and for pinnipeds and polar bears is 190 dB re 1 μPa (rms) RL, while the onset of level B harassment impacts per the MMPA (i.e., the potential to disturb a marine mammal or marine mammal stock by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering) for marine mammals is 160 dB re 1 μPa (rms) RL.

Noise from air guns and survey vessels could disturb nearby marine mammals that may be foraging in open waters or using floe ice for resting, birthing, and the rearing of young. These disturbances would be largely limited to the immediate area of the survey vessel, although animals within a few kilometers of seismic operations may be affected (Richardson et al. 1986). Because cetaceans and pinnipeds are highly mobile species, they may leave an area when a seismic survey is initiated, thereby greatly reducing their exposure to maximal sound levels and, to a lesser extent, masking frequencies. However, if they surveys occur during the winter or spring when areas of open water are restricted or isolated, young ringed or bearded seals may have some difficulty avoiding the on-ice seismic surveying, and if there are ice breakers, some ringed seal pups could be crushed inside of their lairs. If an animal is able to relocate, would likely resume its normal behavioral patterns. During the open water season, displaced or disturbed individuals may return to the area and/or resume normal behavioral patterns after the survey activities have ceased, but this is not necessarily also true for individuals displaced from on-ice seismic surveys.

Among cetaceans, the odontocetes generally demonstrate relatively poor low-frequency hearing sensitivity, and thus might not be expected to experience hearing loss from seismic surveys (unless they are in close proximity to air gun arrays) (MMS 2004a). The odontocetes in the Arctic region (beluga and killer whales and the less frequently encountered harbor porpoise and rare narwhal) may respond behaviorally to seismic surveys by leaving the areas where seismic surveys are being conducted. Unless the surveyed area is further developed, such displacement would be temporary and not expected to result in long-term impacts to either individual animals or populations of these species.

The mysticetes, which include the endangered bowhead, fin, humpback whales, as well as gray and minke whales, are considered to possess good hearing sensitivity at low frequencies down to approximately 10 Hz, and many of their vocalizations occur in the low tens to a few hundred Hz (Richardson et al. 1995; Crane and Lashkari 1996; Ketten 1998; Stafford et al. 1998). Seismic survey air gun arrays output maximal energy in the region of a few tens of Hz, which overlaps with the expected lower end of the hearing sensitivity of mysticetes. Thus, the mysticetes that occur regularly in the Chukchi and Beaufort Seas may be affected by seismic surveys. Exposure of these whales to maximal air gun output during a seismic survey may result in behavioral changes such as area avoidance or short-term or long-term hearing loss, while less than maximal exposure could result in masking effects (Ljungblad et al. 1988b;

Malme et al. 1989). It may also alter or deter migration paths and displacement may then result in fewer feeding opportunities where prey are aggregated.

Bowhead whales can detect sounds produced by seismic pulses from 10 to 100 km (6 to 62 mi) away from the source (MMS 2002a). Bowheads have been rarely observed within 20 km (12 mi) of where air guns are operating. However, occurrences of bowheads within 20 km (12 mi) are similar to those outside this radius about 12 to 24 hours after seismic operations cease (MMS 2002a). At seismic pulses as high as 248 dB re 1 μPa-m, bowhead whales respond by orienting away from the seismic vessels at distances up to 7.5 km (4.7 mi) (Richardson et al. 1986). While high-frequency seismic noises have the potential to permanently harm cetaceans, there is evidence that some cetaceans may habituate to lower-level seismic noises. For example, Richardson et al. (1986) found that bowhead whales initially responded to moderate underwater noise frequencies (110 to 115 dB re 1 μPa-m) by avoiding areas in which seismic exploration activities were occurring, but later became tolerant to prolonged noise exposure. Migrating bowhead whales have also been shown to exhibit avoidance of a 20-km (12-mi) area around seismic surveying where received levels were estimated to be approximately 120 to 130 dB re 1 μPa at 1 m (Richardson et al. 1999). Given their mobility and avoidance reactions to approaching seismic vessels, it is unlikely that whales would occur close to injurious noise levels (MMS 2003e). Some bowhead whales may tolerate noise levels that may reach injury levels when they are engaged or highly motivated during behaviors such as feeding, while others may exhibit more sensitivity, such as females with calves.

Todd et al. (1996) found that humpback whales exhibited little behavioral reaction to underwater anthropogenic noises as high as 153 dB re 1 μPa. However, Richardson et al. (1990) observed that bowhead whales in close proximity to underwater anthropogenic noise sources (<1 km [0.6 mi]) reacted to sound levels as low as 122 dB re 1 μPa by ceasing their feeding behaviors and moving away from the noise source. Watkins and Scheville (1975) observed sperm whales cease vocalization behaviors in the presence of underwater anthropogenic sounds at frequencies between 6 and 13 kHz. Anthropogenic underwater noises as low as 180 dB re 1 μPa can elicit startle reactions and avoidance behaviors in sperm whales and gray whales (Malme et al. 1984; Andre et al. 1997). Malme et al. (1984) also observed behavioral reactions (avoidance) in gray whales in response to received levels of around 164 dB re 1 μPa at 1 m (3 ft); and Richardson et al. (1995) reported that individual gray whales that reacted to noise generally slowed, turned away from the noise source, and increased their respiration rates. Humpback whales off the western coast of Australia changed course at 3 to 6 km (1.9 to 3.7 mi) from an operating seismic survey vessel, with most animals maintaining a distance of 3 to 4 km (1.9 to 2.5 mi) from the vessel. Humpback whale groups containing females involved in resting behavior were more sensitive than migrating animals and showed an avoidance response estimated at 7 to 12 km (4.3 to 7.5 mi) from a large seismic source (McCauley et al. 2000).

As discussed for the GOM (Section 4.4.7.1.1), it is assumed that BOEM will continue to require ramp-up of seismic activities coupled with visual monitoring and clearance within an exclusion zone around a seismic array. These actions would reduce the potential for cetaceans to be exposed to sound levels that could affect hearing or behavior. The avoidance reactions of whales to approaching seismic vessels would normally prevent exposure to potentially injurious noise pulses (NMFS 2001b). The geographic scale of any potential noise effect is probably relatively small compared to the total habitat used by whales in the Chukchi and Beaufort Seas (MMS 2004c). For example, in the Chukchi Sea, fall migrating bowhead whales are commonly seen from the coast to about 150 km (93 mi) offshore (MMS 2004c), while fall migration in the Beaufort Sea occurs over a 100 km (62 mi) wide corridor (Malme et al. 1989).

Pinnipeds in close proximity to sources of seismic noise may experience intense sound pressure levels that could cause temporary hearing loss by masking ambient noise levels, causing damage to hearing structures and body tissues (Richardson et al. 1995). Generally seals move away from seismic vessels, although some are observed swimming in the bubbles generated by large seismic air gun arrays (MMS 2003e).

Walrus hearing has been reviewed in the Pacific Walrus Status Review (Garlich Miller et al. 2011). If exposed to seismic surveys, some walruses may be temporarily displaced or may even experience temporary threshold shifts in hearing. Seismic surveys occur in open water where walruses may be feeding or passing through but are less likely to be present in large numbers (USFWS 2008; BOEMRE 2010e).

Noises associated with seismic surveys are less likely to harm fissipeds than cetaceans (MMS 2007d). It is unlikely that polar bears are affected by seismic noise in water, as they swim with their heads above water, reducing the risk of hearing damage. In contrast, on-ice seismic work during the winter is more apt to disturb polar bears. Females with cubs will abandon den sites when a seismic crew is operating nearby (Amstrup 1993; Linnell et al. 2000). Premature den abandonment could lead to an increase in cub mortality. Polar bears may not be very sensitive to noise (Richardson 1995 in Richardson et al. 1995), but bears in the vicinity of a seismic survey may leave the area. Female bears excavate dens in snow on drifting pack ice and on land. Pregnant females and females with newborn cubs in maternity dens are sensitive to noise and may be disturbed by seismic exploration, and have been reported to abandon den sites when seismic crews are operating nearby (Amstrup 1993). Such abandonment of a maternity den, even if short-term, could reduce cub survival. In addition, polar bears encountered along seismic survey lines may be killed in defense of life and property, although regulatory agencies and the oil and gas industry have made serious efforts to minimize interactions with polar bears (NRC 2003a). However, companies are required to search for dens prior to the onset of work and are also required to maintain a 1-mile buffer around the dens, which, so far, appears to be an effective mitigation measure.

For more information on potential effects to marine mammals from seismic exploration, see the MMS Programmatic Environmental Assessment for Arctic Ocean Outer Continental Shelf Seismic Surveys (MMS 2006c). In summary, seismic noise can alter ambient noise levels, damage marine mammal hearing structures, and cause direct physical injury to marine mammals. Potential effects caused by these stressors include:

- Temporary increased susceptibility to injury, mortality, or predation due to noise masking (e.g., communication, predator avoidance);

- Temporary disturbance of normal behavior;

- Temporary avoidance of habitat;

- Increased susceptibility to injury, mortality, or predation due to hearing loss; and

- Reduced survival due to physical injury.

Construction of Offshore Platforms and Pipelines. As part of the proposed action, 6 to 16 exploration wells and 40 to 120 production wells will be drilled in the Beaufort Sea, while 1 to 20 exploration wells and 60 to 280 production wells will be drilled in the Chukchi Sea. There will also be 1 to 4 platforms in the Beaufort Sea and 1 to 5 platforms in the Chukchi Sea. Additional offshore activities planned as part of the proposed action include 10 subsea production wells and 48 to 217 km (30 to 135 mi) of new offshore pipeline in the Beaufort Sea, and between 18 and 82 subsea production wells and 40 to 402 km (25 to 250 mi) of new offshore pipeline in the Chukchi Sea (Table 4.4.1-4).

Noise and human activity associated with construction of offshore facilities and pipelines could disturb marine mammals that may be present in the vicinity of the construction site. Construction activities could disturb normal behaviors (e.g., feeding, social interactions), mask calls from conspecifics, disrupt echolocation capabilities, and mask sounds generated by predators or prey. Generally, the immediate response of disturbed individuals is to leave or avoid the construction area. From a behavioral perspective, increased anthropogenic noise could interfere with communication among cetaceans, such as gray, minke, beluga, and killer whales and harbor porpoise, mask important natural and conspecific sounds, or alter natural behaviors (i.e., displacement from migration routes or feeding areas, disruption of feeding or nursing). Behavioral impacts appear to be affected by the animal's sex and reproductive status, age, accumulated hearing damage, type of activity engaged in at the time, group size, and/or whether the animal has heard the sound previously (e.g., Olesiuk et al. 1995; Richardson et al. 1995a; Kraus et al. 1997; National Research Council 2003a, 2005a). Toothed whales can be particularly sensitive to high-frequency sounds given their use of high-frequency sound pulses in echolocation, and moderately high-frequency calls for communication. Baleen whales, a group including gray and minke whales, are similarly sensitive to the low frequency noise that is often characteristic of construction, machinery operation, vessel noise, and aircraft noise. Bowhead whales stop feeding and move from within 0.8 km (0.5 mi) of experimental dredge sounds to more than 2 km (1.2 mi) away (MMS 2002a). In addition, some individuals may habituate to dredging and other construction activities (MMS 2002a). Because some marine mammal species exhibit seasonal changes in distribution and are absent or infrequent in the Beaufort and Chukchi Sea Planning Areas in winter, winter construction of offshore platforms would affect relatively few animals. In spring and summer, species present in construction area would be expected to leave the area to other habitats. Displacement could be of short- or long-term duration and could affect survival of young if adults abandon young or are displaced from important foraging areas as well as adults if they are kept from their feeding areas for a long period of time. The construction of new infrastructure in polar bear habitat has the potential to adversely impact these animals through disturbance and displacement.

To date, documented impacts to polar bears in Alaska by oil and gas development activities are few. The potential for adverse impacts is largely associated with increases in industrial activity or expansion of industrial footprints, as well as related increases in human/polar bear interactions. Minimal impacts could result from the potential increase in human/polar bear interactions associated with expanding the onshore facility, installing the offshore and onshore pipelines, and extending the production timeframe within the action area. The FWS and USGS have predicted that polar bears may be extirpated throughout much of their range within the next 40 to 75 yr if current trends in sea ice reduction continue (73 FR 28212 [15 May 2008]). Nonetheless, impacts to bears as a direct result of routine, OCS-related oil and gas activities appear to be minimal.

Any activity causing noise reaching 160 re 1 μPa would risk level B harassment take of whales, and require a take authorization under the MMPA. Additional mitigation measures required to avoid significant adverse impacts would be required by later BOEM and NMFS review processes. Detailed analysis of potential Exploration Plans and Development & Production Plans, along with mitigation measures incorporated into any necessary Incidental Take Authorizations (ITA), would further reduce the potential for any significant adverse impacts. Overall, while development activities may impact whales through masking and avoidance, significant impacts are not expected. Such effects would likely be limited to individuals or small groups, be limited in duration to the construction period, and be sublethal.

Pipeline trenching may also disrupt mammal species (e.g., Pacific walrus, gray whale, bowhead whale). Despite the long, linear nature of pipelines, their construction is a slow-moving, relatively stationary operation. Thus, pipeline construction represents a temporary and avoidable source of disturbance. The extent to which benthic food sources are affected and the subsequent impact to marine mammals depend on the type and amount of benthic habitat that would be permanently disturbed by trenching, the importance of the specific habitats in providing food resources to marine mammals, and the marine mammal species and numbers of individuals that could be affected.

Pipeline construction could cross barrier island and nearshore coastal habitats. Polar bears may be temporarily displaced, or their behavior modified (e.g., by changing direction or speed of travel), by construction activities. As explained in a recent biological opinion, "disturbance from stationary activities could elicit several different responses in polar bears. Noise may act as a deterrent to bears entering the area, or conversely, it could attract bears. Bears attracted to development facilities may result in human–bear encounters, leading to unintentional harassment, or intentional hazing of the bear" (USFWS 2009). Mitigation measures (such as implementation of a human-bear conflict management plan) generally required under MMPA Incidental Take Authorizations (typically a Letter of Authorization) would reduce the potential for these impacts. Any adverse impacts would be localized and negligible.

Because no more than 13.5 ha (33.4 ac) of bottom area would be disturbed by platform construction and no more than 567 ha (1,401 ac) of bottom area would be disturbed by pipeline construction under the proposed action (Table 4.4.1-4), relatively little benthic habitat would be disturbed compared to that present in the Beaufort and Chukchi Sea Planning Areas. Natural recovery of the disturbed benthic habitats would occur within 3 to 10 yr of initial disturbance (Section 4.4.6.2.3). Pipeline trenching is expected to have a limited effect on the overall availability of food sources for marine mammals. Impacts to marine mammal food sources would be localized and would not result in population-level impacts. To avoid or minimize adverse impacts, relevant organizations (i.e., project proponents, BOEMRE, NMFS) will need to develop timing guidelines and operational protocols to govern the specifics of this project. This review would take place at a later stage of review, when more site-specific information would be known.

<u>Construction of Onshore Pipelines.</u> Under the proposed action, 16 to 129 km (10 to 80 mi) of new pipelines onshore of the Beaufort Sea will occur, causing up to 584 ha (1,443 ac) of soil disturbance (Table 4.4.1-4). No other onshore construction will occur under the proposed action (Section 4.4.1.3). Onshore construction activities would not affect most of the marine mammals in the Arctic region because these species typically occur in offshore open-water habitats and ice floes and along pack ice away from coastal areas where construction might occur. Individuals that might be present in nearshore waters adjacent to a construction area would leave the area. Onshore pipeline construction has the potential to directly affect pinnipeds and fissipeds and their habitats through impacts associated with direct contact with construction equipment or infrastructure, as well as indirect impacts associated with perceived habitat loss. Most pinnipeds and fissipeds are alert and mobile enough to be able to avoid areas where construction is occurring. Juveniles are smaller and less mobile than adults; therefore, human disturbances associated with construction activities may have a greater effect on younger pinniped and fissiped individuals.

The activities associated with onshore construction may also indirectly affect pinniped and fissiped species by reducing habitat quality, and thereby affecting the distribution of the species. Pinnipeds and fissipeds may avoid certain areas of human disturbance. Polar bears may be affected by oil and gas development by abandoning dens in close proximity to onshore disturbances, which may lead to range conflicts with other polar bears or greater cub mortality (Amstrup 1993; Linnell 2000). However, there is evidence that some species or individuals of pinnipeds and fissipeds may be capable of habituating to moderate levels of oil and gas exploration and development activities (Moulton et al. 2003; Blackwell et al. 2004; Smith et al. 2007).

The spotted seal, Pacific walrus, and polar bear are the three species of marine mammals in the Beaufort and Chukchi Sea Planning Areas likely to occur in coastal habitats, and therefore to be affected by onshore construction. The spotted seal uses coastal habitats such as beaches and river delta sandbars for sunning and resting, while the polar bear forages along shore ice locations, and may have onshore maternity dens located as much as 8 to 10 km (5 to 6 mi) inland of the coast (Section 3.6.4.2.1). Walrus also haul out in large numbers along the Chukchi Sea Coast and beluga use the near shore areas, such as Kaseguluk Lagoon, in the spring. Foraging bears and resting seals would probably leave or avoid areas where onshore construction is occurring. If an active maternity den is present at or near the construction site, construction may cause the female to abandon the den and her cubs, potentially decreasing cub survival (Linnell et al. 2000); however, there is evidence that denning polar bears can become tolerant of low levels of human activity (Amstrup 1993). This was also recently seen (2011) when a sow with cubs denned on Spy Island next to an offshore facility. As only a small number of individuals of either species might be disturbed, no population-level effects are expected.

Given the small amount of onshore construction that could occur under the proposed action, it is unlikely that onshore construction would have long-term impacts to pinniped and fissiped populations. Onshore construction activities would be sited to avoid areas of known sensitive habitats (e.g., polar bear dens), minimizing the potential for affecting pinniped and fissiped populations.

Operations of Offshore and Onshore Facilities. Noise associated with OCS drilling and production is of relatively low frequency, typically between 4.5 and 30 Hz (Richardson et al. 1995). Potential effects on marine mammals may include disturbance (e.g., changes in behavior, short- or long-term displacement) and masking of calls from conspecifics or other natural sounds (e.g., surf, predators).

Because odontocetes use sounds at frequencies that are generally higher than the dominant sounds generated by offshore drilling and production activities, they may not be sensitive to or affected by these sounds. In contrast, mysticetes (the minke, gray, humpback, fin and bowhead whales) are considered to have good low-frequency hearing and exhibit vocalizations at low frequencies, and thus may be affected by drilling and production noise. Effects would be similar to those identified for exploration and construction activities, namely, behavioral disruption and avoidance of or displacement from the immediate vicinity of the operating facility. For example, bowhead whales have been observed to deflect from their migratory path by 20 km (12 mi) or more in response to drilling noises (MMS 2002a). However, bowhead whales tolerate high levels of continuous drilling noise when necessary to continue with migration (MMS 2002a).

Avoidance or displacement can be of short- or long-term duration, depending on whether or not affected individuals may become acclimated to the operational activities. Because affected individuals would most likely leave the area for other appropriate habitats, neither behavioral disturbance nor the displacement of individuals by normal operations would be expected to result in long-term effects to either individuals or populations. The presence of an operating onshore facility could reduce the suitability of some areas for use by denning female polar bears, while normal operations of offshore facilities could decrease the suitability of offshore areas as pinniped foraging or pup-rearing habitats. Exposure events that elicit a response also may induce stress and further energy expenditure. The frequency that an individual is exposed and reacts to noise levels throughout a given season or lifetime can reach thresholds whereby individual health or reproductive performance could be adversely affected.

Under the Final Rule designating critical habitat for polar bears, terrestrial denning habitat (Critical Habitat Unit 2) was not designated along the U.S. Chukchi Sea coastline (75 FR 76086 [Dec. 7, 2010]). In the Bering and Chukchi Seas, the majority of dens that have been documented occur on Wrangel and Herald islands, and on the Chukotka Peninsula in Russia. In recent years, sea ice formation along the coastline is occurring later in winter, which may preclude access to coastal denning areas along the U.S. Chukchi Sea coastline. While the USFWS has determined that the coastlines of the Chukchi and Bering Seas are not critical habitat, some dens may occur along the coast. Disturbance at den sites from construction or other human activities could result in a female with cubs abandoning the den site, resulting in death from hypothermia or predation to the cubs. Should construction activities be proposed near an active den, mitigation measures (such as den detection and avoidance) generally required under the Letter of Authorization would reduce the potential for these impacts. The raised onshore pipeline would not pose a physical barrier to polar bear movement, and once away from the coast, would not be in polar bear habitat.

Discharges and Wastes. Table 4.4.1-4 presents information on drilling fluids, drill cuttings, and produced waters discharged offshore as a result of the proposed action in the Beaufort and Chukchi Seas. Figure 4.4.7-4 (Section 4.4.7.1.1) presents a conceptual model for potential effects of operational waste discharges on marine mammals. Produced water, drilling muds, and drill cuttings will be discharged into offshore marine waters in compliance with applicable regulations and permits. Compliance with regulations and permits will limit the exposure of marine mammals to waste discharges. In some cases, drilling muds may be recycled and not discharged and cuttings may be transported offsite.

Up to 500 bbl of drill fluids and 600 tons of drill cuttings will be discharged at each exploration and delineation well (Table 4.4.1-4). Heavier components of these muds and cuttings (such as rock) would settle to the bottom, while lighter components could increase turbidity around the drill site. While this increased turbidity could cause marine mammals to avoid the area, any increase in suspended solids associated with the discharge of drilling wastes would be rapidly diluted and dispersed, and thus not be expected to adversely affect marine mammals in the area. Drilling fluids and cuttings associated with development and production wells would be treated and disposed of in the wells; therefore, negligible impacts to marine mammals from these wastes are expected.

Some marine mammals may be exposed to waste fluids (such as bilge water) generated by and discharged from OCS vessels. Discharges of such wastes from OCS service and construction vessels, if allowed, would be regulated under applicable NPDES permits and would also be rapidly diluted and dispersed. Sanitary and domestic wastes would be processed through shipboard waste treatment facilities before being discharged overboard, and deck drainage would also be processed shipboard to remove oil before being discharged. Thus, permitted waste discharges from OCS service and construction vessels would not affect marine mammals.

Ingestion or entanglement with solid debris can adversely impact marine mammals (Marine Mammal Commission 2004). Mammals that have ingested debris, such as plastic, may experience intestinal blockage which, in turn, may lead to starvation, while toxic substances present in the ingested materials (especially in plastics) could lead to a variety of lethal and sublethal toxic effects. Entanglement in plastic debris can result in reduced mobility, starvation, exhaustion, drowning, and constriction of, and subsequent damage to, limbs caused by tightening of the entangling material. The discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by the BOEM (30 CFR 250.40) and the USCG (MARPOL, Annex V, Public Law 100-220 [101 Statute 1458]). Thus, entanglement in or ingestion of OCS-related trash and debris by marine mammals would not be expected under the proposed action during normal operations.

Vessel and Aircraft Traffic. There would be up to 12 surface vessels and 12 helicopter trips per week in the Beaufort Sea and up to 15 surface vessels and 15 helicopter trips per week in the Chukchi Sea under the proposed action (Table 4.4.1-4). The majority of vessel traffic in the Beaufort and Chukchi Seas primarily occurs during summer, at which time it could contribute to ambient noise and potential disturbance to marine mammals (MMS 2002a). Which species could be affected by vessel and aircraft traffic, the nature of their response, and the potential consequences of the disturbance, will be a function of a variety of factors, including the specific routes, the number of trips per day, the altitude of the aircraft overflights, the seasonal habitats along the routes, the species using the habitats and the level of their use, and the sensitivity of the mammals to vessel and aircraft traffic. Traffic over heavily used feeding or calving habitats could result in population-level effects for some species, while impacts from traffic over other areas with less sensitive species would likely be limited to a few individuals and not result in population-level effects.

Marine mammals may be affected by this traffic either by disturbance from passing vessels or helicopters or by direct collisions with vessels. Among the cetaceans, the beluga, gray, and bowhead whales are the most abundant in the Beaufort and Chukchi Sea Planning Areas. Thus, these species have the potential to encounter OCS-related vessels. The other cetaceans are present in relatively low numbers (e.g., less than 2,000 throughout the entire planning area), and thus are less likely to encounter OCS-related vessels. During their spring migration (April through June), bowhead whales would likely encounter few, if any, vessels along their migration route, as NMFS (in their IHAs) and FWS (in their LOAs) restrict access to the Chukchi Sea to protect animals in the spring lead system.

Bowheads react to the approach of vessels at greater distances than they react to most other industrial activities. According to Richardson and Malme (1993), most bowheads begin to swim rapidly away when vessels approach rapidly and directly. This avoidance may be related to the historic commercial and continuing subsistence hunting. Avoidance usually begins when a rapidly approaching vessel is 1–4 km (0.62–2.5 mi) away. A few whales may react at distances from 5–7 km (3–4 mi), and a few whales may not react until the vessel is <1 km (<0.62 mi) away. Received noise levels as low as 84 dB re 1 μPa (decibels relative to one micropascal) or 6 dB above ambient may result in strong avoidance of an approaching vessel at a distance of 4 km (2.5 mi) (Richardson and Malme 1993). Vessel disturbance has been known to disrupt activities and social groups. Fleeing from a vessel generally stopped within minutes after the vessel passed, but scattering may persist for a longer period. Parks et al. (2011) note for North Atlantic right whales (a species similar to bowhead whales) and Holt and Noren (2008) note for killer whales that individuals modified calls in response to increased background and vessel noise, respectively, by increasing the amplitude of their calls. McDonald, Hildebrand, and Mesnick (2009), however, noted the decline in blue whale song tonal frequencies was not fully explained by the hypothesis of increasing ocean noise. But these authors suggest that post whaling population increase is altering sexually selected trade-offs for singing males between song intensity (ability to be heard at a greater distance) and song frequency (ability to produce songs of lower pitch).

Where vessels approach slowly or indirectly, bowheads are much more tolerant, and reactions are generally less dramatic. The encounter rate of bowhead, humpback, and fin whales with vessels associated with natural gas development would depend on the location of the platform in relation to both shipping routes and areas of heavy use. During their spring migration (April through June), bowheads likely would encounter few, if any, vessels along their migration route, because ice at this time of year typically would be too thick for supply vessels to operate in. Bowheads, as with other "right whales" (family Balaenidae), are among the slowest moving of whales, which may make them particularly susceptible to ship strikes. Despite their likely greatest susceptibility to vessel strikes, records of strikes on bowheads are rare compared with records of strikes on some other large whales (Laist et al. 2001). About 1% of the bowhead whales taken by Alaskan Iñupiat bore scars from ship strikes (George et al. 1994). Until recently, few large ships have passed through most of the Western Arctic bowhead's range but this situation is changing and the potential for increasing opportunity for vessel strikes may be increasing as northern sea routes become more navigable with the decline in sea ice. At present, bowheads, humpback, and fin whales probably would adjust their individual swimming paths to avoid approaching within several kilometers of vessels attending the production platform, and would also move away from vessels that approached them within a few kilometers (Richardson et al. 1995).

Worldwide, at least 11 species of cetaceans have been documented as being hit by ships (Laist et al. 2001; Jensen and Silber 2003). In most cases, the whales are not seen beforehand or are seen too late to avoid collision. Most lethal or severe injuries involve ships traveling ≥14 knots (26 km/hr or 16 mph) or faster, and collisions with vessels greater than 80 m (262 ft) in length are usually either lethal or result in severe injuries (Laist et al. 2001). Most seismic vessels typically operate around 4–5 knots. Gray whale use of shallow coastal habitat during migration makes ship strikes a potential source of mortality. Only one ship strike mortality has been reported in Alaska when a killer whale hit the prop during a groundfish trawl in the Bering Sea (MMS 2008b; Allen and Angliss 2011), however, to-date, there have been no vessel strikes reported in the Arctic. Although, harvested bowhead whales have had scarring, indicating they had been hit by the prop of a ship (Rosa 2008). Pinnipeds may also be struck by vessels. There is a possible, but unlikely, potential for polar bears to be struck by vessels (MMS 2009a).

In addition to possible collision-related injuries, cetaceans may be disturbed by the observation of the vessel and the noise it generates. Disturbed individuals would be expected to cease their normal behaviors and likely move away from the vessel. Following passage of the vessel, affected individuals may return and resume normal behaviors. However, if vessel traffic occurs along a consistent route, some species may permanently leave the area. If the abandoned areas represent important feeding or calving areas, physical condition and reproductive success may be adversely affected. Of 236 bowhead whales examined between 1976 and 1992, only three ship-strike injuries were documented, indicating that they do not often encounter vessels, avoid interactions with vessels, or that interactions usually result in the death of the animals (Shelden and Rugh 1995; Rosa 2008). Current rates of vessel strikes of bowheads are low, and there are no known fin or humpback strikes in the Alaskan Arctic (BOEMRE 2010e). Bowhead whales do not seem to react to aircraft overflights at altitudes above 300 m (984 ft). Most bowheads do not deflect more than a few kilometers from a single noise disturbance, and behavioral responses last only a few minutes. Most reactions include a change in migration speed and swimming direction to avoid the sound source (Richardson et al. 1991). Bowhead whales typically avoid vessels at distances ranging from 1 to 4 km (0.6 to 2.5 mi); drilling noise may deflect individuals 20 km (12.4 mi) or more from their migratory paths. Schick and Urban (2000) suggest that the spatial pattern of bowhead distribution is highly correlated with distance from drilling rigs, and the presence of drilling rigs results in a temporary loss of available habitat. Miles et al. (1987) suggest icebreakers pushing ice would cause half of the bowheads within 4.6 to 20 km (2.9 to 12.4 mi) of the source to demonstrate an avoidance behavior. Beluga whales are also known to avoid ice breakers by long distances (Erbe 1997, 2000; Cosens 2003).

Fixed wing aircraft may serve as whale spotters during pipeline route surveys or pipeline installation activities in the nearshore areas. The use of spotter aircraft could be an important mitigation technique that would reduce the overall potential for gas development to cause adverse impacts to whales. Helicopters are likely to be used to transport crews and supplies in support of modification of the production platform for gas development. Aircraft noise may elicit a response, such as a turn or hasty dive, from a whale or group of whales. But given the altitude at which these aircraft are expected to fly, the potential for adverse reactions is small. Any impacts that did occur would be temporary and minor. To avoid potential disturbance effects on marine mammals, aircraft maintain minimum flight altitudes — human safety will take precedence at all times over this recommendation.

Construction- and operation-related noises that have the greatest potential to impact pinnipeds, including those generated from vessel and aircraft traffic. Noises emitted by shipping vessels range between 140 dB re 1 μPa for smaller vessels to 198 dB re 1 μPa for larger tankers and cargo ships (Heathershaw et al. 2001; Erbe 2002; Hildebrand 2004). Helicopters flying at 150 m (492 ft) altitude are expected to emit noises received at ground level of approximately 80 to 86 dB re 20 μPa (Born et al. 1999). These noises may impact nearby pinniped species, which typically have in-air hearing thresholds between 20 to 80 dB and underwater hearing thresholds between 60 to 120 dB (Kastak and Schusterman 1998; NRC 2005). Noises associated with approaching vessels and helicopters may cause hauled out pinnipeds to flee to aquatic habitats. Fay et al. (1984) observed Pacific walruses diving into the water from pack ice when approached by a helicopter within 400 to 600 m (1,300 to 1,968 ft) upwind and 1,000 to 1,800 m (3,280 to 5,905 ft) downwind. Ringed, spotted, and bearded seals have also been known to avoid approaching vessels by fleeing from haul out sites into the water (Frost et al. 1993; Born et al. 1999; Burns and Frost 1999; COSEWIC 2003). During pinniped flight reactions, young pups could be trampled or become isolated from their mothers, leading to injury or making them more susceptible to predators. Despite this, there is evidence that pinnipeds may habituate to moderate levels of human activity (Moulton et al. 2003; Blackwell et al. 2004); therefore, the impacts to pinnipeds from operational noises are expected to be either negligible or minor depending on the species affected.

Vessel traffic may disturb pinnipeds in the water and hauled out on ice or terrestrial habitats. Hauled out pinnipeds may exhibit behavioral reactions to the physical disturbance of an approaching vessel or aircraft (sometimes >1 km [0.6 mi] away) by exhibiting startle reactions, escaping the immediate area into the water. Project aircraft has the greatest potential to adversely affect pinnipeds haul out and rookery sites (Frost et al. 1993), where disturbed adults may temporarily cease normal behaviors (such as feeding of young), leave the rookery site, and thereby increase predation risks of unattended pups, or risk of trampling while adults are fleeing. However, pinnipeds may habituate to the presence of project vessels (Moulton et al. 2003;

Blackwell et al. 2004), and the escape reactions of hauled out pinnipeds may be minimized over time. At times, many of these species, such as seals, are attracted to moving vessels. Pinnipeds could be injured or killed by ship collisions.

Vessel traffic associated with icebreaking activities in the Alaskan OCS may alter the behaviors of walruses at greater distances (sometimes >2 km [1.2 mi] away) than ordinary ship traffic (Fay et al. 1984). In response to icebreaking vessels, female and young walruses typically react more than males do. Hauled out females and young typically responded to approaching icebreaking vessels by fleeing into the water at distances of 0.5 to 1 km (0.3 to 0.6 mi); males responded by entering the water at distances of 0.1 to 0.3 km (0.06 to 0.2 mi) (Brueggeman et al. 1991; Johnson et al. 1988).

Vessel and aircraft traffic may disturb fissipeds in aquatic and terrestrial habitats. It is unlikely for polar bears to be directly impacted by vessel collisions; instead, impacts to polar bears from vessel and aircraft traffic may occur from the physical disturbance associated with such activities. Fissipeds are generally considered to be more tolerant than other marine mammals to noises associated with the construction of offshore oil and gas platforms (MMS 2007d). However, construction-related noises may still affect fissiped populations. Vessel, terrestrial vehicle, and aircraft activities can affect polar bear behavior. Vessel traffic associated with natural gas development activity is not expected to cause impacts to polar bears, because they show little reaction to vessels and generally do not linger in open water where vessels are more likely to travel. As explained in a Biological Opinion (USFWS 2009), "During the open-water season, most polar bears remain offshore on the pack ice. Barges and vessels transporting materials for construction and on-going operations of facilities usually travel in open-water and avoid large ice floes. Therefore, there is some spatial separation between vessels and polar bears." If there is an encounter between a vessel and a bear, it would most likely result in short-term behavioral disturbance only. Polar bear responses to vessels are brief, and generally include walking toward, stopping and watching, and walking/swimming away from the vessel.

Polar bears typically flee from low flying aircraft that are at an altitude of <200 m (656 ft) and a lateral distance of <400 m (1,312 ft) (Shideler 1993). Extensive or repeated overflights by helicopters travelling to and from offshore facilities could disturb polar bears. Polar bears have been known to run from other sources of noise and the sight of aircraft, especially helicopters. According to a Biological Opinion (USFWS 2009), "Behavioral reactions of polar bears would likely be limited to short-term changes in behavior and have no long-term impact on individuals. In addition, [BOEMRE] requires these types of flights to operate at an altitude of >1,500 ft AGL where possible, which would significantly reduce disturbance." It is expected that flight altitude requirements will minimize disturbances and that adverse impacts from this activity will be temporary and minimal.

The effects of air traffic on pinnipeds in the action area are expected to be localized and transient. Some seals may be disturbed on the ice or at haulouts on land and enter the water, although their responses may be highly variable and brief in nature (Born et al. 1999; Boveng et al. 2008, 2009; Burns and Harbo 1972; Cameron et al. 2010; Kelly et al. 2010). Mitigation measures prohibiting aircraft overflights below 457 m (1,500 ft) will lessen aircraft impacts to these pinnipeds. Results from studies of an existing facility (specifically, the Northstar development) are roughly analogous to what is contemplated under the present natural gas development scenario and suggest that any adverse impacts to phocids would be minor, short-term, and localized, with no measurable consequences to seal populations.

Pacific walrus are particularly vulnerable to disturbance events given their tendency to aggregate in large groups. Reactions to disturbances when on ice are highly variable (Richardson et al. 1995a). Reactions at group haulouts (on land) are more consistent; walrus will flee haulout locations in response to disturbance from aircraft and ship traffic, though walrus in the water are thought to be more tolerant. Females with dependent young are considered the least tolerant of disturbances. Walrus are particularly sensitive to helicopters and changes in engine noise, and are more likely to stampede when aircraft turn or bank overhead. Disturbances caused by vessel and air traffic may cause walrus groups to abandon land or ice haulouts. Severe disturbance events could result in trampling injuries or cow-calf separations, both of which are potentially fatal. But while adverse impacts can be severe, they are also to a large extent avoidable. The USFWS has concluded that a minimum altitude of 1000 ft ASL is sufficient in sea ice habitats (see p. 24 of the USFWS Chukchi Sea EA, 2008) with a 0.5-mi (80-m) horizontal buffer. BOEMRE has taken the more precautionary approach of a 1-mi horizontal buffer and 1500-ft AGL or ASL based in part on industry data and on unpublished ADFG and USFWS haulout monitoring data. While BOEMRE does not regulate air space within the project area, direct overflights of terrestrial or sea ice walrus haulouts by industry are strongly discouraged. Typical mitigation measures include flight corridors, a minimum of 1 to 2 mi inland and directly from shore to the exploration site, while maintaining a minimum of 1 horizontal mi from groups of walrus hauled out on ice or land. Overall, the potential for adverse impacts to individuals or groups of walrus do exist, but the probability is minimal in light of mitigation techniques, such as minimum altitude requirements for aircraft. Impacts to walrus are expected to be minor.

<u>Decommissioning.</u> Under the proposed action, no platforms will be removed with explosives from the Beaufort and Chukchi Sea Planning Areas. Therefore, potential impacts of decommissioning on marine mammals, as summarized in Figure 4.4.7-4 (Section 4.4.7.1.1), will not occur.

Accidents. Accidental oil spills could occur in the Beaufort and Chukchi Sea Planning Areas under the proposed action (Section 4.4.2). Table 4.4.2-1 presents the oil spill assumptions for the proposed action; while Figure 4.4.7-5 (Section 4.4.7.1.1) presents a conceptual model for potential effects of oil spills on marine mammals. Small oil spills (≤1,000 bbl) break up and dissipate within hours to a day (MMS 2009a). Large spills, particularly those that continue to flow for extended periods (i.e., days, weeks, or months), pose an increased likelihood of impacting marine mammal populations (MMS 2008b). Operational discharges such as tank washing with seawater, oil content in ballast water, and fuel oil sludge are among the sources of small oil spills from tankers (Jernelöv 2010). Large oil spills from tankers have decreased significantly in recent years while spills from ageing, ill-maintained, or sabotaged pipelines have increased.

Oil spills could affect marine mammals in a number of ways, and the magnitude and severity of potential impacts would depend on the location and size of the spill, the type of product spilled, weather conditions, the water quality and environmental conditions at the time of the spill, and the species and habitats exposed to the spill. Marine mammals may be exposed to spilled oil by direct contact, inhalation, and ingestion (directly, or indirectly through the consumption of contaminated prey species). Such exposures may result in a variety of lethal and sublethal effects (Geraci 1990).

Fresh crude oil releases toxic vapors that when inhaled may irritate or damage respiratory membranes, congest lungs, and cause pneumonia. Following inhalation, volatile hydrocarbons may be absorbed into the bloodstream and accumulate in the brain and liver, leading to neurological disorders and liver damage (Geraci and St. Aubin 1982; Geraci 1990). Toxic vapor concentrations may occur just above the surface of a fresh oil spill, and thus be available for inhalation by surfacing cetaceans. Inhalation would be a threat only during the first few hours after a spill (Hayes et al. 1992; ADNR 1999). Prolonged exposure to freshly spilled oil could kill some whales (including bowheads, pinnipeds, and polar bear), but the numbers would be small due to a low chance of such contact. This would most likely occur if oil spilled into a lead that bowhead whales could not escape (MMS 2001).

Direct contact of oil may irritate, inflame, or damage skin and sensitive tissues (such as eyes and other mucous membranes) (Geraci and St. Aubin 1982). Prolonged contact to petroleum products may reduce food intake; foul baleen on mysticete whales, elicit agitated behavior; alter blood parameters, respiration rates, and gas exchange; and depress nervous functions (Lukina et al. 1996). Under less extreme exposures (lower concentrations or shorter durations), oil does not appear to readily adhere to or be absorbed through cetacean skin, which, due to a thick fat layer, may provide a barrier to the uptake of oil-related aromatic hydrocarbons through the body surface (Geraci and St. Aubin 1982, 1985; Harvey and Dahlheim 1994).

Effects of oil spills would depend on how many whales contacted oil, the duration of contact, and the age/degree of weathering of the spilled oil. The number of whales contacting spilled oil would depend on the size, timing, and duration of the spill; how many whales were near the spill; the whales' inclination or ability to avoid contact; and the effectiveness of cleanup activities (MMS 2001, 2004c). Some displacement of bowhead whales may occur in the event of a large oil spill, and avoidance of the contaminated area may last for several years (MMS 2001; NMFS 2001b). This indicates that bowhead whales may have some ability to detect an oil spill and would avoid surfacing in the oil by detouring away from the spill area (NMFS 2001b). Modeling efforts have indicated that only up to 2% of the Beaufort Sea bowhead whale population would be affected by a large oil spill (NMFS 2001b).

An oil spill into ice leads or polynyas in the spring could have devastating effects, trapping bowhead whales where they may encounter fresh crude oil. Calves would be more vulnerable than adults because they need to surface more often to breathe. Feeding bowhead whales are also sometimes observed aggregating in large numbers during the summer open-water season, when they could also be vulnerable to a spill. Beluga whales, that also use the spring lead system to migrate, would be susceptible to a spill that concentrates in these leads (Nuka Research and Planning Group, LLC and Pearson Consulting, LLC 2010).

Pinnipeds and fissipeds may be exposed while coming ashore onto oiled beaches. In addition, adults and juveniles may also be indirectly affected if an accidental spill reduces the quality or quantity of foraging or breeding habitats. Impacts to calving grounds could result in population-level effects. Fouling of fur of some species (e.g., ringed seal pups, polar bear cubs) could affect thermoregulation and reduce survival of the affected young. Ice seals tend to be solitary and would most likely be exposed to oil at sea or on ice. Walrus and spotted seals would most likely be exposed at sea, on ice, or at coastal haulouts. Polar bears would most likely come into contact with spilled oil at sea, on ice, or on shore.

Oil would affect pinnipeds if it were to directly contact individuals, haulouts, or major prey species. For example, bearded seals and walrus are vulnerable to spilled oil from direct exposure and from the indirect effects through the benthic organisms on which they feed (Cameron and Boveng 2009). Although some adult pinnipeds (e.g., walruses) have thick skin that would protect them from absorption of oil, direct contact with oil would affect sensitive tissue areas, causing irritation to eyes, nasal passages, and lungs. Inhalation of hydrocarbon vapors may damage or irritate lung tissue. These injuries may affect already stressed adults and could lead to some fatalities. While adult ice seals depend on a thick fat layer for insulation, seal pups rely on a dense layer of underfur until they are several weeks old. The fouling of this underfur in young pups could reduce its insulating properties, increasing the potential for hypothermia and increasing pup mortality. While there is no conclusive evidence of past oil spills causing a decline in prey species sufficient to result in a decline in any marine mammal population, there is still the possibility of such an effect occurring. Because pinniped species in the Arctic do not congregate in rookeries, the overall effects of accidental oil spills on pinnipeds will be species-specific.

An oil spill that contacts an aggregation of walruses or displaces them from their haulouts may have a severe impact on the population. Walruses could also be impacted by consuming contaminated molluscs and being exposed to oil residues in sediments. As they have a long life span, they could suffer severe effects from the bioaccumulation of oil-derived contaminants (Nuka Research and Planning Group, LLC and Pearson Consulting, LLC 2010). According to Geraci and St. Aubin (1990), ice seals have the ability to metabolize oil if ingested in low amounts and some researchers believe walrus may share this ability (GarlichMiller, Pers. Comm.).

Accidental oil spills could potentially affect polar bears through contamination of prey or reduction of prey availability, fouling of fur, and oiling of ice. Polar bears are very sensitive to oil contact (Engelhardt 1981). Fouling of fur greatly reduces its ability to insulate, and can result in hypothermia and death. Direct contact with oil or secondary contact with contaminated ice could be fatal. However, in most areas, polar bears occur at low densities; therefore, small numbers of bears would be affected by a single spill. Multiple spills or spills along the ice edge where bear density is greater would potentially increase mortality rate. Ringed seals are the primary prey of polar bears and are, therefore, directly linked to their survival. If seal density is affected by oil spills or cleanup operations, polar bears could experience increased stress and possibly lower survivorship.

Marine mammals may incidentally ingest floating or submerged oil or tar, and may consume oil-contaminated prey (Geraci 1990). Spilled oil may also foul the baleen fibers of mysticete whales, temporarily impairing food-gathering efficiency or resulting in the ingestion of oil or oil-contaminated prey (Geraci and St. Aubin 1987). Ingested oil can remain within the gastrointestinal tract and be absorbed into the bloodstream, thus irritating and/or destroying epithelial cells in the stomach and intestine. Oil ingested during grooming of fouled fur has been reported to result in liver and kidney damage in polar bears and ringed seals (NRC 2003a; Oritsland et al. 1981). It should be noted that ringed seals and likely other ice seals can detoxify their bodies by renal and bilary pathways. Further, seals do not typically orally groom themselves and are therefore less likely to ingest toxins in that way (Kooyman et al. 1976; Geraci and Smith 1976).

An accidental oil spill may result in the localized reduction, extirpation, or contamination of prey species. Invertebrate and vertebrate species (such as zooplankton, crustaceans, mollusks, and fishes) may become contaminated and subsequently expose marine mammals that feed on these species.

Depending on their habitat preferences, feeding styles, and migration patterns, some species may be more vulnerable to exposure than other species. Spills occurring in spring may affect a greater number of individuals due to animals congregating during migration. Spills occurring in or reaching coastal areas, especially sheltered coastal habitats such as bays and estuaries, would be more likely to affect species such as the beluga whale and spotted seal that use coastal habitats for calving and resting. Bowheads are most sensitive to oil contamination during the spring migration when calves are present and their movements are restricted to open leads in the ice (MMS 2002a).

Polar bears may be directly affected by an oil spill, since they spend the majority of their time on ice, through oiling of fur, ingestion of oil from grooming, or by feeding on oiled prey or carcasses. Large oil spills could have a significant impact on polar bear habitat and can result in food chain effects. Spills associated with onshore facilities (and especially any onshore pipelines) would potentially affect polar bears. While it is unlikely that a bear would be directly exposed to an accidental pipeline release, bears could be affected by feeding on contaminated prey. However, because of the relatively low density of bears in the Arctic region, no more than a few individuals would be expected to be affected by an onshore release. Onshore spills that enter a stream system may be carried to coastal areas, where other marine mammals may be exposed.

Because benthic organisms (such as crustaceans and mollusks) accumulate oil compounds more readily and to higher levels than pelagic biota, the potential for ingesting oil-contaminated prey is highest for benthic feeding species, such as the gray whale, less so for zooplankton-feeding cetaceans, and least for fish-eating cetaceans (Würsig 1990). Similar differences in exposure via food ingestion may be expected among benthic and fish-eating pinnipeds (i.e., Pacific walrus, spotted seals). Species with a dependence on or preference for offshore areas or habitats for feeding, shelter, or reproduction would be more likely to be affected by a spill than would other marine mammals (Würsig 1990).

Spills occurring in winter may accumulate and may be incorporated into the ice matrix and move with the ice pack. In spring, this oil may be released into ice leads that are used by migrating whales (such as beluga and bowhead whales) and by pinnipeds that use these areas, resulting in the exposure of relatively large numbers of individuals. Spills under ice or associated with leads may affect haulout sites, causing either abandonment or repeated exposure through use of the contaminated haulout. Because some species are relatively restricted to open-water areas associated with ice, individuals may not be able to disperse from spills in these areas, and thus may incur increased exposures. Because polar bears are closely associated with ice edges, spills accumulating along these areas may expose the greatest number of bears to an offshore spill. An oil spill in areas where polar bears congregate (e.g., leads or polynyas and beachcast marine mammal carcasses) could have negative population effects.

Marine mammals that frequently groom, such as polar bears, would be most likely to ingest oil. Feeding on contaminated prey or carcasses also causes ingestion of oil (Fair and Becker 2000). With the exception of bearded seals who may enter the water within hours of being born, newborn seals are more sensitive to oil than adult seals, as they have little fat and rely on a dense layer of fur (lanugo). Loss of this waterproofing by oil could cause hypothermia and death (Fair and Becker 2000).

The magnitude and extent of any adverse effects will also depend on how quickly a spill is contained and how quickly and effectively cleanup is accomplished (USFWS 2004). Arctic conditions (i.e., sea ice, wind, temperature, limited visibility, and sea state) can potentially impact oil spill responses. Other than high sea state (choppy waves), which can enhance the effectiveness of chemical dispersants, most extremes in arctic conditions hinder spill response activities (Nuka Research and Planning Group 2007). Lessees are required to have contingency plans to prevent, address, and clean up oil spills (ADNR 1999). Spill cleanup operations could result in short-term disturbance of marine mammals in the vicinity of the cleanup activity, while a collision with a cleanup vessel could injure or kill marine mammals. Disturbance of adults with young during cleanup could reduce survival of the young animals. For example, vessel and human activities associated with cleanup efforts may cause pinnipeds to abandon coastal haulout areas and/or rookeries for an extended period of time. Cleanup operations, including helicopter overflights and vessel traffic, could also potentially increase pup mortality if operations were to occur near rookeries. Aircraft readily disturb pinnipeds and walruses, which can cause adults to stampede into the water, trampling pups in the process. Any increased mortality in a pinniped population could impact the population as a whole, especially for sensitive or declining populations (e.g., Pacific walruses).

An approved oil spill response plan would be required for all exploration and production activities. Oil-containment and cleanup activities would be initiated a short time following an oil spill (MMS 2003e). Oil spill response activities may affect marine mammals through exposure to spill response chemicals (e.g., dispersants or coagulants) or through behavioral disturbance by cleanup operations or habitat disturbance. The chemicals used during a spill response are toxic, but are considered much less so than the constituents of spilled oil (Wells 1989), although there is little information regarding their potential effects on marine mammals. The presence of, and noise generated by, oil spill response equipment and support vessels could temporarily disturb marine mammals in the vicinity of the response action, with affected individuals likely leaving the area. While such displacement may affect only a small number of animals and not result in population-level effects, cleanup operations disturbing adults in pup-rearing areas may decrease pup survival. Oil spill response support vessels may also increase the risk of collisions between these vessels and marine mammals in the vicinity of the spill response. During oil spill cleanup activities, interactions with humans could cause polar bear disturbance, injury, or death. For example, cleanup operations that disturb a den could result in the death of cubs through abandonment and perhaps death of the mother.

Catastrophic Discharge Event. The PEIS analyzes a CDE of 1.4 to 2.2 million bbl for the Chukchi Sea and 1.7 to 3.9 million bbl for the Beaufort Sea (Table 4.4.2-2). If a CDE occurs, there is greater potential for more severe effects compared to the risk of effects from a large oil spill. A CDE would result in sustained degradation of water quality and, to a lesser extent, air quality that would impact marine mammals from direct contact, inhalation, and ingestion (either directly or indirectly through the consumption of oiled forage or prey species). These effects would be significant, causing a multitude of acute and chronic effects. Additional effects on marine mammals would occur from water and air quality degradation associated with response and cleanup vessels, *in situ* burning of oil, dispersant use, discharges and seafloor disturbances from relief well drilling, and activities on shorelines associated with cleanup, booming, beach cleaning, and monitoring. A CDE has the potential to increase the area and duration of an oil spill, thereby increasing the potential for population-level effects, or at a minimum, an increase in the number of individuals killed. For example, a catastrophic discharge event contaminating ice leads or polynyas in the spring could have devastating effects, trapping bowhead whales where they may encounter fresh crude oil. Beluga whales that also use the spring lead system to migrate would also be susceptible to a spill that concentrates in these leads.

Terrestrial Mammals. The terrestrial mammal communities present within the Beaufort and Chukchi Sea Planning Areas include a variety of small mammals (e.g., rodents), big game, and furbearer species. Species of particular concern are the caribou, muskoxen, grizzly bear, and arctic fox. Section 3.6.4.2.1 provides an overview of these species.

Routine Operations. Under routine operations for the proposed action, terrestrial mammals could be affected by the construction and operation of new onshore pipelines and from vehicle traffic and helicopter overflights.

<u>Construction and Operation of Onshore Pipelines.</u> Under the proposed action, 16 to 129 km (10 to 80 mi) of new onshore pipeline would be installed along the Beaufort Sea, which could result in 73 to 584 ha (180 to 1,443 ac) of soil disturbance (Table 4.4.1-4). The areas disturbed represent an extremely small portion of terrestrial wildlife habitat that occurs inshore of the Beaufort and Chukchi Sea Planning Areas.

Caribou. In general, caribou use coastal areas of the North Slope largely in June, July, and August, although a portion of the Western Arctic Herd may overwinter in coastal habitats bordering the Chukchi Sea, and in some years, the Teshekpuk Lake Herd may remain on the Arctic Coastal Plain throughout the winter. Because onshore pipeline construction would likely occur in winter to minimize impacts on the ground surface and vegetation, construction activities would not affect caribou calving or foraging in summer. Construction could, however, disturb caribou in overwintering areas, causing them to vacate preferred overwintering areas and move into less suitable habitats. Such displacement could affect individuals or local populations as a result of increased energy expenditure associated with movement to, and use of, suboptimal habitat, with subsequent mortality and reduced productivity (NRC 2003a).

If construction were to occur in late spring and summer, calving caribou, females with newborn calves, and older foraging calves could be disturbed. Affected individuals would likely leave or avoid habitats in the vicinity of the construction activities and move into potentially less suitable habitats. During the calving season from late May until late June, which includes the actual calving dates and the following 2 to 3 weeks, cows with calves are particularly susceptible to disturbance by human activities, and such displacement could result in population-level effects if calving success and calf survival are reduced (NRC 2003a).

Overall, caribou may be disturbed during construction or affected by the presence of new onshore pipeline. The response of caribou may include the avoidance or abandonment of preferred habitats in the vicinity of the new pipeline, with subsequent displacement to other potentially suboptimal areas. The magnitude of any such effects would be a function of the specific location of the new pipeline relative to preferred habitats (such as calving and foraging grounds and insect-avoidance areas), the location and length of the pipeline, and the number of individuals affected — the greater the length and distance of the new pipeline from existing pipelines (particularly TAPS), the greater the potential for affecting caribou and the greater the number of caribou and caribou herds that could be affected.

While pipelines built lower than 1.5 m (4.9 ft) above the ground surface may act as physical barriers to movement (NRC 2003a), a pipeline constructed to current clearance standards (with a minimum clearance of 1.5 m [4.9 ft]) would not be expected to physically hinder caribou crossings (Curatolo and Murphy 1986). Caribou have been shown to be reluctant in approaching pipelines and to exhibit reduced crossing success of pipelines located in close proximity to roadways with traffic. Thus, the presence of a new pipeline may affect daily or seasonal movements of some individuals and herds.

Muskoxen. Muskoxen are expected to avoid the area where construction of new pipeline is occurring. It is not known how construction disturbance or the presence of a completed pipeline would affect muskoxen habitat use and reproductive success. However, muskoxen may be particularly vulnerable to disturbance in winter because of limited habitat, the length of the arctic winter, the need to conserve energy throughout the winter, and, for females, the need to maintain good body condition throughout winter and spring for calving (Reynolds et al. 2002). However, because of the small population size of muskoxen, disturbance from pipeline construction could result in population-level effects, especially if this species is disturbed during winter. The limited distribution and small population size of muskoxen in the coastal and inland areas adjacent to the Beaufort and Chukchi Sea Planning Areas would greatly reduce the likelihood for disturbance of this species.

The presence of a completed pipeline may hinder movement by muskoxen if there is insufficient pipeline clearance for this species. However, muskoxen do not exhibit as extensive seasonal or daily movements as caribou. If undisturbed, muskoxen remain in relatively small areas throughout the winter, while in summer they exhibit longer movements that track the emergence of high-quality forage plants (Reynolds et al. 2002). In summer, most daily movements of radio-tracked individuals in the Arctic National Wildlife Refuge (ANWR) were reported to be less than 5 km (3 mi) in length, and many were typically less than 1 km (0.6 mi) in length (Reynolds et al. 2002). Existing pipelines associated with the North Slope oil fields and TAPS do not appear to have hindered the westward expansion of muskoxen from ANWR. For muskoxen to have expanded their range from ANWR to the Colville River, some individuals had to cross the TAPS ROW or travel through the oil fields on the North Slope (BLM 2002). Thus, the presence of a new pipeline is not expected to adversely affect muskoxen populations in onshore areas adjacent to the Beaufort and Chukchi Sea Planning Areas.

Brown Bear. The brown bear uses the coastal environments and/or terrestrial oil transportation routes onshore of the entire Beaufort and Chukchi Sea Planning Areas. Winter construction of onshore pipeline could disrupt individual bear dens. In summer, some individuals may temporarily leave habitats in the vicinity of active construction. However, because bears often habituate to human activities and facilities (Follmann and Hechtel 1990), the presence of new pipeline is not expected to directly adversely affect the grizzly bear.

Arctic Fox. Arctic foxes occur throughout the Beaufort and Chukchi Sea Planning Areas, using the coastal and shore-fast ice habitats. The arctic fox would not be adversely affected by the construction or operation of new pipeline. Individuals would likely abandon habitats temporarily in the vicinity of construction activities. Because the completed pipeline could provide increased shelter and den habitat, populations of arctic fox could increase along the pipeline corridor. An increase in fox abundance could lead to increased outbreak of disease (rabies, canine distemper) among foxes living along the pipeline corridor, as well as increased predation pressures on populations of prey species.

Foxes are highly mobile, and in late autumn and winter, they disperse out onto the sea ice in search of food. Because of this mobility, foxes may visit new offshore facilities (e.g., drilling platforms, ice roads, exploratory seismic trains) in search of food when sea ice is present. Arctic foxes were regularly observed near Seal Island in the Northstar development during the ice-covered season (MMS 2002a). Thus, depending on their number and distance from shore, new offshore platforms may provide additional winter food supplies and increase winter survival of some individuals.

<u>Vehicle Traffic and Helicopter Overflights.</u> Vehicle traffic associated with operations of a pipeline (e.g., pipeline monitoring) could affect wildlife along the new pipeline and any associated access roads. In addition, new access roads may also increase the incidence of vehicles associated with recreation, subsistence hunting, and other activities. Vehicle traffic could disturb wildlife foraging along roadways, causing affected wildlife to temporarily stop normal activities (e.g., foraging, resting) or leave the area. Collision with vehicles could result in mortality, especially in areas with concentrations of wildlife or along migration corridors. Vehicle traffic along any access road associated with the proposed action would likely be light. Thus, the incidence of such collisions would be very low and not expected to result in population-level impacts on wildlife.

Helicopter overflights associated with pipeline monitoring and transport of personnel and supplies may disturb wildlife. The effects of helicopters on wildlife vary by species, populations, habitat type, and environmental variables. Some species may become habituated and experience no adverse effects (e.g., see Harting 1987). Routine overflights by surveillance helicopters would result in a short-term disturbance to animals along the pipeline route, causing them to temporarily alter behaviors, and would not be expected to result in long-term population-level effects.

Caribou. Responses to vehicle and helicopter traffic by caribou can vary from no response to panic behavior. Cow and calf groups appear to be most sensitive (Valkenburg and Davis 1984; MMS 1998). Because caribou tend to avoid transportation corridors (Dau and Cameron 1986; Griffith et al. 2002; Cameron et al. 2002; NRC 2003a), disturbance of caribou by vehicle traffic associated with normal operations of an onshore pipeline would be infrequent. Single passes by helicopters may result in short-term disturbances that should not adversely affect caribou (MMS 1998). Low-flying helicopters are more likely to produce negative responses from caribou than are light, fixed-wing aircraft (Maier et al. 1998). McKechnie and Gladwin (1993) evaluated altitude tolerance thresholds below which aircraft overflights elicit panic and escape responses and determined that the tolerance threshold for a fixed-wing aircraft was 61 m (200 ft), with few or no response reactions observed above 153 m (500 ft). In contrast, the tolerance threshold for helicopters was determined to be 306 m (1,000 ft) in altitude (Miller and Gunn 1979).

Muskoxen. Vehicle traffic along a pipeline access road would likely result in temporary disturbance of muskoxen in the immediate vicinity of the roadway. The response of muskoxen to aircraft overflights has been reported to range from calm to excitable, and the nature of the response depends in part on the altitude of the overflight, terrain, climate, sex, group size, number of calves present in a group, and habituation (Miller and Gunn 1979, 1980). Helicopter and low-flying aircraft overflights can cause muskoxen to stampede and abandon their calves (NRC 2003a). While responses of muskoxen to vehicle traffic and aircraft overflights associated with the proposed action are not expected to adversely affect muskoxen populations, energetic costs associated with forced movements (especially if frequent) in winter could adversely affect spring calving and could result in population-level effects.

Brown Bear. Some brown bears may be injured or killed by collisions with vehicles along access roads, while bears in the vicinity of vehicle traffic may be disturbed and temporarily cease normal behavior or leave the area until the vehicle has passed. Aircraft overflights have been reported to elicit a variety of responses in brown bears, including escape behavior and hiding (Larkin 1996). While vehicle traffic and aircraft overflights associated with the proposed action may on occasion temporarily disturb individual bears, long-term population-level effects would not be expected from normal operations.

Arctic Fox. The Arctic fox may experience temporary disturbance from vehicle traffic and aircraft overflights, resulting in hiding, departure from the immediate area, or cessation of normal behaviors. Some individuals crossing or traveling along access roads may be injured or killed by vehicle traffic. Relatively few individuals are expected to be affected, and population-level impacts would not be expected under normal operations.

Accidents. Accidents under the proposed action that could affect terrestrial wildlife would be largely limited to an oil spill from a new pipeline. The impacts on wildlife from an oil spill would depend on such factors as the time of year and volume of the spill, type and extent of habitat affected, and home range or density of the wildlife species. The potential effects on wildlife from oil spills could occur from direct contamination of individual animals, contamination of habitats, and contamination of food resources. Acute (short-term) effects usually occur from direct oiling of animals (e.g., exposure to toxic hydrocarbons via inhalation and/or by ingestion of oil while grooming contaminated fur), while chronic (long-term) effects generally result from such factors as accumulation of contaminants from food items and environmental media (e.g., water).

Up to two large pipeline spills are expected to occur over the lifetime of the proposed action (Table 4.4.2-1). For the most part, expected spills would occur at offshore facilities rather than from the onshore pipeline. Wildlife may be exposed to spilled oil by eating a variety of oiled vegetation, wildlife, and/or contaminated carrion. In addition, animals occurring within a spill area may also be exposed via inhalation of aromatic hydrocarbons. Such exposure would likely result in sublethal or lethal effects. The magnitude of the effect will depend on the level of exposure, the life stage of the exposed bear (i.e., adult, cub), and the condition of the exposed animal (i.e., healthy, injured).

Oil spills could potentially affect arctic foxes through contamination of prey, reduction of prey availability, and fouling of fur, causing loss of its insulating capacity. Arctic foxes would be vulnerable to oil ingestion from grooming their fur (Nuka Research and Planning Group, LLC and Pearson Consulting, LLC 2010). Although arctic foxes are abundant predators on the North Slope, their mobility allows them to disperse from oiled areas, if necessary. Because arctic foxes are opportunistic carnivores, they may prey on oiled birds and small mammals and consume oiled carcasses, thereby increasing their potential for incurring lethal and sublethal exposure to the spilled oil and its breakdown products. While some loss of arctic foxes may occur as a result of this exposure, this loss would be limited to animals in the vicinity of the spill. While a local population-level effect may result, recruitment from other areas would likely quickly replace the lost individuals.

Staging and support activities for cleanup of a large offshore spill could temporarily displace terrestrial mammals. Oil spill cleanup activities on land may displace these animals from not only contaminated habitats but also nearby uncontaminated habitats. This displacement could reduce energy reserves (especially in winter), which in turn could affect body condition and calving success.

Catastrophic Discharge Event. The PEIS analyzes a CDE of 1.4–2.2 million bbl in the Chukchi Sea and 1.7-3.9 million bbl in the Beaufort Sea (Table 4.4.2-2). If a CDE occurs, there is greater potential for more severe effects compared to the risk of effects from a large oil spill. A CDE would result in sustained degradation of water quality, shoreline terrestrial habitats, and, to a lesser extent, air quality that could impact terrestrial mammals from direct contact, inhalation, and ingestion (either directly or indirectly through the consumption of oiled forage or prey species). These effects could be severe where persistent, heavy oil makes contact with important habitat and prey base, causing a multitude of acute and chronic effects. Additional effects on terrestrial mammals would occur from land and air quality degradation associated with response and cleanup vessels, *in situ* burning of oil, dispersant use, and activities on shorelines associated with cleanup, booming, beach cleaning, and monitoring. A CDE has the potential to alter terrestrial mammal habitats and populations. The potential for a population-level impact would occur in the unlikely event that a spill occurred in an area where a large number of individual animals are concentrated. For instance, population-level effects to caribou would be most likely from spills occurring in calving areas and along migration corridors. For the muskoxen, the potential for population-level effects would be greatest for a spill occurring in winter when this species remains in small areas, restricted by the availability of forage (Reynolds et al. 2002).

4.4.7.1.4 Conclusion.

Routine Operations.

Marine Mammals.

Under the proposed action, routine operations could affect marine mammals in the northern GOM. The levels of impacts to marine mammals for each of the planning areas are:

- GOM: Impacts on cetaceans could range from negligible to moderate, while impacts on the West Indian manatee would be negligible. Rare or extralimital species are not likely to be affected by routine operations.

- Cook Inlet: Impacts to marine mammals could range from negligible to moderate. Many of the listed cetacean species occur infrequently, if at all, within the Cook Inlet Planning Area and thus would not be expected to be affected by normal operations. Cook Inlet belugas primarily occur in the upper portion of Cook Inlet that is not in the Cook Inlet Planning Area.

- Arctic: Impacts to marine mammals could range from negligible to moderate.

Noise generated during seismic surveys, exploration and production activities, platform removal, and by OCS-related vessels and helicopters may temporarily disturb some individuals. Contaminants in waste discharges and drilling muds might indirectly affect marine mammals through food-chain biomagnification, although the scope of effects and their magnitude are not known. However, this information is not essential to the determination of a reasoned choice among alternatives. Small numbers of marine mammals could be killed or injured by chance collision with service vessels and by eating indigestible debris, particularly plastic items, lost from service vessels, drilling rigs, and platforms (including FPSO facilities for the GOM). While vessels may collide with marine mammals, the most likely impact on marine mammals would be changes in behavior (e.g., avoidance responses). Normal behavior is expected to return once a vessel or helicopter has passed. It is expected that structure removal would cause only minor behavioral changes and non-injurious physiological effects on cetaceans as a result of the implementation of BOEM guidelines and the NOAA Fisheries Observer Program for explosive removals.

Terrestrial Mammals.

Gulf of Mexico. The four federally endangered GOM coast beach mice subspecies and the federally endangered Florida salt marsh vole and their habitats would not be affected by normal operations under the proposed action.

Cook Inlet. Overall, routine activities associated with the proposed action will have negligible to minor impacts on the size and productivity of terrestrial mammal species along the shorelines of Cook Inlet. Up to 120 km (75 mi) of onshore pipeline would be constructed and operated as part of the proposed project; thus, impacts to terrestrial mammals would include a minor loss or modification of habitat and behavioral responses associated with occasional helicopter traffic to and from new platforms. Loss or modification of habitat for the pipeline would affect a very minor amount of wildlife habitat within the Cook Inlet area. The disturbance of wildlife by helicopter flights would be short-term in nature and not expected to result in population-level effects.

Arctic. Impacts to terrestrial mammals could range from negligible to moderate. The construction and normal operations of up to 129 km (80 mi) of new pipeline could result in a variety of short-term and long-term impacts to terrestrial mammals. Short-term impacts would largely be behavioral in nature, with affected animals avoiding or vacating the construction areas. Similarly, vehicle and aircraft traffic associated with the proposed action could temporarily disturb mammals near access roads or under flight paths. While the disturbance of these animals would be short-term in nature, the energetic costs incurred by some of the disturbed biota (especially overwintering muskoxen and pre-calving female caribou) could affect reproductive success. Therefore, disturbances could result in longer term impacts to animal populations. The presence of a new onshore pipeline may result in the displacement from preferred habitats to less suitable habitats for overwintering muskoxen, calving female caribou, and female caribou and their calves. Such displacement may reduce overwinter conditioning or survival as well as calving success. While population-level effects may not be likely for caribou, local population-level effects may occur for muskoxen because of the small population size in Alaska. While vehicle traffic and aircraft overflights associated with the proposed action may on occasion temporarily disturb brown bears and arctic foxes, long-term population-level effects would not be expected from normal operations. Overall, routine activities associated with the proposed action are not expected to have long-term major impacts on the size and productivity of terrestrial mammal species of the North Slope of Alaska.

Accidents.

Marine Mammals. Any of the oil spill scenarios developed for the proposed action (Section 4.4.2) may expose marine mammals to oil or its weathering products. Overall, oil spills are expected to have small to medium impacts to marine mammals, while impacts from oil spill response activities are expected to be small. In the case of a low probability CDE, there is greater potential for more severe and population-level effects compared to a large oil spill. The magnitude of effects from accidental spills would depend on the location, timing, and volume of the spills; the environmental settings of the spills (e.g., restricted coastal waterway, deepwater pelagic location); and the species (and its ecology) exposed to the spills. Spill cleanup operations could result in short-term disturbance of marine mammals in the vicinity of the cleanup activity, while a collision with a cleanup vessel could injure or kill the affected individual. In general, oil spill impacts on species that are extralimital to rare are expected to be small, but could be larger depending on the number of individuals contacted by a spill.

Terrestrial Mammals.

GOM. Because of their locations on inner dunes, the habitats of the beach mice are unlikely to be affected by an accidental offshore oil spill. While the habitat of the Florida salt marsh vole could be affected by an oil spill, this species and its habitat are located far from areas where oil leasing and development may occur under the proposed action. Thus, it is highly unlikely that this habitat would be contacted by an accidental oil spill from OCS oil and gas activities. Potential impacts of accidents on terrestrial mammals are not expected.

Cook Inlet and Arctic. Overall, oil spills are expected to have minimal to small impacts to terrestrial mammals, while impacts from oil spill response activities are expected to be very small. In the event of an accidental spill, terrestrial mammals may be exposed via ingestion of contaminated food, inhalation of airborne oil droplets, and direct ingestion of oil during grooming, which may result in a variety of lethal and sublethal effects. However, because most spills would be relatively small (≤ 1,000 bbl), relatively few individuals would likely be exposed. While some individuals may incur lethal effects, population-level impacts would not be expected for most species. Cleanup activities could temporarily disturb terrestrial mammals in the vicinity of the cleanup operation, causing those animals to move from preferred to less optimal habitats, which, in turn, could affect overall condition. Such displacement would be limited to those relatively few animals in the vicinity of the cleanup activity, and thus would not be expected to result in population-level effects.

4.4.7.2 Marine and Coastal Birds

Each of the four phases of OCS oil and gas development have associated impact-producing factors (Table 4.1.1-1), some of which may affect marine and coastal birds in the Planning Areas included in the proposed action. Oil and gas development activities that may occur following lease sales under the proposed action and that may affect marine and coastal birds include (1) offshore structure placement and pipeline trenching; (2) offshore structure removal; (3) operational discharges and wastes; (4) OCS vessel and aircraft traffic; (5) construction and operation of onshore infrastructure (including new pipeline landfalls); and (6) noise. Table 4.4.7-2 identifies the impacting factors associated with routine operations that could affect birds and the aspects of marine and coastal birds that could be affected by those factors.

In general, routine operations associated with oil and gas development are not expected to result in population-level effects on marine and coastal birds. Most impacts from routine

TABLE 4.4.7-2 Impacting Factors and the Marine and Coastal Bird Resource Components That Could Be Affected with Oil and Gas Development under the Proposed Action

	Resource Component Potentially Affected								
	Habitat[a]			Life Stage[b]			Behavior		
Development Phase and Impacting Factors That May Affect Marine and Coastal Birds	Nesting	Foraging	Overwintering	Nestlings	Juveniles	Adults	Foraging	Courtship/ Nesting	Migration/ Staging
Impacting Factors Common to All Phases									
Helicopter noise	-[c]	-	-	+	+	+	+	+	-
Helicopter traffic	-	-	-	+	+	+	+	+	-
Ship noise	-	-	-	-	-	-	-	-	-
Ship traffic	-	-	-	+	+	+	+	+	+
Hazardous materials	-	-	-	+	+	+	-	-	-
Solid wastes	-	-	-	+	+	+	-	-	-
Offshore lighting	-	-	-	-	+	+	-	-	+
Offshore air emissions	-	-	-	-	-	-	-	-	-
Exploration – Exploratory Drilling									
Seismic noise	-	-	-	-	+	+	+	-	-
Drilling noise	-	-	-	-	+	+	-	-	-
Drilling mud/debris	-	-	-	-	+	+	-	-	-
Offshore Development									
Drilling noise	-	-	-	-	+	+	+	-	-
Trenching noise	-	-	-	+	+	+	+	+	-
Drilling mud/debris	-	-	-	-	+	+	+	-	-
Pipeline trenching	-	+	+	+	+	+	+	-	-
Wellhead and platform placement	-	-	-	-	+	+	+	-	-
Onshore Development									
Site clearing	++	++	-	++	+	+	++	++	+
Construction activity	-	-	-	+	+	+	+	+	+
Construction noise	-	-	-	+	+	+	+	+	+
Production									
Platform collisions	-	-	-	-	+	+	-	-	-
Production noise	-	-	-	-	+	+	-	-	-
Produced water	-	-	-	-	+	+	-	-	-
Drill mud/debris	-	-	-	-	-	-	-	-	-
Decommissioning									
Explosive platform removal	-	-	-	-	+	+	+	-	-
Non-explosive platform removal	-	-	-	-	+	+	+	-	-

[a] Reflects only direct loss or physical degradation of the habitat and not habitat use.

[b] Reflects only injury or mortality of affected life stage.

[c] A dash (-) indicates no or negligible effect anticipated; "+" indicates potentially minor impacts, "++" indicates potentially moderate impacts, and "+++" indicates possible major impacts and possible population-level effects. See Section 4.1.4 for impact level definitions.

operations would be localized to the site of the project infrastructure or along support vehicle routes, would for most operations be short term or transient, and would likely affect relatively few individuals or habitats. The greatest potential for longer term and possibly population-level impacts would be associated with very large accidental oil spills. In most areas, small spills would likely affect relatively small numbers of birds and habitats. In contrast, very large spills could affect habitats along extensive areas of coastline and large numbers of birds and important habitats (such as nesting colonies or wintering grounds). Depending on the timing, duration, size, and location of a very large spill, population-level impacts could be incurred by some species.

4.4.7.2.1 Gulf of Mexico.

Routine Operations. Routine activities associated with the proposed action that may affect marine and coastal birds in the northern GOM include (1) offshore structure placement and pipeline trenching, (2) offshore structure removal, (3) operational discharges and wastes, (4) OCS vessel and aircraft traffic, (5) construction and operation of onshore infrastructure (including new pipeline landfalls), and (6) noise. Potential impacts associated with these activities may include injury or mortality of birds from collisions with platforms, vessels, and aircraft; exposure to operational discharges; ingestion of trash or debris; loss or degradation of habitat due to construction; and behavioral disturbance due to the presence of, and noise generated by, equipment and human activity (Russell 2005). The nature and magnitude of effects on birds will depend on the specific location of an activity or completed structure (e.g., with greater impacts if a pipeline landfall construction would occur adjacent to a heron rookery), the timing of the activity (e.g., construction that occurs during nesting), and the nature and magnitude of the activity (e.g., the number of miles of trenching through nearshore coastal habitats, the quantity and concentrations of the production water discharges).

Offshore Structure Placement and Pipeline Trenching. The construction of new offshore infrastructure is not expected to adversely affect marine and coastal birds. Pipeline trenching may affect birds in nearshore coastal areas if trenching occurs in or near foraging or nesting areas. For many species, the effects would be primarily behavioral, namely, the short-term avoidance or abandonment of habitats in the immediate area of trenching. Pipeline trenching near nesting colonies (such as heron rookeries) may disturb adults that are incubating eggs or feeding young, potentially affecting nesting success. Because trenching could result in some long-term loss of coastal habitat (see Section 4.4.6.1.1), habitat loss for some species may also occur. Such impacts could be avoided or minimized by locating pipeline corridors away from nesting aggregations and/or by scheduling trenching activities to avoid the nesting period.

Seabirds such as the brown pelican often use offshore oil and gas production platforms as rest areas or as temporary shelters during inclement weather. In addition, offshore platforms are also used in spring and fall for resting and feeding stopovers by birds migrating to and from more southern wintering areas (Baust et al. 1981; Russell 2005). For example, in the fall, many migratory species (including waterfowl, shorebirds, and passerines) arrive at the GOM coast and then fly several hundred miles across the open GOM waters directly for to Central and South America (Lincoln et al. 1998). This route appears to be preferred over the safer but more circuitous land or island routes by way of Texas or Florida. The use of offshore platforms may increase the survivability of individuals using these structures to rest or as shelter during bad weather conditions in the open waters of the GOM (Russell 2005).

Migrating birds may collide with offshore platforms. Annual bird mortality from collisions with offshore platforms has been estimated at 200,000 birds in the northern GOM, with an average of 50 collision deaths per platform per year (Russell 2005). This is probably an underestimate of actual collision mortality incurred by migrating birds, because it is based only on birds recovered from the platforms; birds falling into the water are not reflected in these mortality estimates (Russell 2005). Applying the 50 collision deaths per platform per year estimate, new platforms that could be constructed following lease sales held under the proposed action may result in a total incremental increase of about 10,000 to 22,500 bird collision mortalities. By comparison, hundreds of millions of birds are killed each year colliding with communication towers, windows, electric transmission lines, and other structures (e.g., see Klem 1989, 1990; Dunn 1993). Migrating birds may also be drawn to a lighted platform and circle the platform before moving on or stopping on the platform (Russel 2005). Such circling behavior could increase the potential for a platform collision and use up valuable energy reserves needed for completing the trans-GOM migration.

Offshore Structure Removal. Under the proposed action, up to 275 existing platforms could be removed from the GOM planning areas. Because many marine birds, as well as migratory birds, are attracted to platforms, there is a potential for some individuals to be affected if they are present during platform removal activities. Typical platform decommissioning involves dismantling many of the above-platform structures, followed by the use of underwater explosives to collapse the platform proper. Birds using a platform undergoing decommissioning would likely leave the platform during dismantling activities. Any remaining birds would be startled by the underwater detonations and quickly leave the collapsing structure. Thus, only negligible minor impacts on relatively few individual birds would be expected from decommissioning activities under the proposed action.

The explosive removal of offshore structures is not expected to affect any of the birds listed under the ESA that occur in the three planning areas. Only two species, the roseate tern and the red knot (a candidate species), are likely to visit offshore platforms either during migration (red knot) or during normal foraging activities (roseate tern). The NMFS has previously evaluated the explosive removal of offshore platforms in the GOM and issued a Biological Opinion that concluded that such structure removal would not jeopardize birds listed under the ESA (NMFS 1988). In addition, the BOEMRE has established guidelines for explosive platform removals (30 CFR 250). These guidelines require structure removal–specific plans to protect marine life and the environment and specify procedures and mitigation measures to be taken to minimize potential impacts. BOEMRE conducts detailed technical and environmental reviews of proposed removal projects to ensure that listed species would not be affected; these reviews include consultation with NMFS and USFWS. Thus, compliance with the BOEMRE guidelines should further reduce the likelihood that offshore structure removal would affect either the red knot or the roseate tern.

Operational Discharges and Wastes. Normal operational wastes may include produced water, drilling muds, and drill cuttings discharged from offshore platforms, waste fluids produced on OCS vessels, and trash and debris generated on platforms and vessels. A number of normal operational discharges and wastes have the potential to affect marine and coastal birds.

The discharge of production wastes into open water is prohibited in coastal waters but permitted in marine waters under the NPDES program (see Section 4.4.3.1). Produced water, drilling muds, and drill cuttings are routinely discharged from production platforms in the GOM into offshore marine waters in compliance with applicable regulations and permits, and would continue to be so discharged with any development following lease sales under the proposed action. The discharged materials may contain a variety of constituents (e.g., trace metals, hydrocarbons) that may be toxic to birds. In marine waters, birds could be exposed to these materials by direct contact or through the ingestion of contaminated food items. Birds most likely to be present at offshore production locations where operational discharges are occurring are those that forage on fish in offshore waters and may frequent offshore facilities; these include pelicans, frigatebirds, gannets, and terns.

Upon discharge in accordance with permit specifications, production wastes would be rapidly diluted in the water column (i.e., to ambient levels within several thousand meters of discharge [see Section 4.4.3.1.1]) and dispersed by currents, thus greatly reducing the magnitude of exposure that a bird might incur. If constituents of the discharged materials bioaccumulate or biomagnify, there is a potential that some birds may be exposed through their food. Field studies have shown that the concentrations of trace metals, hydrocarbons, or NORM in the tissues of fishes collected around production platforms are within background levels (Neff 1997a). Thus, food chain uptake is likely not a major exposure pathway for fish-eating birds at offshore facilities.

Among the threatened and endangered species present in the northern GOM planning areas (see Section 3.8.2.1.2), only the roseate tern and the candidate red knot may be expected at offshore platforms. The roseate tern, which is known to occur in oceanic waters, occurs within the Florida Keys and southeastern Florida (USFWS 1999; FFWCC 2003). Because these areas are hundreds of kilometers away from the portion of the EPA where oil and gas leasing and development might occur under the proposed action, the roseate tern would not be expected to be exposed to production wastes generated at offshore facilities. The red knot is a shorebird that would occur only at a platform during spring and fall migrations, and then only if stopping to rest on a platform while crossing the GOM. As this species is not an open-water feeder or swimmer, no exposure to operational discharges would be expected for the red knot.

Some bird species may also be affected indirectly if the discharges reduce the abundance of prey species (NRC 1983; API 1989; Kennicutt 1995). However, because of the rapid dilution that would occur, potential impacts on prey populations inhabiting the water column (e.g., fish, plankton) would likely be limited in extent and not be expected to significantly affect overall prey abundance (see Sections 4.4.7.3.1 and 4.4.7.5.1). While some production-related contaminants may reach sediments and reduce macroinfaunal abundance (Rabalais et al. 1998), the potentially affected macroinvertebrate biota would be at depths beyond the diving limits of birds. Sediment impacts can last for years after the discharge period has ended (Rye et al. 2008) and can cause an overall impoverishment of the benthic community (Daan and Mulder 1996). These sediment changes may affect benthic larval or juvenile stages of species which would eventually become prey for seabirds.

Many species of marine birds (especially gulls) often follow ships and forage in their wake on fish and other prey injured or disoriented by the passing vessel. In doing so, these birds may be affected by discharges of waste fluids (such as bilge water) generated by OCS vessels. Discharges of such wastes from OCS service and construction vessels, when allowed, would be regulated under applicable NPDES permits (see Section 4.4.3.1); any discharged wastes would be quickly diluted and dispersed and thus not be expected to affect marine birds.

Marine and coastal birds may become entangled in or ingest floating, submerged, and beached debris (Heneman and the Center for Environmental Education 1988; Ryan 1987, 1990). Entanglement may result in strangulation, the injury or loss of limbs, entrapment, or the prevention or hindrance of the ability to fly or swim, and all these effects may be considered lethal. Ingestion of debris may irritate, block, or perforate the digestive tract, suppress appetite, impair digestion of food, reduce growth, or release toxic chemicals (Fry et al. 1985; Dickerman and Goelet 1987; Ryan 1988; Derraik 2002). Because the discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by the BOEMRE (30 CFR 250.40) and the USCG (MARPOL, Annex V, Public Law 100-220 [101 Statute 1458]), entanglement in or ingestion of OCS-related trash and debris by marine and coastal birds would not be expected under normal operations.

Vessel and Aircraft Traffic. Under the proposed action, up to 600 vessel and 5,500 helicopter trips may take place weekly within the northern GOM planning areas. Birds may be affected in the following ways by this traffic: (1) they may be induced by vehicle noise to cease a particular activity (such as nesting or feeding) and leave the area, (2) they may incur injury or mortality through collision with a ship or helicopter, or (3) nests may be disturbed by excessive boat wakes.

Disturbance from noise is addressed later in this section. Birds disturbed by the presence of an OCS vessel may flee an area. Displaced birds would move to other habitats and may or may not return. In most cases, such displacement would be short term and transient and would not be expected to result in any lasting effects. However, if the displaced birds were occupying active nests, incubating eggs, or feeding and protecting hatchlings, even a short-term absence of the adult birds could increase predation of eggs or unfledged young, or reduce hatching success. However, because of the heavy commercial and recreational boat traffic in the northern GOM, most birds of the area are likely habituated to ship traffic and may only minimally react to passing OCS support vessels. In addition, OCS vessel traffic would likely occur within designated traffic lanes and not in waterways where birds may be nesting on beaches or other shoreline habitats. For this same reason, wakes from OCS-related vessels are also not expected to affect coastal birds and their nests. In addition, low-wake or wake-free vessel speeds are required while transiting across waterways that have sensitive shoreline resources (such as shorebird nesting colonies). Thus, compliance with such requirements would further minimize potential wake-induced impacts on birds.

A number of studies have examined the responses of birds to low-flying aircraft and atypical noise (see *Noise* discussion below). The results of many of these studies have indicated that although habituation may vary among species (Conomy et al. 1998), many species of birds will habituate to low-flying aircraft and noise and exhibit no effects on reproductive success (Black et al. 1984; Andersen et al. 1989; Delaney et al. 1999).

FAA guidelines for helicopter operations in the GOM request that pilots maintain a minimum altitude of 213 m (600 ft) while in transit offshore, 305 m (1,000 ft) over unpopulated areas or across coastlines, and 610 m (2,000 ft) over populated areas and sensitive habitats such as wildlife refuges and park properties (FAA 2010). Compliance with these guidelines regarding service altitudes for OCS helicopters would minimize disturbance of nesting or roosting birds within coastal areas.

Construction and Operation of Onshore Infrastructure. Loss or alteration of preferred habitat due to new OCS pipeline landfalls could result in the displacement of individuals or groups of birds from the affected area(s), including a possible decrease in nesting activities. Some pipelines in the central and western GOM have been brought to shore using a directional drilling process (MMS 2006a, 2008a) in which pipelines pass beneath coastal habitats to emerge inland at an onshore receiving facility, away from coastal habitats. Where used, this process could greatly reduce or avoid impacts on coastal habitats that are important to listed and non-listed marine and coastal birds.

Under the proposed action, up to 12 landfalls would be expected in the Western and Central GOM Planning Areas, with none occurring in the EPA. The location and small number of landfalls that could occur with development associated with the proposed action would greatly limit the amount of coastal bird habitat that might be disturbed. In addition, siting of pipeline landfalls would consider the presence of sensitive habitats and areas, and avoid such areas to the maximum extent possible, further reducing the likelihood of affecting coastal bird habitats and the magnitude and extent of impacts on such habitats.

Noise. Noise generated during facility and pipeline construction, production operations, and platform removal activities, and by OCS ships and helicopters, may affect birds in a variety of ways. Unexpected noise can startle birds and potentially affect feeding, resting, or nesting behavior, and often causes flocks of birds to abandon the immediate area.

Much of the wildlife-related noise effects research has shown that noise may affect territory selection, territorial defense, dispersal, foraging success, fledging success, and song learning (e.g., Anderson et al. 1986; Gladwin et al. 1988; Larkin 1996). In many cases, the effects are temporary, with the birds becoming habituated to the noise. For example, weapons testing noise has been reported to have no significant effect on bald eagle activity or reproductive success, suggesting habituation of the birds to the noise (e.g., Brown et al. 1999). Studies of birds exposed to frequent low-level military jet aircraft overflights and simulated (with mortars, shotguns, and propane cannons) mid- to high-altitude sonic booms have shown aircraft and detonation noise to elicit some short-term behavioral responses but to have little effect on reproductive success (Ellis et al. 1991). Birds of prey have been reported to habituate to low-level helicopter flights and exhibit no effects on their reproductive success (Delaney et al. 1999;

Andersen et al. 1989), and low-level (<500 ft AGL) military training flights have been shown to have no effects on the establishment, size, and reproductive success of wading bird colonies in Florida (Black et al. 1984). On the basis of these studies, noise generated during normal operations is expected to have only short-term and transient effects on birds, and would not be expected to result in long-term disturbance or population-level effects.

Accidents. The accidental oil spill scenario for the GOM under the proposed action identifies as many as 8 large (≥1,000 bbl) and as many as 470 small (<1,000 bbl) oil spills potentially occurring with development that could result through the lease sales of the proposed action (Table 4.4.2-1). In the event of an accidental oil spill, birds may be adversely affected through direct contact with the spilled oil, by the fouling of their habitats and contamination of their food by the oil, and as a result of oil spill-response activities. Exposure of eggs, young, and adult birds to oil may result in a variety of lethal and sublethal effects. Fouling of habitats can reduce habitat quality, while contamination of foods may lead to a variety of lethal and sublethal toxic and physiological effects. Finally, oil spill-response activities may disturb birds in nearby habitats that are unaffected by an oil spill.

Adult and young birds may come in direct contact with oil on the water's surface or on oiled beaches, mudflats, and other shore features. Oil may also be physically transferred by nesting adults to eggs or young. Direct contact with oil by young and adult birds may result in the fouling or matting of feathers, which would affect flight and/or diving capabilities, affecting such activities as foraging and fleeing predators. Birds that have been fouled by oil also experience a loss in the insulating properties of their feathers, making them susceptible to hypothermia during cold weather periods. Oil making contact with skin, eyes, or other sensitive tissues may result in an irritation or inflammation of skin or sensitive tissues (Fry and Lowenstine 1985), while oiled eggs would incur reduced gas exchange.

Birds may ingest oil incidentally while foraging and while preening oiled feathers. Ingested oil may depress egg-laying activity or may result in the death or deformities of young (Fry et al. 1985; Leighton 1990). Direct effects of oil contact may be amplified under conditions of environmental stress such as low temperatures, migration movements, and molting. Indirect effects of oil contact include toxic effects from the consumption of contaminated food or starvation from the reduction of food resources (Lee and Socci 1989). The latter effects may hinder the recovery of impacted bird populations after a spill (Hartung 1995; Piatt and Anderson 1996; Piatt and Ford 1996).

Certain species of marine and coastal birds may be more susceptible to contact with spilled oil than others, based on their life histories. For example, diving birds and underwater swimmers such as loons, cormorants, and diving ducks may be the most susceptible to spilled oil because of their relatively long exposure time within the water and at the sea surface (Camphuysen 2007; Williams et al. 1995). Shorebirds and wetland birds may also be susceptible to direct oiling if a spill were to reach the beach intertidal zone or inshore wetland habitats, respectively, where these species forage and raise young (King and Sanger 1979). Oiled birds collected during response actions to the DWH event included seabirds, shorebirds, wetland birds, waterfowl, passerines, and raptors, with the majority of oiled birds being seabirds (see Section 3.8.2.1.5 and Table 3.8.2-6).

The magnitude of the impact would depend on the size, location, and timing of the spill; the species and life stage when exposed; and the size of the local bird population.

Spills in deep water are not likely to affect the listed and candidate bird species identified for the northern GOM (Table 3.8.2-3). Only the roseate tern and the red knot would be expected in areas of the outer inner continental shelf where deepwater spills could occur, and these occurrences would be transient and not expected to result in direct exposure to spilled oil. In contrast, all the listed and candidate species with the exception of the roseate tern could be exposed if a deepwater spill were to move into coastal waters and reach coastal habitats utilized by these species. Even if a deepwater spill were to reach coastal habitats, because of the great distance from shore at which a deepwater spill would originate, the oil would be greatly weathered, and therefore reduced in toxicity, by the time it reached the shore (see Section 4.4.3.1.2).

In contrast, a number of non-listed seabird species (e.g., terns, gulls, shearwaters, boobies, frigatebirds) could be exposed to deepwater spills. Some of these species are found only in pelagic areas of the GOM, while others inhabit waters of the continental shelf (see Section 3.1.2.3.2) (Duncan and Havard 1980; Davis et al. 2000). A number of these species forage in deepwater areas, are attracted to offshore platforms, and often follow vessels. These birds may be directly exposed while feeding or resting in spills originating from deepwater platforms or transport tankers and could incur lethal or sublethal effects. Depending on its size, location, and timing, a deepwater spill may affect only a few individuals or, as in the case of aggregations of overwintering gannets, a relatively large number of birds.

A shallow water spill in an offshore or nearshore area has the potential to affect a greater number of bird species than a deepwater spill of comparable size. Most threatened or endangered avian species are not likely to be affected by a spill unless a hurricane were to occur and spread oil inland to freshwater and terrestrial habitats. The piping plover and red knot could be exposed if their beach habitats become fouled by a spill. Because shorebirds tend to be flocking species, spills reaching habitats used by these species could result in the exposure of a relatively large number of individuals. While the sandhill crane, wood stork, and whooping crane could be exposed if a spill were to foul their coastal wetland habitats. Because of the very specific and limited winter habitat that supports the majority of whooping cranes, a spill affecting this habitat could result in a major impact on this species. Audubon’s crested caracara, while reported to use coastal dune habitats, is generally more of a terrestrial species and would not be expected to occur along beach and wetland habitats. The roseate tern breeds in scattered colonies along the Florida Keys (see Section 3.8.2.1.2) and could be exposed if a spill were to occur in the extreme southeastern portion of the EPA. Under the proposed action, however, lease sales would be limited to the extreme western portion of this planning area, hundreds of miles from the nearest nesting colony of this tern. Thus, this species would not be expected to be exposed to any accidental spills that might occur in association with a lease sale under the proposed action.

Accidental spills in shallow water could affect a wide variety of non-listed species. In offshore locations, shallow water spills could expose any of a large number of ducks, cormorants, terns, grebes, and gulls. Spills reaching shoreline habitats such as beaches, mudflats, and wetlands could affect shorebirds (e.g., sandpipers, plovers), wading birds (e.g., herons, bitterns), wetland birds (e.g., rails, coots, blackbirds), and a wide variety of migratory birds. Spills occurring during the fall or spring migrations have the potential to expose large numbers of birds in both nearshore coastal waters and in coastal habitats such as beaches, flats, and wetlands. The magnitude of impacts that could result from an accidental spill in shallow water would depend on the timing, duration, location, and size of the spill; the habitats that came in contact with the spill; and the species and numbers of birds exposed to the spill.

Besides being affected by the spill itself, marine and coastal birds may be affected during spill containment and cleanup activities. During cleanup, some oiled birds could be successfully cleaned, and cleanup of the affected habitat could be necessary to avoid chronic exposure. Nesting or roosting birds in nearby habitats unaffected by the spill could be disturbed by cleanup of contaminated habitats. Coastal cleanup and remediation activities in coastal habitats may impact local populations of coastal birds, resulting in their temporary displacement from these areas. If the abandoned area is an important nesting habitat (especially during the breeding season), local population-level impacts may be incurred. The application of dispersant chemicals to spilled surface oil could also affect birds. While dispersant chemicals contain constituents that are considered to have low levels of toxicity when compared to toxic constituents of spilled oil (Wells 1989), the effects of these dispersants on seabirds are poorly understood. Because the use of these chemicals and spill cleanup activities would be localized and infrequent, potential impacts from spill response activities would largely be short term (e.g., avoidance of the cleanup area).

The specific nature and magnitude of effects of an oil spill on marine and coastal birds of the GOM will depend on the size, location, timing, and duration of the spill and the birds and habitats exposed to the spill. Small spills may be expected to affect relatively small numbers of birds and habitats and would not be expected to cause population-level impacts.

Catastrophic Discharge Event. The PEIS analyzes a CDE with a volume ranging from 900,000 to 7,200,000 bbl (Table 4.4.2-2). A low probability CDE would have similar impacts on bird populations as spills of other magnitudes; however, the area affected would increase and the degree of impact would be more severe. A much greater number of birds and habitats could be affected, and population-level impacts for some species could be incurred as CDEs can affect extensive areas of shoreline. For example, the Gulf Coast Least Tern Colony (see Section 3.8.2.1.4) on the Mississippi coast has one of the world's largest colonies of least tern. A catastrophic discharge event reaching this colony site during the nesting season could foul several thousand nests and result in the loss of an entire reproductive season, the effects of which may cause long-term population effects.

4.4.7.2.2 Alaska – Cook Inlet.

Routine Operations. Oil and gas development that could occur in the Cook Inlet Planning Area following a lease sale under the proposed action would include (1) offshore exploration; (2) construction of offshore platforms and pipelines; (3) construction of onshore pipeline landfalls and pipelines; (4) operations of offshore and onshore facilities; and (5) OCS-related vessel and aircraft traffic (Table 4.4.1-3). While activities supporting this development may be expected to affect marine and coastal birds in the vicinity of the development activities, these impacts would largely be short term, generally affect only a relatively small number of birds at any one time, and not be expected to result in population-level impacts on any species.

Offshore Exploration. Under the proposed action, oil and gas exploration could include the placement of up to 12 exploration and development wells in the Cook Inlet Planning Area. Seismic surveys and placement and operation of the wells could affect some birds. Disturbance of birds during seismic surveys would be limited to the immediate area around survey vessels, be short term, and be largely behavioral (MMS 2005e). For example, noise from air guns and disturbance from survey vessel traffic could displace foraging seabirds in offshore waters, especially if exploration were to occur in areas with high seabird density (such as the open waters adjacent to the Stevenson and Kennedy Entrances to Cook Inlet and off the northwestern coast of Kodiak Island [see Section 3.8.2.2.4]) where seabirds are likely to be encountered. If disturbed, affected birds would likely cease foraging activities and leave the vicinity to feed in other areas. Because the lease sale would occur no closer than 3 NM from shore, offshore exploration activities (including the placement of exploration and development wells) would not be expected to disturb marine or coastal birds or their habitats (such as seabird colonies or wintering grounds) in coastal areas. Thus, normal offshore exploration activities are expected to have negligible or minor effects on marine and coastal birds, and are not expected to result in any population-level effects for local bird populations.

Construction of Offshore Platforms and Pipelines. Under this proposed action, up to three offshore platforms could be constructed in the Cook Inlet Planning Area. These platforms would likely be constructed outside of the planning area and towed to their final location, and marine and coastal birds could be temporarily disturbed during the transportation and placement of the platforms. Disturbance would likely result in affected birds leaving the immediate area of activity (either the platform location or the transportation route). Because of the small number of platforms, the transient nature of their transport and construction, and their offshore locations being well away from coastal habitats and seabird colonies, any impacts on marine and coastal birds may be expected to be short term, affect relatively few birds, and not result in long-term population-level effects for any species.

In addition to the new platforms, up to 241 km (150 mi) of new offshore pipeline could be constructed following leasing under the proposed action. Pipeline trenching could affect birds in nearshore coastal habitats if trenching occurs in or near foraging, overwintering, or staging areas or near seabird colonies. Trenching may also disturb marine species foraging in offshore waters. For many species, disturbance from pipeline trenching would result primarily in a behavioral response, namely, the short-term abandonment or avoidance of habitats in the immediate area of trenching. Pipeline trenching near seabird colonies could cause adults to abandon nests (at least temporarily) and cease incubating eggs or feeding young, and thereby potentially affecting nesting success. If nests are permanently abandoned, some population-level effects may be incurred by the affected species. Potential impacts could be avoided or minimized by locating pipeline corridors and the landfall away from nesting aggregations (seabird colonies), and by scheduling trenching activities to avoid staging, overwintering, and nesting periods.

Construction of up to 241 km (150 mi) of new offshore pipeline could affect as much as 210 ha (519 ac) of benthic habitat within the Cook Inlet Planning Area and locally affect the availability of foraging habitat for some marine and coastal birds. Because portions of the new pipelines would be in water depths potentially unavailable for most marine and coastal birds, pipeline construction may be expected to have limited effect on the overall availability of foraging habitat for marine and coastal birds. Any impacts on food sources would be localized to the pipeline footprint and are expected to have negligible or minor impacts on local marine and coastal bird populations.

Construction of Onshore Pipelines and Landfalls. Under the proposed action, up to 169 km (105 mi) of new pipeline and possibly one new pipeline landfall could be constructed in onshore areas adjacent to the Cook Inlet Planning Area. Construction of new pipelines would likely be located in the general vicinity of existing oil and gas infrastructure, delivering oil to existing refineries in Nikiski and natural gas to existing transmission facilities in the Kenai area (Table 4.4.1-3). Depending on the proximity of the new onshore pipelines or a new pipeline landfall to existing roads, one or more new access roads could be needed to bring in construction equipment and supplies to the construction areas. The construction of new pipelines would permanently eliminate a relatively small amount of habitat (about 4.9 ha [12 ac], assuming a 30.5-m [100-ft] construction ROW) along the pipeline routes, while construction camps to support onshore construction activities would affect an additional very small amount of terrestrial habitat. Siting new pipelines and facilities away from coastal areas would reduce the amount of marine or coastal bird habitat that could be affected. Potential habitat impacts could be reduced by locating the new pipelines within existing utility or transportation ROWs. Because there are relatively few nesting colonies along the Kenai Peninsula north of Anchor Point (USGS undated), only a few seabird colonies could be affected by onshore construction activities. The disturbance of birds in these colonies could be reduced or avoided by siting any new onshore infrastructure away from colony sites and by scheduling construction activities to avoid nesting periods. Overall, onshore construction activities are expected to affect only a relatively small number of birds and not to result in population-level effects for any affected species.

Operations of Offshore Facilities. During normal operations, birds may be affected by noise and human activities at onshore and offshore facilities and by the presence of the facilities themselves. Noise and human activities (such as normal maintenance) could affect birds moving through Cook Inlet during spring and fall migration, as well as birds moving into nesting, fall molting, or overwintering habitats in the planning area. Affected birds would likely avoid the platforms and nearby habitats. Although operational noise and human activity may cause birds to avoid areas where platforms are located, affected birds would likely select other suitable areas of the planning area. Because of the small number of new platforms (no more than three), the disturbance of birds in offshore waters by operational noise and human activity would be limited to only a few areas around the platforms and is not expected to adversely affect marine or coastal bird populations.

Offshore platforms may pose a collision hazard to birds, especially during migration and/or periods of low visibility. No information is available regarding bird collisions with platforms and other structures in Cook Inlet or elsewhere in Alaskan waters. However, a reasoned estimate of the potential number of such collisions can be made from information available about potential collisions in the GOM. Annual bird mortality in the northern GOM (a major migratory area with several hundred million migrants estimated to pass through annually) from collisions with offshore platforms has been estimated to average 50 collision deaths per platform per year (Russell 2005). Applying a similar collision mortality rate to development that could occur under the proposed action, about 150 bird collision mortalities might be expected annually for the three new platforms.

Operational Discharges and Wastes. Oil and gas development occurring following a lease sale under the proposed action would result in the generation of drilling fluids and debris (Table 4.4.1-3). Produced water, drilling muds, and drill cuttings generated by development and production wells would be disposed of through down-hole injection. Thus, no impacts on marine and coastal birds from these wastes would be expected under normal operations. In contrast, produced water, drilling muds, and drill cuttings generated by exploration and delineation wells would be discharged at the well sites in compliance with applicable regulations and permits. The discharged materials may contain a variety of constituents (e.g., trace metals, hydrocarbons) that may be toxic to birds. In marine waters, birds could be exposed to these materials by direct contact or through the ingestion of contaminated food items. Birds most likely to be present at well sites are those that forage on invertebrates and fish in offshore waters; these include seabirds such as the alcids (such as the common murre, pidgeon guillemot, and ancient murrelet), gulls and terns (such as the mew gull and Arctic tern), and others.

Upon discharge in accordance with permit specifications, production wastes would be rapidly diluted in the water column (i.e., to ambient levels within several thousand meters of discharge [see Section 4.4.3.2.1]) and dispersed by currents, thus greatly reducing the potential for, and the magnitude of, exposure. If constituents of the discharged materials bioaccumulate or biomagnify, there is a potential for some birds to be exposed through their food. Field studies have shown that the concentrations of trace metals, hydrocarbons, or NORM in the tissues of fishes collected around production platforms are within background levels (Neff 1997a).

Normal operations may be expected to generate a variety of operational wastes, such as waste oils, bilge water on support ships, and sanitary wastes. Hazardous waste materials such as lubricating oils, paint, and industrial cleaners would be controlled and disposed of at licensed onshore facilities. Domestic wastewater and sanitary wastes generated on platforms or support vessels would be treated and then discharged to surrounding waters, where they would be quickly diluted (Section 4.4.3.2.1). Many species of marine birds (such as gulls) often follow ships and forage in their wake on fish and other prey injured or disoriented by the passing vessel. Because there would be up to 3 platforms and no more than three weekly vessel trips, only a relatively small volume of operational wastes would be discharged. Any such discharges would be quickly diluted and dispersed and thus not expected to affect marine or coastal birds that could be following the vessels or visiting waters immediately around the production platform.

Marine and coastal birds may become entangled in or ingest floating, submerged, and beached debris (Ryan 1987, 1990). Because the discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by the BOEMRE (30 CFR 250.40) and the USCG (MARPOL, Annex V, Public Law 100-220 [101 Statute 1458]), entanglement in or ingestion of OCS-related trash and debris by marine and coastal birds would not be expected under normal operations.

Vessel and Helicopter Traffic. There could be up to three helicopter trips and three vessel trips each week supporting up to three offshore platforms that could be installed following leasing under the proposed action. Vessel and helicopter traffic could disturb birds in foraging, molting, and staging area habitats as well as in nesting areas (such as seabird colonies) that may occur along the traffic routes. Birds may also be injured as a result of collisions with aircraft. Birds responding to approaching support vessels may be expected to cease normal behaviors and move away from the oncoming vessel; this would have little overall impact on affected birds.

In contrast to ship traffic, helicopter overflights likely have a greater potential for disturbing birds. Both the relatively sudden appearance (compared to an approaching ship) and the noise of helicopter overflights may startle birds, causing them to cease their normal behaviors and flee. The reactions of birds to aircraft overflights will depend on a variety of factors, including the species present, the altitude of the flights, and the frequency of the flights (e.g., see Gladwin et al. 1988; Ellis et al. 1991; Derksen et al. 1992; Miller et al. 1994; Larkin 1996; Delany et al. 1999). Helicopter overflights of open water may startle birds that are resting or foraging on the water surface, causing them to cease normal behavior and possibly try to flee the area. Should birds be disturbed while nesting, nesting success may be affected, especially if the disturbance results in nest abandonment and/or increased nest predation. Alternately, some birds may become habituated to aircraft disturbance. For example, no significant decrease in reproductive success was reported in a thick-billed murre colony located near an airport compared to other thick-billed murres that nested away from the airport (Curry and Murphy 1995). FAA guidelines for helicopter oceanic operations request that pilots maintain a minimum altitude of 213 m (600 ft) while in transit offshore, 305 m (1,000 ft) over unpopulated areas or across coastlines, and 610 m (2,000 ft) over populated areas and sensitive habitats such as wildlife refuges and park properties (FAA 2010).

It is assumed that helicopter support for the new platform would originate from the municipal airport in the Kenai-Nikiski area, north of the Cook Inlet Planning Area, and potential for disturbance of marine and coastal birds would be greatest along the east coast of Cook Inlet in this area and southward into the planning area. This area has several areas that provide important habitat for migrating shorebirds and waterfowl in spring, and some of which provide important overwintering habitat for Steller's eider (Table 3.8.2-2). Although there are no large seabird colonies in this area, small numbers of nesting seabirds could be affected by the overflights. Because of the low amount and transient nature of daily support traffic that might occur under the proposed action, relatively few birds may be expected to be affected by vessel or aircraft traffic, with negligible or minor impacts on affected birds. While disturbance of nesting birds has the potential for moderate impacts, the number of affected birds would likely be very limited, and if seabird colonies are present, the disturbance of nesting birds could be avoided by using flight paths and vessel routes that avoid the colonies.

Potential Effects on ESA-listed Species in the Cook Inlet Planning Area. Normal operations may affect listed bird species in the same manner as non-listed species (i.e., primarily behavioral disturbance). Compliance with ESA regulations and coordination with the NMFS and USFWS would ensure that lease-specific operations would be conducted in a manner that avoids or greatly minimizes the potential for affecting these species.

The endangered short-tailed albatross, the threatened Steller's eider, and the candidate Kittlitz's murrelet occur in or near the Cook Inlet Planning Area and thus could be affected by oil and gas development in the area. The short-tailed albatross does not breed in or near the Cook Inlet Planning Area, occurring only as an occasional visitor that forages on the continental shelf edge beyond the southern boundary of the planning area (see Section 3.8.2.2.2). The Steller's eider also does not nest in the Cook Inlet Planning Area, but does overwinter in lower Cook Inlet and in the Shelikof Strait. Thus, normal operations would not be expected to affect nesting habitats or reproductive success of either of these species.

Because of its uncommon occurrence in marine waters in and around the Cook Inlet Planning Area, relatively few short-tailed albatross would be expected to be present in areas where seismic exploration, offshore platform and pipeline construction, or OCS vessel and aircraft traffic is occurring. If present, disturbed individuals would likely move to areas away from the OCS activity and not be adversely affected. While it is possible for a bird to collide with an OCS-related aircraft, the combination of the very low number of short-tailed albatrosses that could be present around platforms or along associated flight lines with the very small amount of aircraft traffic supporting only new platforms means that few, if any, birds would be expected to incur collisions with support aircraft or with a platform. While such collisions would likely result in the mortality of the affected individual, population-level effects would not be expected to result from such collisions.

Overwintering flocks of Steller's eider could be temporarily disturbed by seismic exploration and by the construction of offshore platforms and pipelines, if those activities were to occur in or near areas where the birds are overwintering. Overwintering birds may also be disturbed by OCS-related vessel and aircraft traffic. If affected, birds would be expected to move away from oncoming vessels and would not be adversely affected. Overwintering birds may be startled by helicopter overflights and may or may not take flight and flee the immediate vicinity. Some birds could be killed or injured as a result of collisions with platforms or OCS-related aircraft. Because there would only be no more than three new platforms and three flights per week to the platforms by support aircraft, such collisions are not expected, few if any individuals would be affected, and no population-level effects would be expected.

While Kittlitz's murrelet can be found in the Cook Inlet Planning Area, it is present in a very patchy and clumped distribution, preferring areas of heavy glaciation, high turbidity, and partial ice cover (Day et al. 2000b; Van Pelt and Piatt 2003). This species has been reported to be sensitive to excessive noise and human activity (Day and Nigro 1999). Offshore platform or pipeline construction activities occurring near concentrations of this species could result in the short- or long-term displacement of birds from the construction areas. Construction of onshore pipelines and facilities could disturb nesting birds and affect nest sites, although it is unlikely that more than a few individuals would be affected. This species nests on cliffs and scree slopes, in a terrain typically avoided when pipelines are being sited. Long-term platform operations and daily vessel and aircraft traffic may also result in the long-term displacement of birds from platform locations and along frequently used flight line locations. In addition, some individuals could collide with OCS-related aircraft. Because of the disjunct distribution of this species, exposure to routine operations would be expected to be infrequent and localized.

Accidents. Under the proposed action, no more than one large spill (between 1,700 and 5,000 bbl from either a platform or a pipeline), and as many as 18 small spills (<1,000 bbl) may be expected over the lifetime of the lease. The magnitude and extent of impacts on marine and coastal birds from such spills will be a function of a variety of factors, including (1) the time of year of the spill, (2) the volume of the spill, (3) the habitats exposed to the spill, and (4) the species exposed to the spill or that utilize the impacted habitats. Oil spills from onshore pipelines may affect terrestrial habitats and birds. Because of the lower number of birds that would be present in winter, as well as their more limited winter distribution, a greater number of birds may be expected to be affected by an accidental oil spill in summer than in winter. Birds in areas near habitats that have been affected by oil may also be disturbed during spill cleanup operations. Spill cleanup activities may displace birds from nearby habitats, which, depending on the nature of those habitats (e.g., nesting, molting, staging), could result in reduced reproductive success or survival. In addition, the duration of cleanup activities may preclude birds from using the area for quite some time.

Exposure of eggs and young and adult birds to oil may result in a variety of lethal and sublethal effects, while oil may foul habitats, reducing habitat quality and contaminating foods; these potential effects apply to both non-listed and listed bird species of the Cook Inlet Planning Area. The short-tailed albatross, Steller's eider, and Kittlitz's murrelet may be directly affected by an accidental oil release in the same manner as described for non-listed birds, namely, via direct contact and through the ingestion of contaminated foods. These three species may also be indirectly affected as a result of spill-related impacts on their habitats, which may also be affected during oil spill cleanup activities. Direct exposure of birds or their habitats could result in a variety of lethal and nonlethal effects that may affect survival and reproductive success, potentially resulting in population-level effects on the exposed species (e.g., see Hartung 1995; Piatt and Anderson 1996; Day et al. 1997; Esler et al. 2000; Lance et al. 2001; Golet et al. 2002; Esler et al. 2002). The types of effects that exposed birds could incur are discussed in Section 4.4.7.1.

During ice-free conditions (i.e., summer), accidental spills (especially small ones) may be expected to be quickly diluted (see Section 4.4.3.2.2). In contrast, spills occurring under ice may persist for a longer period of time and be transported by currents to areas much more distant from the site of the accidental spill. Previous modeling of similar size oil spills in Cook Inlet indicate that land segments with the highest chance of contact with an offshore platform or pipeline spill are generally along the western shore of lower Cook Inlet in Kamishak Bay and Shelikof Strait (MMS 2003a). Several areas that provide important habitat to migrating and overwintering birds (see Figure 3.8.2-8 and Table 3.8.2-8), as well as a number of seabird colonies, occur in these areas (USGS undated).

Offshore spills that reach coastal areas may expose species that forage or nest in coastal habitats along Cook Inlet and Shelikof Strait. As discussed in Section 3.8.2.2, these areas support thousands of migrating shorebirds and waterfowl, provide important wintering habitat for Steller's eider, and include numerous seabird colonies. Spills reaching these areas could directly or indirectly expose adults, eggs, young, and food resources. Because of the large number of Steller's eider that overwinter in coastal areas of Cook Inlet (in the vicinity of Homer Spit and Kamishak Bay) (Larned 2005), an accidental spill reaching wintering areas could expose a large number of birds. This species concentrates in shallow, vegetated nearshore habitats, and spills contacting such areas could locally reduce foraging habitat and food resources and contaminate potential prey. The number of birds affected would depend on the size and location of the spill, the number of birds directly exposed to the spill, and the amount of habitat affected.

Offshore spills in marine waters may also expose migrating seabirds and waterfowl, as well as pelagic seabirds that forage in areas such as the offshore marine waters of Cook Inlet near the Barren Islands (Figure 3.8.2.2-1). The short-tailed albatross is considered to be highly vulnerable to the impacts of oil pollution (King and Sanger 1979). Because this species does not breed in the planning area, accidental spills would not be expected to affect nesting colonies. Because this species is widely dispersed and is only a regular visitor to the marine waters of the planning area, few individuals would be expected to be exposed to an accidental spill, and few individuals would be expected to be disturbed during spill cleanup activities. The exposure of a very small number of short-tailed albatross would not be expected to result in population-level impacts on the species. This species forages in open marine waters, and no specific foraging habitat type or location has been identified as being of prime importance for this species. In the event of an accidental spill, members of this species would likely relocate their foraging activities, with no resulting significant impacts expected. Thus, accidental spills would not be expected to adversely affect foraging habitats and associated prey items available to the short-tailed albatross in the Cook Inlet Planning Area.

Spills may also indirectly affect bird populations by reducing food resources and prey availability in affected habitats. These indirect effects could reduce foraging success and energy assimilation, which may affect growth, survival, and reproductive success. Depending on the species affected, these effects could result in population-level effects. Because of the small number and size of spills assumed for development that might occur under the proposed action (Table 4.4.2-1), widespread exposure and impacts such as those observed for the *Exxon Valdez* oil spill in Prince William Sound are not expected for this alternative.

Because of the preference of Kittlitz's murrelet for glacially influenced habitats and its patchy and disjunct distribution among coastal areas, accidental oil spills would generally not be expected to affect more than a few individuals. A moderate to large spill in a high-use area could, however, result in the oiling of a relatively large number of birds. While the chronic effects of long-term exposure of this species are not known, studies on the effects of the *Exxon Valdez* oil spill on marine birds indicate that while murrelets as a whole are especially vulnerable to and adversely affected by large oil spills, this group recovers within a relatively short time following the initial spill and exposure (Day et al. 1997a,b; Murphy et al. 1997). The greatest potential for population-level impacts would be associated with offshore spills occurring in spring and summer and affecting breeding adults. Because this species nests in terrestrial habitats up to 129 km (80 mi) inland (see Section 3.8.2.2.2), nest sites would not be expected to be affected by offshore spills but could be affected by spills from onshore pipelines. However, because this species nests in habitats such as coastal cliffs, scree slopes, and talus above timberline, which are typically considered unsuitable and thus are avoided when a pipeline is being sited, nest sites are unlikely to be affected by an onshore oil spill.

Catastrophic Discharge Event. The PEIS analyzes a CDE with a volume ranging from 75,000 to 125,000 bbl (Table 4.4.2-2). A low-probability CDE would have similar impacts on bird populations as spills of other magnitudes; however, the area affected would increase and the degree of impact would be more severe. A much greater number of birds and habitats could be affected, and population-level impacts for some species could be incurred as CDEs can affect extensive areas of shoreline. Such a spill contacting important migratory staging areas for waterfowl and shorebirds could have major adverse effects on a variety of species. Similarly, a catastrophic discharge event reaching wintering areas for waterfowl could have serious population-level effects, especially with the increased difficulty in addressing spills under winter conditions.

4.4.7.2.3 Alaska – Arctic.

Routine Operations. Under the proposed action, a number of facilities could be constructed and operated in offshore and onshore portions of the Beaufort Sea and Chukchi Sea Planning Areas (Table 4.4.1-4). Under the exploration and development scenarios for these two planning areas, it is assumed that development would be limited to the shelf areas of both planning areas and to water depths less than 91 m (300 ft). Because the shelf is relatively narrow in the Beaufort Sea, ranging from 90 km (about 60 mi) in the west to 50 km (30 mi) in the east, oil and gas activities would occur within 200 km (100 mi) of shore. In contrast, the Chukchi Sea Planning Area has a very wide shelf area with water depths less than 91 m (300 ft), and oil and gas activities may occur in areas 200 km (120 mi) or more from shore. Figure 4.4.1-2 shows the locations of historic lease sales in the Beaufort Sea and Chukchi Sea Planning Areas; future lease sales and development may be expected to occur in similar areas. Thus, coastal birds are more likely to be affected by development in the Beaufort Sea Planning Area than in the Chukchi Sea Planning Area following lease sales under the proposed action. Marine and coastal birds could be affected during routine operations at these locations by (1) offshore exploration, (2) construction of offshore platforms and pipelines, (3) construction of onshore pipelines, (4) operation of offshore platforms, (5) operational discharges and wastes, and (6) vessel and aircraft traffic.

Offshore Exploration. During offshore exploration, seismic surveys conducted in offshore areas could affect primarily seabirds, because these are the species most likely to be foraging or otherwise using pelagic open waters areas of the two planning areas. Potentially affected birds may include puffins, murres, auklets, gulls and terns. Noise from air guns and disturbance from survey vessel traffic could displace birds from nearby habitats. These disturbances would be limited to the immediate area around survey vessels, would be short term, and would not be expected to result in adverse impacts on local bird populations.

Construction of Offshore Platforms and Pipelines. Under the proposed action, one to four offshore platforms could be constructed in the Beaufort Sea Planning Area, and one to five in the Chukchi Sea Planning Area (Table 4.4.1-4). Construction of offshore platforms would likely involve the construction of gravel islands to support drilling operations, and seabirds and waterfowl that utilize offshore waters could be affected by construction of these islands. However, construction of these offshore islands would occur in winter when most species are absent. Thus, construction of offshore platforms would not be expected to affect seabirds or waterfowl.

The exploration and development scenario for the proposed action identifies the construction of many miles of new offshore pipeline in the two planning areas: 48 to 2,422 km (30 to 1,505 mi) for the Beaufort Sea and 40 to 402 km (25 to 250 mi) for the Chukchi Sea. Because pipeline construction would also occur in winter when most species have left the area, few birds would be affected by this construction.

Construction of the offshore gravel islands to support drilling operations would likely use gravel mined from the vicinity of the offshore islands. On the North Slope, gravel is generally extracted from the floodplains of large rivers (Pamplin 1979; BLM 2002). Because the mining of gravel would occur in winter along with other construction activities, gravel mining would not be expected to disturb seabirds, waterfowl, or shorebirds, because these would normally be absent during that time. The winter excavation of gravel could result in the conversion of some riverine floodplain habitats into open water habitats, potentially affecting the distribution and availability of nesting and foraging habitats for some species arriving the following spring after gravel excavation has occurred.

A variety of waterfowl and shorebird species nest in floodplain habitats along the Arctic coast. The extent to which some of these species could be affected by gravel excavation will depend on the specific habitats excavated, the extent of habitat disturbance, and the level of nesting use that the affected habitat typically supported. Because gravel excavation would occur in winter, active nests would not be disturbed. Instead, birds arriving in spring searching for suitable nesting habitat would simply search for other nesting locations. Because the relatively small number of offshore facilities that could be constructed under the proposed action (no more than nine platforms total for the two planning areas) would require a relatively limited amount of gravel, excavation activities (and associated habitat impacts) would likely be limited to a few locations.

Although pipeline trenching would also be carried out in winter when most seabird and waterfowl species are not present, seafloor trenching could locally disrupt benthic invertebrate communities that may serve as food sources for waterfowl during other seasons. The extent to which benthic food sources could be affected and the subsequent impact on waterfowl will depend on the type and amount of benthic habitat that would be permanently disturbed by trenching, the importance of the specific habitats in providing food resources to waterfowl, and the number of waterfowl that could be affected.

Pipeline trenching could disturb as much as 13.5 ha (33 ac) and 567 ha (1,400 ac) of benthic habitat in the Beaufort Sea and Chukchi Sea Planning Areas, respectively. Much of this disturbance would occur in water depths of 30 m (100 ft) or more and thus affect benthic habitats that are largely inaccessible by seabirds and diving ducks. Trenching could, however, affect the egg or larval survival/development (through direct mortality and increased turbidity) of fish species that will eventually become prey for seabirds (SAFMC 2005). The environmental changes caused by trenching would be temporary and would only affect more sensitive prey species. Thus, pipeline trenching is expected to have limited effects on the overall availability of waterfowl food sources, and any impacts on food sources would be very localized and would not be expected to result in population-level impacts on local seabird and waterfowl populations.

The winter construction would also utilize ice roads to build and access gravel island construction sites during the winter. Ice roads may be constructed over both tundra habitats and frozen ocean habitats. During the construction of ice roads, water from local rivers and lakes would be pumped onto the desired area to build up a rigid surface. Ice roads over frozen ocean habitats would have little effect on most bird species because few species would be present in this season. However, species that do overwinter (such as ptarmigan and snowy owl) may temporarily leave the construction area and move to similar habitats in nearby locations.

Construction of Onshore Pipelines. Under the proposed action, up to 129 km (80 mi) of new onshore pipeline could be constructed in onshore areas adjacent to the Beaufort Sea Planning Area; no onshore pipelines would be constructed in support of new development in the Chukchi Sea Planning Area (Table 4.4.1-4). The construction and operation of up to 129 km (80 mi) of new overland pipelines could disturb coastal and tundra species; it could degrade or eliminate as much as 390 ha (970 acres; assumes 30.5-m [100-ft] pipeline ROW) of potential nesting or post-molting habitat that would be permanently lost within the footprint of the new pipelines, causing birds to select habitats in other locations. Construction camps to support onshore construction activities would temporarily disturb some areas and limit use by birds; this disturbance would be short or long term, depending on the nature and effectiveness of camp abandonment and restoration activities following completion of construction activities. The impacts on potential habitat would be temporary and localized, and birds would likely respond by selecting other areas for nesting or post-molting. Regardless of the duration of the effect, the amount of habitat that would be disturbed would be relatively small and not be expected to affect more than a few birds. Careful pipeline ROW siting to avoid important nesting or post-molting habitats, and avoiding construction during post-molting and staging periods near such habitats, would further reduce the magnitude of any potential effects on local bird populations.

Operations of Offshore Platforms. During normal operations, birds may be affected by noise and human activities at the platforms, as well as by the presence of the platforms themselves. Noise generated during drilling and production activities could affect the use of surrounding waters by birds arriving during spring migration, foraging in surrounding waters during nesting season, and later in the year during fall molting and staging periods. Some species may react by avoiding areas immediately in the vicinity of the platforms, other species may show little avoidance or become acclimated, and still others may be attracted to the offshore platforms. Because of the small number of offshore platforms (no more than nine for both planning areas), the disturbance of birds by operational noise and activity would likely be limited to relatively few individuals and would not be expected to result in population-level effects for any species.

Operational platforms may pose collision threats to migrating and nesting birds alike. Many coastal nesting species travel out to open waters of the shelf to forage, while many species of waterfowl and seabirds migrate along the shelf in spring and summer (Section 3.8.2.3). While little information is available regarding bird collisions with platforms in the Arctic, annual bird mortality from collisions with offshore platforms in the northern GOM has been estimated to average 50 collision deaths per platform per year (Russell 2005). By applying a similar collision mortality rate to the platforms that would be developed in the Beaufort Sea and Chukchi Sea Planning Areas, a total of 200 annual bird collision mortalities might be expected for the four new platforms in the Beaufort Sea Planning Area, and 250 total annual collision mortalities for the five new platforms in the Chukchi Sea Planning Area. The incidence of bird collisions in the GOM may be much greater than the incidence that could occur in the two Arctic planning areas because of the much greater number of migrants in the GOM. However, some Arctic species such as the murres and puffins) are present in very large numbers (Section 3.8.2.3.1) in some locations along the Arctic coast and exhibit daily migrations between coastal nesting areas and foraging areas as far as 80 km (50 mi) or more offshore, which could increase the potential for encountering offshore platforms.

Operational Discharges and Wastes. Produced water, drilling muds, and drill cuttings generated by development and production wells would be disposed of through down-hole injection. Thus, no impacts on marine and coastal birds from these wastes would be expected under routine operations. In contrast, produced water, drilling muds, and drill cuttings generated by exploration and delineation wells would be discharged at the well sites in compliance with applicable regulations and permits. In marine waters, birds could be exposed to these materials by direct contact or through the ingestion of contaminated food items. Birds most likely to be present at well sites are those that forage on invertebrates and fish in offshore waters; these include seabirds such as the murres and puffins, gulls, and jaegers.

Many species of marine birds (especially gulls) often follow ships and forage in their wake on fish and other prey injured or disoriented by the passing vessel. In doing so, these birds may be affected by discharges of waste fluids (such as bilge water) generated by OCS vessels. The discharge of such wastes from OCS service and construction vessels, if allowed, would be regulated under applicable NPDES permits, and any discharged wastes would be quickly diluted and dispersed and thus not be expected to affect marine birds.

Marine and coastal birds may become entangled in or ingest floating, submerged, and beached debris (Heneman and the Center for Environmental Education 1988; Ryan 1987, 1990). Entanglement may result in strangulation, the injury or loss of limbs, entrapment, or the prevention or hindrance of the ability to fly or swim, and all these effects may be considered lethal. Ingestion of debris may irritate, block, or perforate the digestive tract, suppress appetite, impair digestion of food, reduce growth, or release toxic chemicals (Fry et al. 1985; Dickerman and Goelet 1987; Ryan 1988; Derraik 2002). Because the discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by the BOEMRE (30 CFR 250.40) and the USCG (MARPOL, Annex V, Public Law 100-220 [101 Statute 1458]), entanglement in or ingestion of OCS-related trash and debris by marine and coastal birds would not be expected under routine operations.

Vessel and Aircraft Traffic. Development occurring under the proposed action could include up to 12 weekly vessel and helicopter trips in the Beaufort Sea Planning Area and as many as 15 weekly helicopter and vessel trips in the Chukchi Sea Planning Area. The presence of ships and helicopters, as well as noise associated with their passage, can disturb birds and potentially affect feeding, resting, or nesting behavior, and may cause affected birds to abandon the immediate area. Which birds could be affected, the nature of their response, and the potential consequences of the disturbance will be a function of a variety of factors, including the specific routes, the number of trips per day, the altitude of the flights, the seasonal habitats along the routes, the species using the habitats and the level of their use, and the sensitivity of the birds to vessel and aircraft traffic. Traffic near or over heavily utilized feeding or nesting habitats of sensitive species could result in population-level effects, while impacts from traffic in other areas with less sensitive species would largely be limited to a few individuals and would not result in population-level effects. The use of shipping lanes and aircraft routes avoiding sensitive bird areas would greatly reduce or eliminate the potential for vessel and aircraft traffic to cause population-level effects in marine and coastal birds.

Helicopter overflights are generally conducted at low altitudes and have the potential for disturbing birds in onshore and offshore locations (Ward and Stein 1989; Ward et al. 1994; Miller 1994; Miller et al. 1994). FAA guidelines for helicopter oceanic operations request that pilots maintain a minimum altitude of 213 m (600 ft) while in transit offshore, 305 m (1,000 ft) over unpopulated areas or across coastlines, and 610 m (2,000 ft) over populated areas and sensitive habitats such as wildlife refuges and park properties (FAA 2010). The type of response elicited from the birds and the potential effect on the birds will depend in large part on the time of year for the overflights and the species disturbed. Helicopter overflights during spring breakup of pack ice may disturb marine species feeding in open water leads and waterfowl in open coastal waters, causing birds to leave the area. Similarly, overflights in summer could displace waterfowl and seabirds from preferred foraging areas and from coastal nesting or brood-rearing areas such as seabird colonies and the lagoon systems of the Beaufort and Chukchi Seas. Molting and staging waterfowl may temporarily leave an area experiencing helicopter overflights (Derksen et al. 1992), while geese have been reported to exhibit alert behavior and flight in response to helicopter overflights (Ward and Stein 1989; Ward et al. 1994).

While bird strikes are possible, any such events would affect only an occasional individual and not result in any population-level effects. However, the increased energy demand associated with birds leaving foraging or staging areas for other, potentially less favorable areas could result in a lowered fitness of the affected birds. While birds disturbed from nesting or brood-rearing habitats by occasional overflights would be expected to return, birds experiencing frequent overflights may permanently relocate to less favorable habitats (MMS 2002b). In addition, the temporary absence of adult birds may increase the potential for predation of unguarded nests and young (NRC 2003a).

Accidents. Marine and coastal birds could be affected by accidental oil spills from offshore platforms and pipelines, as well as from onshore processing facilities and pipelines. The magnitude and extent of impacts will be a function of a variety of factors, including (1) the time of year of the spill, (2) the volume of the spill, (3) the habitats exposed to the spill, and (4) the species exposed to the spill or that utilize the exposed habitats. Exposure of eggs and young and adult birds to oil may result in a variety of lethal and sublethal effects. Oil moving into coastal and inshore areas may foul habitats, reducing habitat quality and contaminating vegetation and invertebrate foods. Ingestion of contaminated foods may lead to a variety of lethal and sublethal toxic and physiological effects. Finally, oil spill-response activities may disturb birds in nearby habitats that are unaffected by an oil spill.

Certain species of marine and coastal birds may be more susceptible to contact with spilled oil than others, based on their life histories. For example, diving seabirds and underwater swimmers such as loons and diving ducks may be the most susceptible to offshore spills because of their extensive use of such areas and their relatively long exposure time on the sea surface. In contrast, shorebirds and waterfowl may be most susceptible to spills that reach the beach intertidal zone, coastal lagoons, or inshore wetland habitats where these species forage and raise young. The magnitude of the impact will depend on the size of the spill, the species and life stage when exposed, and the size of the local bird population.

Offshore spills in spring that reach coastal barrier islands and mainland coastal wetland areas may expose common eiders, gulls, and other birds that nest in these habitats along the Beaufort and Chukchi Seas. Some of these areas support large nesting colonies, and direct and indirect exposure of adults, eggs, young, and food resources may adversely affect reproductive success and result in population-level effects on some species.

Offshore spills in spring may also expose migrating seabirds and waterfowl. Exposed individuals may experience lethal or sublethal effects from the exposure. Depending on the species, mortality or subsequent impacts on reproduction could result in population-level impacts on some species. Species with naturally low reproductive rates, such as the long-tailed duck and red-throated loon, may be especially vulnerable to population-level impacts. Because these species have a low reproductive rate that limits natural population growth, the loss of comparatively few individuals could result in more substantive population impacts.

Spring spills contacting shoreline areas have the potential to expose thousands of migrating shorebirds, as well as contaminating nesting and foraging habitats and oiling nests and eggs. Exposure of individuals could result in lethal or sublethal effects, while oiling of nests and/or eggs would reduce reproductive success.

Spills occurring in late summer through autumn and that enter coastal lagoons and delta areas could expose large numbers of waterfowl (loons, tundra swans, king eiders, long-tailed duck) that use these habitats for molting and staging, and potentially result in adverse population-level effects. For example, mortality estimates of long-tailed ducks in the central Beaufort Sea from a hypothetical spill ranged as high as 35%, depending on the amount of oil spilled and the number of birds present (MMS 2003a). A winter spill under the ice could contaminate ice leads that develop during spring breakup, exposing eiders and other waterfowl that use these features while migrating.

Oil spills from onshore pipelines would likely be limited to a much smaller area than would a spill in an offshore location. Those birds exposed could incur a variety of lethal or sublethal effects; however, because relatively few individuals or nests would be expected to be exposed, no population-level impacts would be expected. However, an oil spill from an onshore pipeline that reaches an aquatic habitat such as a stream, wetland, or lake on the Arctic coastal plain may have greater impacts on shorebirds and waterfowl. Many such aquatic habitats are used by a variety of waterfowl and shorebirds for brood rearing, molting, and staging. Thus, a terrestrial spill reaching such habitats could expose a much larger number of birds than a spill restricted to a terrestrial environment.

Spill cleanup activities may disturb and displace birds from nearby habitats. Depending on the use of those habitats (e.g., nesting, molting, staging), displaced birds could incur reduced reproductive success or survival. In addition, the duration of cleanup activities may not only displace birds currently present but also preclude birds using the area for quite some time. For example, cleanup activities associated with a large spill may involve hundreds of workers and numerous boats, aircraft, and onshore vehicles, operating in the affected area for a year or more. During this time, migrating birds arriving in spring would be expected to bypass habitats that are near areas undergoing active cleanup operations.

Catastrophic Discharge Event. The PEIS analyzes CDEs for the Chukchi Sea and Beaufort Sea Planning Areas with volumes ranging from 1,400,000 to 2,200,000 bbl and 1,700,000 to 3,900,000 bbl, respectively (Table 4.4.2-2). A low-probability CDE would have similar impacts on bird populations as spills of other magnitudes; however, the area affected would increase and the degree of impact would be more severe. A much greater number of birds and habitats could be affected, and population-level impacts for some species could be incurred as impacts of CDEs in this region are prolonged by the cold water and cold air temperatures.

4.4.7.2.4 Conclusion. Routine operations may be expected to affect some birds in each of the planning areas included in the proposed action. The nature and magnitude of effects on birds would depend on the specific location, the timing, and the nature and magnitude of the operation, as well as the species that would be exposed to the operation. For routine Program activities, the primary effects would be the disturbance of birds (and their normal behaviors) by noise, construction and development equipment, and human activity, and habitat loss in areas of infrastructure construction. Birds may also incur injury or mortality as a result of collisions with infrastructure and support vessels. Impacts to birds from routine operations associated with the Program are expected to range from negligible to moderate.

Because birds tend to habituate to human activities and noise, potential impacts for many species associated with such disturbance would be short term and would not be expected to result in population-level effects. This could be especially true in the GOM planning areas, where local bird populations are regularly exposed to noise, construction, and vessel traffic associated with commercial and recreational activities. However, depending on the time of year, construction activities near coastal habitats could disrupt breeding and nesting activities of colonial nesting birds, potentially affecting local populations. In most cases, the disturbance of birds would be short term or transient, and would not be expected to result in population-level effects on affected species.

Construction of pipelines, landfalls, and offshore gravel islands (to support Arctic drilling platforms) would result in the permanent disturbance of habitat within the immediate footprint of the new facilities and gravel excavation areas. Because of the relatively small amount of habitat that could be disturbed, as well as the limited use of some of the affected habitats (such as deep water benthic habitat), habitat disturbance or loss is expected to have only minor impacts on marine and coastal birds. However, the level of impact that could be incurred by any species will depend on the type of habitats affected and the importance of those habitats to local bird populations. Loss of nesting, molting, or staging habitats (especially in the Alaska Planning Areas) has the potential to affect reproductive success, foraging success, and survival of some species, and may result in population-level impacts on affected species. Careful siting of infrastructure to avoid sensitive and important habitats would greatly reduce or eliminate the potential for population-level effects.

Some mortality may be expected for birds colliding with offshore platforms and, to a lesser extent, with helicopters providing support services to offshore platforms. Impacts from such collisions are anticipated to affect relatively few birds and result in only minor impacts on bird populations, with no population-level effects. Because the discharge of production wastes and other materials generated at offshore platforms and OCS-related vessels is regulated and because permitted production wastes discharged into marine waters would be quickly diluted and dispersed, relatively few birds would be exposed to these waste materials and impacts from such discharges would likely be negligible.

While normal operations could affect listed bird species in the same manner as non-listed species (primarily behavioral disturbance), compliance with ESA regulations and coordination with the USFWS would ensure that lease-specific operations would be conducted in a manner that avoids or greatly minimizes impacts on these species.

Accidental oil spills (and especially those associated with a CDE) pose the greatest threat to marine, coastal, and migratory birds, and could affect both birds and their habitats. Exposed birds may experience a variety of lethal or sublethal effects, including reduced reproductive success. The magnitude and ecological importance of any effects would depend upon the size of the spill, the species and life stages that are exposed, and the size of the local bird population. A spill associated with a CDE would affect the greatest number of species, individuals, and habitats, and have the potential to cause population-level impacts to affected species. Exposure to spills in deep water would be largely limited to pelagic birds, while shallow-water spills could affect the greatest variety and number of birds, including shorebirds, waterfowl, wading birds, gulls and terns. Birds that become heavily oiled by direct contact with a spill would likely perish, while lightly oiled birds may experience a variety of lethal or sublethal effects. Oil washing ashore may contaminate eggs and nest sites, as well as foul foraging areas and food resources.

In the GOM, spills in deep water are not likely to affect listed marine and coastal birds because, with the exception of the roseate tern, none of the seven listed species would be expected offshore where deepwater spills could occur. The roseate tern does not normally frequent waters in close proximity to the Western, Central, and Eastern GOM Planning Area where lease sales and subsequent oil and gas activities may occur under the proposed action. In the Alaskan Planning Areas, only the short-tailed albatross would be expected with any regularity in OCS areas more than 200 km (124 mi) from shore. For the GOM and Alaskan OCS Planning Areas, most of the listed and candidate species could be exposed to shallow-water spills or to large deepwater spills (especially large or CDE-level spills) that have moved into coastal waters. In coastal areas, most of the listed species could be directly exposed while foraging in oiled flats, beaches, and coastal wetlands. Because all of the wild populations of the endangered whooping crane use limited habitats on the GOM coast (in Texas, Florida, and Louisiana), the entire population of this species may be especially vulnerable to a spill that reaches these locations. In Alaska, the threatened spectacled eider congregates in specific habitats during molting and when staging for fall migration, this listed species may also be particularly vulnerable to population-level effects should a spill contact molting or staging habitats with large numbers of individuals. Similarly, the threatened Steller's eider overwinters in Cook Inlet and a large spill could locally affect a relatively large number of birds. Spills occurring in glacially influenced coastal habitats could expose relatively large numbers of Kittlitz's murrelet, a candidate species for listing under the ESA. This species has been reported to be particularly vulnerable to oil exposure. Because neither the albatross nor the eider breeds in the Cook Inlet Planning Area, accidental spills would not be expected to affect nest sites of these species. While Kittlitz's murrelet breeds in Cook Inlet, it nests on cliffs, scree slopes, and other areas where its nests would not be expected to come in contact with accidental oil spills.

4.4.7.3 Fish

4.4.7.3.1 Gulf of Mexico.

Fish Resources.

***Routine Operations*.** See individual habitat sections for detailed discussions of the impacts of oil and gas activities on fish habitat in the GOM. Potential OCS oil and gas development impacting factors for fish in the GOM are shown by phase in Table 4.4.7-3. Impacting factors common to all phases include platform lighting, increased ship traffic, vessel discharges (bilge and ballast water), and miscellaneous discharges (deck washing, sanitary waste). Impacts from waste discharges would be localized and temporary and are expected to have negligible impacts on fish populations. Many of these waste streams are disposed of on land, and all vessel and platform wastes that are discharged into surface waters must meet USEPA and/or USCG regulatory requirements. Studies conducted in the northern GOM suggest that platform lighting could alter predator-prey dynamics by enhancing phytoplankton productivity around the platform, potentially improving food availability and the visual foraging environment for fishes (Keenan et al. 2007). Potential impacts from platform lighting would be localized but long term and are expected to have minimal impacts on fish populations.

Exploration and Site Development. During the OCS oil and gas exploration and development phase, fish could be affected by noise from seismic surveys and noise and bottom disturbance from drilling, platform placement, and pipeline trenching and placement activities. Releases of drilling muds and cuttings could also affect fish by contaminating food resources in sediments and surrounding surface waters (Table 4.4.7-3).

TABLE 4.4.7-3 Impacting Factors on Fish and Their Habitat in the GOM Planning Areas

Development Phase and Impacting Factor	Life Stage Affected[a] Eggs	Larvae	Adults
Impacting Factors Common to All Phases			
Vessel noise	X	X	X
Vessel traffic	X	X	X
Hazardous materials	X	X	X
Solid wastes	X	X	X
Offshore lighting	X	X	X
Aircraft noise			
Offshore air emissions			
Onshore air emissions			
Aircraft traffic			
Miscellaneous platform discharges	X	X	X
Vessel discharges	X	X	X
Bottom disturbance from vessel anchors	X	X	X
Exploration and Development			
Seismic noise	X	X	X
Noise from drilling and construction	X	X	X
Bottom disturbance from platform placement, drilling, and pipeline placement and trenching	X	X	X
Discharge of drilling muds and cuttings	X	X	X
Production			
Production noise	X	X	X
Produced water discharge	X	X	X
Artificial reef	X	X	X
Decommissioning			
Platform removal (non-explosive)	X	X	X
Platform removal (explosive)	X	X	X

[a] Colors indicate impact level: white = negligible; blue = minor; yellow = moderate; red = major.

All fish species in the GOM are presumed to be able to hear with varying degrees of sensitivity and within the frequency range of sound produced by exploration site development activities. Noises generated during platform and pipeline placement, vessel traffic, and seismic surveys are all potential sources of disturbance to fish communities. Noise could kill or injure fish, induce behavioral alterations, produce generalized stress, and interfere with communication (Smith et al. 2004; Vasconcelos et. al. 2007; see Popper and Hastings 2009 for a recent review). A primary source of noise during exploration and site development would be air guns used during seismic surveys. There is some experimental evidence that noise generated by seismic surveys could kill or injure organisms typically within a few meters of the noise source, but other studies found no injury or mortality even for sensitive, early life stages (Dalen and Knutsen 1986; Holliday et al. 1987; reviewed in NSF and USGS 2010). Several researchers have also documented startle responses or temporary avoidance of areas exposed air gun noise, but these effects are not found consistently (Turnpenny and Nedwell 1994; reviewed in Popper and Hastings 2009 and NSF and USGS 2010). Continuous long-term exposure to high-pressure sound waves has been shown to cause damage to the hair cells of the ears of some fishes under some circumstances (Popper 2003). Several studies have found that species with gas bladders, which includes many of the pelagic and demersal fish species in the GOM, are more vulnerable to injury or mortality from explosions than species without gas bladders such as flatfish (MMS 2004a). For adult fishes, continuous exposures would not exist under natural circumstances as fish could move from the area. However, fish larvae may suffer greater mortality because of their small size and relative lack of mobility. The severity and duration of noise impacts would vary with site and development scenario, but overall the impacts would be temporary, localized, and minor. A recent review of seismic survey noise on marine fish concluded that although data were limited, there would be no significant impacts on marine fish populations from seismic surveys (BOEMRE 2010c; NSF and USGS 2010).

Bottom-disturbing activities such as coring and drilling, platform placement and mooring, and pipeline trenching and placement would displace fish in the vicinity of the activities. Bottom disturbance would result in temporary sedimentation and increased turbidity, which could damage fish gills and bury benthic invertebrate prey resources within some distance of the disturbance. Fish mortality may also be greater if bottom disturbance occurs in areas of high larval and juvenile fish density such as estuaries and nearshore areas. In addition, the physical changes to benthic habitat resulting from drilling could affect food resources for benthic fishes by altering benthic invertebrate community composition. Soft sediment fishes, particularly in shallow water, are subject to frequent bottom disturbance from human activities such as trawling and natural occurrences such as storms and are presumably well adapted to such conditions.

The discharge of drilling muds and cuttings (including synthetic drilling fluids adhering to the cuttings) can affect fish in several ways. Impacts from turbidity would be similar to those described above and could damage respiratory structures, cause fish to temporarily move from the area, and disrupt food acquisition. Drilling muds and cuttings released near the sediment surface or in shallow water would bury benthic food resources in the release area although conditions would eventually recover. Trace metal and hydrocarbon constituents in drilling fluids can be toxic to all life stages of fishes if exposed to high enough concentrations. Planktonic eggs and larvae that contact the mixing zone would be at greatest risk (e.g., Kingsford 1996), while juveniles and adults passing through a discharge are not likely to be adversely affected. The disturbance would be short, and based on the assumption of a relatively widespread distribution of eggs, larvae, and prey, only a very small proportion of the population of a given fish species is likely to be affected. In addition, all discharges must comply with NPDES permit requirements regarding the discharge amount, rate, and toxicity, which would greatly reduce the impact on fish communities. BOEM-sponsored research on the biological effects of drilling fluids on marine communities in the GOM (Continental Shelf Associates, Inc. 2004, 2006) found that fish densities were elevated near the platforms compared to control locations and certain classes of benthic invertebrate food sources were also more abundant within 300 m (984 ft) of the well compared to control areas (Continental Shelf Associates, Inc. 2006).

There are several protective measures in place to protect sensitive fish habitat from oil and gas activities. Impacts on hard-bottom areas from bottom-disturbing activities would be minimized by the Topographic Features Stipulation that establishes No Activity Zones, where no operations, anchoring, or structures are allowed. There is also a lease stipulation that requires avoidance of low-relief live-bottom and pinnacle features. In deep water, there are stipulations requiring the avoidance of chemosynthetic communities and deepwater corals.

Based on the discussion above, the site development and exploration represent a minor disturbance, primarily affecting demersal fishes, with the severity of the impacts generally decreasing dramatically with distance from bottom-disturbing activities.

<u>Production.</u> Production activities that could affect soft sediment habitat include operational noise, bottom disturbance, and the release of process water. In addition, the platform would replace existing featureless soft sediments and serve as an artificial reef (Table 4.4.7-3).

Chronic bottom disturbance could result from the movement of anchors and chains associated with support vessels and floating platform moorings. Bottom disturbance would affect fish and their food resources in a manner similar to that described above for the exploration and site development phase. Some of the disturbance could be episodic and temporary, but others would last for the lifetime of the platform.

Sessile epifaunal invertebrates requiring hard substrate (i.e., barnacles and corals) as well as small motile invertebrates (amphipods and worms) would colonize fixed or floating platform structures, creating an artificial reef. Pipelines not buried would also provide hard substrate for sessile and structure-oriented fish species. Reef fish and epipelagic fishes such as tunas, dolphin fish, and jacks would be attracted to these platforms in concentrations greater than those of surrounding soft sediments and even natural reefs (Wilson et al. 2003). The platforms could possibly enhance feeding of predators by attracting and concentrating smaller prey species. However, concerns have been expressed that highly migratory species could be diverted from normal migratory routes and consequently from normal spawning or feeding areas because of attraction to structures such as oil platforms (Carney 1997). Similarly, platforms may attract reef fish from natural hard-bottom areas. Thus platforms may simply attract fish rather than increasing fish production and at the same time make them easier to harvest by commercial and recreational fisheries (Brickhill et al. 2005). Because of the wide distribution of reef and epipelagic species and the great number and spatial extent of production platforms, such effects could extend to the regional scale. Ultimately, the benefit or detriment of artificial reefs as habitat depends on how fisheries are managed on the reef and the individual life histories and habitat requirements of the species present (Bohnsack 1989; Macreadie et al. 2011).

Produced water contains several toxic elements (Neff 1997a), and direct and continuous exposure to produced waters can be lethal to all life stages of fishes. Because more chemicals are required to maintain adequate flow in deep waterwells, produced water from deepwater wells is expected to contain more chemical contaminants than wells in shallow water. Direct exposure would occur only in the water column near the discharge point; thus pelagic adults and planktonic eggs and larvae would be most susceptible. Higher impacts would be realized if eggs and larvae were unusually concentrated. Thus, local circulation patterns greatly influence the degree of potential impact. Nevertheless, population-level effects on fishes are not likely, as contaminants are not expected to reach toxic levels in the sediment and water column because of dilution and NPDES permitting requirements regarding discharge rate, contaminant concentration, and toxicity. In studies of the potential long-term ecological effect of oil and gas development, no significant bioaccumulations of hydrocarbons or metals were observed in fish collected near platforms, and histopathological evaluations of fish found no damage to liver tissue (Peterson et al. 1996). In addition, benthic invertebrate food sources collected in sediments near platforms do not appear to bioaccumulate the common contaminants in produced water, and their tissues did not exceed USEPA-specified concentrations considered harmful (Continental Shelf Associates, Inc. 1997). Organisms attached to oil platforms have not been found to accumulate metals, although they have been found to bioaccumulate organic contaminants (Continental Shelf Associates, Inc. 1997). Produced water discharge has also not been found to contribute significantly to hypoxia in the GOM (Rabalais 2005; Bierman et al. 2007). Thus, production activities are expected to result in minor impacts on fish communities.

Decommissioning. Platform removal in general would temporarily affect fish by displacing resident fishes, disturbing sediments, and increasing noise and turbidity for some length of the water column. In addition, it is assumed that up to 275 platforms would be removed using explosives, which could kill or cause sublethal injury to many of the fishes associated with the structures. Small fish and fish with swimbladders are most susceptible to injury and mortality from underwater blasts. In a study of 792 explosive platform removals in the GOM, an average of 567 dead fish were observed floating at the surface, although the actual number dead is likely to be higher (Continental Shelf Associates, Inc. 2004b). Mark and recapture studies conducted at platform removal sites in the central and western GOM (Gitschlag 2000) estimated that between 2,000 and 5,000 fishes greater than 8 cm (3 in.) in length and more than 6,200 fish less than 8 cm (3 in.) were killed during explosive removals in water depths ranging from 14 to 32 m (46 to 105 ft). Sheepshead, spadefish, red snapper, and blue runner accounted for 89% of the mortality estimated by these studies. Mortality estimates of red snapper associated with the platform ranged from 57 to 90%. Assuming 275 explosive removals, a large number of fish could potentially be killed during the Program. Displaced fish would repopulate the area over a short period of time, although the species composition would likely shift to soft sediment species and away from reef and migratory pelagic species of fish. Overall, decommissioning activities are expected to result in up to moderate effects on fish communities.

If fixed platforms are toppled and left in place, the platform would continue to serve as an artificial reef, although the density and composition of fish may change. For example, the high vertical relief of the platform is important in attracting fish; thus fish density may decline once the platform is toppled (Wilson et al. 2003). Pipelines not buried, in both shallow and deepwater would provide hard substrate and habitat for structure-oriented fishes. As discussed above, the ability of artificial reefs to enhance fish production is controversial. In addition, artificial reefs may allow the spread of non-native fish species across the GOM, especially as waters warm due to climate change (Hickerson et al. 2008). For example, lionfish (*Pterois volitans*) have spread from the reefs of the West Florida shelf to the central and western GOM, where they are often found associated with oil platforms (http://www.lsu.edu/seagrantfish/biological/invasive/redlionfish.htm). In the future, other species could become established through range expansion or human introductions. Ultimately, the benefit or detriment of artificial reefs as habitat depends on how fisheries are managed on the reef and the individual life histories and habitat requirements of the species present (Bohnsack 1989; Macreadie et al. 2011).

***Accidents*.** Impacts of most accidental hydrocarbon releases on fish and their habitat are expected to be relatively minor, as most spills would be small and hydrocarbons would be diluted and broken down by natural processes. The location of the spill, habitat preference of the fish, and the season in which the spill occurred would be important determinants of the impact magnitude of the spill.

Toxic fractions of PAHs in spilled oil can cause death or illness in adult fishes. Less is known about the impacts of natural gas on fish, but natural gas could have lethal or sublethal impacts as well, depending on concentration. Impacts of hydrocarbons differ among various life stages of fishes. For example, pelagic eggs and larval stages of fish, whose movements are largely controlled by water currents, could be killed if they came into contact with surface oil spills (Patin 1999). Conversely, oil and gas would typically rise above the seafloor, which would limit direct contact with demersal fishes. Evidence also indicates that the majority of adult pelagic fish can likely detect and avoid heavily oiled waters in the open sea, thereby avoiding acute effects (Patin 1999; Roth and Baltz 2000). However, adult fish could still be exposed to sublethal hydrocarbon concentrations through direct contact with gills or through ingestion of spilled oil. In addition, oil could ultimately enter the benthic food web as oil-contaminated pelagic organic matter and biota settled to the seafloor.

Catastrophic Discharge Event. The PEIS analyzes a CDE up to 7.2 million bbl could result from pipeline ruptures, a loss of well control, and from tanker spills associated with an FPSO system (Table 4.4.2-2). At the population level, hydrocarbon spills could affect fish by causing high mortality of eggs, larvae, juveniles, or adults; triggering abnormal development; impeding the access of migratory fishes to spawning habitat; displacing individuals from preferred habitat; reducing or eliminating prey populations available for consumption; impairing feeding, growth, or reproduction; causing adverse physiological responses; increasing susceptibility to predation, parasitism, diseases, or other environmental perturbations; and increasing or introducing genetic abnormalities. Most of the fishes inhabiting shelf or oceanic waters of the GOM have planktonic eggs and larvae (Ditty 1986; Ditty et al. 1988; Richards et al. 1993). Catastrophic spills occurring during recruitment periods or spills that affect areas with high larval fish concentrations such as estuaries could result in population-level impacts. Because of the wide dispersal of early life history stages of most fishes in the GOM, it is anticipated that only a relatively small proportion of early life stages present at a given time would be affected by a particular oil spill event, and this would limit the potential for population-level effects. For example, an evaluation of the response of coastal fishes to the DWH event suggests that large-scale losses of 2010 cohorts were largely avoided and that there were no discernible shifts in species composition following the spill (Fodrie et al. 2011). However, the impact magnitude would also depend on the temporal and spatial scope of the oil spill. Since some species of fish spawn in a limited geographic area(s) during a small temporal window, a spill could have population-level impacts if the spill coincided in time and space with spawning activity. In addition, fish species such as tuna, swordfish, and other billfish that currently have depressed populations and critical spawning grounds in the GOM could experience major impacts if high numbers of early life stages were killed by a spill.

Protected Species: Gulf Sturgeon.

Routine Operations.

Exploration and Site Development. No information is available on the hearing or acoustic biology of Gulf sturgeon from which to assess effects. The only noise sources strong enough to produce impacts other than behavioral disruption are seismic surveys. Since the seismic sources (air guns) are fired in the upper water column, Gulf sturgeon are unlikely to be injured, but the noise could have behavioral effects such as disruption of feeding and movement behaviors. Adult Gulf sturgeon wintering in shelf waters of the GOM may be affected by sounds emanating from working platforms and their attendant operations. However, the most likely effects would be short-term behavioral disruption or avoidance of certain areas.

The placement of bottom-founded structures during the exploratory drilling phase may affect adult Gulf sturgeon and their designated critical habitat (50 CFR 226.214) directly and indirectly. As with all fish, the drilling platform and pipeline placement could injure or displace Gulf sturgeon and reduce or eliminate their benthic food resources. These disturbances could affect adult Gulf sturgeon during cooler months, which is their primary feeding period of the year when they move from coastal rivers into inner shelf waters of the eastern and central GOM (Huff 1975; Mason and Clugston 1993). However, most new oil and gas production activities would not occur in the shallow coastal waters less than 10 m (33 ft) in depth (67 FR 39106–39199) preferred by Gulf sturgeon. Consequently, only a small proportion of the areas of bottom disturbance would potentially be used by Gulf sturgeon.

Drilling muds and cuttings can be released at or near the sea surface or the seafloor. Muds and cuttings are diluted and dispersed rapidly in the ocean; therefore, cuttings released at the surface are unlikely to have measurable impacts on Gulf sturgeon. However, food resources for Gulf sturgeon may be buried by muds and cuttings released near the seafloor or settling in thick accumulations in shallow water. Gulf sturgeon are known not to have an affinity for structured habitat, and they occur in water shallower than that typically used for drill sites. Thus, accumulations of drilling muds and cuttings are not likely to affect Gulf sturgeon or their habitat.

Production. Produced water discharges dilute rapidly in the open ocean, and direct exposure would occur only in the water column near the discharge point where adult sturgeon are not likely to be located. Vulnerable early life stages of Gulf sturgeon exist only in rivers far removed from produced water discharges, making exposure unlikely. The discharge of produced water is not thought to contribute to significantly increasing the size or severity of the hypoxic zone in the GOM (Rabalais 2005). Consequently, it is believed that discharges resulting from the proposed action will not affect dissolved oxygen levels in areas used by Gulf sturgeon.

Decommissioning. Under the proposed action, it is assumed that explosives would be used to remove up to 275 platforms in the entire GOM. Explosive blasts can be lethal to fishes that may be present near the structure (Gitschlag 2000). However, the Gulf sturgeon are known not to have an affinity for offshore structures; thus, they are not likely to be affected.

***Accidents*.** Hydrocarbons could affect adult sturgeon by direct contact with gills or via direct ingestion. Adult and juvenile fishes would likely avoid oil from a spill. Eggs and larvae of fishes could die or become deformed if exposed to certain toxic fractions of spilled oil (Longwell 1977; Collier et al. 1996; Kingsford 1996). However, contact with early life stages of Gulf sturgeon is unlikely because floating oil is not likely to penetrate to the middle reaches of most rivers where eggs are deposited and because oil would float on the freshwater outflow and never reach or settle directly on demersal eggs (Sulak and Clugston 1998; Fox et al. 2000).

Protected Species: Smalltooth Sawfish.

Routine Operations.

<u>Exploration and Site Development.</u> Smalltooth sawfish are considered rare from Texas to the Florida panhandle (NMFS 2009) and are not likely to be present in the Central and Western Planning Areas where exploration and site development, production, and decommissioning activities occur. In addition, smalltooth sawfish are livebearers; therefore sensitive egg and larval life stages are not present in the water column, which makes them less susceptible to impacts from exploration and production activities.

Noise from underwater construction and seismic surveys could produce impacts ranging from lethal to sublethal and behavioral (Popper and Hastings 2009). Since the seismic sources (air guns) are fired in the upper water column, smalltooth sawfish are unlikely to be affected. Juvenile smalltooth sawfish occupy shallow estuaries and nearshore areas away from noise-generating oil and gas exploration and development activities. Adult smalltooth sawfish are found in waters up to 122 m (400 ft) or deeper and could be affected by exploration and production noises. However, the most likely effects would be short-term behavioral disruption or avoidance of certain areas.

The placement of bottom-founded structures during the exploratory drilling phase may affect adult smalltooth sawfish and their designated critical habitat (50 CFR 226.214) directly and indirectly. As with all fish, the drilling platform and pipeline placement could injure or displace smalltooth sawfish and reduce or eliminate their benthic food resources. Small juveniles typically occupy shallow estuarine waters and would not be located in the vicinity of most bottom disturbance. However, most new platform and drilling activity would occur at the depth range occupied by large juveniles and adults. Given their size, most adults would likely be able to swim away from bottom-disturbing activities, thereby avoiding injuries. However, foraging habitat would be temporarily eliminated and food resources in the disturbed area may be reduced.

Drilling muds and cuttings can be released at or near the sea surface or the seafloor. Muds and cuttings are diluted and dispersed rapidly in the ocean; therefore, cuttings released at the surface are unlikely to have measurable impacts on smalltooth sawfish. However, food resources for smalltooth sawfish may be buried by muds and cuttings released near the seafloor or settling in thick accumulations in shallow water. Small juvenile smalltooth sawfish occur in water shallower than that typically used for drill sites and are not likely to be affected.

Production. Vulnerable early life stages of smalltooth sawfish exist only in shallow estuarine areas far removed from produced water discharges, making exposure unlikely. Adults and larger juveniles do occupy coastal waters where produced water discharge would occur. Produced water discharges dilute rapidly in the open ocean, and direct exposure would occur only in the water column near the discharge point where adult sawfish are not likely to be located. The discharge of produced water is not thought to contribute to significantly increasing the size or severity of the hypoxic zone in the GOM (Rabalais 2005). Consequently, it is believed that discharges resulting from the proposed action will not affect dissolved oxygen levels in areas used by smalltooth sawfish.

Decommissioning. Under the proposed action, it is assumed that explosives would be used to remove up to 700 platforms in the entire GOM. Explosive blasts can be lethal to fishes that may be present near the structure (Gitschlag 2000). However, smalltooth sawfish are known not to have an affinity for offshore structures; thus, they are not likely to be affected.

Accidents. Smalltooth sawfish are considered rare from Texas to the Florida panhandle and are not likely to be present in the Central and Western Planning Areas where accidental oil spills would occur. Adult and juvenile fishes would likely avoid oil from a spill, although they could be exposed to sublethal concentrations through aqueous or dietary routes. Smalltooth sawfish are livebearers and the exposure of eggs to hydrocarbons would occur only by adult exposure. Contact with early small juvenile smalltooth sawfish is unlikely unless oil penetrates shallow estuarine areas. However, actively reproducing populations are thought to exist only in south Florida, and therefore small juveniles are not likely to be exposed to oil spills (NMFS 2009).

4.4.7.3.2 Alaska – Cook Inlet.

Routine Operations. Potential OCS oil and gas development impacting factors for fish in the Cook Inlet Planning Area are shown by phase in Table 4.4.7-4. Impacting factors common to all phases include vessel traffic, platform lighting, vessel discharges (bilge and ballast water), and miscellaneous discharges (deck washing, sanitary waste). Impacts from waste discharges would be localized and temporary and are expected to have negligible impacts on fish populations. Many of these waste streams are disposed of on land, and those that are discharged must meet USEPA and/or USCG regulatory requirements that minimize environmental impacts. Studies of platform lighting suggest the lights could alter predator-prey dynamics by enhancing phytoplankton productivity around the platform, potentially improving food availability and the visual foraging environment for fishes (Keenan et al. 2007). Potential impacts from platform lighting would be localized but long term and expected to have minimal impacts on fish populations.

Exploration and Site Development. During the OCS oil and gas exploration and development phase, fish could be affected by noise from seismic surveys and noise and bottom

TABLE 4.4.7-4 Impacting Factors on Fish and Their Habitat in the Cook Inlet Planning Area

Development Phase and Impacting Factor	Life Stage Affected[a] Eggs	Larvae	Adults
Impacting Factors Common to All Phases			
Vessel noise	X	X	X
Vessel traffic	X	X	X
Hazardous materials	X	X	X
Solid wastes	X	X	X
Offshore lighting	X	X	X
Aircraft noise			
Offshore air emissions			
Onshore air emissions			
Aircraft traffic			
Miscellaneous platform discharges	X	X	X
Vessel discharges	X	X	X
Bottom disturbance from vessel anchors	X	X	X
Exploration and Development			
Seismic noise	X	X	X
Noise from drilling and construction	X	X	X
Bottom disturbance from platform placement, drilling, and pipeline placement and trenching	X	X	X
Discharge of drilling muds and cuttings	X	X	X
Production			
Production noise	X	X	X
Produced water discharge	X	X	X
Artificial reef	X	X	X
Decommissioning			
Platform removal (non-explosive)	X	X	X

[a] Colors indicate impact level: white = negligible; blue = minor; yellow = moderate; red = major.

disturbance from drilling, platform placement, and pipeline trenching and placement activities (Table 4.4.7-4).

Noise disturbance from drilling, construction, and seismic surveys could potentially kill, injure, or displace fish depending on the magnitude of the noise, fish size, and distance from the noise source. Seismic survey data are usually collected by discharging compressed air from arrays of air guns towed behind ships. All fish species in Cook Inlet are presumed to be able to hear, with varying degrees of sensitivity, within the frequency range of sound produced by exploration and site development activities. The effects of air gun discharges on fishes depend on the fish life history stage and biology, distance to and type of the sound source, and the magnitude of the explosion. Noise generated by seismic surveys could kill or injure organisms typically within 1 to 5 m (3 to 16 ft) of the air gun or cause some species to temporarily avoid the area (Turnpenny and Nedwell 1994; Popper and Hastings 2009). Noise might also produce generalized stress (Smith et al. 2004) and interfere with communication (Vasconcelos et al. 2007). Several studies have found that species with gas bladders (e.g., salmonids, coregonids, and gadids) are more vulnerable to injury or mortality from explosions than species without gas bladders such as flatfish (MMS 2004a). The juvenile and adult fish in Cook Inlet likely to be affected by the noise generated from seismic surveys include salmon, cod, whitefishes, and herring. Continuous, long-term exposure to high-pressure sound waves has also been shown to cause damage to the hair cells of the ears of some fishes under some circumstances (Popper and Hastings 2009). For adult fishes, continuous exposures would not exist under natural circumstances, as fish could move from the area. However, fish larvae may suffer greater mortality because of their small size and relative lack of mobility. In a confined area such as Cook Inlet, noise from seismic surveys can also alter fish behavior. For example, disruption of normal behaviors during critical spawning and feeding periods in spring and summer has the potential to adversely affect survival and reproduction. The severity and duration of noise impacts would vary with site and development scenario, but overall the impacts would be temporary. Recent reviews of seismic survey noise on marine fish concluded that although data were limited, significant impacts on marine fish populations from seismic surveys were not likely (BOEMRE 2010c; National Science Foundation and USGS 2010).

Bottom-disturbing activities such as coring and drilling, platform placement and mooring, and pipeline trenching and placement would displace fish in the vicinity of the activities and result in temporary sedimentation and turbidity, which could damage fish gills and bury benthic invertebrate prey resources within some distance of the disturbance. Fish mortality may be greater if bottom disturbance occurred in areas of high larval and juvenile fish density such as estuaries and nearshore areas. The migrations of anadromous species common in Cook Inlet such as Pacific salmon and eulachon could also be disrupted. Soft sediments in Cook Inlet are subject to frequent bottom disturbance from high discharge and storms and Cook Inlet waters are naturally high in suspended sediments. Thus, fish communities in Cook Inlet are presumably well adapted to such conditions.

It is assumed that drilling muds and cuttings would be discharged into Cook Inlet for exploration wells only, while drilling wastes from development and production wells would be reinjected into the wells. The discharge of drilling muds and cuttings (including synthetic drilling fluids adhering to the cuttings) can adversely affect fish in several ways. Impacts from turbidity associated with drilling waste discharge would be similar to those described above and could damage respiratory structures, cause fish to temporarily move from the area, and disrupt food acquisition. Drilling wastes released near the sediment surface or in shallow water would bury benthic food resources in the release area, although conditions would eventually recover. Trace metal and hydrocarbon constituents in drilling fluids can be toxic to fish at all life stages if they are exposed to high enough concentrations. Impacts would be greatest for planktonic eggs and larvae that contact the mixing zone, while juveniles and adults passing through a discharge are not likely to be adversely affected. Based on the assumption of a relatively widespread distribution of eggs, larvae, and prey in Cook Inlet, drilling waste discharge is not likely to alter the population dynamics of fisheries resources in Cook Inlet or the Gulf of Alaska. In addition, drilling discharges must comply with NPDES permit requirements regarding the discharge amount, rate, and toxicity, which would greatly reduce the impact on fish communities.

While an exact route cannot be determined at this time, any onshore pipeline route would be required to comply with various Alaska Coastal Management Program policies. As a consequence, construction activities in sensitive aquatic habitat would be minimized. Specifically, the route for onshore pipeline facilities would be sited inland from shorelines and beaches, and crossings of anadromous fish streams would be minimized and consolidated with other utility and road crossings of such streams. In addition, onshore pipelines would be designed, constructed, and maintained to minimize risk to fish habitats from a spill, pipeline break, or construction activities.

Overall, site development and exploration activities represent a minor and temporary disturbance primarily affecting demersal fishes, with the severity of the impacts generally decreasing dramatically with distance from the disturbance.

Production. Production activities that could affect fish communities in Cook Inlet include operational noise, bottom disturbance from anchors and the release of process water. In addition, the platform would replace existing featureless soft sediments and serve as an artificial reef (Table 4.4.7-4).

Chronic disturbance to demersal fish communities could result from the movement of pipelines and anchors and chains associated with support vessels. Bottom disturbance would affect fish in a manner similar to that described above for the exploration and site development phase. The disturbance would be episodic and temporary, but would last for the lifetime of the platform.

Produced water contains metals, hydrocarbons, salts, and radionuclides, and their discharge could contaminate habitat, resulting in lethal and sublethal effects on fish, particularly early life stages. However, NPDES permitting requirements regarding discharge rate, contaminant concentration, and toxicity would greatly reduce the potential for impacts on fish. It is assumed that all produced water would be disposed of by injection into permitted disposal wells. Therefore, the effects of produced water discharges on fish are expected to be minimal.

Platforms would add a hard substrate to the marine environment, providing additional habitat for marine plants and animals (e.g., kelp and mussels) that require a hard substrate. Fish species in Cook Inlet that prefer hard substrate, such as rockfish, may be attracted to platforms. The platform would likely increase shell material and organic matter in the sediments surrounding the platform, potentially resulting in a shift in benthic invertebrate food sources.

A two-year (1997–1998) study of contaminant levels in the sediments of the Shelikof Strait and Cook Inlet provide information on potential effects of oil and gas development in the Cook Inlet Planning Area (MMS 2001a). Samples of sediment from depositional areas (where sediment contamination is expected to be greatest) suggested that metals and PAHs in sediments derived primarily from natural sources rather than past oil and gas developments (MMS 2001a). In addition, sediment concentrations of metals and organic contaminants in outermost Cook Inlet and Shelikof Strait (1) have not increased significantly since offshore oil exploration and production began in Cook Inlet (circa 1963) and (2) posed only minor risks to benthic biota or fish (MMS 2001a). Consequently, it is expected that production activities would have negligible effects on fish communities in Cook Inlet.

Decommissioning. No explosive platform removals are anticipated under the proposed action. Nonexplosive removals (e.g., abrasive, mechanical, or diver cutters) would have negligible long-term impacts to fish populations, although individuals associated with the platform would experience a loss of habitat. Pipelines installed and anchored on the seafloor would be capped and left in place, although there is the potential for chronic sediment disturbance from pipeline movement. If fixed platforms are left in place, the changes to fish communities resulting from the initial platform installation would be permanent. Overall, impacts on fish populations associated with decommissioning activities are expected to be negligible.

Accidents. Accidental hydrocarbon releases in Alaska may have greater ecological consequences than in temperate areas because oil is likely to persist in the environment due to the colder temperatures. Hydrocarbons can have a range of effects on fish depending on the concentration, the length of exposure, and the life history stage of the fish involved (Starr et al. 1981; C.I. Hamilton et al. 1979; Malins 1977; Neff and Stubblefield 1995). Prolonged exposure to elevated levels of petroleum hydrocarbons can result in lethal or sublethal (reproduction, recruitment, physiology, growth, development, and behavior) impacts at the level of the individual, while catastrophic oil spills could result in population-level effects in some cases (Peterson et al. 2003). Fishes most likely to be affected by an oil spill would be those that migrate extensively (e.g., arctic cisco and salmon), those with high fidelity to natal streams (e.g., Dolly Varden), and those confined to nearshore environments (e.g., broad whitefish and rainbow smelt). Gas and particularly oil releases in Cook Inlet could affect fish populations by causing mortality of eggs, larvae, juveniles, or adults; triggering abnormal development; impeding the access of migratory fishes (e.g., salmon and herring) to spawning habitat; altering behaviors; displacing individuals from preferred habitat; reducing or eliminating prey populations available for consumption; impairing feeding, growth, or reproduction; causing adverse physiological responses; increasing susceptibility to predation, parasitism, diseases or other environmental perturbations; and increasing or introducing genetic abnormalities. It is anticipated that pelagic eggs and larval stages of fish, whose movements are largely controlled by water currents, would be killed if they came into contact with surface oil spills (Patin 1999). Conversely, evidence indicates that the majority of adult pelagic fish can likely detect and avoid heavily oiled waters in the open sea, thereby avoiding acute effects (Patin 1999). Adult salmon are able to return to natal streams and hatcheries even under very large oil spill conditions (Brannon et al. 1986; Nakatani and Nevissi 1991), as evidenced by the return of pink and sockeye salmon to Prince William Sound and sockeye salmon to Cook Inlet during and after the *Exxon Valdez* oil spill.

Impacts from spills would be greatest if a large spill occurred during a reproductive period or contacted a location important for spawning or growth such as intertidal and nearshore subtidal habitats. However, it is anticipated that only a small amount of shoreline would be affected by these smaller oil spills and would not, therefore, present a substantial risk to fish populations. Most small hydrocarbon releases would be rapidly diluted and are expected to primarily affect fish in the water column, as most oil and gas would float above the sediment surface. Because pelagic species of fishes in Cook Inlet are relatively abundant and widely distributed in waters across much of the central Gulf of Alaska, even a large oil spill (up to 4,600 bbl) is not likely to cause population-level impacts on most fish populations inhabiting the central Gulf of Alaska (i.e., South Alaskan Peninsula, Kodiak Archipelago, Shelikof Strait, Cook Inlet, and Prince William Sound).

Catastrophic Discharge Event. The PEIS analyzes a CDE of 75 to 125 thousand bbl in the Cook inlet Planning Area. The likelihood of oil from a CDE (Table 4.4.2-2) contacting part of the shoreline is relatively high because the Cook Inlet Planning Area is located within a relatively confined estuary. Spilled oil affecting nearshore and intertidal areas would likely result in the greatest impacts on fisheries resources. Oil may persist for years in intertidal areas and could represent a persistent source of exposure for fish such as herrings that generally spawn near shorelines. Oil spills in intertidal areas also have the potential to contaminate or alter the composition and abundance of benthic food resources. For example, evidence from the *Exxon Valdez* oil spill suggests stress-tolerant invertebrates such as polychaetes and snails would not suffer long-term population declines in oiled areas, but clams and mussels could be contaminated and reduced in abundance for several years (*Exxon Valdez* Oil Spill Trustee Council 2010c). A catastrophic oil spill and/or multiple smaller spills could result in a decline in local abundances of fish stocks or subpopulations, with recovery potentially requiring multiple generations. Some stocks are already in decline due to non-OCS anthropogenic and natural impact-producing factors (e.g., commercial fisheries, climatic shifts).

Some of the potential effects that catastrophic oil spills in Cook Inlet could have on fish resources can be inferred based upon the impacts of the 1989 *Exxon Valdez* oil spill, which released approximately 257,000 bbl of oil into nearby Prince William Sound. The potential effects of the Valdez spill are best known for salmon and Pacific herring. Population-level effects on salmon were primarily through exposure of eggs and larvae to oil in sediments. Because of their long incubation period in intertidal gravel and because salmon embryos have a large lipid-rich yolk that can accumulate hydrocarbons from low-level exposures, salmon embryos are vulnerable to contamination from oil spills that reach intertidal areas (Peterson et al. 2003). For example, pink salmon embryos in oiled intertidal streams of Prince William Sound continued to show higher mortality than those in non-oiled streams until 1993 (Bue et al. 1998), and from 1989 to 1990, the growth rates of cutthroat trout and Dolly Varden in oiled streams were lower than those in clean streams (Hepler et al. 1993). However, salmonid populations appeared to recover within 15 years. Pink and sockeye salmon populations were considered to have recovered in 1999 and 2002, respectively (*Exxon Valdez* Oil Spill Trustee Council 2010c). Dolly Varden char were considered recovered in 2002, and cutthroat trout are considered to have very likely recovered (*Exxon Valdez* Oil Spill Trustee Council 2010c).

Although the *Exxon Valdez* oil spill occurred a few weeks before Pacific herring spawned in Prince William Sound, adult herring appeared to be relatively unaffected by the spill. About half of the herring egg biomass was deposited within the oil trajectory, and toxicity tests suggested egg-larval mortality in the oiled areas was twice as great as in the non-oiled areas and that larval growth rates in oiled areas were depressed compared to those in areas unaffected by the spill (Brown et al. 1996; McGurk and Brown 1996). After a record harvest in 1992 (following the *Exxon Valdez* spill), the Pacific herring population in Prince William Sound collapsed and has remained depressed, with reduced or no commercial harvest allowed. The Pacific herring stock of Prince William Sound is still classified as "not recovered" from the *Exxon Valdez* oil spill (*Exxon Valdez* Oil Spill Trustee Council 2010c). However, because of natural variability in population and confounding environmental factors, there has not been full consensus among researchers that the currently low herring numbers are fully attributable to the effects of spilled oil. Pathogens, rather than lingering effects of the Valdez spill, may be primarily responsible for the lack of recovery (*Exxon Valdez* Oil Spill Trustee Council 2010c).

Although the effects of the spill on rockfish, a common demersal fish in Cook Inlet, were never well understood, their populations and habitat are considered recovered from the *Exxon Valdez* spill (*Exxon Valdez* Oil Spill Trustee Council 2010c). In general, adult demersal fishes are believed to avoid oil slicks, although individuals in coastal shallow waters with slow water exchange could be exposed to sublethal hydrocarbon concentrations (Patin 1999). A large or catastrophic spill could adversely affect hundreds of millions of eggs and juvenile stages, especially spills that reach nearshore areas, which are important to many species of demersal fishes as juveniles (Moles and Norcross 1998). Adult demersal and bentho-pelagic fish, including pollock, sablefish, Pacific cod, eulachon, and Pacific sand lance, would probably not be harmed by spilled oil at the surface. However, many demersal fishes such as walleye pollock, halibut, and cod all have buoyant eggs and larvae that float near the surface where they could be exposed to spilled oil (NPFMC 2010).

4.4.7.3.3 Alaska – Arctic.

Routine Operations. Potential OCS oil and gas development impacting factors for fish are shown by phase in Table 4.4.7-5. Impacting factors common to all phases include vessel traffic, platform lighting, vessel discharges (bilge and ballast water), and miscellaneous discharges (deck washing, sanitary waste). Impacts from waste discharges would be localized and temporary and would be expected to have negligible impacts on fish populations. Many of these waste streams are disposed of on land, and any discharges into surface waters must meet USEPA and/or USCG regulatory requirements before discharge. Studies of platform lighting suggest that the lights could alter predator-prey dynamics by enhancing phytoplankton productivity around the platform, potentially improving food availability and the visual foraging environment for fishes (Keenan et al. 2007). Potential impacts from platform lighting would be localized but long term and are expected to have minimal impacts on fish populations.

Exploration and Site Development. During the OCS oil and gas exploration and development phase, fish could be affected by noise from seismic surveys and noise and bottom disturbance from drilling, subsea well, gravel island, and platform placement, and pipeline trenching and placement activities (Table 4.4.7-5). The effects of these activities on fish communities are described in detail in Section 4.4.7.3.2.

Fish in the Beaufort Sea and Chukchi Sea Planning Areas most likely to be affected by the noise generated from drilling, vessel traffic, and seismic surveys include salmon, cod,

TABLE 4.4.7-5 Impacting Factors on Fish and Their Habitat in the Beaufort Sea and Chukchi Sea Planning Areas

	Life Stage Affected[a]		
Development Phase and Impacting Factor	Eggs	Larvae	Adults
Impacting Factors Common to All Phases			
Vessel noise	X	X	X
Vessel traffic	X	X	X
Hazardous materials	X	X	X
Solid wastes	X	X	X
Offshore lighting	X	X	X
Aircraft noise			
Offshore air emissions			
Onshore air emissions			
Aircraft traffic			
Miscellaneous platform discharges	X	X	X
Vessel discharges	X	X	X
Bottom disturbance from vessel anchors	X	X	X
Exploration and Development			
Seismic noise	X	X	X
Noise from drilling and construction	X	X	X
Bottom disturbance from drilling and placement of subsea wells, platforms, and pipelines	X	X	X
Discharge of drilling muds and cuttings	X	X	X
Production			
Production noise	X	X	X
Produced water discharge	X	X	X
Artificial reef	X	X	X
Decommissioning			
Platform removal (non-explosive)	X	X	X

[a] Colors indicate impact level: white = negligible; blue = minor; yellow = moderate; red = major.

whitefishes, and herring. The effect on the overall fish population would be negligible since fishes are distributed over wide geographic areas and air gun operations are localized (Section 4.4.7.3.2). While it is anticipated that there would be no permanent population-level effects on managed species from seismic surveys, individual fish, especially egg and larval life stages in close proximity (1 to 5 m [3 to 16 ft]) to air gun arrays (Dalen and Knutsen 1986; Holliday et al. 1987; Turnpenny and Nedwell 1994), could suffer mortality or injury, and adult fishes more distant from the noise could exhibit short-term avoidance and behavioral alteration. A recent review of seismic survey noise on marine fish concluded that although data were limited, there would be no significant impacts on marine fish populations from seismic surveys (BOEMRE 2010c; National Science Foundation and USGS 2010).

Development and construction activities that could affect fish in the Beaufort and Chukchi Sea Planning Areas include drilling, installation of pipelines and construction of subsea wells, platforms, artificial islands, and ice roads. Bottom disturbance would result in temporary sedimentation and turbidity, which could damage fish gills and bury benthic invertebrate prey resources within some distance of the disturbance. Individual fish would likely temporarily move away from affected areas (Section 4.4.7.3.2). The total area affected by seafloor disturbance under the proposed action would be relatively small compared to the availability of similar seafloor habitat in surrounding areas.

Onshore, up to 129 km (80 mi) of oil pipeline could be constructed. While an exact route cannot be determined at this time, the pipeline route would be required to comply with various Alaska Coastal Management Program policies. As a consequence, construction activities in sensitive aquatic habitats would be minimized. Specifically, the route for onshore pipeline facilities would be sited inland from shorelines and beaches, and crossings of anadromous fish streams would be minimized and consolidated with other utility and road crossings of such streams. In addition, onshore pipelines would be designed, constructed, and maintained to minimize risk to fish habitats from a spill, pipeline break, or construction activities.

It is assumed that drilling muds and cuttings would be discharged into the Beaufort and Chukchi Sea Planning Areas for exploration wells only and that drilling wastes from development and production wells would be reinjected into the wells. The discharge of drilling muds and cuttings (including synthetic drilling fluids adhering to the cuttings) can adversely affect fish in several ways. Impacts from turbidity associated with drilling waste discharge would be similar to those described above and could damage respiratory structures, cause fish to temporarily move from the area, and disrupt food acquisition. Drilling wastes released near the sediment surface or in shallow water would bury benthic food resources in the release area, although conditions would eventually recover. Trace metal and hydrocarbon constituents in drilling fluids can be toxic to fish at all life stages if they are exposed to high enough concentrations. Impacts would be greatest for planktonic eggs and larvae that contact the mixing zone, while juveniles and adults passing through a discharge are not likely to be adversely affected. Assuming a relatively widespread distribution of eggs, larvae, and prey in the Beaufort and Chukchi Seas, drilling waste discharge is not likely to alter the population dynamics of fisheries resources. In addition, drilling discharges must comply with NPDES permit requirements regarding the discharge amount, rate, and toxicity, which would greatly reduce the impact on fish communities.

Overall, site development and exploration activities represent a minor and temporary disturbance primarily affecting demersal fishes, with the severity of the impacts generally decreasing dramatically with distance from the disturbance.

Production. Production activities that could affect fish communities in the Beaufort and Chukchi Seas include operational noise, bottom disturbance from anchors and the release of process water. In addition, the platform would replace existing featureless soft sediments and serve as an artificial reef (Table 4.4.7-5). Chronic disturbance to demersal fish communities would result from the movement of anchors and chains associated with support vessels. Pipelines not buried would be anchored in place which would minimize their movement and potential to disturb fish habitat. Bottom disturbance would affect similar to that described above for the exploration and site development phase. The disturbance would be episodic and temporary, but would last for the lifetime of the platform.

Artificial islands would increase the diversity of habitat available on an otherwise homogeneous ocean. Specifically, such construction would introduce an artificial hard substrate that opportunistic benthic species, especially those that prefer gravel substrate, could colonize. Fishes may be attracted to the newly formed habitat complex, and fish population numbers in the immediate vicinity of the platforms are likely to be higher than in surrounding waters away from the structures. The overall change in habitat could result in changes in local community assemblage and diversity (Howarth 1991). The number of platforms projected for the Beaufort and Chucki Sea Planning Areas under the proposed action (up to nine) would create a small amount of hard substrate habitat and would likely have little effect on overall fish populations.

Produced water contains metals, hydrocarbons, salts, and radionuclides, and their discharge could contaminate habitat, resulting in lethal and sublethal effects on fish, particularly early life stages. It is assumed that all produced water would be disposed of by injection into permitted disposal wells. Therefore, the effects of miscellaneous and produced water discharges on fish communities are expected to be minimal.

The results of the Arctic Nearshore Impacts Monitoring in the Development Area study funded by BOEM provide a good summary of the long-term changes to benthic communities resulting from oil and gas development in the Arctic. Hydrocarbons are primarily derived from river inputs rather than oil and gas development (Brown 2005; Neff and Associates LLC 2010). Tissue hydrocarbon and metals concentrations in fish and their invertebrate food sources sampled near the Northstar development and Liberty prospect area were similar to or lower than invertebrate tissue levels found elsewhere in the world. No increase in hydrocarbons and metals in fish or invertebrate tissues was attributable to oil and gas production (Neff and Associates LLC 2010).

Overall, production activities would result in negligible and temporary effects on fish communities in the Beaufort and Chukchi Sea Planning Areas.

Decommissioning. No explosive platform removals are anticipated under the proposed action. Nonexplosive removals (e.g., abrasive, mechanical, or diver cutters) would have negligible long-term impacts to fish populations, although fish associated with the platform would experience a loss of habitat. Pipelines installed and anchored on the seafloor would be capped and left in place, although there is the potential for chronic sediment disturbance from pipeline movement. Overall, impacts on fish populations associated with decommissioning activities are expected to be negligible.

Accidents. Most accidental hydrocarbon releases would be small and rapidly diluted and are expected to primarily affect fish in the water column, as most oil and gas would float above the sediment surface. Impacts from spills would be greatest if a large spill occurred during a reproductive period or contacted a location important for spawning or growth such as intertidal and nearshore subtidal habitats. However, it is anticipated that in most cases only a small amount of shoreline would be affected by these smaller oil spills and would not, therefore, present a substantial risk to fish populations. Most small hydrocarbon releases would be rapidly diluted and are expected to primarily affect fish in the water column, as most oil and gas would float above the sediment surface. Because pelagic species of fishes in the Beaufort and Chukchi Sea Planning Areas are widely distributed, even a large oil spill (up to 4,600 bbl) is not likely to cause population-level impacts on most fish populations.

Catastrophic Discharge Event. The PEIS analyzes a CDE of 1.4 to 2.2 million bbl in the Chukchi Sea and 1.7 to 3.9 million bbl in the Beaufort Sea (Table 4.4.2-2). A CDE (Table 4.4.2-2) has the potential to affect multiple species in the Arctic Planning Areas. Such spills can have a range of effects on fish depending on the concentration, the length of exposure, and the life history stage of the fish involved (Starr et al. 1981; Hamilton et al. 1979; Malins 1977; Neff and Stubblefield 1995). During the spill, adult and juvenile fish may be temporarily displaced, which could interfere with movements to feeding, overwintering, or spawning areas. Fish eggs, larvae, and juveniles are the most sensitive life history stages (Section 4.4.7.3.2). Spilled petroleum hydrocarbons may persist for years (Howarth 1991; Wiedmer et al. 1996), especially in sediments of cold waters, making it likely that some fish species would be exposed to low levels of hydrocarbons for an extended time after an oil spill. Similarly, petroleum hydrocarbons could remain available for uptake and bioaccumulation by benthic food sources for years following a spill (Howarth 1991).

Among the most abundant marine fish in the Beaufort and Chukchi Sea Planning Areas are arctic cod, sculpin, eelpout, pricklebacks, and flatfish. Of these, the arctic cod may be the most susceptible to lethal hydrocarbon effects because the larvae are pelagic and most likely to come into contact with oil and gas, which tend to float on the surface. Arctic cod are also susceptible because they are dependent on algal production in open water and under sea ice, which could be affected by oil and gas exposure. Among the most abundant anadromous species are the arctic and least cisco, broad whitefish, Dolly Varden, and rainbow smelt. Fishes most likely to be affected by an oil spill would be those that migrate extensively (e.g., Arctic cisco), those with high fidelity to natal streams (e.g., Dolly Varden), and those confined to nearshore environments (e.g., broad whitefish and rainbow smelt). Some pelagic species (e.g., Pacific herring; capelin) spawn in intertidal zones where their eggs may be susceptible to oil (Rice et al. 1984). Herring generally spawn near shorelines over 3–4 week periods, and oil driven onshore could contact spawning adults and developing eggs (MMS 1996a). Larval herring are also susceptible after moving into deeper water because they rise diurnally to feed on plankton and could be exposed to surface oil repeatedly if a spill occurs. Demersal fishes such as walleye pollock, halibut, and cod all have buoyant eggs and larvae that float near the surface where they could be exposed to spilled oil (MMS 1996a).

A CDE spill could have population-level consequences if vital habitat areas were affected or if it occurred in spawning areas or juvenile feeding grounds when fish populations are highly concentrated (e.g., the Arctic cisco population concentrated near the Colville River). In such cases, catastrophic spills could cause substantial reductions in population levels for one or more years. However, no permanent impacts on fish populations are expected. See Section 4.4.7.3.2 for a detailed discussion of oil spills on fish following the catastrophic *Exxon Valdez* spill.

4.4.7.3.4 Conclusion. The primary potential impacts on fish communities from Program activities could result from seismic surveys and bottom-disturbing activities such as drilling, platform placement and mooring, and pipeline trenching and placement, which could displace, injure, or kill fish in the vicinity of the activity. Fixed platforms, particularly the large number projected for the GOM, would also serve as artificial reefs that would attract substantial numbers of fish. Oil and gas activities would be temporary, and no permanent or population-level impacts on fish are expected. Displaced fish and invertebrate food sources would repopulate the area over a short period of time in the GOM, but fish habitat recovery may be long term in Alaskan waters. The effects of drilling muds and produced water discharge on fish would be localized, and no population-level effects are expected. Drilling waste and produced water discharge would be far less in Alaska because fewer wells would be drilled in Alaska and because it is assumed that drilling muds and cuttings from production wells and all produced water would be reinjected into the wells. Overall, impacts to fish from routine Program activities are expected to range from negligible to minor, and no impacts on threatened or endangered fish species are expected.

Small spills would be localized and are unlikely to affect a substantial number of fish before dilution and weathering would reduce concentrations of toxic fractions to nontoxic levels. Large and especially CDE-level spills would affect a wider area, with the magnitude of the impacts depending on the location, timing, and volume of spills, distribution and ecology of affected fish species, and other environmental factors. Most adult fish are highly mobile and would likely avoid lethal hydrocarbon exposures, although they may be subjected to sublethal concentrations. Smaller species and egg and larval life stages are more likely to suffer lethal or sublethal exposures from oil contact because of their relative lack of mobility. Under most circumstances, any single large or CDE spill would affect only a small proportion of a given fish population; therefore, overall population levels may not be affected. However, fish species that currently have depressed populations or have critical spawning grounds present in the affected area could experience population-level impacts. Oil contacting shoreline areas used for spawning or providing habitat for early life stages of fish could result in large-scale lethal and long-term sublethal effects on fish. In Alaskan waters, where oil may be slow to break down, coastal oiling could measurably depress some fish populations for several years especially if the spill were very large (such as a CDE spill). However, no permanent impacts on fish populations are expected.

4.4.7.4 Reptiles

4.4.7.4.1 Routine Operations. The discussion of impacts to reptile species from OCS oil and gas development is primarily focused on sea turtles that may occur throughout the GOM. There is the potential for other reptile species to be affected from a small number of impacting factors related to OCS oil and gas development. Additional reptile species (e.g., American crocodile) will be identified as impacting factors are discussed in this PEIS.

There are five species of sea turtle that may be encountered in the GOM OCS Planning Areas: green, hawksbill, Kemp's ridley, leatherback, and loggerhead. All of these species have the potential to occur throughout the planning areas as hatchlings, juveniles, and adults. All but the hawksbill have been reported to nest on beaches within the GOM Planning Areas, and the number and distribution of nests differ dramatically among these species across bordering States (Section 3.8.3; Figure 3.8.3-1). Sea turtles may be affected in all phases of OCS oil and gas development. Under the proposed action, one or more of the sea turtle life stages could be affected under routine operations due to (1) airborne and underwater noise, (2) offshore structure placement and pipeline trenching, (3) removal of offshore structures, (4) OCS vessel traffic, (5) construction and operation of onshore infrastructure, and (6) exposure to operational discharges and wastes. In addition, reptiles may be affected by unexpected and accidental spills of oil and other contaminants. Table 4.4.7-6 illustrates how each of the various impact factors associated with OCS oil and gas development may affect sea turtles and their habitats in the GOM. Many of these impacting factors could occur during multiple project phases. Conceptual models illustrated in Figures 4.4.7-6 through 4.4.7-10 show how various activities associated with seismic surveys, onshore and offshore construction, normal O&G operations, decommissioning, and accidental oil releases may impact sea turtles. While OCS O&G projects have the potential to affect sea turtles of all life stages, it has been determined that impacts to later life stages (large juveniles and adults) result in greater population-level impacts (Crouse et al. 1987).

As discussed in Section 3.3.1, climate change in the GOM is expected to affect coastal systems through processes such as warming temperatures, changes in precipitation, sea level rise, and more frequent intense storms. Rising water temperatures, increased sea levels, and intense storms may affect the availability and suitability of foraging and nesting habitats for coastal and marine reptiles (Hawkes et al. 2009). For reptiles that rely on temperature to determine the gender of offspring in incubating eggs (referred to as temperature-dependent sex determination), including sea turtles and crocodilians, subtle increases in atmospheric temperatures could skew sex ratios of hatchlings, which could have future population implications (Walther et al. 2002). It is also predicted that global warming and increased precipitation rates associated with climate change will cause sea levels to rise (Church et al. 2001). This phenomenon could alter sea turtle coastal habitat in many areas (Hawkes et al. 2009). For example, a study in Hawaii predicted that as much as 40% of green sea turtle nesting habitat could be affected with a 0.9 m (2.7 ft) sea level rise (Baker et al. 2006).

Noise. Hearing sensitivity includes the hearing threshold (the minimum sound level that an animal can perceive in the absence of significant background noise) and the hearing bandwidth (the range of frequencies that an animal can hear). There is very little published data on sea turtle hearing sensitivities, but the little available data suggests that sea turtle species exhibit best hearing at low frequencies 200–700 Hz (BOEMRE 2010c), with an upper hearing limit of 1,600 Hz (Dow et al. 2008). Reported hearing thresholds are also of low frequency, estimated to be between 50 and 1,000 Hz (Tech Environmental, Inc. 2006). Threshold detection levels for these species over this frequency range are relatively high (>100 dB referenced to 1 micropascal within 1 meter of the source [dB re 1 μPa-m]) (Tech Environmental, Inc. 2006).

Potential responses to noises generated during normal operations may be expected to be behavioral and may include avoidance of the noise source, disorientation, and disturbance of normal behaviors such as feeding. Evidence suggests that sea turtles may be affected by seismic

TABLE 4.4.7-6 Potential OCS Oil and Gas Development Impacting Factors for Reptiles in the GOM

	O&G Impacting Factor								
	Noise								
Resource Receptor Category Potentially Affected	Seismic Exploration	Construction, Operation, and Decommissioning	Collisions with OCS Vessels	Presence of OCS Vessels	Construction and Decommissioning of Onshore and Offshore Infrastructure	Offshore and Onshore Lighting	Produced Water, Drill Cuttings and Mud, Liquid Wastes, Hazardous Materials	Solid Wastes and Debris	Accidental Oil Spills
Sea turtle nest sites – individual nests and nesting beaches	–	–	–	–	Destruction of nests; degradation or loss of nesting beaches	–	–	–	Physical disturbance and reduced quality from fouling
Sea turtle hatchlings	Injury; disruption of normal behavior (feeding, nesting)	Disruption of normal behavior (feeding, nesting)	Injury of mortality from ship strikes	Disruption of normal behavior (feeding, nesting)	Injury; disruption of normal behavior	Attraction of reproductive adults to low quality nesting habitats	Toxicity	Ingestion and/or entanglement	Fouling, toxicity
Sea turtle juveniles					Injury; disruption of normal behavior	Attraction of reproductive adults to low quality nesting habitats			Fouling, toxicity
Sea turtle adults					Injury; disruption of normal behavior	Attraction of reproductive adults to low quality nesting habitats			Fouling, toxicity
Sea turtle migration	Displacement or impediment	Displacement or impediment	–	Displacement or impediment	Displacement or impediment	Attraction of reproductive adults to low quality nesting habitats	–	–	Displacement or impediment
Sea turtle juvenile foraging habitats	–	–	–	–	Temporary habitat disturbance during construction; possible long-term increase in habitat	Attraction of reproductive adults to low quality nesting habitats	Reduced habitat quality	–	Physical disturbance; reduced habitat quality
Sea turtle adult foraging habitats	–	–	–	–	Temporary habitat disturbance during construction; possible long-term increase in habitat	Attraction of reproductive adults to low quality nesting habitats	Reduced habitat quality	–	Physical disturbance; reduced habitat quality

TABLE 4.4.7-6 (Cont.)

	O&G Impacting Factor								
	Noise								
Resource Receptor Category Potentially Affected	Seismic Exploration	Construction, Operation, and Decommissioning	Collisions with OCS Vessels	Presence of OCS Vessels	Construction and Decommissioning of Onshore and Offshore Infrastructure	Offshore and Onshore Lighting	Produced Water, Drill Cuttings and Mud, Liquid Wastes, Hazardous Materials	Solid Wastes and Debris	Accidental Oil Spills
Sea turtle wintering grounds	–	–	–	–	Temporary habitat disturbance; possible long-term increase in habitat	Attraction of reproductive adults to low quality nesting habitats	Reduced quality	–	Physical disturbance; reduced quality
American crocodile nest sites, adults, juveniles, hatchlings, and their habitat	–	–	–	–	–	–	–	–	Fouling, toxicity; physical disturbance; reduced habitat quality

[a] – = No impact anticipated.

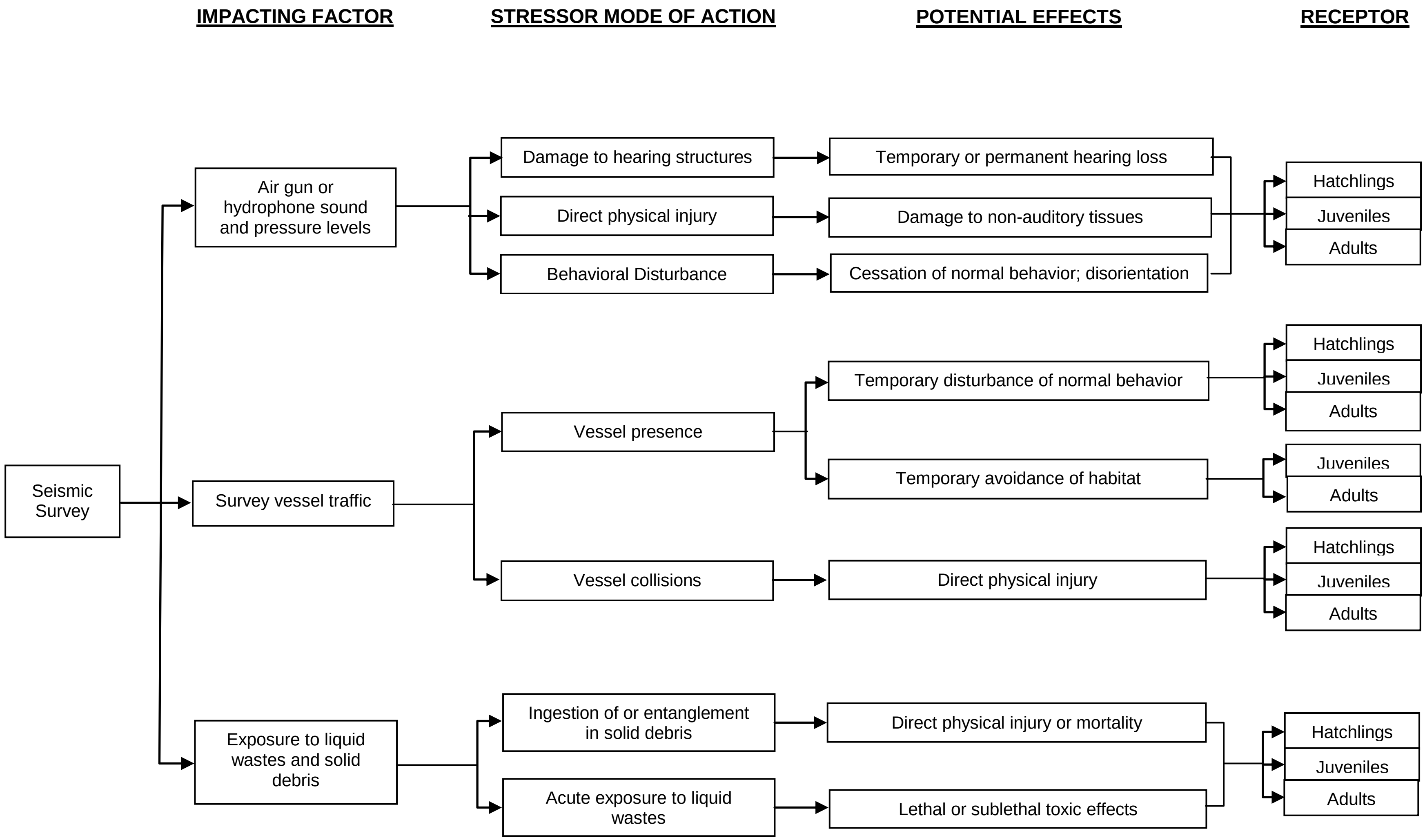

FIGURE 4.4.7-6 Conceptual Model for Potential Effects of Seismic Survey Activities on Turtles in the GOM

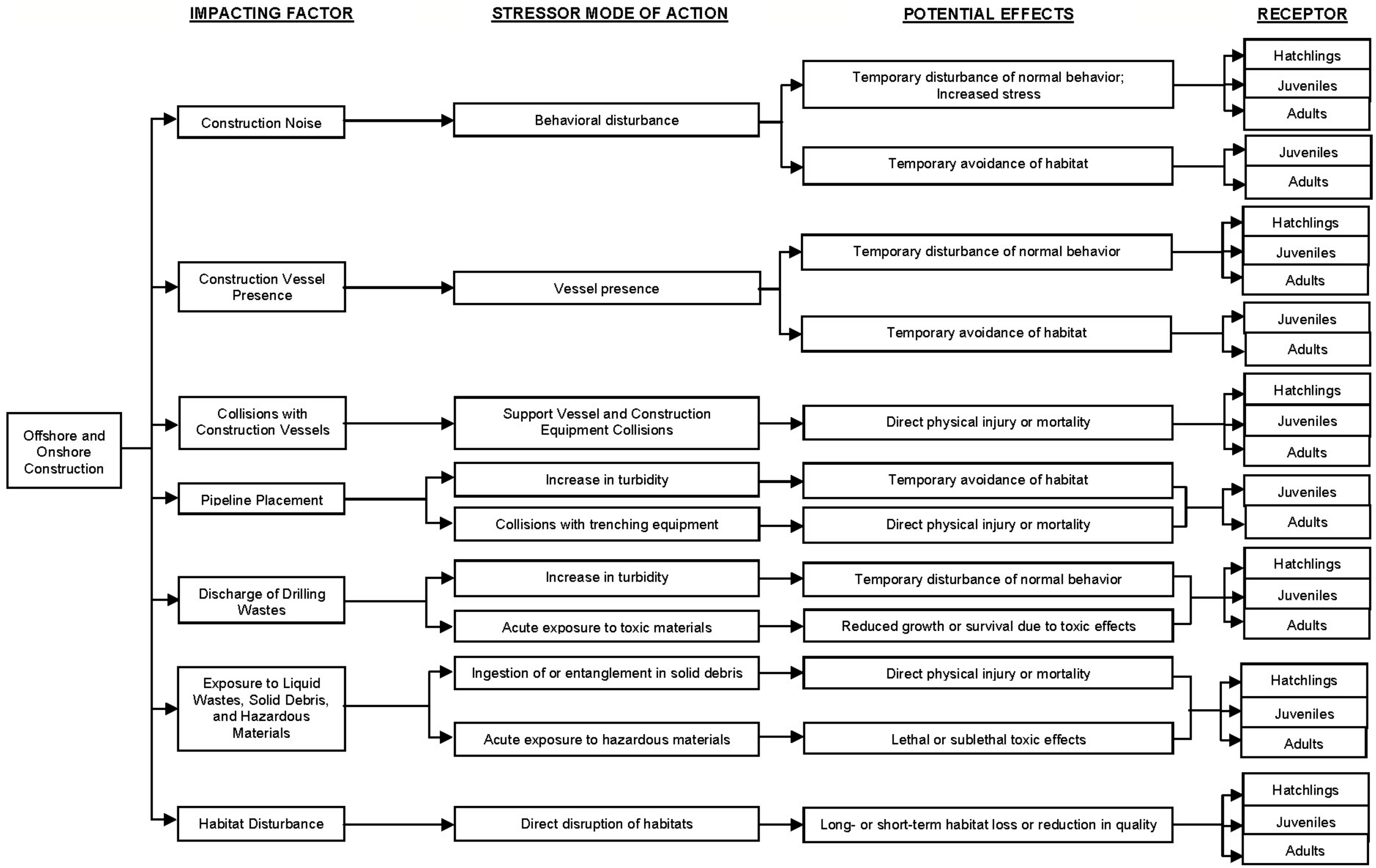

FIGURE 4.4.7-7 Conceptual Model for Potential Effects of OCS-Related Construction Activities on Turtles in the GOM

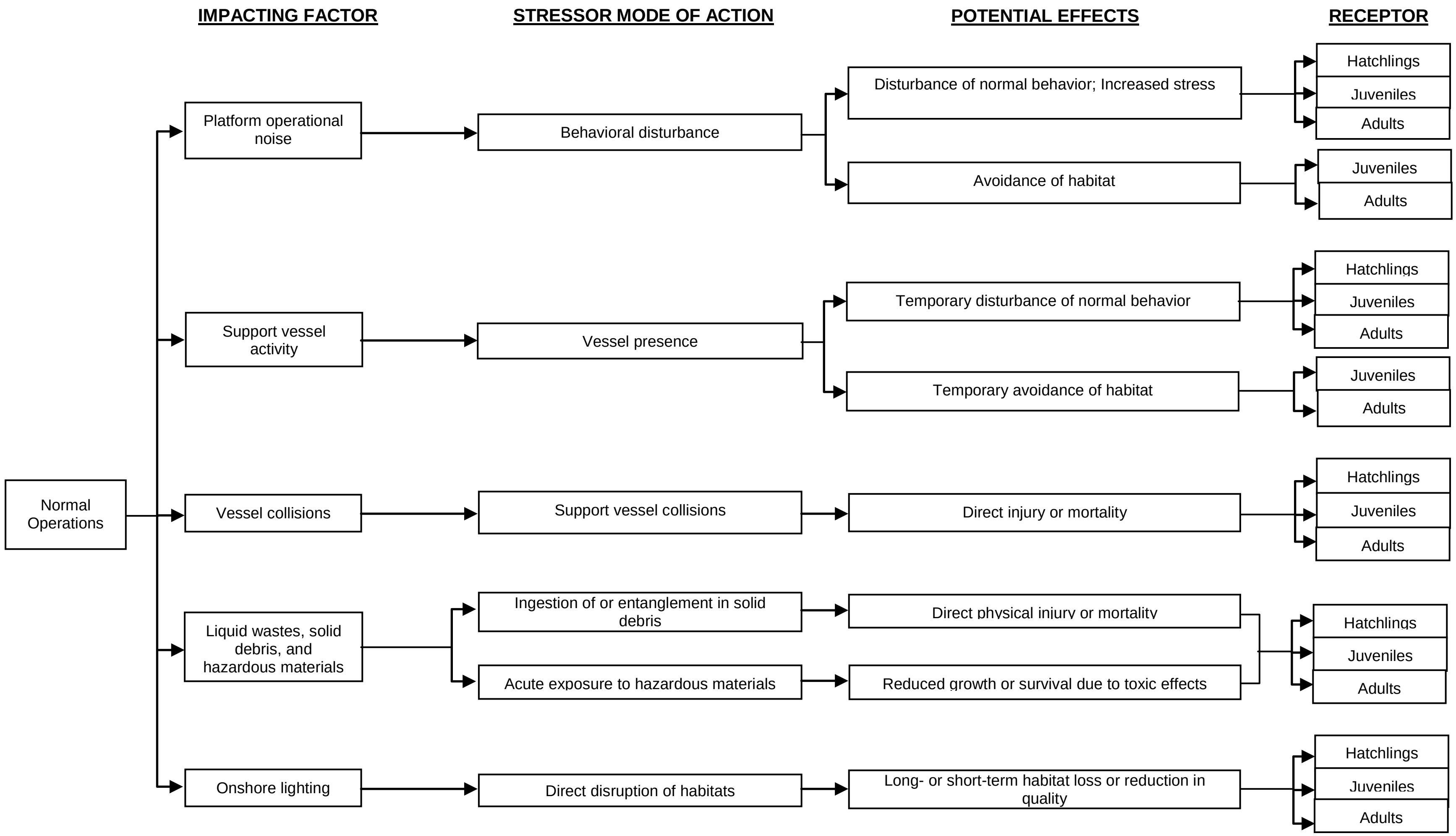

FIGURE 4.4.7-8 Conceptual Model for Potential Effects of OCS Operation on Turtles in the GOM

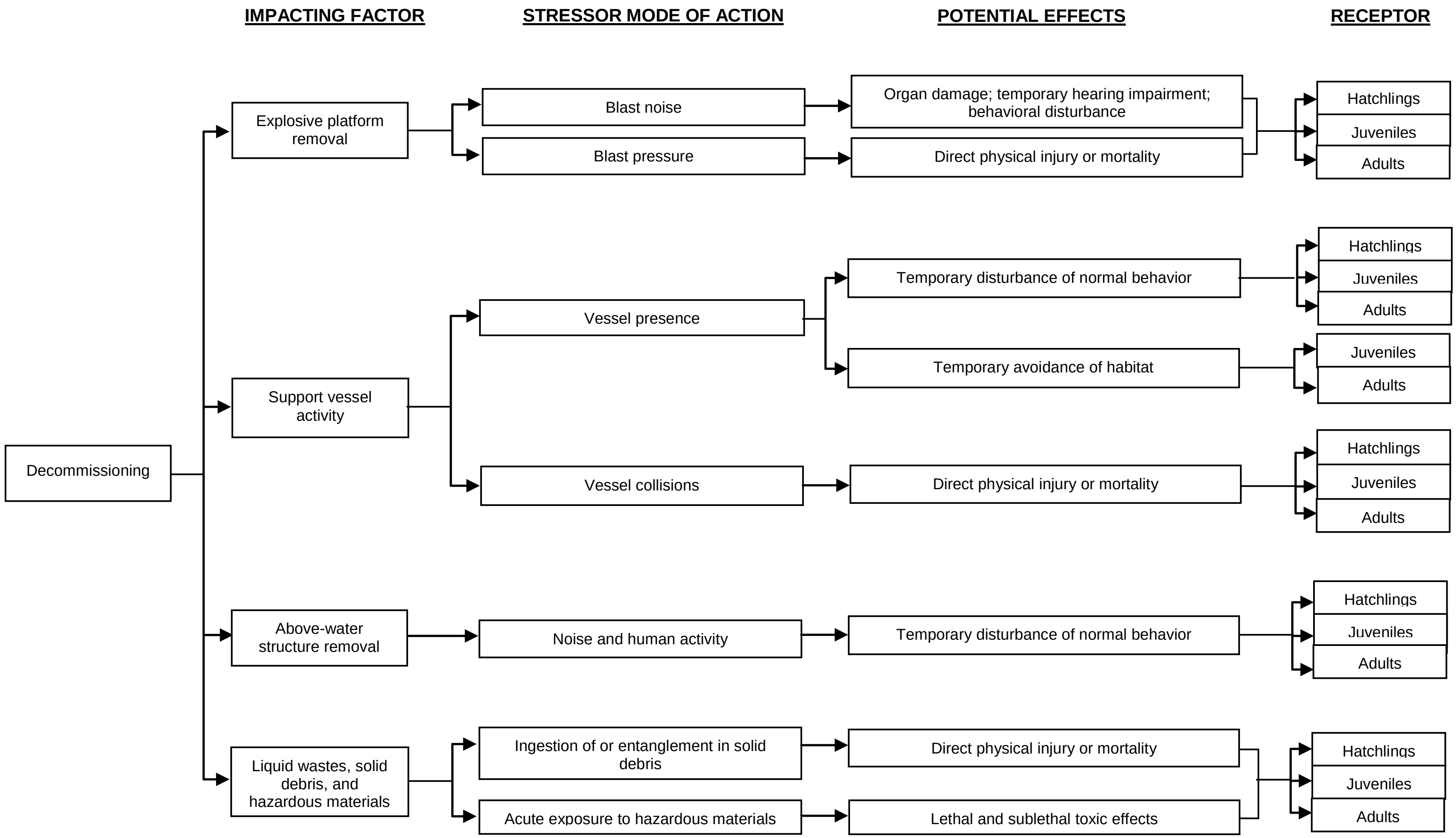

FIGURE 4.4.7-9 Conceptual Model for Potential Effects of Platform Decommissioning on Turtles in the GOM

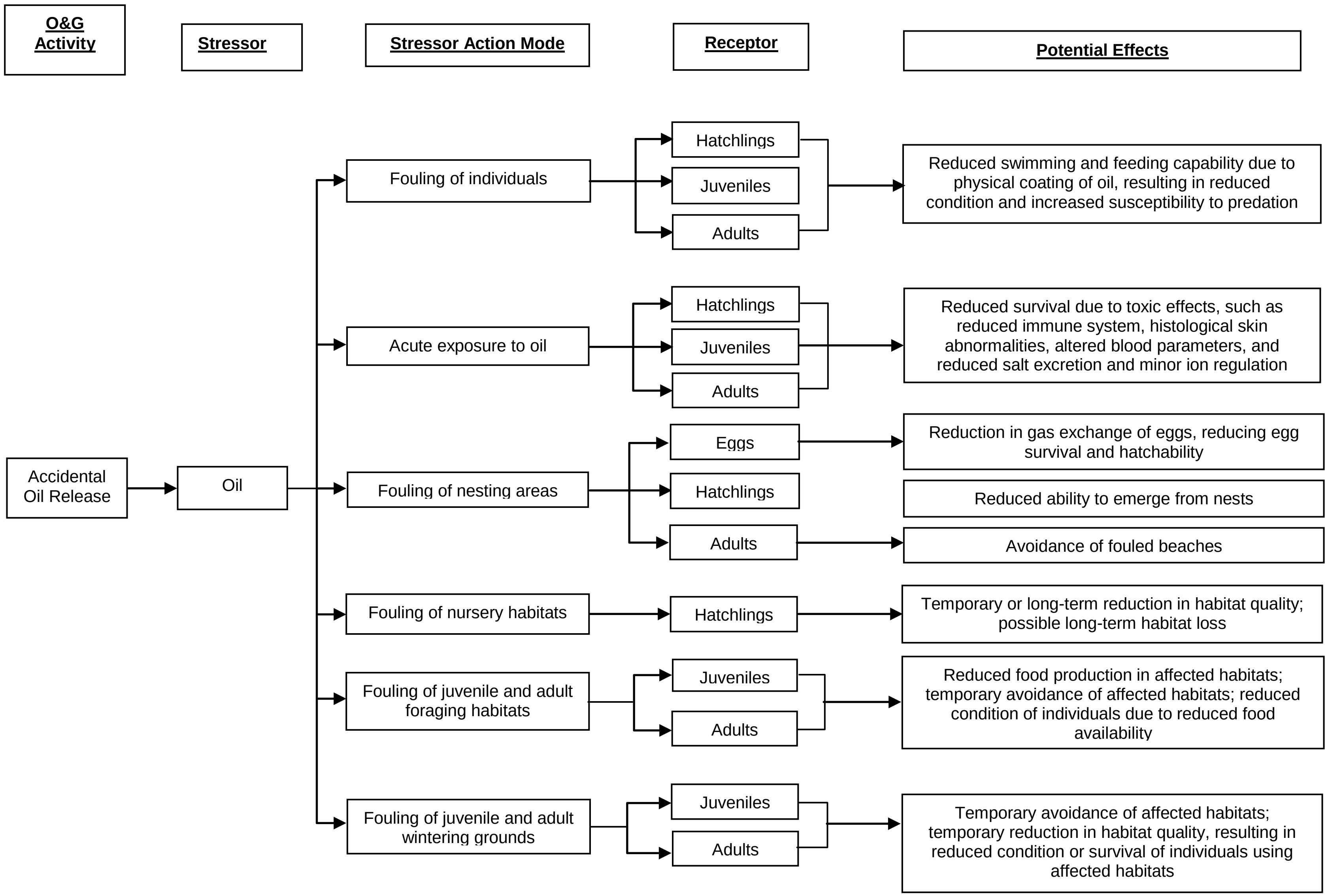

FIGURE 4.4.7-10 Conceptual Model for Potential Effects of Oil Spill on Reptiles in the GOM

noises (McCauley et al. 2000; BOEMRE 2010c; NSF and USGS 2010), but it is largely unknown how sea turtles may respond to and be affected by noise generated during structure placement, drilling and production, pipeline trenching, vessel traffic, and explosive structure removal (Geraci and St. Aubin 1987). Because some sea turtles, such as the loggerhead, may be attracted to OCS structures, these may be more susceptible to sounds produced during routine operations.

Noise generated by seismic surveys may affect sea turtles (Figure 4.4.7-6). Seismic surveys generate both high-frequency and low-frequency noise at levels up to 250 dB re 1 μPa-m, with emitted energy levels in the low-frequency range of 10–120 Hz (IACMST 2006). These survey noises are expected to be detected by sea turtles. Table 4.4.7-7 provides a general summary of available information on the effects of exposure to seismic noises (e.g., sonar) on sea turtles. It has been suggested that sound levels above 175 dB re 1 μPa-m induce behavioral reactions in sea turtles. Air guns and pingers typically used in seismic surveys have nominal source outputs ranging from 192 to 265 dB re 1 μPa-m. Therefore, depending on the species of turtle, its age class, and proximity to the acoustic source, there is potential for air gun blasts to affect sea turtle behavior. Currently, the effects of seismic noise on sea turtle physiology are unknown (BOEMRE 2010c; NSF and USGS 2010; Table 4.4.7-7).

Offshore drilling and production structures produce a broad array of sounds at frequencies and levels that may be detected by sea turtles within the area of the installation (Geraci and St. Aubin 1987). These sounds are generally of relatively low frequencies, typically 4.5–30 Hz, and may be generated at sound levels up to 190 dB re 1 μPa-m. Helicopters and service and construction vessels may affect sea turtles due to machinery noise and/or visual disturbances (NRC 1990). The effects of noise generated from construction and operations are illustrated in Figures 4.4.7-7 and 4.4.7-8.

Underwater explosions associated with the explosive removal of offshore facilities may generate noises that disturb sea turtles (Figure 4.4.7-9; MMS 2005d). Underwater explosions associated with the explosive removal of offshore facilities may generate sound levels in excess of 267 dB re 1 μPa-m. Exposure criteria developed by the U.S. Navy (as cited in Frankel and Ellison 2005) to evaluate the potential for impacts of impulsive sounds (i.e., underwater detonations) on marine biota include a sound level of 182 dB re 1 μPa-m. Using this criterion, a sea turtle may be affected if exposed to a sound level that exceeds 182 dB re 1 μPa-m. Depending on the size of the charges used in an explosive detonation, the surrounding water depth, and the distance to the nearest sea turtles, individual turtles in the vicinity of the facility undergoing explosive removal may be exposed to sound at or above this level. Based on responses reported for marine mammals, sea turtles exposed to explosive noise may experience temporary hearing loss as well as behavioral changes (NRC 2003c, 2005). Behavioral responses may include avoidance of the noise source, disorientation, and disturbance of normal behaviors such as resting or feeding. Turtles may also sustain organ or tissue damage when exposed to explosive noise (Klima et al. 1988).

In advance of explosive severance activities, BOEMRE and NOAA fisheries have implemented protocols to detect the presence of sea turtles within a 1,000-yard radius around decommissioning sites through observer programs operated by vessels, platforms, and

TABLE 4.4.7-7 Summary of Known and Anticipated Effects of Seismic Noise on Sea Turtles in the GOM

Species	Masking	Disturbance	Temporary Hearing Impairment	Injury	Other Physiological Effects	Comments
Green	Unknown	Possible – Short-term	Possible if close to high-energy acoustic source	Unknown	Unknown	Potential for limited adverse effects due to frequency overlap between seismic source and green sea turtle hearing, based on airborne sounds not measured behaviorally (Ridgway et al. 1969; Bartol and Ketten 2006; Dow et al. 2008)
Hawksbill	Unknown	Possible – Short-term	Possible if close to high-energy acoustic source	Unknown	Unknown	No studies available
Kemp's ridley	Unknown	Possible – Short-term	Possible if close to high-energy acoustic source	Unknown	Unknown	Potential for limited adverse effects due to frequency overlap between seismic source and juvenile Kemp's ridley sea turtle hearing (Bartol and Ketten 2006)
Leatherback	Unknown	Possible – Short-term	Possible if close to high-energy acoustic source	Unknown	Unknown	Potential for limited adverse effects due to frequency overlap between seismic source and leatherback vocalizations (Mrosovksy 1972)
Loggerhead	Unknown	Possible – Short-term	Possible if close to high-energy acoustic source	Unknown	Unknown	Potential for limited adverse effects due to frequency of seismic source and a study indicating that loggerheads avoided low-frequency sound (O'Hara and Wilcox 1990)

Source: 2010 Marine Seismic Research PEIS (NSF and USGS 2010, Table 3.4-5).

helicopters. Since 1987, these observer programs have documented takes of four sea turtles (all loggerheads) in the GOM as a result of explosive severance. Of these four takes, one animal was killed, one stunned, and two injured (MMS 2005d). BOEMRE continues to require these mitigation measures (see Appendix F of MMS 2005d) and, with compliance, expects these requirements to reduce the potential for negative impacts to sea turtles from explosive removals.

Noise related to exploration, construction vessel passage, and facility removal may be expected to be transient, while noise generated during production may be more long-term. The dominant source of noise from vessels is propeller operation, and the intensity of this noise is largely related to ship size and speed. Vessel noise resulting from O&G activities in the GOM is expected to occur at low levels, generally 150 to 170 dB re 1 μPa-m at frequencies below 1,000 Hz. Vessel noise is transitory and generally does not propagate at great distances from the vessel. Also, available information suggests that sea turtles are not thought to rely on acoustics; the effects to sea turtles from vessel noise are discountable (NMFS 2007).

As few studies on sea turtle hearing sensitivities or noise-induced stress exist, a full understanding of physical and behavioral impacts from sounds generated during exploration, normal operations, and explosive facility removal is not available. Experiments using air guns to try to repel turtles to avoid hopper dredges have been inconclusive (O'Hara and Wilcox 1990; Moein et al. 1995), while sea turtles exposed to an operating seismic source of 166 dB re 1μPa-m were shown to increase their swimming speed in response to the sound (McCauley et al. 2000). In addition, BOEM has implemented mitigation measures for seismic surveys in the GOM requiring ramp-up, protected species observer training, visual monitoring, and reporting for all surveys potentially affecting marine mammals and sea turtles (MMS 2004b). These measures were developed in consultation with NOAA fisheries, and with operator compliance, they are expected to reduce the potential for impacts to sea turtles.

Offshore Structure Placement and Pipeline Trenching. The placement of offshore structures and pipeline trenching may affect hatchling, juvenile, and adult sea turtles in two ways (Figure 4.4.7-7). Individuals coming in contact with construction or trenching equipment may be injured or killed; construction and trenching activities may also temporarily affect habitat use as habitats may experience short-term and long-term changes in abundance and quality.

During placement, pipelines are placed on or in the seafloor to connect offshore platforms with onshore facilities (MMS 2001b). Burial of pipelines using equipment such as jetting sleds physically digs a trench in the bottom sediment and results in a temporary, localized increase in turbidity. This increased turbidity may temporarily affect habitat use by sea turtles, with sea turtles avoiding such areas. Increases in turbidity from trenching at any particular location may be expected to be short-lived, as jet sleds can lay pipe at an average of 1.6 km/day (1 mi/day) (MMS 2001b). While some turtles may alter their use of habitats in the vicinity of a pipeline, affected turtles would likely return to these areas following a return to more normal turbidity levels and experience little adverse affect from any temporary avoidance of the area.

Because hatchlings are not strong swimmers and undergo passive transport by ocean currents, it is unlikely that they would be able to avoid or leave areas where pipeline trenching or structure placement is occurring, and, if present during offshore construction or trenching, they could be injured or killed. In contrast, juvenile and adult sea turtles are active swimmers, and thus may be able to avoid areas where construction or trenching is occurring. Sea turtles have been known to be killed or injured during dredging operations (Dickerson 1990; Dickerson et al. 1992), and thus may also be affected during trenching activities. Juveniles or adults may also be affected if the placement of new structures occurs in foraging or developmental habitats or offshore of nesting beaches (see Section 3.6.4.1 for a discussion of these habitats and areas). Following several years out in open water as growing hatchlings, juvenile sea turtles move into nearshore habitats for further growth and maturation. Adults also utilize nearshore habitats for feeding and may mate in nearshore habitats directly off nesting beaches. In addition, females may become residents in the vicinity of nesting beaches. Offshore construction and trenching may reduce the quality or availability of foraging habitat for juveniles and adults, and may affect adult nesting behavior or access to nest sites. It is assumed that habitats such as seagrass beds and live-bottom areas commonly used by turtles for feeding or resting would be avoided during facility siting and pipeline routing, and that some soft-bottom areas affected by construction or trenching would recover (see Section 4.4.6.2.1).

Based on exploration and development (E&D) scenario estimates (Section 4.4.1.1), up to 2,100 exploration wells and 2,600 production wells may be constructed and up to 12,000 km (7,500 mi) of new pipeline may be installed among the GOM planning areas under the proposed action. At any single location, construction and trenching activities would be of relatively short duration (only until the offshore structure or pipeline is in place). Thus, any impacts incurred from structure placement or trenching would be short-term and localized to the construction area and immediate surroundings and, therefore, would likely affect relatively few juveniles or adults. Because they are passively aggregated by currents, a greater number of hatchlings may be affected if present in a construction or trenching area. However, these effects are not expected to result in population-level impacts.

Removal of Offshore Structures. Sea turtles are known to be attracted to offshore platforms (Lohoefener et al. 1990); therefore, they may be killed or injured during explosive platform removal (Klima et al. 1988; Gitschlag and Herczeg 1994). Even if turtles are not capable of hearing the acoustic properties of an explosion, physiological or behavioral responses (startle) to detonations may still result (MMS 2007b). The effects of blast pressure on sea turtles during explosive platform removal activities are illustrated in Figure 4.4.7-9. Exposure to explosion pressure could result in internal injuries, such as lung hemorrhaging, and individuals may be rendered unconscious by the force of the blasts (Duronslet et al. 1986; Klima et al. 1988). However, evidence of sea turtle mortality or injury from blast pressure is sparse, probably due to the difficulty in observing submerged turtles and because affected turtles may remain submerged rather than float to the surface (NRC 1990). Despite this, the relative importance of oil platform removal to overall sea turtle mortality (from human activities) is considered to be low (NRC 1990; NOAA 2003). Under the proposed action, approximately 150 to 275 existing platforms could be removed from the planning areas using explosives.

Mitigation measures in the form of guidelines for explosive platform removals have been established by BOEMRE with the cooperation of the National Marine Fisheries Service (NMFS). These guidelines require a mitigation plan that uses qualified observers to monitor the detonation area for protected species prior to and after each detonation. The detection of sea turtles within a predetermined radius from the structure prior to detonation would, without exception, delay structure removal. As long as operators comply with these mitigating measures, it is expected that impacts other than short-term behavioral disturbance would be avoided or greatly reduced, and no population-level effects would occur.

OCS Vessel Traffic. Sea turtles could be disturbed by the presence of OCS project vessels traveling from port locations to the construction area, as well as ships supporting pipeline trenching activities. It is unknown whether or how the presence of passing project vessels might affect nearby sea turtles. Sea turtles exposed to a passing vessel could exhibit short-term cessation of normal behaviors and possibly exhibit behavioral responses such as fleeing (Hazel et al. 2007). Construction vessel traffic would be expected in both offshore and coastal areas, and thus could affect sea turtles in coastal nest staging, foraging, and wintering habitats, as well as in offshore foraging areas and along migration routes. Several studies have reported sea turtles to exhibit strong fidelity to migration corridors, habitat foraging grounds, and nesting areas (e.g., see Morreale et al. 1996; Morreale and Standora 1998, Avens et al. 2003; and Casale et al. 2007). Many important coastal habitats for sea turtles are in areas with high levels of commercial and recreational boat traffic (e.g., see USDOT 2008). In such areas, construction vessel traffic would likely result in only a very small incremental increase in overall vessel traffic in many locations.

Boat collisions are reported to be a major cause of injury and mortality in sea turtles (Lutcavage et al. 1997; TEWG 2007). While juvenile and adult sea turtles may avoid areas with heavy vessel traffic, most species generally exhibit considerable tolerance to ships. Because of their limited swimming abilities, hatchlings would likely not be able to avoid oncoming vessels, and thus may be more susceptible to vessel collisions, especially if aggregated in areas of current convergence or in mats of floating *Sargassum*. To date, there is no direct evidence of OCS vessel collisions with sea turtles (of any life stage) in the GOM from oil and gas activities.

The likelihood of such a collision would vary depending upon species and life stage present, the location of the vessel, its speed, and its visibility. Hatchling turtles, including those aggregated in convergence zones or patches of *Sargassum*, would be difficult to spot from a moving vessel because of their small size and generally cryptic coloration patterns, which blend in with the color and patterns of the *Sargassum*. While adult and juvenile turtles are generally visible at the surface during periods of daylight and clear visibility, they may also be very difficult to spot from a moving vessel when resting below the water surface and during nighttime and periods of inclement weather.

While sea turtles are distributed within nearshore waters and waters of the continental shelf throughout the GOM, they appear to occur in greatest abundance east of Mobile, Alabama, in the Eastern Planning Area (Davis et al. 2000). Only a small portion of the Eastern GOM located greater than 160 km (100 mi) from the Florida coast (Figure 1-2) is being considered for the Program. Service vessels that would go to this area are assumed to originate from bases located in coastal areas adjacent to the Central Planning Area; thus the potential for sea turtle collisions with OCS project boats may be very low for the Eastern Planning Area. In contrast, there may be a greater potential for turtle-vessel collisions in the Western and Central Planning Areas, due to the large number of vessel trips in these areas. Under the proposed action, it is estimated that between 300 and 600 vessel trips would occur per week; most of this activity would occur in the Central and Western Planning Areas. However, BOEMRE has implemented measures for all oil and gas operators in the GOM that require actions to minimize the risk of vessel strikes to protected species, including sea turtles and reporting observations of injured or dead animals (see NTL 2003-G10 [MMS 2003b]). In lieu of a formal observer program, this Notice to Lessees and Operators (NTL) also provides specific guidelines for operators to follow to avoid injury to marine mammals and sea turtles. With compliance, the BOEM expects these measures to reduce the potential for negative impacts to sea turtles from vessel collisions.

Construction and Operation of Onshore Infrastructure. Unless existing onshore facilities are available, new platforms and pipelines will require the construction of new onshore infrastructure such as pipeline landfalls. Onshore construction activities may disturb nesting adults, hatchlings, and nest sites along the northern GOM coastline.

If present in a construction area, nests containing eggs or emerging hatchlings could be destroyed by site clearing and grading activities. Females ready to nest may avoid disturbed historic nesting beaches or may dig nests in poor quality locations where hatchling success may be greatly reduced. Lighting from construction areas may disorient hatchings emerging from nearby nests, which could increase exposure to predators, cause entanglement in vegetation, or lead hatchlings away from the surf (NRC 1990; Witherington and Martin 1996; Lorne and Salmon 2007). Onshore lighting may also draw hatchlings back out of the surf, as well as disorient adult females seeking to nest on nearby beaches.

Although disturbed beaches may undergo restoration activities, such as placement of new sand in disturbed areas, the effectiveness of such actions to restore nesting activity is unknown. Constructed beaches often differ physically from natural beaches and depending on the type of sand used may exhibit sand temperatures quite different from the original pre-disturbed beaches (NMFS and USFWS 2008). Loggerhead nesting activity on restored beaches was found to be reduced the first season following restoration, but much less reduced by the second season, suggesting that nesting activity may return to pre-disturbance levels within a few years (Rumbold et al. 2001). Because nest temperatures affect the sex of hatchlings, restored beach sites with cooler temperatures may skew sex ratios toward males (Milton et al. 1997). Similar impacts could be incurred to more inland reptile species that may occur in brackish environments that are listed as species of concern by the USFWS (e.g., diamondback terrapin [*Malaclemys terrapin*], gulf salt marsh snake [*Nerodia clarkia*]).

Given the small amount of onshore construction that could occur with a pipeline landfall, it is unlikely that onshore construction would impact more than a few nests. The implementation of all mitigation measures required by statutes, regulations, and/or lease stipulations that have applied in past lease sales would also greatly limit the potential for impacts to nests and emerging hatchlings. Applicable mitigation measures may include preconstruction surveys for nest sites and delay of construction activities until hatchlings have emerged and moved into open water. In addition, onshore facilities could be located such that known nesting beaches would not be affected by construction and operation of such facilities.

Operational Discharges and Wastes. Normal operations generate a variety of wastes such as produced water, drilling muds and cuttings, sanitary and other waste fluids, and miscellaneous trash and debris. Hatchling, juvenile, and adult sea turtles may be exposed to these wastes by permitted and accidental discharges from onshore and offshore facilities and OCS service and construction vessels. Produced water and drilling muds may contain a variety of constituents, such as trace metals, hydrocarbons, and NORM (Neff 1997b), which may be toxic to fish and wildlife, including sea turtles. Exposure to these wastes may occur through direct contact with the wastes in the ocean water and through the ingestion of food contaminated by one or more of the waste constituents. Because produced water and other liquid wastes would be rapidly diluted in the open ocean (i.e., to ambient levels within several thousand meters of the discharge), sea turtles would be expected to experience only very low levels of exposure from the water column. Species such as loggerheads and Kemp's ridleys that feed at the top of the food chain have been found to have higher tissue levels of bioaccumulative compounds than species feeding at lower trophic levels (Pugh and Becker 2001).

While there is limited information regarding the levels of some contaminants (such as polychlorinated biphenyls [PCBs] and metals) in sea turtle tissues, little is known about what concentrations are within normal ranges of a particular species or what tissue levels may result in acute or chronic effects (Pugh and Becker 2001; NOAA 2003). In loggerhead turtles, chlordane concentrations have been negatively correlated with blood parameters indicative of anemia, and several classes of organic contaminants have been correlated with hepatocellular damage and possible alterations of protein and ion regulation (Keller et al. 2004).

Ingestion of, or entanglement with, discarded solid debris can adversely impact sea turtles. Ingestion of plastic and other nonbiodegradable debris has been reported for almost all sea turtle species and life stages (NOAA 2003). Ingestion of waste debris can result in gut strangulation, reduced nutrient uptake, and increased absorbance of various chemicals in plastics and other debris (NOAA 2003). Sublethal quantities of ingested plastic debris can result in various effects including positive buoyancy, making them more susceptible to collisions with vessels, increasing predation risk, or reducing feeding efficiency (Lutcavage et al. 1997). Some species of adult sea turtles, such as loggerheads, appear to readily ingest appropriately sized plastic debris. In oceanic waters, floating or subsurface translucent plastic material and sheeting may be mistaken for gelatinous prey items such as jellyfish. Entanglement in debris (such as rope and discarded fishing line) can result in reduced mobility, drowning, and constriction of and subsequent damage to limbs (Lutcavage et al. 1997). However, the discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by BOEMRE (30 CFR 250.40) and the USCG (MARPOL, Annex V, Public Law 100-220 [101 Statute 1458]). Assuming compliance with these regulations and laws and only accidental releases occur, very little exposure of sea turtles to solid debris generated during normal operations is expected.

Produced waters, drilling muds, and drill cuttings are routinely discharged into offshore marine waters and regulated by USEPA NPDES permits and USCG regulations. Compliance with these permits and regulations will greatly limit the exposure of sea turtles to produced water and other wastes generated at offshore facilities and on OCS vessels. Most operational discharges, as regulated, are diluted and dispersed when released in offshore areas and are considered to have sublethal effects (API 1989; Kennicut 1995). Any potential for impact on sea turtles from drilling fluids would be indirect, either by impact on prey items or through ingestion via the food chain (API 1989). Contaminants in drilling muds or waste discharge may biomagnify and bioaccumulate in the food web, which may kill or debilitate prey species or species lower in the food web. Sea turtles may bioaccumulate chemicals (Sis et al. 1993), which may ultimately reduce fitness characteristics, such as reproductive output.

4.4.7.4.2 Accidents. All sea turtle life stages, as well as nest sites and eggs, may be exposed to accidental oil releases in the GOM planning areas. In extreme catastrophic oil spills, all life stages of the American crocodile and their habitats may also be exposed to oil (Table 4.4.7-6). The American crocodile inhabits brackish and freshwater environments and is primarily known to occur in coastal mangrove swamps in southern Florida. Depending on location and magnitude, catastrophic oil spills in the GOM have the potential to affect coastal mangrove and beach habitats in southern Florida for the American crocodile.

The effects of accidental oil spills on reptiles are illustrated in Figure 4.4.7-10. Nests may be exposed by oil washing ashore and soaking through overlying soils onto buried eggs, while hatchlings may be exposed as they emerge from nests. Hatchlings, juveniles, and adults may be exposed while swimming through oil on the water surface, through inhalation of petroleum vapors, and through ingestion of contaminated foods and floating tar. Nesting adults (females) may also be exposed while coming ashore on oiled beaches. In addition to direct adverse effects from such exposures, adults and juveniles may also be indirectly affected if an accidental spill reduces the quality or quantity of foraging or nesting habitats. Impacts to nesting habitats could result in population-level effects. Similar impacts could be incurred to more inland reptile species that may occur in brackish environments that are listed as species of concern by the USFWS (e.g., diamondback terrapin [*Malaclemys terrapin*], gulf salt marsh snake [*Nerodia clarkia*]).

Sea turtle behavior may put the turtles at greater risk of oil exposure in the event of an accidental spill. Sea turtles are air breathers and must surface frequently to breathe. Many turtles surface at convergence areas, highly productive areas where ocean currents converge and where spilled oil could be pushed by the ocean currents. These convergence areas also provide food, shelter, and habitat for sea turtles, especially young individuals. Therefore, the accumulation of oil in GOM convergence areas increases the risk of sea turtle exposure to oil (NOAA 2010a).

Sea turtles accidentally exposed to oil or tarballs have been reported to incur a variety of conditions, including inflammatory dermatitis, breathing disturbance, salt gland dysfunction or failure, hematological disturbances, impaired immune responses, and digestive disorders or blockages (Vargo et al. 1986; Lutz and Lutcavage 1989).

Sea turtle nest sites and emerging hatchlings may be exposed to and subsequently affected by oil spills that wash up on nesting beaches and contaminate active nests. Oil may interfere with gas exchange within an oiled nest, may alter hydric conditions of the sand so that it is too wet or too dry for optimal nesting, or may alter nest temperatures by changing the color or thermal conductivity of the overlying sand (NOAA 2003). Adult females may refuse to use oiled beaches (NOAA 2003).

Eggs exposed to freshly oiled sands may incur a significant decrease in hatching success and an increase in developmental abnormalities in hatchlings (Fritts and McGehee 1982). In contrast, eggs exposed to weathered oil did not produce measurable impacts on hatchling survival or development, suggesting that impacts to nest sites would be greatest if the accidental spill occurred during the nesting season. Because most sea turtles nest above the high-tide line and oil washing ashore would be deposited at and just above the high-tide line, oiling of actual nests is unlikely except possibly in the event of exceptionally high tides or storms.

Hatchlings may become oiled while traveling from the nest to water, and a heavy oil layer or tar deposits on the beach may prevent the hatchlings from reaching water. Oiled hatchlings may have difficulty crawling and swimming, increasing the potential for predation. Open-water convergence zones where hatchlings may aggregate are also areas where oil slicks may aggregate. For example, the Sargasso Sea has been estimated to annually entrap 70,000 metric tons of tar (NOAA 2003). Because hatchlings spend more time at the sea surface, they will be more likely to be exposed to surface oil slicks than adults or juveniles. Post-hatchling sea turtles have been collected from convergence zones off Florida with tar in their mouths, esophagi, and stomachs, and tar caking their jaws (Loehefener et al. 1989; Witherington 1994). Ingested tar may result in starvation from gut blockage and decreased food adsorption efficiency, absorption of toxins, local necrosis or ulceration associated with gut blockage, interference with fat metabolism, and buoyancy problems (NOAA 2003).

Sea turtles surfacing and diving in an oil spill may inhale petroleum vapors and aspirate small quantities of oil. While no information is available about the effects of petroleum vapors or aspirated oil on sea turtles, inhalations by mammals of small amounts of oil or petroleum vapors have been shown to result in acute fatal pneumonia, absorption of hydrocarbons in organs and other tissues, and damage to the brain and central nervous system.

Ingested oil, particularly the lighter fractions, could be toxic to sea turtles. Ingested oil may remain within the gastrointestinal tract, irritate and/or destroy epithelial cells in the stomach and intestine, and subsequently be absorbed into the bloodstream (NOAA 2003). Certain constituents of oil, such as aromatic hydrocarbons and PAHs, include some well-known carcinogens. These substances, however, do not show significant biomagnification in food chains and are readily metabolized by many organisms. Hatchling and juvenile turtles feed opportunistically at or near the surface in oceanic waters and may be especially vulnerable and sensitive to spilled oil and oil residues such as floating tar (Lutz and Lutcavage 1989; Lutcavage et al. 1995). Tar found in the mouths of turtles may have been selectively eaten or ingested accidentally while feeding on organisms or vegetation bound by tar (Geraci and St. Aubin 1987; Geraci 1990).

Certain species of sea turtles may be at greater risk of exposure to spilled oil based on their distributions and habitat preferences and also on the timing of a spill. For example, loggerhead and Kemp's ridley sea turtles frequent current-restricted areas such as bays and estuaries. Because oil entering these areas may remain for longer periods of time due to reduced weathering rates and natural dispersion, sea turtles using habitats in these areas may incur longer exposure periods. Spills occurring in coastal waters of the Western Planning Area may affect greater numbers of green, hawksbill, loggerhead, and leatherback sea turtles during summer months when nearshore densities are greater than offshore densities.

Oil spill response activities that may adversely affect sea turtles include artificial lighting at night, machine and human activity and related noise, sand removal and cleaning, and the use of dispersant or coagulant chemicals. Lights used to support nighttime cleanup activities may attract sea turtles to the spill location or disorient hatchlings emerging from nearby nests. Machine and human activity may cause a temporary avoidance of nearby habitats (including nest sites) by sea turtles, produce noise that may disturb sea turtles, and also increase the potential for sea turtle collisions with vessels and onshore vehicles. Onshore activities may also crush existing nests and result in beach compaction, reducing the suitability of existing nest sites for future use. Sand removal may also directly impact nest site habitat quality. While oil dispersants or coagulants contain constituents that are considered to be low in toxicity when compared to many of the constituents of spilled oil (Wells 1989), there are little available data regarding the effects of these chemicals on sea turtles (Tucker and Associates, Inc. 1990).

The magnitude and severity of impacts that could result from such exposures would depend on the location of the spill, spill size, type of product spilled, weather conditions, the water quality and environmental conditions at the time of the spill, and the species and life stage of the sea turtle exposed to the spill. The magnitude and extent of any adverse effects would also depend on how quickly a spill is contained and how quickly and effectively cleanup is accomplished. Based upon spill scenario estimates provided in Section 4.4.2, between 200 and 400 spills of <50 bbl of oil and up to 70 spills of ≥50 bbl of oil could be expected in the GOM under the proposed action.

Catastrophic Discharge Event. The PEIS analyzes a CDE up to 7.2 million bbl (Table 4.4.2-2). The recent oil spill associated with the DWH oil rig explosion, which occurred in April 2010 approximately 66 km (41 mi) off the Louisiana coast, may have had detrimental consequences to sea turtles that had direct contact with spilled oil. A total of 1,146 sea turtles were recovered from the GOM that had come in contact with or were in the vicinity of spilled oil. The recovered turtles included adults or free-swimming juveniles of four species: green, hawksbill, Kemp's ridley, and loggerhead. However, some recovered sea turtle species could not be identified (Table 4.4.7-7). Of the total number of turtles recovered, 608 (53%) were found dead and 537 (47%) were found alive. Most of the recovered sea turtles (dead or alive) were Kemp's ridley sea turtles (Table 4.4.7-7). Approximately 85% of the live turtles recovered were visibly oiled; approximately 3% of the dead turtles recovered were visibly oiled (Restore the Gulf 2010a). While in the case of the DWH event, the cause of death of the deceased turtles remains unclear, it is possible for turtles to ingest or inhale oil during a CDE that could be potentially fatal without any noticeable external indications.

A CDE spill also has the potential to affect sea turtle populations by fouling habitats such as seagrass beds and nesting beaches. In the case of the DWH event, preliminary reports on the DWH event from the NOAA Natural Resource Damage Assessment Team have indicated that about 1,600 km (1,000 mi) of shoreline along the GOM has tested positive for oil, including salt marshes, beaches, mudflats, and mangroves (NOAA 2010b). The presence of oil in these areas likely affected foraging and nesting habitats for sea turtles, although the true ecological consequences of these effects are not known.

4.4.7.4.3 Conclusion. Under the proposed action, some routine operations could affect individual sea turtles, but population-level impacts are not expected. Noise generated during exploration and production activities and platform removal may result in the temporary disturbance of some sea turtles, while some turtles may be injured or killed during the use of underwater explosives for platform removal. Sea turtles could be directly affected by construction of offshore and onshore facilities and pipeline trenching, and also indirectly by short-term and long-term impacts to habitats. The construction and operation of new onshore facilities may impact nest sites, possibly result in eggs being crushed, and disturb hatchling movement from the nest sites to the water. Sea turtles may also be injured or killed by collisions with OCS vessels. Sea turtles may also be exposed to a variety of waste materials which have the potential to cause a variety of lethal and sublethal effects. Accidental spills have the potential to foul habitats and injure or kill exposed sea turtles. Depending on magnitude and location, catastrophic accidental oil spills have the potential to affect American crocodile habitats and exposed individuals. Many of these impacts would be of relatively short duration and localized and would likely affect relatively few individuals in the immediate project area. Existing permit requirements, regulatory stipulations, and BOEM guidelines and mitigation measures, if applied, target many of the routine operations and could limit the potential effects. Impacts to reptiles from routine operations associated with the Program are expected to range from minor to moderate.

Any of the oil-spill scenarios developed for the proposed action (Section 4.4.2) may result in the exposure of one or more life stages of reptiles to oil or its weathered products. Oil may reduce egg hatching and hatchling survival and may inhibit hatchling access to water. Hatchlings, juveniles, and adults may inhale or ingest oil and oil vapors and may incur any of a variety of physiological impacts. The presence of oil slicks or oiled beaches may alter habitat use and affect nest site access and use. Small spills that may occur under the proposed action are unlikely to affect a large number of sea turtles or their habitats and are not expected to have long-term effects on sea turtle populations in the GOM. A large spill could affect many more individuals and habitats, including nesting beaches, and, in the case of a CDE, potentially may incur population-level effects. The magnitude of effects from accidental spills would depend on the location, timing, and volume of the spills; the environmental settings of the spills; and the species and life stages of sea turtle exposed to the spills. Because 93% of the new oil production that is expected to occur during the Program is assumed to occur far from the coast in deep water (>200 m [656 ft] deep), the likelihood of a large spill occurring close enough to the coastline to affect turtle nesting beaches is expected to be small. However, a CDE occurring in deep water has a greater likelihood of reaching coastal areas, although this will depend on the specific location of the spill and the prevailing currents in that area. The rapid deployment of spill-response teams and implementation of cleanup activities could limit the magnitude of impacts incurred by sea turtles in the event of an accidental spill; however, cleanup operations themselves could also impact sea turtle habitats.

4.4.7.5 Invertebrates and Lower Trophic Levels

4.4.7.5.1 Gulf of Mexico.

Routine Operations. Impacting factors common to all phases include vessel discharges (bilge and ballast water), miscellaneous discharges (deck washing, sanitary waste), and offshore lighting. Many of these waste streams are disposed of on land, and all vessel and platform waste streams must meet USEPA and/or USCG regulatory requirements before discharge into surface waters. Impacts from waste discharges would be localized and temporary and are expected to have negligible impacts on invertebrate populations. Studies conducted in the northern GOM suggest that platform lighting could alter predator-prey dynamics by enhancing phytoplankton productivity around the platform, attracting phototaxic pelagic invertebrates, and potentially improving the visual foraging environment for fishes (Keenan et al. 2007). Consequently, increased predation of invertebrates may occur in the vicinity of the platform. Potential impacts from platform lighting would be localized but long-term and are expected to have minimal impacts on invertebrate populations.

Exploration and Site Development. During the OCS oil and gas exploration and development phase, invertebrates could be affected by noise from seismic surveys and noise and bottom disturbance from drilling, platform placement, and pipeline trenching and placement activities. Releases of drilling muds and cuttings could also affect invertebrates by contaminating sediments and surrounding surface waters (Table 4.4.7-8).

Noise from vessel traffic, construction, seismic surveys, and drilling could kill or injure invertebrates close enough to the noise source, as well as reducing habitat suitability, as some species would avoid the area. For example, decapods and cephalopods, two numerically abundant and commercially important groups of invertebrates, are known to detect vibrations from underwater noise and may be sensitive to noise from vessel traffic, seismic surveys, and drilling (DFO 2004; National Science Foundation and USGS 2010). Recent reviews of the impacts of anthropogenic noise on invertebrates indicates that invertebrates exposed to noise could exhibit pathological effects (i.e., injury and mortality), physiological changes (i.e., changes in hormone, protein, and enzyme levels), and/or behavioral changes (such as a startle response) and change swimming and movement patterns (DFO 2004; National Science Foundation and USGS 2010). Although data is limited, zooplankton and larvae stages may be injured because of their small size and relative lack of mobility, while noise is often found to have negligible effects on adult invertebrates (reviewed in DFO 2004 and National Science Foundation and USGS 2010). The studies typically suggested that injury was limited to within 10 m (33 ft) of the noise source. The numbers of invertebrates that could be affected by noise during the exploration and site development phase make it unlikely that noise impacts would have appreciable effects on invertebrate populations in the Western and Central Planning Areas. A recent review of the effects of seismic survey activities on marine invertebrates concluded that although data were limited, mortality and injury of invertebrates would be limited to organisms located within a few meters of the air gun, and that there would be no significant impacts on marine invertebrate populations from air gun and sonar sounds (National Science Foundation and USGS 2010). The severity and duration of noise impacts would vary with site and development

TABLE 4.4.7-8 Impacting Factors Potentially Affecting Invertebrates and Their Habitat in the GOM Planning Areas

Development Phase and Impacting Factor	Life Stage Affected[a]		
	Eggs	Larvae	Adults
Impacting Factors Common to All Phases			
Vessel noise	X	X	X
Vessel traffic	X	X	X
Hazardous materials	X	X	X
Solid wastes	X	X	X
Offshore lighting	X	X	X
Aircraft noise			
Offshore air emissions			
Onshore air emissions			
Aircraft traffic			
Miscellaneous platform discharges	X	X	X
Vessel discharges	X	X	X
Bottom disturbance from vessel anchors	X	X	X
Exploration and Development			
Seismic noise	X	X	X
Noise from drilling and construction	X	X	X
Bottom disturbance from platform placement, drilling, and pipeline placement and trenching	X	X	X
Discharge of drilling muds and cuttings	X	X	X
Production			
Production noise	X	X	X
Produced water discharge	X	X	X
Artificial reef	X	X	X
Decommissioning			
Platform removal (non-explosive)	X	X	X
Platform removal (explosive)	X	X	X

[a] colors indicate impact level: white = negligible; blue = minor; yellow = moderate; red = major.

scenario, but given the temporary and localized nature of the noise generating activities, impacts on invertebrates are expected to be negligible.

Bottom-disturbing activities such as coring and drilling, platform placement and mooring, and pipeline trenching and placement would displace, injure, or kill invertebrates in the vicinity of the activities. The estimated bottom habitat that may be directly disturbed by new pipeline and platform installation ranges from 2,150 to 14,000 ha (5,313 to 34,594 ac) over the entire GOM. In the initial drilling phase before a riser is installed, drilling muds would accumulate around the well and bury benthic invertebrates as well as create a turbidity plume that could impact pelagic invertebrates located near the bottom. Drilling is also expected to increase the amount of sand in sediments surrounding the well for at least 300 m (984 ft) (Continental Shelf Associates, Inc. 2006). This change in grain size could alter community composition and prevent the settlement of some species. In addition, bottom disturbance during platform and pipeline placement would result in sedimentation and turbidity, which could bury benthic infauna and damage the gills of water-column and benthic invertebrates present within some distance of the disturbance. These disturbances would be localized and temporary. Species most likely to be affected are sessile benthic organisms and small zooplankton, which lack the mobility to avoid the direct disturbance and the associated turbidity plumes. An FPSO system may be employed for deepwater wells. Under the FPSO system, oil would be transported from the well to a surface vessel and ultimately to shore. By eliminating the need for pipelines, an FPSO system would greatly reduce bottom disturbance and the chance for disturbing benthic and near-bottom invertebrates and their habitat. Most disturbed areas would be recolonized quickly, but, if grain size is significantly altered, the benthic community may take several years to return to its pre-disturbance composition (Bolam and Rees 2003 and references therein).

The effects of drilling muds and cuttings (including drilling fluids adhering to the cuttings) on invertebrates can be chemical such as toxicity or physical such as gill abrasion, burial, or displacement from turbidity and sedimentation. Impacts from turbidity and sedimentation would be similar to those described above and could damage respiratory structures and disrupt food acquisition at all trophic levels. Drilling wastes released near the sediment surface or in shallow water would bury benthic organisms in the release area. Muds released in deeper water or near the water’s surface would be spread over a greater area in a thinner layer and may not result in high mortality, although impacts to water-column invertebrates may be greater under this scenario. The disturbance would be short in duration, with repopulation of the affected area occurring by larval recruitment. In addition, drilling discharges must comply with NPDES permit requirements regarding the discharge amount, rate, and toxicity, which would greatly reduce the impact to invertebrate communities.

The USEPA and BOEM have sponsored research on the biological effects of drilling fluids on benthic invertebrates. In studies conducted on the GOM continental shelf and slope, synthetic drilling fluids in sediments were elevated within 500 m (1,640 ft) of the well (Continental Shelf Associates, Inc. 2004, 2006). Meiofaunal and macroinvertebrate abundance were typically highest near the well, and were often found to increase with the concentration of drilling fluids in the sediment (Continental Shelf Associates, Inc. 2006). However, the effects of drilling muds appears to be species-dependent. Amphipod, ophiuroid, and ostrocod densities were depressed within 300 m (984 ft) of the well compared to control areas, while copepods, nematodes, and several classes of dominant infauna including worms, clams, and snails were more abundant within 300 m (984 ft) of the well (Continental Shelf Associates, Inc. 2006). Sediments collected near the well were found to be toxic to amphipods, which explains their depressed abundance (Continental Shelf Associates, Inc. 2004, 2006). The elevated abundance of most infauna may have been due to the high organic matter content of the drilling fluids adhering to the muds and cuttings. Some sites showed particularly high abundance of species tolerant of organic enrichment (Continental Shelf Associates, Inc. 2006). However, the high organic matter content also created anoxic patches along the seafloor that contained very few infauna. The recovery time for benthic communities will depend on impact magnitude and species present, and existing data suggest recovery will begin rapidly but may take years for recovery to pre-disturbance communities (Continental Shelf Associates, Inc. 2004, 2006).

Overall, the site development and exploration represent a moderate disturbance primarily affecting benthic invertebrates, with the severity of the impacts generally decreasing dramatically with distance from bottom-disturbing activities. Recovery of invertebrate communities could range from short-term to long-term.

Production. Production activities that could affect soft sediment habitat include operational noise, bottom disturbance from the movement of mooring anchors, chains, and cables, and the release of process water. In addition, the platform would replace existing featureless soft sediments and potentially serve as an artificial reef (Table 4.4.7-8).

Chronic bottom disturbance would result from the movement of anchors and chains associated with support vessels and floating platform moorings. Bottom disturbance would impact invertebrates in a manner similar that described above for the exploration and site development phase. The disturbance would be episodic and temporary, but would last for the lifetime of the platform.

Sessile epifaunal invertebrates requiring hard substrate (i.e., barnacles and corals) as well as small motile invertebrates (amphipods and worms) would be able to colonize the structure of the platform, resulting in an artificial reef. Unburied pipelines would also provide hard substrate for sessile and structure-oriented invertebrates. Although densities of some zooplankton species were elevated near the platforms in the northern GOM, the effect was not consistent (Keenan and Benfield 2003). The platform would likely increase shell material and organic matter in the surrounding sediments, potentially resulting in a shift in benthic invertebrate community composition. The replacement of soft sediment with artificial reef would only exist during the production phase, unless the platform was permitted to remain in place after decommissioning. Because platforms are spread across a large area of the GOM, they could provide habitat for non-native invertebrate species that prefer hard substrate. Such species could be introduced by a number of mechanisms both natural and anthropogenic (commercial shipping and human introduction). In the deep sea, floating production platforms are used that could create a floating reef habitat at the surface. In deep sea soft sediment, communities may form on mooring structures, but colonization would likely be slow and mooring structures would be completely removed during decommissioning, so impacts, if any, would be temporary.

Produced water contains metals, hydrocarbons, salts, and radionuclides, and its discharge could contaminate habitat resulting in lethal and sublethal effects on invertebrates. Organisms attached to oil platforms have not been found to accumulate metals, although they have been found to bioaccumulate organic contaminants (Neff 2005; Trefry et al. 1995). Produced water from deepwater wells is expected to contain more chemical contaminants to maintain adequate flow. Contaminants from produced water discharges are not expected to reach toxic levels in the sediment and water column due to dilution and NPDES permitting requirements regarding discharge rate, contaminant concentration, and toxicity. Invertebrates collected in sediments near platforms in the GOM do not appear to bioaccumulate the common contaminants in produced water, such as radionuclides, metals, and hydrocarbons, and in most cases, the concentration of these contaminants in their tissues did not exceed USEPA-specified concentrations considered harmful (Continental Shelf Associates, Inc. 1997). Produced water is also not expected to contribute significantly to the creation of hypoxic bottom water conditions (Rabalais 2005; Bierman et al. 2007). Consequently, impacts to water-column and benthic invertebrates should be minor.

The results of the GOM Offshore Monitoring Experiment, funded by BOEM, provide a good summary of the long-term sublethal impacts of oil and gas development on invertebrates at the individual, population, and community level (Kennicutt et al. 1995). Stations surrounding petroleum wells were sampled in a radial pattern with stations at 30–50, 100, 200, 500, and 3,000 m distances (98–164, 328, 656, 1,640, and 9,842 ft). Elevated sediment concentrations of sand, organic matter, hydrocarbons, and metals were generally restricted to sediments within 200 m (656 ft) of the platforms. Overall, there was no evidence of sublethal physiological stress or change in distribution of epifaunal invertebrates attributable to the presence of the platform. Oil and gas development activities resulted in altered infaunal communities within 100 m (328 ft) of the platform, with reduced density and diversity of crustaceans (primarily amphipods and copepods) near the platform and enhanced density of polychaetes and deposit-feeding nematodes. The patterns in invertebrate density were often attributable to changes in a few species. Differences in abundance between near- and far-field stations were the product of toxic response of sensitive crustacean species and sediment organic enrichment, which increased the density of worms (Kennicutt et al. 1995). Toxicity tests indicated copepod survival, reproduction, and genetic diversity were lower near the platforms due to metal concentrations (Kennicutt 1996; Montagna and Harper 1996) or the reef effect of the platform (Montagna et al. 2002). Thus, production activities are expected to result in minor impacts to invertebrates.

Decommissioning. Platform removal (potentially using explosives) would temporarily affect benthic and pelagic invertebrates, as described above, by disturbing sediments and increasing noise and turbidity for some length of the water column. Deposition of suspended sediments could bury, smother, or kill some benthic organisms in the vicinity of work sites. Mortality to epifauna should be limited to within a few meters of the blast (O’Keeffe and Young 1984). In addition, the explosive charges typically would be set at 5 m (16 ft) below the seafloor surface, which would significantly attenuate the shock wave as it moved through the seabed. Displaced invertebrate communities would repopulate the area over a short period of time, although a return to the pre-disturbance community may take longer. No permanent change in benthic communities would result from floating platform removal. However, if fixed platforms are toppled and left in place, the changes to invertebrate communities resulting from the initial platform installation would be permanent. Pipelines installed and anchored on the seafloor would be capped and left in place, although there is the potential for chronic sediment disturbance from pipeline movement. Pipelines not buried would also continue to serve as hard substrate for sessile invertebrates and structure oriented invertebrates. Overall, impacts to invertebrates associated with decommissioning activities are expected to be minor.

Accidents. Accidental hydrocarbon spills can occur at the surface or at the seafloor, potentially affecting pelagic and benthic invertebrates. Exposure to hydrocarbons can result in lethal or sublethal (reproduction, recruitment, physiology, growth, development, and behavior) impacts at the level of the individual, while catastrophic oil spills could result in population-level effects and complex indirect effects on species interactions (i.e., competition and predation) in some cases. Invertebrates differ in their sensitivity to hydrocarbon pollution both by organism class and life stage (Laws 1992). For example, crustaceans appear to be among the taxa most sensitive to oil pollution, while certain species of worms, such as Capitellid polychates, appear to be tolerant of oil pollution (Blumer et al. 1971; Laws 1992; NRC 2003b). Among meiofauna, nematodes may be less sensitive to oil than copepods.

Most oil and gas spills would be small and rapidly be diluted and are expected to primarily affect invertebrates in the water column, as most hydrocarbons would float above the sediment surface. However, even a small spill (<999 bbl) could affect intertidal and subtidal invertebrates. After the spill of 600 bbl of crude oil in Barataria Bay, Louisiana, Roth and Baltz (2009) found a reduction in total number of decapod crustaceans as well as reduction in grass shrimp (*Palaeomonetes pugio*) 3 weeks after the spill occurred. The impact magnitude of these small oil spills on invertebrates is primarily a function of the invertebrate species and habitat affected. Impacts from spills would be greatest if a large spill occurred during a reproductive period or contacted a location important for spawning or growth such as intertidal and nearshore subtidal habitats. However, it is anticipated that only a small amount of shoreline would be affected by these smaller oil spills and would not, therefore, present a substantial risk to invertebrate populations. Impacts from small and large spills are expected to be temporary as oil is diluted and broken down by natural chemical and microbial processes.

Catastrophic Discharge Event. The PEIS analyzes a CDE up to 7.2 million bbl (Table 4.4.2-2). Spilled oil has been found to affect pelagic and sediment-dwelling invertebrates (Laws 1992; reviewed in NRC 2003b). Pelagic invertebrates are concentrated in the upper water column so oil and gas reaching the surface from a surface or subsurface CDE spill have the potential to affect the greatest number of invertebrates. Hydrocarbon releases at the seafloor would typically rise in the water column, which would limit direct contact with benthic invertebrates. However, benthic invertebrates could be affected directly by oil reaching intertidal or shallow subtidal habitats or natural deposition of oil contaminated pelagic organic matter and biota, which could ultimately enter the benthic invertebrate food web. The location of the CDE and the season in which the CDE occurred would be important determinants of the impact magnitude of the spill. For example, catastrophic spills occurring during recruitment periods or spills that affect areas with high larval invertebrate concentrations (i.e., estuaries) would have the greatest impact. In addition, the magnitude of a spill’s impacts on invertebrates and their habitat would likely increase with the degree of shoreline oiling, as estuaries have high biological productivity and serve as critical habitat for invertebrates. Oil would persist longer in the environment than gas and oil could be transported to the shoreline where it could reduce local populations of shallow subtidal and intertidal coastal habitat for an extended period of time. However, a spill of this kind is unlikely to occur, and invertebrates typically have short generation times and should recover from even a catastrophic spill. Therefore, no permanent impacts to invertebrate communities are expected to result from an accidental oil spill.

Prior studies provide insight into the potential long-term effects of an oil spill on invertebrate populations in the GOM. A large oil spill in Panama affected intertidal and subtidal infauna and epifauna, with the impact magnitude and recovery time varying with the habitat, organism, and degree of oiling (Jackson et al. 1989; Keller and Jackson 1993). Oysters and mussels within mangroves, as well as amphipods, tanaids, and ophiurods in seagrass habitats, displayed long-term (>9 months) reduction in abundance compared to unoiled areas. Corals and associated biota were also affected by the spill, especially at the reef edge that received the heaviest oiling. Although many species recovered within a few months to 2 years, certain crustaceans and oysters had not recovered within 5 years (Keller and Jackson 1993). Guzman et al. (1993) estimated a total recovery time of 10 to 20 years. The 1979 Ixtoc I spill in the Bay of Campeche was not well studied; therefore it is difficult to assess the extent of impacts on invertebrates (ERCO/Energy Resources Co. Inc 1982). Most studies of the Ixtoc spill occurred in south Texas far from the spill site. In these studies, sediment contamination was not detected and no strong links between Ixtoc oil and changes in invertebrate communities could be found (ERCO/Energy Resources Co. Inc 1982; Laws 1993). In a study of upper Galveston Bay, a site of heavy oil and gas activity with a history of spills, Rozas et al. (2000) found no consistent significant relationships between sediment oil concentration and invertebrate densities, despite testing multiple species. Although sediment contamination did not appear to affect habitat use, sublethal exposure impacts could have been possible.

4.4.7.5.2 Alaska– Cook Inlet.

Routine Operations. Potential OCS oil and gas development impacting factors relevant to invertebrates are shown by phase in Table 4.4.7-9. Impacting factors common to all phases include vessel noise and discharges (bilge and ballast water), miscellaneous discharges (deck washing, sanitary waste), and offshore lighting. Impacts from these activities would be localized and temporary and would range from short-term to long-term. Overall, vessel and miscellaneous discharges are not expected to impact invertebrate communities in the sediment or water column, because many of these waste streams are disposed of on land or must meet USEPA and/or USCG regulatory requirements before being discharged into surface waters. Studies of platform lighting suggest the lights would alter predator-prey dynamics by enhancing phytoplankton productivity around the platform, attracting phototaxic invertebrates and potentially improving the visual foraging environment for fishes (Keenan et al. 2007).

Exploration and Site Development. During the OCS oil and gas exploration and development phase, invertebrates could be affected by noise from seismic surveys and noise and bottom disturbance from drilling, platform placement, and pipeline trenching and placement activities.

Noise from vessel traffic, construction, seismic surveys, and drilling could kill or injure invertebrates close enough to the noise source, as well as reducing habitat suitability, as some species would avoid the area. For example, decapods and cephalopods, two numerically abundant and commercially important groups of invertebrates, are known to detect vibrations from underwater noise and may be sensitive to noise from vessel traffic, seismic surveys, and drilling (DFO 2004; National Science Foundation and USGS 2010). Recent reviews of the impacts of anthropogenic noise on invertebrates indicates that invertebrates exposed to noise could exhibit pathological effects (i.e., injury and mortality), physiological changes (i.e., changes in hormone, protein, and enzyme levels), and/or behavioral changes (such as a startle response)

TABLE 4.4.7-9 Impacting Factors Potentially Affecting Invertebrates and Their Habitat in the Cook Inlet Planning Area

	Life Stage Affected[a]		
Development Phase and Impacting Factor	Eggs	Larvae	Adults
Impacting Factors Common to All Phases			
Vessel noise	X	X	X
Vessel traffic	X	X	X
Hazardous materials	X	X	X
Solid wastes	X	X	X
Offshore lighting	X	X	X
Aircraft noise			
Offshore air emissions			
Onshore air emissions			
Aircraft traffic			
Miscellaneous platform discharges	X	X	X
Vessel discharges	X	X	X
Bottom disturbance from vessel anchors	X	X	X
Exploration and Development			
Seismic noise	X	X	X
Noise from drilling and construction	X	X	X
Bottom disturbance from platform placement, drilling, and pipeline placement and trenching	X	X	X
Discharge of drilling muds and cuttings	X	X	X
Production			
Production Noise	X	X	X
Produced water discharge	X	X	X
Artificial reef	X	X	X
Decommissioning			
Platform removal (non-explosive)	X	X	X

[a] Colors indicate impact level: white = negligible; blue = minor; yellow = moderate; red = major.

and change swimming and movement patterns (DFO 2004; National Science Foundation and USGS 2010). Although data is limited, zooplankton and larvae stages may be injured because of their small size and relative lack of mobility, while noise is often found to have negligible effects on adult invertebrates (reviewed in DFO 2004 and National Science Foundation and USGS 2010). The studies typically suggested that injury was limited to within 10 m (33 ft) of the noise source. The numbers of invertebrates that could be affected by noise during the exploration and site development phase make it unlikely that noise impacts would have appreciable effects on invertebrate populations in the overall Cook Inlet Planning Area. A recent review of the effects of seismic survey activities on marine invertebrates concluded that although data were limited, mortality and injury to invertebrates would be limited to organisms located within a few meters of the air gun, and that there would be no significant impacts on marine invertebrate populations from air gun and sonar sounds (National Science Foundation and USGS 2010). The severity and duration of noise impacts would vary with site and development scenario, but given the temporary and localized nature of the noise generating activities, impacts on invertebrates are expected to be negligible.

Bottom-disturbing activities such as coring and drilling, platform placement and mooring, and pipeline trenching and placement would displace, injure, or kill invertebrates in the vicinity of the activities. Exploration would involve semisubmersible or floating drilling rigs, jack-up rigs, and bottom-founded rigs depending on water depth. Production rigs would most likely be fixed platforms. In the initial drilling phase before a riser is installed, drilling muds and cuttings would accumulate around the well and bury benthic invertebrates as well as create a turbidity plume that could adversely impact pelagic invertebrates located near the bottom. This change in grain size could alter community composition and prevent the settlement of some species. In addition, bottom disturbance during platform and pipeline placement would result in sediment resuspension and turbidity, which could bury benthic infauna and damage the gills of water-column and benthic invertebrates present within some distance of the disturbance. Platforms and pipeline placement would disturb 1.5 to 4.5 ha (4 to 11 ac) and 35 to 210 ha (86 to 519 ac) of bottom habitat, respectively. In addition, up to one pipeline landfill may result from the proposed action. Species most likely to be affected by bottom-disturbing activities are sessile and infaunal benthic organisms and small zooplankton that lack the mobility to avoid the direct disturbance and the associated turbidity plumes. Pipelines would be installed and anchored on the surface or buried. Pipelines could crush, injure, or displace invertebrates, as well as shift invertebrate community composition to those species preferring hard substrate. Soft-sediment invertebrates, particularly in shallow water, are subject to frequent bottom disturbance and sediment resuspension due to human activities such as trawling and natural occurrences such as storms. Thus, disturbed areas would likely be recolonized quickly, but, if grain size is greatly altered and slow to recover, the benthic community may take from a few months to several years to return to its pre-disturbance composition (Bolam and Rees 2003 and references therein).

The discharge of drilling muds and cuttings (including synthetic drilling fluids adhering to the cuttings) can adversely affect invertebrates in several ways. The effects of drilling muds and cuttings (including drilling fluids adhering to the cuttings) on invertebrates can be chemical such as toxicity or physical such as gill abrasion, burial, or displacement from turbidity and sedimentation. Impacts from turbidity and sedimentation would be similar to those described above and could damage respiratory structures and disrupt food acquisition at all trophic levels. Drilling wastes released near the sediment surface or in shallow water would bury benthic organisms in the release area. Muds released in deeper water or near the water's surface would be spread over a greater area in a thinner layer and may not result in high mortality, although impacts to water column invertebrates may be greater under this scenario. The disturbance would be short in duration, with repopulation of the affected area occurring by larval recruitment. In addition, drilling discharges must comply with NPDES permit requirements regarding the discharge amount, rate, and toxicity, which would greatly reduce the impact to invertebrate communities.

Overall, site development and exploration activities would result in moderate and temporary effects on primarily benthic invertebrates, with the severity of the impacts generally decreasing dramatically with distance from the disturbance. Recovery of benthic habitat could range from short-term to long-term.

Production. Production activities that could affect invertebrates in Cook Inlet include operational noise, bottom disturbance from anchors and the release of process water. In addition, the platform would replace existing featureless soft sediments and serve as an artificial reef (Table 4.4.7-9).

Chronic disturbance to benthic invertebrates would result from the movement of pipelines and anchors and chains associated with support vessels. Pipelines not buried would be anchored in place which would minimize their movement and potential to disturb benthic invertebrate communities. Bottom disturbance would impact invertebrates in a manner similar that described above for the exploration and site development phase. The disturbance would be episodic and temporary, but would last for the lifetime of the platform.

Produced water contains metals, hydrocarbons, salts, and radionuclides, and their discharge could contaminate habitat resulting in lethal and sublethal effects on invertebrates, particularly non-mobile benthic infauna. However, NPDES permitting requirements regarding discharge rate, contaminant concentration, and toxicity would greatly reduce the potential for impacts to invertebrates. In addition, it is assumed that all produced water would be disposed of by injection into permitted disposal wells. Therefore, the effects of produced water discharges on invertebrates are expected to be minimal.

Platforms would add a hard substrate to the marine environment, providing additional habitat for marine plants and animals (e.g., kelp and mussels) that require a hard substrate. The platform would likely increase shell material and organic matter in the sediments surrounding the platform, potentially resulting in a shift in benthic invertebrate community composition.

A two-year (1997–1998) study of contaminant levels in the sediments of the Shelikof Strait and Cook Inlet provide information on the overall, long-term potential effects of oil and gas development in the Cook Inlet Planning Area (MMS 2001a). Samples of sediment from depositional areas (where sediment contamination is expected to be greatest) suggested that metals and PAHs in sediments derived primarily from natural sources rather than past oil and gas developments (MMS 2001a). In addition, sediment concentrations of metals and organic contaminants in outermost Cook Inlet and Shelikof Strait (1) have not increased significantly since offshore oil exploration and production began in Cook Inlet (circa 1963) and (2) posed only minor risks to benthic biota or fish (MMS 2001a). Consequently, it is expected that production activities would have negligible effects on invertebrate communities in Cook Inlet.

Decommissioning. No explosive platform removals are anticipated under the proposed action. Nonexplosive removals (e.g., abrasive, mechanical, or diver cutters) would have negligible long-term impacts to invertebrates, although individuals associated with the platform would experience, injury, mortality, or loss of habitat. Most sediments will recover their normal physical characteristics, ecological functions, and biological communities. Pipelines installed and anchored on the seafloor would be capped and left in place, although there is the potential for chronic sediment disturbance from pipeline movement. If fixed platforms are left in place, the changes to invertebrate communities resulting from the initial platform installation would be permanent. Overall, impacts associated with decommissioning activities are expected to be negligible.

Accidents. Accidental hydrocarbon releases can occur at the surface or at the seafloor, potentially affecting pelagic and benthic invertebrates. Exposure to hydrocarbons can result in lethal or sublethal (reproduction, recruitment, physiology, growth, development, and behavior) impacts. Most small hydrocarbon releases would rapidly be diluted and are expected to primarily affect invertebrates in the water column as most oil and gas would float above the sediment surface. The impact magnitude of these oil spills on invertebrates is primarily a function of the invertebrate species and habitat affected. Impacts from spills would be greatest if a large spill occurred during a reproductive period or contacted a location important for spawning or growth such as intertidal and nearshore subtidal habitats. However, it is anticipated that only a small amount of shoreline would be affected by these smaller spills and they would not, therefore, present a substantial risk to invertebrate populations.

Catastrophic Discharge Event. The PEIS analyzes a CDE of 75 to 125 thousand bbl in the Cook Inlet Planning Area (Table 4.4.2-2). Because the Cook Inlet Planning Area is located within a relatively confined estuary, the likelihood of oil from a catastrophic spill contacting part of the shoreline is relatively high and is a function of assumed spill location. Site-specific evaluations would have to be conducted to fully evaluate potential spill trajectories from future lease sales. Benthic invertebrates in intertidal and shallow subtidal areas are likely to be contacted by an oil spill. In addition, some oil spill-response activities could adversely affect lower trophic-level organisms. For example, dispersants could increase oil toxicity, and cleanup techniques, the presence of large numbers of people, or the use of heavy equipment on shorelines could kill some coastal organisms during cleanup responses.

The toxicity of released hydrocarbons would probably decrease rapidly because of evaporation, dispersion, and dilution. Thus, it is concluded that planktonic organisms within the area of lethal hydrocarbon concentration could be killed during the first few days of a hydrocarbon spill; after that, the primary effects would be sublethal responses such as reduction in growth or reproductive rates except at the surface boundary of an oil slick. Large-scale changes in overall plankton populations in Cook Inlet are considered unlikely. However, intertidal invertebrates could experience long-term exposures, as oil could persist in intertidal sediments for decades. Thus invertebrate populations could be depressed for a decade or more (Highsmith et al. 2001; Exxon Valdez Oil Spill Trustee Council 2009a).

Studies following the *Exxon Valdez* spill give insight into the impacts of a catastrophic oil spill on vertebrate communities and their subsequent recovery. Amphipods, sea stars, and certain crabs were less abundant in oiled sites compared to areas not affected by the spill (*Exxon Valdez* Oil Spill Trustee Council 2010c). Studies of mussels indicated hydrocarbons accumulated in their tissue in the decade after the spill at sites where oil did not break down. However, by 1999, contaminant levels in mussels from the most heavily oiled beds in Prince William Sound were similar to background levels even though sediment contamination was still present (*Exxon Valdez* Oil Spill Trustee Council 2010c). Stress-tolerant invertebrates like polychaetes and snails did not appear to suffer long-term population declines in oiled areas. As late as 2002, studies of clams indicated differences in population structure between areas affected by the spill and clean areas (*Exxon Valdez* Oil Spill Trustee Council 2010c). However, much of the long-term reduction in clam densities may have been due to the high-pressure beach washing that occurred after the spill (*Exxon Valdez* Oil Spill Trustee Council 2009a). In intertidal areas, the *Exxon Valdez* spill created large density fluctuations in kelp communities that serve as habitat for benthic invertebrates. Intertidal experimental studies have demonstrated that rocky intertidal communities are particularly slow to recover (+10 years) following disturbance (Highsmith et al. 2001). As of 2009, clams, mussels, and intertidal communities are still listed as recovering (*Exxon Valdez* Oil Spill Trustee Council 2009a).

4.4.7.5.3 Alaska – Arctic. Impacting factors common to all phases include vessel discharges (bilge and ballast water), miscellaneous discharges (deck washing, sanitary waste), and offshore lighting. Impacts from these activities would be localized and temporary and would range from short-term to long-term. These discharges are expected to have no or negligible impacts on invertebrate communities in the sediment and water column because many of these waste streams are disposed of on land or must meet USEPA and/or USCG regulatory requirements before being discharged into surface waters. Studies of platform lighting suggest the lights would alter predator-prey dynamics by enhancing phytoplankton productivity around the platform, attracting phototaxic invertebrates, and potentially improving the visual foraging environment for fishes (Keenan et al. 2007).

Routine Operations.

***Exploration and Site Development*.** During the OCS oil and gas exploration and development phase, invertebrates could be affected by noise from seismic surveys and noise and bottom disturbance from drilling, subsea well, gravel island, and platform placement, and pipeline trenching and placement activities. See Section 4.4.7.5.2 for a complete discussion of the effects of exploration and site development activities on invertebrates.

Noise from seismic surveys and drilling could kill or injure invertebrates close enough to the noise source and reduce habitat suitability as some species would avoid the area. Noise is expected to have negligible effects on invertebrate populations in the overall Beaufort and Chukchi Planning Areas (see Section 4.4.7.5.2).

Bottom-disturbing activities such as drilling, subsea well and platform placement, and pipeline trenching and placement would displace, injure, or kill invertebrates in the vicinity of the activities, as described in Section 4.4.7.5.2. In addition to burying and displacing benthic communities, the construction of artificial islands would permanently alter sediment composition and shift benthic invertebrate communities to species adapted to coarse gravel substrate. Platform and pipeline placements in the Beaufort and Chukchi Planning Areas would disturb 3 to 13.5 ha (7 to 33 ac) and 77 to 567 ha (190 to 1,401 ac) of bottom habitat, respectively. Pipelines would be installed and anchored on the surface or buried in waters less than 50 m (156 ft) to prevent damage from ice gouges. Pipelines could crush, injure, or displace invertebrates, as well as shift invertebrate community composition to those species preferring hard substrate. Benthic habitats such as the Steffanson Boulder Patch and kelpbeds would be protected by stipulations that require surveys for and avoidance of sensitive biological habitat. Although pipeline and platform placement would disturb a large area of the seafloor, it is not expected to have a measurable effect on regional populations. The benthic community in these areas experiences similar naturally occurring disturbances from ice gouging, strudel scour, and severe storms. In the Arctic, recolonization by benthic invertebrates can be slow to begin, and the benthic community may take several years to return to its pre-disturbance composition following bottom-disturbance activities (Conlan and Kvitek 2005). Overall, moderate but temporary impacts to invertebrates are expected to result from platform and pipeline placement.

The discharge of drilling muds and cuttings from exploration wells could adversely affect pelagic and benthic invertebrates (Section 4.4.7.5.2). However, drilling discharges must comply with NPDES permit requirements regarding the discharge amount, rate, and toxicity, which would greatly reduce the impact to invertebrate communities.

Overall, site development and exploration activities represent a moderate and temporary disturbance that would primarily affect benthic invertebrates. The severity of the impacts would generally decrease dramatically with distance from bottom-disturbing activities. Recovery of benthic habitat could range from short-term to long-term.

Production. Production activities that could affect invertebrates include operational noise, bottom disturbance from the movement of mooring anchors, chains, and cables, and the release of process water. In addition, the platform and gravel islands would replace existing featureless soft sediments and serve as artificial reefs (Table 4.4.7-10).

Chronic disturbance to benthic invertebrates would result from the movement of anchors and chains associated with support vessels. Bottom disturbance would impact invertebrates in a manner similar to that described above for the exploration and site development phase. The disturbance would be episodic and temporary, but would last for the lifetime of the platform.

Produced water contains metals, hydrocarbons, salts, and radionuclides, and its discharge could contaminate habitat resulting in lethal and sublethal effects on invertebrates, particularly nonmobile benthic infauna. However, it is assumed that produced water would be reinjected into the well rather than discharged into the ocean. In addition, produced water discharges must comply with NPDES permit requirements regarding the discharge amount, rate, and toxicity, which would greatly reduce the impact to invertebrate communities (Section 4.4.7.5.2).

The presence of platforms or artificial islands would favor invertebrates requiring or preferring hard substrates, thus shifting community composition in some areas. The platform would likely increase shell material and organic matter in the sediments surrounding the platform, potentially resulting in a shift in benthic invertebrate community composition.

The results of the study Arctic Nearshore Impacts Monitoring in the Development Area funded by BOEM provide a good summary of the long-term changes to benthic communities resulting from oil and gas development in the Arctic. Boehm (2001) determined that

TABLE 4.4.7-10 Impacting Factors Potentially Affecting Invertebrates and Their Habitat in the Beaufort and Chukchi Planning Areas

	Life Stage Affected[a]		
Development Phase and Impacting Factor	Eggs	Larvae	Adults
Impacting Factors Common to All Phases			
Vessel noise	X	X	X
Vessel traffic	X	X	X
Hazardous materials	X	X	X
Solid wastes	X	X	X
Offshore lighting	X	X	X
Aircraft noise			
Offshore air emissions			
Onshore air emissions			
Aircraft traffic			
Miscellaneous platform discharges	X	X	X
Vessel discharges	X	X	X
Bottom disturbance from vessel anchors	X	X	X
Exploration and Development			
Seismic noise	X	X	X
Noise from drilling and construction	X	X	X
Bottom disturbance from drilling and placement of platforms, subsea wells, artificial islands, and pipelines	X	X	X
Discharge of drilling muds and cuttings	X	X	X
Production			
Production noise	X	X	X
Produced water discharge	X	X	X
Artificial reef	X	X	X
Decommissioning			
Platform removal (nonexplosive)	X	X	X

[a] Colors indicate impact level: white = negligible; blue = minor; yellow = moderate; red = major.

hydrocarbons in sediments (largely attributable to natural sources) were not readily bioavailable to marine filter feeders and deposit-feeders, and concluded that small incremental contaminant additions from future development activities are unlikely to cause immediate ecological harm to organisms in the Beaufort Sea study area. After reviewing tissue samples between 2000 and 2006, hydrocarbon and metals concentrations in invertebrates sampled near the Northstar development and Liberty Prospect area were found to be similar to or lower than invertebrate tissue levels found elsewhere in the world (Neff and Associates LLC 2010). No increase in hydrocarbons and metals in marine invertebrate tissues was attributable to oil and gas production, even for benthic infauna such as amphipods and clams. Concentrations of metals and hydrocarbons in benthic invertebrates collected in the Boulder Patch were similar to concentrations in invertebrates collected elsewhere in the development area.

Overall, the effects of production activities on invertebrates are expected to be negligible.

Decommissioning. No explosive platform removals are anticipated under the proposed action. Nonexplosive removals (e.g., abrasive, mechanical, or diver cutters) would have negligible long-term impacts on invertebrates, although individuals associated with the platform would experience injury, mortality, and loss of habitat. Pipelines installed and anchored on the seafloor would be capped and left in place, although there is the potential for chronic sediment disturbance from pipeline movement. The changes to invertebrate communities resulting from the construction of artificial gravel islands would be permanent. Overall, impacts associated with decommissioning activities are expected to be negligible.

Accidents. See Section 4.4.6 for a general discussion of hydrocarbon spills in marine habitat and Section 4.4.7.5.2 for a discussion of their impacts on invertebrates. Hydrocarbons can cause both lethal and sublethal effects to marine invertebrates. Sublethal effects occur at lower concentrations and include reduced growth and/or fecundity, increased physiological stress, and behavioral changes that may reduce fitness and population size.

Accidental hydrocarbon releases can occur at the surface or at the seafloor, potentially affecting pelagic and benthic invertebrates. Most hydrocarbon releases would be rapidly diluted and are expected to primarily affect plankton, as most oil and gas would float above the sediment surface. Most accidental releases would be small, and any impacts would be sublethal except in the immediate vicinity of the spill where lethal concentrations of oil may be present. The impact magnitude of these oil spills on invertebrates is primarily a function of the invertebrate species and habitat affected. Impacts from spills would be greatest if a large spill occurred during a reproductive period or contacted a location important for spawning or growth such as intertidal and nearshore subtidal habitats. However, it is anticipated that only a small amount of shoreline would be affected by these smaller oil spills and would not, therefore, present a substantial risk to invertebrate populations. Impacts from small and large spills are expected to be temporary as oil is diluted and broken down by natural chemical and microbial processes.

Catastrophic Discharge Event. The PEIS analyzes a CDE of 1.4 to 2.2 million bbl in the Chukchi Sea and 1.7 to 3.9 million bbl in the Beaufort Sea (Table 4.4.2-2). A CDE oil spill could contaminate sediments and the water column for some distance around the leak or rupture. Most released oil and gas would float above the seafloor, so direct contact with benthic communities in deeper water should be relatively low. If large quantities of oil from a catastrophic oil spill were to reach intertidal sediments or shallow subtidal sediment, benthic invertebrates in the affected areas could experience high levels of contamination and mortality, and, given the slow rate of oil breakdown in the Arctic, benthic invertebrate populations could be depressed for many years. See Section 4.4.7.5.2 for a detailed discussion of oil spills on invertebrates following the catastrophic Exxon Valdez spill.

Hydrocarbon releases contacting the Stefansson Sound Boulder Patch community could have direct impacts on organisms inhabiting the area. The magnitude of impacts to the Boulder

Patch would depend on the location and severity of the spill. Studies show that the Boulder Patch communities are slow to recolonize (Konar 2007 and references therein). Kelp associated benthic animal communities have also been shown to have major shifts in species composition following exposure to oil (Dean and Jewett 2001). Impacts to kelp habitat from an oil spill could be long-term, but are not expected to be permanent. *Laminaria* beds oiled by the *Exxon Valdez* spill recovered within 10 years (Dean and Jewett 2001). Planning and permitting procedures requiring no impacts to sensitive biological communities will also minimize spill impacts to the Boulder Patch area.

Oil from a CDE occurring under ice is more difficult to locate and clean than surface spills. Since weathering would be greatly reduced by ice cover, pelagic invertebrates could continue to be harmed or killed as they drift into the trapped oil. In addition, invertebrates living beneath the ice are a crucial food source in the Arctic food web that could be degraded or lost by contact with oil spills.

4.4.7.5.4 Conclusion. The primary impacts of oil and gas activities on invertebrates in the GOM and Alaska Planning Areas would be from drilling waste discharges and from bottom-disturbing activities during the exploration and site development phase, which could displace, bury, injure, or kill invertebrates in the vicinity of the activities. Displaced invertebrate communities would generally repopulate the area over a short-period of time, although a return to the pre-disturbance community may take longer, particularly in the Arctic. Where floating platforms are used, scour from the movement of mooring structures represents a chronic disturbance to benthic invertebrates lasting the life of the production phase. If discharged into open water, the effects of drilling wastes and produced water on invertebrates would be localized and no population-level effects are expected. Changes in benthic invertebrate community structure and function should be restricted to the vicinity of the platform. Overall, activities conducted during exploration and site development, production, and decommissioning phases could result in moderate impacts to benthic and pelagic invertebrates. Bottom-disturbing activities would be temporary and recovery could be short-term to long-term. No permanent or population-level impacts to invertebrates are expected. Overall impacts from routine Program activities would range from negligible to moderate.

Small surface or subsurface hydrocarbon spills would be rapidly diluted and would likely result in only small localized, sublethal impacts to invertebrates. Large or CDE-level spills could affect a large number of benthic and pelagic invertebrates and their habitats. The location of the spill and the season in which the spill occurred would be important determinants of the impact magnitude of the spills. A large or CDE spill would likely contact shoreline areas, and benthic invertebrates in sensitive intertidal and shallow subtidal habitats could experience large-scale lethal and long-term sublethal effects. In Alaska, local populations of intertidal organisms affected by such large spills could be measurably depressed for several years and oil could persist in shoreline sediments for decades (especially in the case of a CDE spill). However, large or CDE spills are unlikely to occur, and invertebrates typically have short generation times and should recover.

4.4.8 Potential Impacts to Areas of Special Concern

4.4.8.1 Gulf of Mexico

4.4.8.1.1 Routine Operations.

Marine Protected Areas (MPAs). National System MPAs in the Western and Central Planning Areas consist of the FGBNMS, Jean Lafitte National Historical Park and Preserve, Barataria Preserve, and a number of National Wildlife Refuges (NWRs) (Table 3.9.1-1). MPAs would primarily be affected by pipeline landfalls and potentially by accidental oil spills occurring nearshore as well as large offshore oil spills. Impacts on the FGBNMS and NWRs are described below. *De facto* MPAs are primarily military use areas and are also discussed below.

National Marine Sanctuaries of Texas and Louisiana in the Western Gulf of Mexico Planning Area (Figure 3.9.1-1). Potential impacts on the FGBNMS resulting from site exploration and development activities are discussed in detail in (Section 4.4.6.2.1). Direct impacts on the FGBNMS from bottom disturbance would be prevented by the Topographic Features Stipulation, which prohibits exploration and development activities and the deposition of drilling muds and cuttings in the vicinity of the FGBNMS. During the production phase, produced water discharges are not likely to impact the FGBNMS because of the Topographic Features Stipulation requiring large buffers between the FGBNMS and oil and gas development activities (Section 4.4.6.2.1).

New oil and gas production platforms could act as artificial reef habitat and potentially act as stepping stones allowing the establishment of invasive species in the FGBNMS (Section 4.4.6.2.1). However, there is no conclusive evidence this has occurred historically, and it is more likely that invasive species would establish at the FGBNMS even without the platforms, although the platforms may speed the process.

National Parks, National Seashores, Reserves, and Refuges. See Section 4.4.6.1.1 for a discussion of the potential impacts of the Program on coastal habitats. It is assumed that pipeline landfalls, shore bases, and waste facilities would not be located in National Parks, NWR, or National Estuarine Research Reserves because of their special status and protections. Consequently, impacts to these areas from oil and gas exploration and production activities are not expected to occur.

It is possible that shore bases and waste facilities may be located in one or more estuaries in the Western or Central GOM Planning Area. It is assumed that new shore bases and waste facilities would be constructed in existing developed or upland areas and would not be sited in coastal habitats such as barrier beaches or wetlands. Therefore, impacts on parks, seashores, refuges, and reserves are not likely to occur.

Trash and debris from various sources, including OCS operations, frequently wash up on beaches, which could affect Gulf Shores or Padre Island National Seashore. The discharge or disposal of solid debris from OCS structures and vessels is prohibited, and assuming that operators comply with regulations, most potential impacts would be avoided, although some accidental loss of materials is inevitable.

NPS lands, wildlife refuges, and research reserves could potentially be affected by increased boat and aircraft traffic associated with OCS oil and gas activities. Existing mitigation measures limit vessel speeds in inland waterways and aircraft altitudes over Areas of Special Concern. With these measures in place, most impacts on these Areas of Special Concern due to vessel and aircraft traffic would be avoided.

Military Uses. The Military Areas Stipulation applies to all blocks leased in military areas and requires lessees to coordinate their activities with the relevant military authorities and also states that the U.S. Government is not responsible for any accidents involving military operations. The Military Areas Stipulation reduces use conflicts and improves safety but does not reduce or eliminate the actual physical presence of oil and gas operations. Accidents and use conflicts involving oil and gas and military operations would be minimized or eliminated by adherence to the Military Areas Stipulation. Currently, both activities coexist in the GOM, and there has never been an accident involving the military and oil and gas lessees.

4.4.8.1.2 Accidents. It is assumed that up to 8 large spills (between 1,700 and 5,300 bbl), up to 70 spills between 50 and 999 bbl, and up to 400 smaller spills between 1 and 50 bbl could occur during the lease period under the proposed action. Small spills at the seafloor would rise in the water column but are not likely to contact the FGBNMS at concentrations toxic to marine life (see Section 4.4.6.2.1). Small platform spills and tanker spills at the ocean surface could penetrate the water column to documented depths of 20 m (66 ft) or more, which is within the depth range of the crests of some coral reefs and topographic features including the FGBNMS. However, at these depths, the contaminant concentrations are typically several orders of magnitude lower than those demonstrated to have an effect on marine organisms (MMS 2008a). Therefore, it is likely that only small concentrations of oil from surface spills would reach the FGBNMS (MMS 2008a).

An oil spill reaching sensitive coastal habitats could impact National Parks, NWRs, National Estuarine Research Reserves, or National Estuary Program sites. Impacts could result from both oiling of the shoreline and mechanical damage during the cleanup process. Small or large spills (>1,000 bbl) would be rapidly diluted and degraded by natural processes and, given the small size of most spills, impacts to a significant area of the shoreline are unlikely.

Catastrophic Discharge Event. This PEIS analyzes a CDE up to 7.2 million bbl in the GOM. It is possible that such a spill originating from outside the No Activity Zones established by the Topographic Features Stipulations could reach the vicinity of the FGBNMS. However, because of the tendency for oil components to rise toward the surface and to be diluted as they are transported by water currents, any impacts associated with a large or catastrophic spill reaching sensitive corals would most likely be sublethal. Hydrocarbons have been shown to have lethal and sublethal (reproduction, larval settlement, photosynthesis, and feeding) effects on corals, although no effects on corals following oil spills are also frequently reported (Loya and

Rinkevich 1980; Bak 1987; Guzman et al. 1991; Dodge et al. 1995; Haapkyla et al. 2007). Corals have the capacity to recover quickly from hydrocarbon exposure. For example, Knap et al. (1985) found that when *Diploria strigosa*, a common massive brain coral at the Flower Garden Banks, was dosed with oil, it rapidly exhibited sublethal effects but also recovered quickly. However, larval stages of coral are far more sensitive than adults. Therefore, the impact magnitude of a spill is partly dependent on whether the spill occurs during a period of coral spawning. For lethal exposures, the community would likely recover once the area had been cleared of oil, although full recovery could take many years (Haapkvla et al. 2007). Consequently, it is anticipated that impacts of lethal concentrations of oil reaching coral reef or hard-bottom habitat would be long-term but temporary.

A CDE taking place near shore or in deeper water could affect coastal parks, reserves, and refuges if the oil was transported to these areas by currents. Impacts on parks, preserves, and refuges would depend on the size and specific location of the oil spill and the effectiveness of cleanup procedures. If a large volume of heavy oil were to reach these areas, that situation could result in park closure and reduced visitation. In general, oil spills affecting parks, refuges, and reserves would diminish their function by reducing habitat value for wildlife and aquatic biota and interrupting monitoring and research activities.

The impacts of oil spills on parks, preserves, and refuges could include death of wetland vegetation and associated wildlife, oil saturation and trapping by vegetation and sediments (thus causing it to become a chronic source of pollution), and mechanical destruction of the wetland area during cleanup. Spills that damage wetland vegetation protecting canal and waterway banks could accelerate erosion of those banks (see Section 4.4.6.1.1). Some areas may recover completely if proper remedial action was taken. Others may not recover completely. Oil could remain in some coastal substrates for decades, depending on the type of oil spilled, the amount present, sand grain size, the degree of penetration into the subsurface, the exposure to the weathering action of waves, and sand movement onto and off the shore. See Section 4.4.6.1.1 for a discussion of the potential impacts of oil spills on coastal habitats.

4.4.8.2 Alaska – Cook Inlet

4.4.8.2.1 Routine Operations.

Marine Protected Areas (MPAs). The Alaska Peninsula unit and Gulf of Alaska unit of the Alaska Maritime NWR are the only Federal MPAs in the vicinity of the Cook Inlet Planning Area. NWRs could primarily be affected by pipeline landfalls and potentially by accidental oil spills, as described below.

National Parks, National Forests, National Seashores, Reserves, and Refuges. Impacts on National Parks, Forests, Reserves, and Refuges could result from facilities developed to support offshore oil drilling and production, and could include effects from pipeline landfall; dredging and construction; and the construction of roads, processing and waste facilities, and onshore pipelines. In addition, subsistence hunting and fishing, which are permitted on all refuges in Alaska, could be affected by oil and gas operations. It is assumed that pipeline landfalls, shore bases, and waste facilities would not be located in National Parks, National Forests, NWRs, or National Estuarine Research Reserves because of the special status and protections afforded these areas. See Section 4.4.6.1.2 for a discussion of the potential impacts of OCS oil and gas activities on coastal habitats.

National Park Service (NPS) lands are potentially susceptible to impacts from activities related to OCS oil and gas development as a consequence of the Program in Cook Inlet. The potentially affected lands include the Lake Clark National Park and Preserve, the Katmai National Park and Preserve, and Aniachak National Monument. Kenai Fjords National Park is east of Cook Inlet on the GOA, but it could be affected by an oil spill associated with OCS activities in Cook Inlet.

Impacts from routine OCS operations could come from facilities developed to support oil drilling and production, and could include effects from pipeline landfalls, dredging, air pollution, and the construction of roads and new facilities. Onshore oil facilities are permissible only on private acreage within each national park land. All of these national parks, monuments, and preserves contain privately held acreage, and development of onshore oil support facilities is possible in these areas. Because of the more confined nature of Cook Inlet, OCS construction of facilities within the Cook Inlet Planning Area could have some negative effects on scenic values for some users of the Lake Clark and Katmai National Parks and Preserves, if the facilities were visible from shore or the air during flightseeing.

Noise and vessel traffic associated with construction activities in offshore areas adjacent to park and refuge boundaries could temporarily disturb some wildlife and could negatively affect recreational values for park users. It is anticipated that noise generated by offshore construction activities would be at low levels, intermittent, and would not occur for more than a few months. Scenic values for some park users could be negatively affected in the long term by the presence of platforms visible from park areas.

National Wildlife Refuges (NWRs) in the vicinity of Cook Inlet are identified in Section 3.9.2.2. NWRs potentially affected by OCS activities in the Cook Inlet Planning Area include the Alaska Peninsula NWR, Becharof NWR, Kodiak NWR, Kenai NWR, and Izembek NWR. Section 22(g) of the Alaska Native Claims Settlement Act of 1971 (ANCSA) requires that new development on National Wildlife Refuge lands must be in accordance with the purpose for which the refuge was formed. Therefore, although development of onshore oil and gas support facilities is technically possible, such projects would be subject to intensive review. The potential effects of routine operations and accidental events on these NWRs are essentially the same as those discussed above for the NPS lands. Noise and vessel traffic associated with construction activities in offshore areas adjacent to park and refuge boundaries could temporarily disturb some wildlife and could negatively affect recreational values for park users. It is anticipated that noise generated by offshore construction activities would be at low levels, intermittent, and would not occur for more than a few months. Scenic values for some park users could be negatively affected in the long term by the presence of platforms visible from park areas. In addition, subsistence hunting and fishing are permitted on all refuges in Alaska and could, therefore, be affected by accidents and routine operations in the immediate vicinity of refuge properties.

The only national forest within the vicinity of the Cook Inlet Planning Area is the Chugach National Forest, which is located mainly on the eastern side of the Kenai Peninsula (Figure 3.9.2-1). Because there would be no OCS-related development, such as pipelines or other onshore facilities, within the Chugach National Forest, it would not be affected by routine OCS activities associated with lease sales in the Cook Inlet Planning Area. The Chugach National Forest also borders Prince William Sound and is close to Valdez. The Chugach National Forest is, therefore, potentially susceptible to effects of routine oil-related operations from transport and tanker loading of oil produced (OCS and non-OCS) in other regions (e.g., the Beaufort Sea Planning Area) and transported by pipeline to the Port of Valdez. Potential effects include increased noise and air pollution from tanker traffic.

Other Areas of Special Concern. There are multiple State parks and State recreation areas near the Cook Inlet Planning Area, many of which border Cook Inlet or are located in areas that could be contacted by accidental oil spills. Such areas include Captain Cook State Recreation Area, Clam Gulch State Recreation Area, Chugach State Park, Kachemak Bay State Park and State Wilderness Park, and Ninilchik State Recreation Area. In addition, the Kachemak Bay National Estuarine Research Reserve is located in Cook Inlet on the southern end of the Kenai Peninsula. Impacts from OCS activities would be similar to those described above for National Parks and Refuges. Existing protections and restrictions on uses should limit the direct terrestrial impacts from OCS activities on these areas. It is assumed that pipeline landfalls, shore bases, and waste facilities would not be located in the State parks and recreation areas. It is anticipated that noise generated by OCS offshore construction activities would be at low levels, intermittent, and would not persist for more than a few months at any one time. It is considered unlikely that these additional activities would noticeably affect wildlife or park user values compared to current (non-OCS) activities within the considered planning areas. There are no Military Use Areas in the Cook Inlet Planning Area; therefore, no conflicts between OCS activities and the military are expected to occur.

4.4.8.2.2 Accidents. Accidental oil spills could occur from land-based pipelines and facilities, vessels, and offshore platforms and pipelines. It is assumed that 2 small spills between 50 and 999 bbl and 10 smaller spills between 1 and 50 bbl could occur under the proposed action. It is assumed that one large spill between 1,500 and 7,800 bbl could occur in Cook Inlet.

Spills on land are not likely to affect National Parks, Refuges, or National Forests because pipelines and other oil and gas infrastructure would not likely be permitted in these areas. However, there are several NWRs and National Parks along the shorelines of the Cook Inlet Planning Area, as well as one National Estuarine Research Reserve, and coastal areas of all could be significantly affected by large or catastrophic spills. A section of the Chugach National Forest borders Turnagain Arm and could be affected by spills originating in Cook Inlet as well as tanker spills associated with the Port of Valdez. The Lake Clark National Park and Preserve has approximately 50 km (31 mi) of shoreline along Cook Inlet, including shoreline areas in Tuxedni and Chinitna Bays that are considered to contain sensitive habitats. Katmai National Park and

Preserve also contains extensive shoreline in proximity to the Cook Inlet Planning Area and the Shelikof Strait, and it is also adjacent to Katmai Bay, which is considered a sensitive resource area. If a large amount of oil were to contact a National Park, visitation would be likely to decrease or be temporarily prohibited. The several NWRs located in and around Cook Inlet, such as the Kodiak NWR and the Alaska Maritime NWR, could also experience a loss of habitat value if they experienced heavy oiling from offshore spills. Site-specific evaluations would be conducted to fully evaluate potential spill trajectories and spill probabilities in a lease sale EIS.

Several State parks and recreational areas border Cook Inlet and could be affected by accidental releases of oil spilled from onshore facilities and offshore drilling rigs. An oil spill contacting shoreline habitats could affect subsistence harvests in those parks in which recreation and subsistence hunting and fishing are allowed and could affect the number of park visitors. Impacts would depend primarily on the spill location, size, and time of year.

Catastrophic Discharge Event. The PEIS analyzes the impacts of a CDE up to 125,000 bbl in the Cook Inlet Planning Area. If a large volume of oil were to reach the shoreline following a catastrophic spill, NWRs could suffer a reduction in their primary function, which is to support wildlife and aquatic biota. Given the cold temperatures in Alaska, oil could contaminate nearshore refuge habitats for several years to decades and result in lethal and long-term sublethal impacts to refuge biota. Impacts would depend primarily on spill location, spill size, and timing of the spill. In general, directly affected coastal fauna would include marine mammals; fishes that reproduce in, inhabit, or migrate through coastal areas; terrestrial mammals that forage on fish; and marsh and seabirds that use these habitats for nesting and/or foraging. Spilled oil could also affect subsistence harvests in those parks in which subsistence hunting and fishing are allowed. See Sections 4.4.6.1.2 and 4.4.6.1.3 for a description of potential impacts of catastrophic oil spills on coastal areas and biota. Oil could contaminate nearshore habitats for several years to decades and result in lethal and long-term sublethal impacts on refuge biota (Short et al. 2007; Taylor and Reimer 2008; *Exxon Valdez* Oil Spill Trustee Council 2010c). The degree of effects and length of recovery depend on a number of factors such as the type of oil, extent of biota exposure, substrate type, degree of sediment contamination, time of year, and species sensitivity (NOAA 1998; Hayse et al. 1992; Hoff 1995). Sheltered intertidal areas are particularly slow to recover. More than 20 years after the *Exxon Valdez* oil spill, intertidal communities were considered to be recovering, but had not yet fully recovered from the effects of the spill (*Exxon Valdez* Oil Spill Trustee Council 2010a).

4.4.8.3 Alaska – Arctic

4.4.8.3.1 Routine Operations.

Marine Protected Areas (MPAs). The Arctic National Wildlife Refuge (ANWR) and the Chukchi Sea unit of the Alaska Maritime National Wildlife Refuge are the two Federal system MPAs in or adjacent to the Beaufort and Chukchi Planning Areas, and are described in Section 3.6.5.1. NWRs could primarily be affected by pipeline landfalls and potentially by accidental oil spills, as described below.

National Forests, Parks and Refuges. There are no National Forests in the vicinity of the Beaufort and Chukchi Sea Planning Area; therefore, no impacts on U.S. Forest Service lands are expected. Impacts on NWRs could result from facilities developed to support offshore oil drilling and production, and could include effects from onshore pipelines and pipeline landfalls, dredging and construction, air pollution and the construction of roads, and processing and waste facilities. In addition, subsistence hunting and fishing, which are permitted on all NWRs in Alaska, could be affected by OCS activities. See Section 4.4.6.1.3 for a discussion of the potential impacts of the Program on coastal habitats. Oil facility development currently is prohibited on the ANWR and is discretionary on all other NWRs within Alaska. Although numerous refuge lands have been conveyed to private ownership and Native corporations, Section 22(g) of ANCSA requires that new development on these lands must be in accordance with the purpose for which the refuge was formed. Therefore, development of onshore oil and gas support facilities, though technically possible, would be subject to an exhaustive environmental review process. Therefore, it is currently considered unlikely that onshore oil and gas activities would be developed on refuge lands. Indirect impacts resulting from OCS activities, such as noise pollution or emissions associated with transportation of oil from adjacent planning areas, could occur but would be unlikely to have substantial effects on resources within refuge boundaries.

The Iñupiat Heritage Center, located in Barrow, Alaska, is the only NPS-managed area along the coast of the Beaufort and Chukchi Planning Areas. The area is already urbanized and would not be adversely affected by OCS activities. Although not an NPS land, the National Petroleum Reserve is managed by BLM and has a large shoreline component that borders the Chukchi Sea. Cape Krusenstern National Monument and the Bering Land Bridge National Preserve are south of the Chukchi Planning Area. Although oil transport through the Cape Krusenstern National Monument is permitted under the ANCSA and an existing road is present that could be used to access or create support facilities, such development is considered unlikely under the proposed action. Onshore oil and gas development within the boundaries of the Bering Land Bridge National Preserve is also considered to be unrealistic. Consequently, there are likely to be no effects in either of these National Parks from the proposed action.

4.4.8.3.2 Accidents. It is assumed that up to 3 large oil spills between 1,700 and 5,100 bbl, up to 35 small spills (50 to 999 bbl) and up to 190 smaller spills (>1 and <50 bbl) could occur during the lease period under the proposed action. Oil spills can occur from offshore drilling platforms, from vessels, or from pipelines located onshore and offshore. OCS infrastructure and activities are not likely to be permitted in NPS lands or in NWRs. Therefore, impacts to these areas from onshore pipeline spills are not likely. While small oil spills would likely only have limited influence on potentially affected resources within these refuges, a large spill could result in more drastic effects on coastal habitats and fauna.

Catastrophic Discharge Event. This PEIS analyzes the impacts of a CDE up to 2.2 million bbl in the Chukchi Sea Planning Area and 3.9 million bbl in the Beaufort Sea Planning Area (Table 4.4.2-2). Large catastrophic oil spills from offshore pipelines or platforms could potentially contact shoreline habitats and communities in NWRs and NPS lands. However, Cape Krusenstern National Monument and the Bering Land Bridge National Preserve are located more than 322 km (200 mi) south of the Chukchi Sea Planning Area and are therefore unlikely to be adversely affected by accidental spills occurring offshore in the Beaufort and Chukchi Seas. The Arctic NWR and the Chukchi Sea unit of the Alaska Maritime NWR would be susceptible to oil spilled from subsea pipelines or drilling platforms.

If a large volume of heavy oil were to reach the shoreline following a catastrophic spill, NWRs could suffer a reduction in their primary function which is to support wildlife and aquatic biota. Given the cold temperatures in Alaska, oil could contaminate nearshore refuge habitats for several years to decades and result in lethal and long-term sublethal impacts to refuge biota. Impacts would depend primarily on spill location, spill size, and timing of the spill. In general, directly affected coastal fauna would include marine mammals; fishes that reproduce in, inhabit, or migrate through coastal areas; terrestrial mammals that forage on fish; and marsh and seabirds that use these habitats for nesting and/or foraging. Spilled oil could also affect subsistence harvests in those parks in which subsistence hunting and fishing are allowed. See Section 4.4.6.1.3 for a description of potential impacts of catastrophic oil spills on coastal areas and biota.

4.4.8.4 Conclusion

Overall, impacts on areas of special concern resulting from routine Program activities are expected to be negligible to moderate because of the existing protections and use restrictions applicable to these areas. However, increased vessel and aircraft traffic and the construction of pipelines and platforms could have temporary and localized effects on wildlife and reduce the scenic value of National Parks and NWRs for some visitors.

Impacts on areas of special concern from hydrocarbon spills are unlikely because most spills would be small. Should oil from large or CDE-level spills reach an area of special concern, the impacts would depend on the location and size of the spill, the type of product spilled, weather conditions, the type of area affected, the effectiveness of cleanup operations, and other environmental conditions at the time of the spill. Although unlikely, if oil from a large or CDE spill were to reach an area of special concern, coastal habitats and fauna, as well as subsistence use, commercial or recreational fisheries, and tourism, could be negatively affected (especially in the case of a CDE spill). In Alaska, oil in some coastal habitats would likely persist for multiple years.

4.4.9 Potential Impacts on Population, Employment, and Income

4.4.9.1 Gulf of Mexico

4.4.9.1.1 Routine Operations. Under the proposed action alternative, between 200 and 400 new platforms would be located in the GOM over the 40-year planning period. Using impact estimates provided by the MAG-PLAN Model (MMS 2006b), Table 4.4.9-1 shows total

TABLE 4.4.9-1 Average Annual Impacts of the Proposed Action (Alternative 1) on Regional Employment and Income[a]

Area	Employment	Income
Alabama		
Low	350	15
High	800	35
Florida		
Low	950	45
High	2,150	95
Louisiana		
Low	7,500	350
High	16,500	765
Mississippi		
Low	225	10
High	525	25
Texas		
Low	10,900	630
High	22,000	1,270
Total GOM region		
Low	20,000	1,050
High	41,825	2,180

[a] Totals may not add due to rounding. All estimates are totals of direct, indirect, and induced impacts. Employment estimates are in employee years; personal income estimates are in millions of 2010 dollars.

Source: BOEMRE 2011.

(direct, indirect, and induced) employment and regional income for the Labor Market Areas (LMAs) in each State in the GOM coast region (see Section 3.10). Average annual impacts of the proposed action in the GOM coast region would be between 20,000 and 41,825 jobs, which would amount to less than 1% of total GOM coast regional employment. Between $1,050 million and $2,180 million in income would be produced. The largest employment impacts would be in Texas, ranging from 10,900 to 22,000, with smaller impacts in Louisiana, where the employment created would range from 7,500 to 16,500 jobs. Income impacts in these States would range between $630 million and $1,270 million in Texas and between $350 million and $765 million in Louisiana. Employment impacts are lower in the other GOM coast States; the total number of jobs created would be between 950 and 2,150 in Florida, between 350 and

800 in Alabama, and between 225 and 525 in Mississippi. Although only a small amount of OCS oil and gas activity is proposed for the Eastern Planning Area, economic impacts would occur in Florida associated with expenditures on material and equipment supplied by sectors located in Florida, and the and use of ports and infrastructure for the associated transportation.

The additional jobs would create small but noticeable increases in the population of these regions. Using a historically observed ratio of 2.59 persons per new job (MMS 2006b), population increases of between 28,231 and 56,980 would be expected in Texas on average in each year of the proposed action, with increases of between 19,425 and 42,735 occurring in Louisiana. Smaller increases in population of between 2,461 and 5,569 per new job would occur in Florida, with increases of between 907 and 2,072 in Alabama, and between 583 and 1,360 in Mississippi.

Installation and operation of new offshore oil and gas platforms have the potential to impact property values in coastal areas within viewing distances of offshore activities. However, although the extent of the impact of any given platform would vary according to distance to shore, location within a maximum viewing range, and regional visibility conditions, the impact of additional platforms on coastal property values in areas where there is substantial existing offshore oil and gas is likely to be relatively small. There are currently 3,679 offshore platforms in the Western and Central Planning Areas in Federal waters in the GOM. Under the proposed action alternative, between 200 and 450 platforms would be added over the 40-year planning period, an average of between five and ten platforms per year. It is also anticipated that between 150 and 275 platforms would be removed over the same period. Although the location of additional offshore platforms is not known, with some new platforms conceivably located in areas of the GOM with relatively little existing oil and gas development, the majority of new platforms are likely to be located in areas already hosting existing platforms. Given these considerations, it is likely that the impacts of oil and gas development under the proposed action would only have a minor impact on property values in coastal areas in the GOM.

4.4.9.1.2 Accidents. Up to 8 large spills greater than 1,000 bbl, between 35 and 70 spills between 50 and 1,000 bbl, and up to 400 small spills less than 50 bbl could occur in the GOM from the proposed action. It is expected that many of these spills will occur in deepwater areas located away from the coast, based on the established trend for greater oil production activity to move into deepwater located for the most part at a substantial distance from the coast.

In previous oil spill analyses, there is a less than 0.5% probability that an oil spill greater than or equal to 1,000 bbl would reach the shores of the majority of coastal counties and parishes in Texas and Louisiana within 10 days of a spill occurring over the 40-yr leasing period in the Western and Central Planning Areas (BOEMRE 2005). Six counties in Texas and one parish in Louisiana have a 1–5% chance of an OCS offshore oil spill greater than or equal to 1,000 bbl reaching their shoreline within 10 days. BOEM also estimates that between 5 and 15 chemical spills associated with the OCS program are anticipated each year, with a small percentage of these associated with the proposed action. The majority of spills are expected to be less than 50 bbl in size; a chemical spill of greater than or equal to 1,000 bbl as a result of the proposed action is very unlikely.

The immediate socioeconomic impact of a larger oil spill would include the loss of employment, income, and property value; increased traffic congestion; increased cost of public service provision, and possible shortages of commodities or services. In the short term, the impacts of a spill are expected to be modest, measured in terms of projected cleanup expenditures and the number of people employed in cleanup and remediation activities. Longer-term impacts may be more substantial if fishing, shrimping, oystering, and/or tourism were to suffer due to the real or perceived impacts of the spill, or if there were substantial changes to the energy industries in the region as a result of the spill.

The employment and regional income impact from an oil spill would likely be greatest in Texas and Florida, with the highest concentration of tourism-related employment occurring in Florida, particularly in the Miami and Tampa-St. Petersburg areas and the Houston-Galveston areas. In the Central GOM Planning Area, the New Orleans area would also be affected due to their high concentration of tourism-related employment. Net employment impacts from a spill are not expected to exceed 1% of baseline employment for any LMA in any given year, even if they are included with employment associated with routine oil and gas development activities associated with the proposed action.

Catastrophic Discharge Event. The PEIS analyzes a CDE up to 7.2 million bbl (Table 4.4.2-2). The socioeconomic impact of a CDE would include the loss of employment, income, and possible shortages of commodities or services in both coastal and inland areas. In coastal areas, losses of property value and increased traffic congestion could also occur, with increases in the cost of public service provision also possible. In the short term, impacts of a CDE, measured in terms of projected cleanup expenditures and the number of people employed in cleanup and remediation activities, would be expected to be large. Longer-term impacts may also be substantial if fishing activities and tourism were to suffer as a result of the real or perceived impacts of the event, or if there were substantial changes to energy industries in the region as a result of the event.

4.4.9.2 Alaska – Cook Inlet

4.4.9.2.1 Routine Operations. Under the proposed action alternative, between 1 and 3 new platforms would be located in Cook Inlet over the 40-year planning period. Table 4.4.9-2 shows total (direct, indirect, and induced) employment and regional income in Alaska and the rest of the United States. Average annual impacts of the proposed action in the Alaska region would be between 302 and 575 jobs, which would amount to less than 5% of total Alaska employment. An additional 567 to 1,431 jobs would be created in the rest of the United States. Personal income would increase by between $25.4 million and $52.9 million annually in Alaska, and by between $27.0 million and $69.1 million in the rest of the United States.

Based on current trends, it is assumed that most of the workers directly associated with OCS oil and gas activity will work offshore or onshore in worker enclaves separated from local communities, and that most OCS workers will likely commute to work sites from Alaska's larger population centers or from outside the immediate area. It is also assumed that OCS jobs would

TABLE 4.4.9-2 Average Annual Impacts of the Proposed Action (Alternative 1) on Regional Employment and Income[a]

Area	Employment	Income
Cook Inlet		
Low	302	25.4
High	575	52.9
Rest of United States		
Low	567	27.0
High	1,431	69.1

[a] All estimates are totals of direct, indirect, and induced impacts. Employment estimates are in employee years; labor income estimates are in millions of 2010 dollars.

be available to the local populations in all areas, but that rural Alaskan employment in the petroleum industry, especially among Alaska Natives, will remain relatively low.

Many workers on oil rigs in the Cook Inlet Planning Area (and onshore oil and gas facilities on the Kenai Peninsula and the North Slope) currently live in Anchorage or on the Kenai Peninsula. The larger populations and more diverse economies of south central Alaska compared to other Alaskan communities will tend to lessen the potential effect of proposed leasing on their economies. As a result, employment generated by OCS activity in the Cook Inlet Planning Area at its peak is only expected to account for less than 5% of total Alaska employment.

Installation and operation of new offshore oil and gas platforms have the potential to impact property values in coastal areas within viewing distances of offshore activities. However, although the extent of the impact of any given platform would vary according to distance from shore, location within a maximum viewing range, and regional visibility conditions, the impact of additional platforms on coastal property values in areas where there is substantial existing offshore oil and gas is likely to be relatively small. Under the proposed action alternative, between one and three platforms would be added over the 40-yr planning period. It is also anticipated that between one and three platforms would be removed over the same period. Although the location of additional offshore platforms is not known, with some new platforms conceivably being located in areas of the Cook Inlet area, the majority of new platforms are likely to be located in the vicinity of areas already hosting existing platforms. Given these considerations, it is likely that the impacts of oil and gas development under the proposed action would only have a minor impact on property values in coastal areas in the Cook Inlet area.

4.4.9.2.2 Accidents. One large spill greater than 1,000 bbl, up to 3 spills between 50 bbl and 1,000 bbl, and up to 15 small spills less than 50 bbl could occur in the Cook Inlet Planning Area under the proposed action. Although an oil spill could occur anywhere in the lease sale area, cleanup-related employment would likely occur in the area directly affected, generally in locations remote from communities. The hiring of cleanup workers will likely draw from labor markets in both the region and the rest of Alaska. Oil spills will generate only temporary employment (and population) increases during cleanup operations, because such operations are expected to be of short duration. Employment generated by spills will be a function of the size and frequency of spills.

Catastrophic Discharge Event. The PEIS analyzes a CDE of 75 to 125 thousand bbl (Table 4.4.2-2). The socioeconomic impact of a CDE would include the loss of employment, income, and possible shortages of commodities or services in both coastal and inland areas. In coastal areas, losses of property value and increased traffic congestion could also occur, with increases in the cost of public service provision also possible. In the short term, impacts of a CDE, measured in terms of projected cleanup expenditures and the number of people employed in cleanup and remediation activities, would be expected to be large. Longer-term impacts may also be substantial if fishing activities and tourism were to suffer as a result of the real or perceived impacts of the event, or if there were substantial changes to energy industries in the region as a result of the event.

4.4.9.3 Alaska – Arctic

4.4.9.3.1 Routine Operations. Under the proposed action alternative, between one and five new platforms would be located in the Chukchi Sea and one and four platforms in the Beaufort Sea over the 50-yr planning period. Table 4.4.9-3 shows the potential effects of the proposed action alternative in the Arctic region and the rest of the United States. Average annual impacts of the proposed action in the Arctic region would be between 1,466 to 3,646 jobs, which would amount to less than 1% of total Alaska employment. An additional 3,759 to 10,083 jobs would be created in the remainder of the United States. Personal income would increase by between $136.1 million and $329.8 million annually in the Arctic region and between $156.6 million and $398.2 million in the rest of the United States.

Most of the workers directly associated with OCS oil and gas activity will work offshore or onshore in worker enclaves separated from local communities, and most workers will likely commute to work sites from Alaska’s larger population centers, including Anchorage and Fairbanks, or from outside Alaska (MMS 2006b). While OCS jobs would be available to the local populations in all areas, rural Alaskan employment in the petroleum industry, especially among Alaska Natives, would likely remain relatively low.

Employment in the North Slope oil and gas industry has little direct impact on the communities of the North Slope Borough. While actively working, most North Slope oil and gas workers stay in enclave housing separate from local communities, permanently residing in south central Alaska (Anchorage, the Kenai Peninsula Borough, and the Matanuska-Susitna Borough),

TABLE 4.4.9-3 Average Annual Impacts of the Proposed Action (Alternative 1) on Regional and National Employment and Income[a]

Area	Employment	Income
Beaufort Sea		
Low	800	72.0
High	2,052	192.1
Chucki Sea		
Low	667	64.1
High	1,594	137.7
Rest of United States		
Low	3,759	156.6
High	10,083	398.2

[a] All estimates are totals of direct, indirect, and induced impacts. Employment estimates are in employee years; labor income estimates are in millions of 2007 dollars.

or the Fairbanks area, and commute to their homes (or other locations) when not working. As population, employment, and income impacts affect the regional economies in which employees permanently reside, BOEM has not included these impacts in the discussion of impacts of the proposed action in the Arctic region.

The most important benefit of oil and gas development in the Arctic region is revenue from taxation of oil industry facilities. Although jurisdictions in the North Slope Borough and Northwest Arctic Borough are unable to tax offshore OCS facilities, the borough collects property tax revenue from new onshore pipelines and other facilities. The borough also receives indirect benefits from Alaska Native corporation investments in petroleum service companies. The effects of the proposed action on employment and income in Arctic region communities are likely to be significant, especially when combined with the continued decline in Prudhoe Bay and other North Slope production areas, and continued OCS production would allow jurisdictions in the Arctic region to maintain revenue collection from onshore facilities associated with continued offshore production.

4.4.9.3.2 Accidents. Up to 3 large spills greater than 1,000 bbl, 10 and 35 spills between 50 and 1,000 bbl, and up to 190 small spills of less than 50 bbl could occur in the Beaufort and Chukchi Sea area from the proposed action. Although an oil spill could occur anywhere in the lease sale area, cleanup-related employment would likely occur in the area directly affected, generally in locations remote from communities. The hiring of cleanup workers would have a regional and State of Alaska emphasis. Oil spills will generate only temporary employment (and population) increases during cleanup operations, because such operations are expected to be of short duration. Employment generated by spills will be a function of the size and frequency of spills. Large spills of over 1,000 bbl would generate 60 to 90 jobs for up to 6 months and would generate moderate local effects (BOEMRE 2008).

Catastrophic Discharge Event. The PEIS analyzes a CDE of 1.4 to 2.2 million bbl in the Chukchi Sea and 1.7 to 3.9 million bbl in the Beaufort Sea (Table 4.4.2-2). The socioeconomic impact of a CDE would include the loss of employment, income, and possible shortages of commodities or services in both coastal and inland areas. Losses of property value could also occur in coastal communities, with increased cost of local public service provision also possible. In the short term, impacts of a CDE, measured in terms of projected cleanup expenditures and the number of people employed in cleanup and remediation activities, would be expected to be large. Longer-term impacts would likely be small, unless recreational activities and tourism suffered as a result of the real or perceived impacts of the event, or if there were substantial changes to energy production in the region as a result of the event.

4.4.9.4 Conclusions

Routine Program activities would result in negligible impacts in the GOM from small increases in population, employment, and income, and in minor impacts in the Alaska Planning Areas. In the GOM, increases in population, employment, and income would increase by less than 1% of baseline levels, and by less than 5% in Alaska.

Small accidental oil spills would have little socioeconomic impact. In contrast, large and especially CDE-level spills could result in the loss of employment, income, and possible shortages of commodities or services in both coastal and inland areas affected by the spill. Losses of property value could also occur in coastal communities, with increased cost of local public service provision also possible. In the short term, impacts of a CDE, measured in terms of projected cleanup expenditures and the number of people employed in cleanup and remediation activities, would be expected to be large. Longer-term impacts would likely be small, unless recreational activities and tourism suffered as a result of the real or perceived impacts of the event, or if there were substantial changes to energy production in the region as a result of the accidental spill; this would be more likely in the event of a CDE spill.

4.4.10 Potential Impacts to Land Use and Infrastructure

The development of oil and gas facilities within the GOM, the Cook Inlet, and the Arctic would have both direct and indirect impacts on existing and future land use, development patterns, and infrastructure. Impacts of routine activities of the Proposed Action Alternative are presented below. These routine activities include seismic explorations and exploratory drilling, onshore and offshore construction, normal operations, and decommissioning. Impacts on land use and infrastructure potentially resulting from an accident (an oil spill or release) occurring in the three areas also are presented. In general, the nature and magnitude of these impacts would depend upon the level and location of new construction, the degree to which the area is already developed, and, in the case of accidental spills, the size and location of the spill.

Table 4.4.10-1 provides a summary of the resource receptors that pertain to routine activities. As shown in this table, potential receptors include the following:

- Land use categorization,
- Land use plans and initiatives,
- Development patterns, and
- Onshore infrastructure.

Conceptual models illustrated in Figures 4.4.10-1 through 4.4.10-3 show how various activities associated with seismic surveys, onshore and offshore construction, and normal oil and gas operations may impact land use, development patterns, and infrastructure. These figures are applicable to the GOM, the Cook Inlet, and the Arctic.

As shown in these figures, the potential effects of oil and gas activities typically include the following:

- Incompatibility with local land use/comprehensive planning patterns,
- Incompatibility with existing/planned development,
- Loss of use (intended or perceived) to existing landowners or users, and

TABLE 4.4.10-1 Impacting Factors Associated with Each Phase of Oil and Gas Activities[a]

Resource Receptor Category Potentially Affected	O&G Activities Phase				
	Exploration				
	Seismic Survey	Exploratory Wells	Development/ Construction	Production/ Normal Operations	Decommissioning
Land use categorization	I	I	X	I	X
Land use plans/initiatives	I	I	X	I	X
Development patterns	I	I	X	I	X
Onshore infrastructure	I	I	X	I	X

[a] I = Indirect impacts are anticipated; X = Both direct and indirect impacts are anticipated.

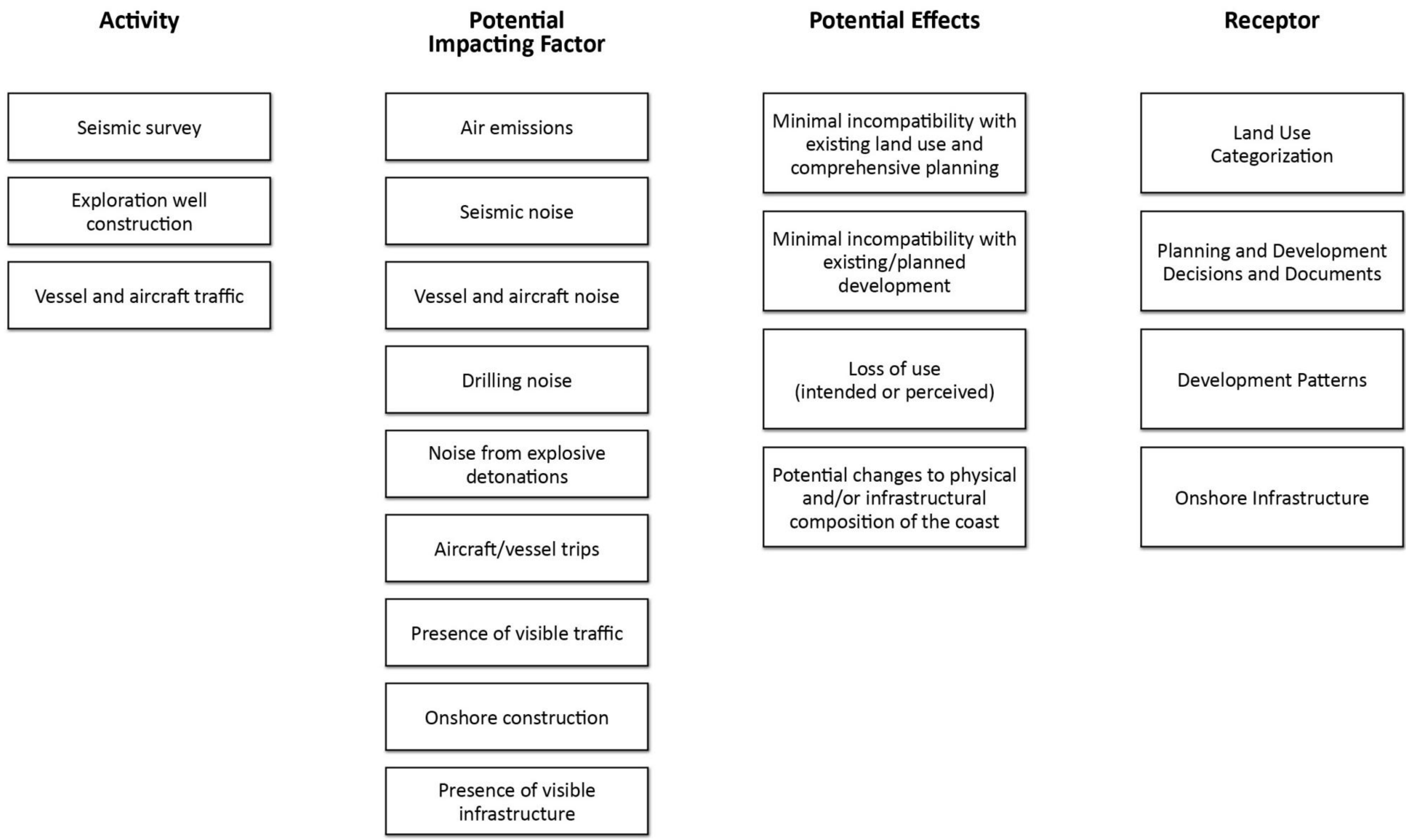

FIGURE 4.4.10-1 Conceptual Model for Potential Direct and Indirect Effects of Seismic Survey Activities on Land Use, Development Patterns, and Infrastructure

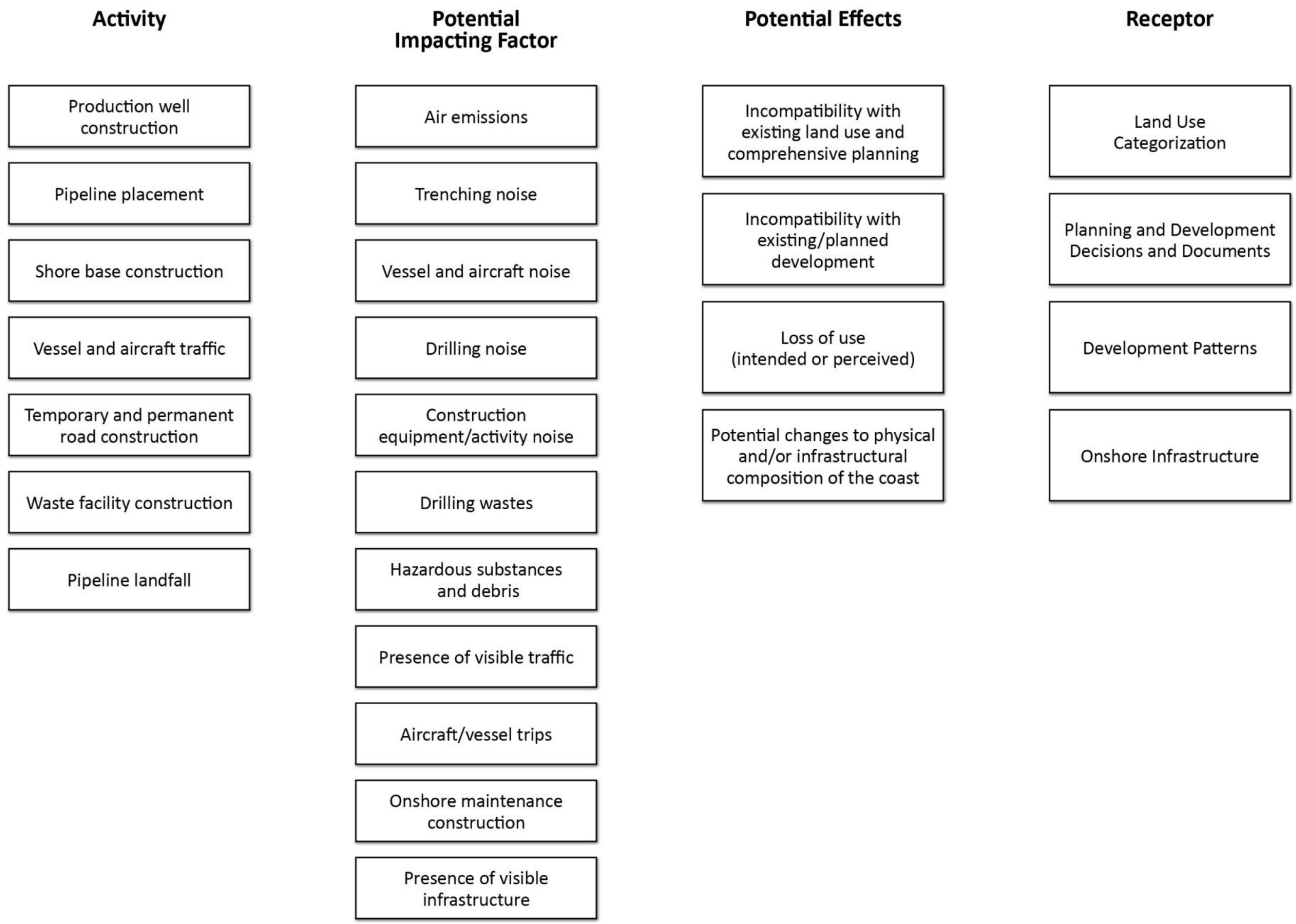

FIGURE 4.4.10-2 Conceptual Model for Potential Direct and Indirect Effects of Onshore/Offshore Construction Activities on Land Use, Development Patterns, and Infrastructure

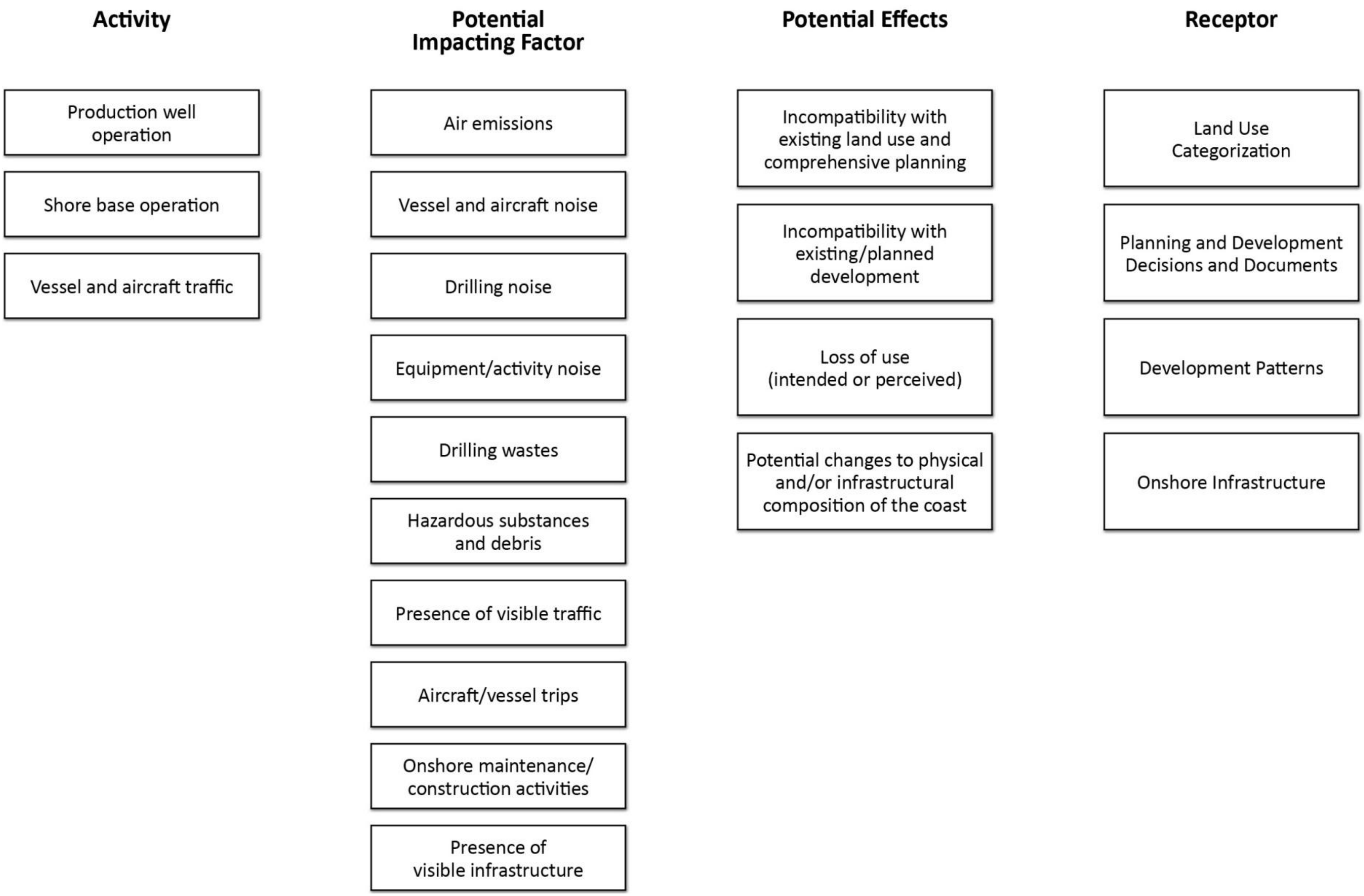

FIGURE 4.4.10-3 Conceptual Model for Potential Direct and Indirect Effects of Normal Operations on Land Use, Development Patterns, and Infrastructure

- Potential changes to the physical and/or infrastructural composition of the coast.

Each of these impacts is discussed in the context of seismic explorations, construction of onshore and offshore facilities, normal operations, and decommissioning. A more general discussion of impacts is provided for accidental releases or spills.

For the purpose of this discussion, land use refers to the activity that occurs on a specific area of land and within the structures that occupy it, whereas zoning regulations include such things as requirements for building size, bulk, and density. General land use is assumed to be the primary factor in determining existing and future development decisions. Specific zoning regulations were not evaluated for areas located within the GOM, the Cook Inlet, or the Arctic due to the large scale of the planning areas. Individual environmental assessments generally would account for localized regulations.

In addition, for the purposes of this discussion, intended land use is that prescribed by regulations or formalized land use plans. For instance, if a parcel of land is dedicated as agricultural land, the intended activities likely would include farming, animal husbandry, or a combination of rural activities. The actual use, however, may differ. For the purpose of this evaluation, "actual use" is the manner in which people physically use the land that may or may not be regulated or prescribed by laws or formal plans. Instead, the use may involve traditional practices or activities occurring for long periods of time.

4.4.10.1 Gulf of Mexico

As indicated in Table 4.4.1-1, potentially available oil includes a range of 2.7 to 5.4 billion barrels (Bbbl) within the GOM, along with 12–24 trillion cubic feet (tcf) of natural gas. In order to provide for production of these resources, a number of routine activities are necessary. As previously indicated, these activities have the potential to impact existing and future land use, development patterns, and infrastructure.

The following analysis provides a description of those impacts that would occur on land use within the Western and Central Planning Areas. No additional or new development is anticipated to occur within the Eastern Planning Area.

4.4.10.1.1 Routine Operations. Impacts from routine activities including exploration, development, production, and decommissioning are presented below.

Seismic Explorations and Exploratory Drilling. Activities associated with exploration typically include a seismic survey, exploratory well construction, and aircraft and vessel traffic (see Figure 4.4.10-1).

Local Land Use/Comprehensive Planning and Development Patterns. Seismic explorations and exploratory drilling would not impact land use, development patterns, and infrastructure directly, as a majority of the activities would be located offshore. In general, existing and future land use categorizations would remain unchanged, along with current development patterns. Existing and planned activities associated with local planning initiatives and plans likely would not be hindered, as the jurisdiction of these plans typically would not extend to the offshore activities. State and Federal planning initiatives, such as the National Coastal Zone Management (CZM) Program, would generally be consistent with seismic surveys and exploratory drilling due to the need for prioritizing coastal-dependent uses (see Section 3.11.1 for more information on this program).

Loss of Use to Existing Landowners or Users. Seismic explorations and exploratory drilling activities would not impact access or use of a particular land area. Some safety-related temporary restrictions on access may be necessary both onshore and offshore; however, these restrictions likely would be temporary, lasting only as long as the exploration activities, with access restrictions lifted afterwards.

In addition, the use of individual properties may be affected indirectly if excessive noise and air emissions generated by survey equipment/vessels and onshore/offshore vehicular and air traffic (e.g., helicopters and automobiles) were to occur, or if a small increase in the amount of trash and debris washing ashore were to result from exploration. These occurrences may cause a temporary disturbance or annoyance among particular landholders or users and thereby interfere with their intended or actual use of the land. These impacts would be temporary in nature due to the short time frame of these activities. The level of impact would depend on the specific location of the exploration activities within the GOM, but generally would be anticipated to be minimal.

Physical and/or Infrastructural Composition. While additional infrastructure, such as machinery and staging area improvements, may be needed to accommodate equipment and workers associated with the exploration activities, the increase likely would be negligible at this stage of oil and gas development. In general, existing infrastructure within the GOM would likely be able to accommodate activities associated with exploration (see Section 3.11.1 for further information regarding existing GOM infrastructure).

Onshore and Offshore Construction. Impacts on land use, development patterns, and infrastructure associated with onshore and offshore construction are presented below. As indicated in Figure 4.4.10-2, activities associated with this phase include production well placement, pipeline placement, onshore construction, and aircraft and vessel traffic. Similar to the exploration phase, these activities have the potential to impact local land use and comprehensive planning and existing and planned development; access and use of particular properties; and the physical and infrastructural makeup of the GOM as pertaining to emissions, waste, noise, and traffic; each is discussed below.

Local Land Use/Comprehensive Planning and Development Patterns. As indicated in Section 3.11.1, a number of onshore and offshore facilities are associated with the development of offshore oil and gas. Among these are ports, ship and shipbuilding yards, support and transport, pipelines, pipe coating yards, natural gas processing and storage, refineries, petrochemical plants, and waste management facilities. Current BOEM data suggests that more than 3,900 offshore production facilities are located within the GOM within Federal waters. Most of these facilities are located within the Western and Central Planning Areas.

According to previous government documents, a steady pace of offshore leasing has persisted in the GOM for nearly six decades with the first Federal lease sale in 1954 (MMS undated). Consequently, land use categorizations in the Western and Central Planning Areas often would be able to accommodate this type of industry. Therefore, negligible impacts on land use categorizations (i.e., receptor) are predicted by the continuation of leasing and subsequent exploration and development activities in the Western and Central GOM Planning Areas. In addition, the development of oil and gas facilities likely would be compatible with existing local land use, zoning, and comprehensive planning in these areas. Land use likely would evolve over time, with most changes occurring as a result of general regional growth rather than specific activities associated with the production of oil and gas (BOEMRE 2011).

As a result of the DWH event, the overall climate for development of oil and gas has been altered in response to a recent suspension and changes in Federal requirements for drilling safety in the whole of the GOM (BOEMRE 2011a). In some areas of the GOM, for instance, local planning initiatives have been drafted in response to the recent event that could impact the construction of new and/or infill facilities. Some of these initiatives focus on the economic diversification of the GOM coast, rather than upon oil and gas activities, while other strategies focus on the investment of monies for necessary human services (Restore the Gulf 2010b). In this manner, perceptions about the spill may influence future decisions regarding the need for oil and gas investments, improvements to existing infrastructure, and the construction of new oil and gas facilities.

Likewise, individual businesses and organizations have adapted to the altered, post-DWH environment. For instance, some companies have removed a portion of their equipment, and a substantial decrease in helicopter flights and servicing of rigs has occurred. Companies have trimmed budgets by cutting hours and salaries of workers; associated support services, such as chemical suppliers and welders, also have been affected by the DWH event.

The effects of this decreased demand have rippled through the various infrastructure categories (e.g., fabrication yards, shipyards, port facilities, pipecoating facilities, gas processing facilities, and waste management facilities) and have affected the oil and gas support sector businesses (e.g., drilling contractors, offshore support vessels, helicopter hubs, and mud/drilling fluid/lubricant suppliers) (BOEMRE 2011a). Land use has been impacted indirectly through various economic incentives, compliance with permitting requirements, and the lack of use of existing facilities. As indicated in a 2011 lease sale, some locations offered a 30% reduction in rental rates in order to keep businesses (BOEMRE 2011a). Actions of this nature influence the overall development pattern. As a consequence, BOEM anticipates monitoring the overall oil and gas development climate as it pertains to the DWH event (BOEMRE 2011a).

If new infrastructure is needed onshore, some developments may be subject to local, State, and/or other Federal permitting and regulations. Within the Western and Central Planning Areas, infill development likely would occur in areas already established for oil and gas development. Specific timelines and requirements would vary by location, as the BOEM typically is not the permitting or regulating agency for development activities that occur onshore.

Loss of Use to Existing Landowners or Users. In addition to receiving proper permitting and approvals, onshore and offshore construction generally would not interfere with or prevent use by existing owners or users within areas of immediate development. During construction activities, a temporary loss of access to some areas may be required for safety reasons, with access restored upon completion of the activities. Some users of surrounding land may be inconvenienced by closure or restrictions on access routes, as well. Permanent loss of use is not anticipated. If new land were necessary in order to construct onshore facilities, the acquisition would follow all pertinent local, State, and Federal requirements.

In addition, the use of individual properties in the vicinity of the construction activities may be affected indirectly if excessive noise and air emissions generated by the construction equipment and onshore/offshore vehicular and air traffic (e.g., helicopters and automobiles) were to occur, or if a small increase in the amount of trash and debris washing ashore were to result from the activities. These occurrences may cause a temporary disturbance or annoyance among particular landholders or users, thereby inhibiting the intended or actual use of a property. The level of impact would depend on the specific location within the GOM, but generally would be anticipated to be minimal.

Physical and/or Infrastructural Composition. Physical land disturbance also would occur in locations where new facilities are needed. As indicated in Table 4.4.1-1, the Western and Central Planning Areas may require up to 12 new pipeline landfalls, four to six new pipe yards, and the potential for up to 12 new natural gas processing facilities. Approximately 3,862–12,070 km (2,400–7,500 mi) of new pipeline could be needed, as well.

The creation of pipeline landfalls could involve such activities as clearing land, preparing a ROW, and digging and backfilling trenches. These activities could alter the physical composition of the landscape, thus potentially limiting the intended use of a parcel unless located in existing utility ROWs. Likewise, the construction of new shore bases and waste facilities could involve, but would not be limited to, the preparation of a site through grading and clearing, excavations, and foundation building. As with a pipeline, these types of activities would alter the existing landscape and, depending on the scale and location, could alter the intended use of a parcel. While these changes would be necessary in some locations within the GOM, the activities associated with the oil and gas construction would not likely cause an extensive change to existing development patterns; as such, the impacts would be anticipated to be minimal.

The construction of more permanent facilities could be a positive impact or a negative impact depending on the specific location within the GOM. For instance, where new roads would provide additional routes and capacity for coastline travel, they may be perceived as a positive impact by some stakeholders. However, if the same roadways added large traffic volumes to existing roadways that already were over capacity, the construction could be seen as a negative impact.

Additional indirect impacts include those associated with climate change. Siting of new facilities may account for potential changes resulting from rises in sea level, increased storm frequency and intensity, and temperature changes. Figure 4.4.10-4 provides an illustration of the potential sea rise levels in the GOM. Potential solutions to account for these changes include facility relocation, the construction of seawalls and storm surge barriers, dune reinforcement, and land acquisitions to create buffer areas (IPCC 2007).

Consequently, indirect impacts on land use, development patterns, and infrastructure could include locating facilities further inland and/or strengthening the foundations or building materials of existing facilities. These actions potentially could increase costs associated with development or lead to the construction of new facilities rather than the reuse or expansion of existing properties associated with oil and gas production. These decisions may be influenced by the potential for increased flooding and/or erosion.

Routine Operations. Routine operation activities would consist of production well operation, onshore facility operation, and vessel and aircraft traffic, and would also include the transport of oil from offshore to onshore locations using ships or pipelines (see Figure 4.4.10-3). Potential impacts associated with these activities would range in extent from negligible to minimal.

Local Land Use/Comprehensive Planning and Development Patterns. Once in operation, negligible to minimal impacts are anticipated to result on land use, development patterns, and infrastructure, because a majority of the activities would be located offshore. As previously indicated, land use likely would evolve over time, with most changes occurring as a result of general regional growth rather than through activities associated with oil and gas production (BOEMRE 2011a). Some regions within the GOM may be impacted to a greater extent than others depending on the site-specific conditions.

Loss of Use to Existing Landowners or Users. Once the new offshore oil and gas facilities were in operation, temporary or permanent loss of use is not anticipated. As indicated in Section 3.11.1, many facilities already are located within the GOM to support oil and gas development. At times, some access to particular areas may be restricted within surrounding lands to accommodate a brief alteration in normal operations, such as an emergency response. These impacts would be limited and temporary.

Similar to construction, the use of individual properties in the vicinity of the operating platforms may be affected indirectly if excessive noise and air emissions were generated from equipment and onshore/offshore vehicular and air traffic (e.g., helicopters and automobiles), or if a small increase in the amount of trash and debris washing ashore were to result from the activities. These occurrences may cause disturbances or annoyance among particular landholders or users, thereby inhibiting the intended or actual use of a property. The level and extent of impact would depend on the specific location within the GOM, but generally would be anticipated to be minimal.

Physical and/or Infrastructural Composition. To the extent possible, existing facilities would be used to support activities under new leases, and new facilities would be built only

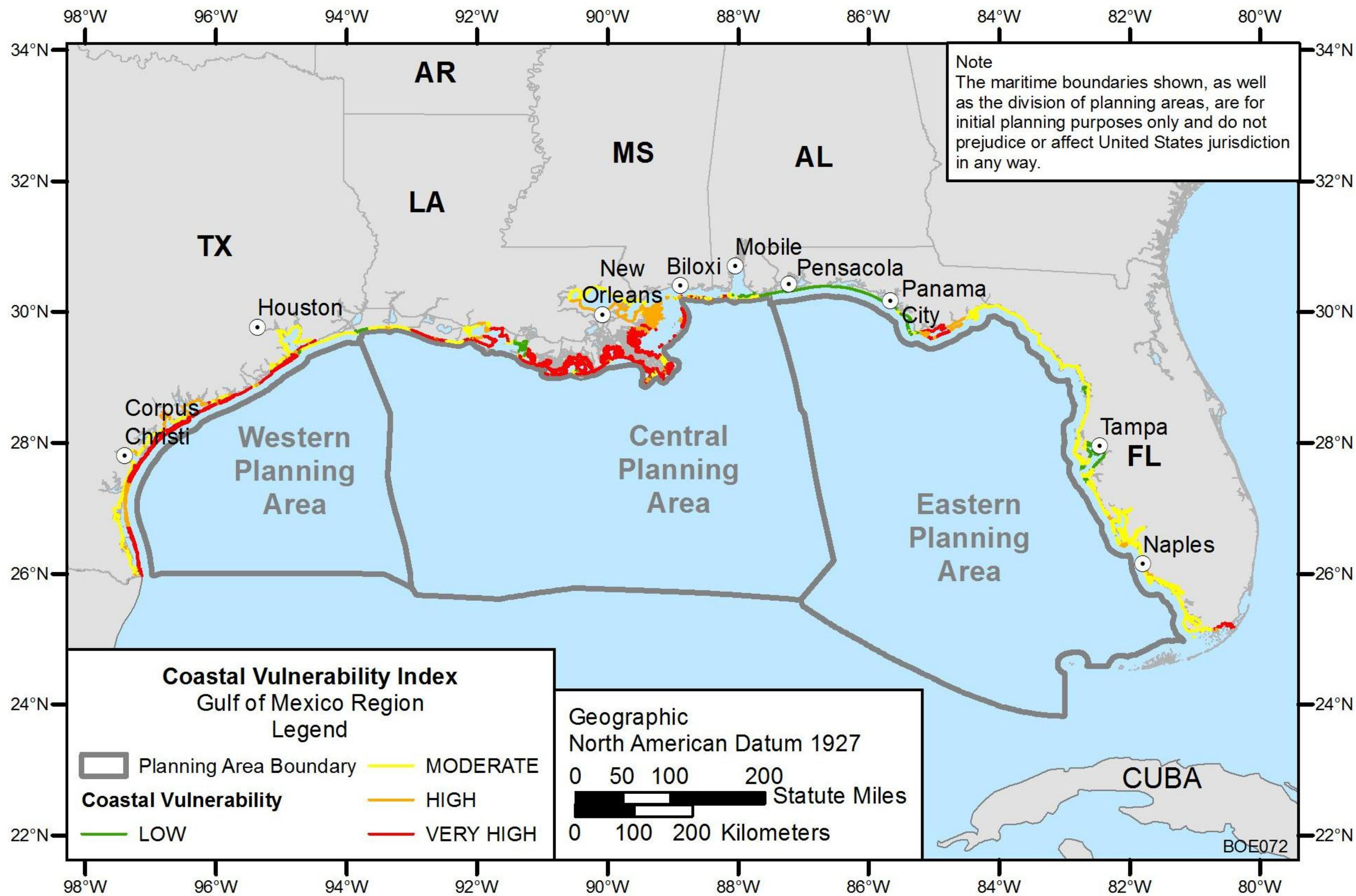

FIGURE 4.4.10-4 Coastal Vulnerability Index

where necessary, which would tend to limit the potential to create lasting changes to the physical and/or infrastructural makeup of the GOM during operations.

Decommissioning. Typical activities during the decommissioning/reclamation phase could include, but are not limited to, the closure of all wells, removal of access roads (not maintained or intended for other uses) and associated facility sites, and revegetation. These activities have the potential to directly impact land use, development patterns, and infrastructure.

Impacts associated with decommissioning, however, generally would be site-specific. In some cases, return to pre-exploration and preconstruction conditions may not be feasible.

Local Land Use/Comprehensive Planning and Development Patterns. Depending on the location of the production wells and associated infrastructure, decommissioning activities onshore may be regulated by local land use, zoning, and comprehensive planning initiatives or requirements. The continued use of the facilities after production could impact planned development in a positive manner, either by providing an opportunity for reuse of facilities or allowing for the potential for additional or future oil and gas development.

Loss of Use to Existing Landowners or Users. No permanent loss of use is anticipated to occur during the decommissioning/reclamation phase. Some temporary loss may occur if road or area closures are necessary to accommodate equipment, workers, or specific activities associated with this type of process. Access typically would be restored to its preconstruction or operations state.

In addition, the use of individual properties in the vicinity of the activities may be affected indirectly if excessive noise and air emissions generated by the decommissioning equipment, activities, and onshore/offshore vehicular and air traffic (e.g., helicopters and automobiles) were to occur, or if a small increase in the amount of trash and debris washing ashore were to result from the activities. These occurrences may cause a temporary disturbance or annoyance among particular landholders or users, thereby inhibiting the intended or actual use of a property. The level of impact would depend on the specific location within the GOM, but generally would be anticipated to be minimal.

Physical and/or Infrastructural Composition. In addition, potential changes to the physical and infrastructural makeup of the GOM coast could occur. Any equipment added may be removed; defunct equipment also could be removed. These alterations would be site-specific and the extent of their impact likely could range from negligible to minimal with regard to the existing composition of land use and infrastructure.

4.4.10.1.2 Accidents. Oil spills are the principal accidental impact-causing event. If oil spills were to occur and were to contact the coast, overall impacts on land use and existing infrastructure typically would be minor. Approximately 8 large spills, 35–70 medium-sized spills, and 200–400 small spills are anticipated to occur in the GOM as a result of new development (see Table 4.4.2-1).[14] Oil spilled in offshore areas usually is localized and has a low probability of contacting coastal areas, because much of the oil volatilizes or is dispersed by currents (MMS 2008a). In most cases, coastal or nearshore spills would have short-term adverse effects on coastal infrastructure requiring cleanup of any oil or chemicals spilled (MMS 2006a).

Potential impacts on land use and existing infrastructure would likely include "stresses of the spill response on existing infrastructure, direct land-use impact (such as impacts of oil contamination to a recreational area or to agricultural land), and restrictions of access to a particular area, while the cleanup is being conducted" (MMS 2007c). These impacts generally would be temporary and localized. However, as shown by recent events in the GOM (i.e., the Deepwater Horizon event), the degree of impact is influenced by many factors including, but not limited to, spill location, spill size, type of material spilled, prevailing wind and current conditions, the vulnerability and sensitivity of the land use and infrastructure, and response capability.

Catastrophic Discharge Event. In addition to small and large releases, the PEIS analyzes the impacts of a CDE of 0.9 to 7.2 million bbl in size (Table 4.4.2-2). While no direct major land use impacts would be expected following a CDE, post-spill habitat restoration efforts could result in enhanced barrier islands and wetlands. A number of indirect effects may result, including adaptations in commercial industries, such as fishing and tourism, fluctuating economic patterns, and changes in demographic distributions; all of these impacts could affect land use or development patterns by altering spending patterns of consumers and developers. Following the DWH event, perceptions regarding emergency planning have created a need for future planning and accounting for potential events of greater magnitude than typically anticipated. Trickle-down effects of the DWH event may include more stringent safety protocols in the operation and construction of infrastructure, which may include onshore facilities as well as offshore facilities. Similar types of effects would be anticipated if a catastrophic discharge event were to occur during the life of the Program.

4.4.10.2 Alaska – Cook Inlet

New oil and gas production is anticipated in the Cook Inlet, an area previously used for offshore production. As indicated in Table 4.4.1-3, oil production is anticipated to include a range of 0.1 to 0.2 Bbbl within south central Alaska; currently no active Federal leases are located within the Inlet. However, 16 active offshore producing platforms are located within the Cook Inlet in State submerged land. These platforms are served by more than 320 km (200 mi) of undersea gas and oil pipelines, as well as onshore facilities (see Section 3.11.2).

A number of routine activities would be necessary to provide for additional production; these activities have the potential to impact existing and future land use, development patterns, and infrastructure. This analysis of impacts, therefore, focuses solely on new production within the Cook Inlet.

[14] As indicated in Section 4.4.2.1, large spills are categorized as those that result in over 1,000 barrels of oil being released; medium-sized are those between 50 and 1,000 barrels, and small spills are those under 50 barrels.

4.4.10.2.1 Routine Operations.

Seismic Explorations and Exploratory Drilling. As previously noted, activities associated with exploration typically include a seismic survey, exploratory well construction, and aircraft and vessel traffic (Figure 4.4.10-1). The impacts resulting from these activities are discussed below.

Local Land Use/Comprehensive Planning and Development Patterns. Seismic explorations and exploratory drilling would not directly impact land use, development patterns, and infrastructure within the Cook Inlet, because a majority of the activities would be located offshore. During this phase, existing and future land use categorizations would remain largely unchanged, along with current development patterns.

In general, activities to support exploration would be located onshore within existing developments in order to act as staging areas for the seismic surveys and exploratory wells. Temporary onshore service bases could be needed to support offshore exploratory drilling operations. These bases would transfer materials between land and the offshore drilling rigs. In addition, supply vessels and helicopters would be used to shuttle personnel, equipment, and supplies. Existing facilities generally would be used within the Cook Inlet, if they were available in the selected location for exploration; if necessary, new facilities would be built, or prefabricated modules could be moved to the base of the exploration activities (Kenai Peninsula Borough 2008).

Loss of Use to Existing Landowners or Users. Activities associated with seismic explorations and exploratory drilling could impact access or use of a particular land area, although to a minimal extent. Some temporary onshore and offshore access restrictions could be necessary for safety reasons; however, these restrictions likely would be temporary, lasting only as long as the exploration activities.

The perception of loss of land or use, however, might increase among tribal communities,[15] local inhabitants, and visitors within the Cook Inlet. As offshore exploration includes the temporary siting of large drilling rigs and discharges of drilling muds and cuttings, some people using the coastal area for subsistence hunting and gathering or for recreation and tourism might perceive the effects of the drilling as a disruption to their regular activities (see Sections 4.4.13 and 4.4.14 for a further discussion of subsistence activities, Section 4.4.12 for a discussion of recreation and tourism, and Section 4.4.3.2 for a discussion of water quality). If the perceived disruption or "nuisance" becomes too intense, users may relocate to other parts of the Inlet in order to conduct their regular activities in anticipation of the new oil and gas activities. Thus, the actual use of the land may be impacted, even if the intended land use designation or categorization is not altered. Within the Cook Inlet, this impact would be anticipated to be minimal, due to the presence of the existing oil and gas industry.

---

[15] Approximately 8.9% of all land within the Kenai Peninsula Borough is owned by Native Village and Regional Corporations. Large tracts of this type of land surround Nanwalek, Port Graham, Tyonek, Ninilchik, Seldovia, and Kenai. Some of the parcels have been used for logging, oil and gas extraction, and mining (Kenai Peninsula Borough 2005).

In addition, the use of individual properties in the vicinity of the exploration activities may be affected indirectly if excessive noise and air emissions generated by the exploratory equipment, activities, and onshore/offshore vehicular and air traffic (e.g., helicopters and automobiles) were to occur, or if a small increase in the amount of trash and debris washing ashore were to result from the activities. These occurrences may cause a temporary disturbance or annoyance among particular landholders or users, thereby inhibiting the intended or actual use of a property. The level of impact would depend on the specific location within the Cook Inlet, but generally would be anticipated to be minimal.

Physical and/or Infrastructural Composition. As noted in Table 4.4.1.2-1, approximately 4–12 exploration wells would be drilled within south central Alaska. Due to the existing oil and gas infrastructure already present, a minimal amount of additional machinery and staging area improvements would be needed in order to accommodate equipment and workers associated with exploration activities.

Onshore and Offshore Construction. Onshore and offshore construction could impact local land use and comprehensive planning and existing and planned development; access and use of particular properties; the physical and infrastructural composition of the Cook Inlet; and existing conditions as they pertain to emissions, waste, noise, and traffic (see Figure 4.4.10-2).

As indicated in Section 4.1.1-2, construction activities often include production well placement, pipeline placement, onshore construction, and aircraft and vessel traffic. Per the proposed development scenario within south central Alaska, construction of approximately one to three new platforms is anticipated, along with 40–241 km (25–150 mi) of new offshore pipeline and 80–169 km (50–105 mi) of onshore pipeline. Up to one new pipeline landfall also may be needed, as indicated in Table 4.4.1.1-3. Potential impacts of these activities are presented below.

Local Land Use/Comprehensive Planning and Development Patterns. Due to a long history of oil and gas development, existing land use categorizations in Cook Inlet often would be able to accommodate new leases for the proposed development scenario. As indicated in Section 4.4.1.2, existing infrastructure would be used to the extent possible, limiting the need for the acquisition of new sites for development. Therefore, negligible to minor impacts on land use categorizations (i.e., receptors) are predicted by the addition of new leases and subsequent construction activities.

Loss of Use to Existing Landowners or Users. Onshore and offshore construction generally would not interfere with or prevent use by existing owners or users within areas already used for oil and gas. As previously indicated, the use of existing facilities generally would be preferred over new construction. However, during construction activities, a temporary loss of access for some users may occur, even within an existing oil and gas development area. Restrictions on access may be put in place for safety reasons or to allow certain activities to occur. Depending on the location of the activities, the restrictions would be lifted after the completion of construction.

Likewise, some users of surrounding land may be inconvenienced by closure or restrictions on access routes or within areas used for subsistence activities. For example, within the Cook Inlet, as in other parts of Alaska, air carriers generally provide a large share of the cargo and passenger service to and within the State. Water transport, especially for large and heavy materials, also is an important component of the transportation network. Activities related to the construction may impact Alaska's air routes, air-terminal facilities, and barge-cargo services, causing delays or changes in scheduling or service (MMS 2002a). Consequently, the perceived impact associated with these restrictions or closures to access routes or land areas may weigh more heavily on permanent communities using surrounding lands or routes for subsistence activities or for daily employment than on temporary visitors or tourists.

While plans for oil and gas development generally would limit the amount of permanent loss of use, especially during construction, some users may be subject to this type of impact dependent on the specific location chosen. A permanent loss of use generally would be associated with land parcels in which land use categorizations were amended to allow for oil and gas construction activities. If new land were necessary in order to construct onshore facilities, such as a new pipeline or landfall, the acquisition process would need to follow all pertinent local, State, and Federal requirements.

In addition, the use of individual properties in the vicinity of the construction activities may be affected indirectly if excessive noise and air emissions generated by the construction equipment and onshore/offshore vehicular and air traffic (e.g., helicopters and automobiles) were to occur, or if a small increase in the amount of trash and debris washing ashore were to result from the activities. These occurrences may cause a temporary disturbance or annoyance among particular landholders or users, thereby inhibiting the intended or actual use of a property. The level of impact would depend on the specific location within the Cook Inlet, but generally would be anticipated to be minimal.

Physical and/or Infrastructural Composition. The physical and infrastructural composition of south central Alaska would be altered by the expansion and/or improvement of existing facilities, as well as by new construction. The extent of the impacts associated with these activities ultimately would depend on their specific location within the Cook Inlet. For example, this region has an inland network of oil and gas gathering distribution pipelines; one such community is Nikiski, which has existing oil and gas support facilities to account for current leasing (MMS 2007a). The basic onshore support and processing infrastructure that would be necessary to support the anticipated levels of activity are already in place within the Cook Inlet; these transport, loading, and storage capabilities would require expansion to handle an increased volume of produced crude oil rather than extensive construction of new facilities (MMS 2002a, 2007a).

While the oil and gas industry within Cook Inlet was one of the largest sources of high paying jobs within the last decade, natural gas production recently has provided a more stable source of employment. As a result, some of the aging infrastructure associated with offshore drilling is in poor repair, and thus would require updates, expansion, and/or other improvements (Fried and Windisch-Cole 2004). In these locations, new construction could be a more appropriate solution to accommodate offshore oil and gas production.

If new infrastructure were needed, it would be built either as infill within an existing industrial or port area or within an area recently designated for this type of development. A greater impact on the existing physical landscape would be experienced in those areas not already used for oil and gas production. For instance, the construction of the pipeline landfall could involve clearing land, preparing a ROW, and digging and backfilling trenches. Additional clearance could be necessary in order to accommodate the new on shore pipeline, as well. These types of activities or similar ones could alter the physical composition of the landscape, thus potentially limiting the intended, actual, or future use of a parcel. If needed, this type of construction would have extensive impacts in lands used for subsistence hunting or other similar activities.

Additional indirect impacts concern those associated with climate change. New facilities may be sited in different locations in response to anticipated rises in sea level, increased storm frequency and intensity, and temperature changes. Other activities that might be undertaken in response to real or potential climate change–induced rises in sea level include facility relocation, the construction of seawalls and storm surge barriers, and land acquisitions to create buffer areas (IPCC 2007).

Consequently, indirect impacts on land use, development patterns, and infrastructure could include locating further inland and/or strengthening foundations or building materials of existing facilities. These actions potentially could increase costs associated with development or force the construction of new facilities rather than the reuse or expansion of existing properties associated with oil and gas production. These decisions may be influenced by the potential for increased flooding and/or erosion, as well.

Routine Operations. Routine operations would include production well operation, onshore facility operation, and vessel and aircraft traffic, as well as the transport of oil from offshore to onshore locations using pipelines. Potential impacts associated with these activities would range in extent from negligible to minimal (see Figure 4.4.10-3).

Local Land Use/Comprehensive Planning and Development Patterns. Once offshore oil and gas facilities were in operation,[16] negligible to minimal impacts on land use, development patterns, and infrastructure would be expected, because a majority of the activities would be located offshore, with some activity occurring within onshore bases and transportation facilities.

In addition, as shown in Table 4.4.1-3, no new shore bases, processing facilities, or waste disposal facilities are associated with the proposed action. Since existing infrastructure would be used to the extent possible, the anticipated use of onshore facilities during normal operations would not be expected to generate noticeable changes to the current setting that would impact the overall land use, development patterns, or infrastructure of Cook Inlet.

[16] For the purposes of this evaluation, normal operations exclude events leading up to the production of offshore oil and gas.

Loss of Use to Existing Landowners or Users. Once offshore oil and gas facilities were in operation, a temporary or permanent loss of use would not be anticipated, because a sufficient number of facilities already are located within Cook Inlet to support the increased oil and gas development. At times, some access may be restricted within surrounding lands to accommodate a brief alteration in normal operations (e.g., an emergency response).

Furthermore, the use of individual properties in the vicinity of the operating platforms may be affected indirectly if excessive noise and air emissions were generated from equipment and onshore/offshore vehicular and air traffic (e.g., helicopters and automobiles), or if a small increase in the amount of trash and debris washing ashore were to result from the activities. These occurrences may cause disturbances or annoyance among particular landholders or users, thereby inhibiting the intended or actual use of a property. The level and extent of impact would depend on the specific location within the Cook Inlet, but generally would be anticipated to be minimal.

Physical and/or Infrastructural Composition. To the extent possible, existing facilities would be used and new facilities would be built only where necessary, once initial construction was completed. Since the anticipated new development is modest, large impacts on the physical and/or infrastructural composition of Cook Inlet during the operation phase would not be expected.

Decommissioning. When activities for oil and gas become uneconomical to continue production operations or when a lease expires, many of the structures built for production would be dismantled, shut down, or converted to other uses. Typical government regulations require that offshore structures be cut off below the mud line and entirely removed, while pipelines often are left in place due to the high cost of removal. Offshore wells would be cemented in, and sea bottom well sites would be dragged to remove obstructions (Kenai Peninsula Borough 2008). Due to the physical nature of these activities, land use, development patterns, and infrastructure might be impacted directly. These impacts generally would be site-specific. In some cases, a return to pre-exploration and preconstruction conditions might not be feasible.

Local Land Use/Comprehensive Planning and Development Patterns. Depending on the location of the production wells and associated infrastructure, decommissioning activities onshore might be regulated by local land use, zoning, and comprehensive planning initiatives or requirements. In turn, local planning initiatives often account for developments of this nature in future planning. For instance, the continued use of the facilities after production could impact planned development in a positive manner, either by providing an opportunity for reuse of facilities or allowing for additional or future oil and gas activities (MMS 2007b).

Loss of Use to Existing Landowners or Users. No permanent loss of use is anticipated to occur during the decommissioning/reclamation phase. Some temporary loss might occur if road or area closures were necessary to accommodate equipment, workers, or specific deconstruction activities. If feasible, access would be restored to its preconstruction or operations state.

During decommissioning, the use of individual properties in the vicinity of the activities may be affected indirectly if excessive noise and air emissions were generated from equipment and onshore/offshore vehicular and air traffic (e.g., helicopters and automobiles), or if a small increase in the amount of trash and debris washing ashore were to result from the activities. These occurrences may cause temporary disturbances or annoyance among particular landholders or users, thereby inhibiting the intended or actual use of a property. The level and extent of impact would depend on the specific location, but generally would be anticipated to be minimal.

Physical and/or Infrastructural Composition. In addition, potential changes to the physical and infrastructural makeup of Cook Inlet could occur. Any equipment added may be removed; other defunct equipment also could be removed. Impacts on land use and infrastructure would be site-specific and could range from negligible to minor. Moreover, if any offshore or onshore infrastructure were deemed a visual intrusion within the landscape for the duration of the project, removal of the structure during decommissioning would remove the feature, and thus help to alleviate the impact (MMS 2003a).

4.4.10.2.2 Accidents. The risk of a spill is present whenever crude oil or petroleum products are handled. Oil spills could be associated with the exploration, development, production, storage, and/or transportation processes and might occur from losses of well control or pipeline or tanker accidents. As indicated in Table 4.4.2-1, approximately 1 large spill, 1 to 3 medium-sized spills, and 7 to 15 small spills are anticipated to occur as part of new development within Cook Inlet. From 1999 to 2008, 18 crude oil spills of 380 L (100 gal) or more from pipelines, platforms, onshore production facilities, storage facilities, and marine tankers have occurred in Cook Inlet. Six of these were more than 1,900 L (500 gal) (ADNR 2009b).

Based upon knowledge acquired from previous spills, potential impacts to land use and infrastructure resulting from an oil spill would likely include moderate temporary stresses of the spill response on existing community infrastructure, increased boat and air traffic to respond to the spill and cleanup operations, and restrictions of access to a particular area while the cleanup is conducted (MMS 2007c). These stresses could lead to a temporary loss of use of certain parcels both for their intended and actual uses, but generally no permanent land use categorization changes.

Within Cook Inlet, a geographic response strategy (GRS) has been formulated to account for 17 sites within the central Cook Inlet, 18 sites for the southwest, 21 sites for Kachemak Bay, and 22 sites for the southeast. Strategies within this plan focus on minimizing the environmental damage, using a small response footprint, and selecting sites for equipment deployment that would not cause further harm (ADNR 2009b).

Catastrophic Discharge Event. The PEIS analyzes the impacts of a CDE that could range in size from 75 to 125 thousand bbl (see Table 4.4.2-2). These events have the potential to impact future development patterns if irreversible changes to the land composition occur within certain areas. For example, one of the largest events of this type occurred in 1989; it consisted of the *Exxon Valdez* discharge. This event led to the closure or disruption of many Cook Inlet businesses, including fisheries (ADNR 2009b).

However, only one spill of this size is anticipated to occur within this region (see Table 4.4.2-2). It would likely be a result of oil transport from a tanker carrying Arctic and Cook Inlet OCS oil from the Valdez terminal to U.S. ports (see Section 4.4.2.1 for additional information). In most cases, a worst-case oil discharge from an exploration facility, production facility, pipeline, or storage facility would be restricted by the maximum tank or vessel storage capacity or by a well's ability to produce oil.

Potential impacts to land use and infrastructure resulting from a CDE would likely include moderate to high temporary stresses of the spill response on existing community infrastructure, increased boat and air traffic to respond to the spill and cleanup operations, and restrictions of access to a particular area while the cleanup is conducted (MMS 2007c). Some of these impacts may lead to more permanent changes in the way land is used, such as closure or disruptions of business as occurred for the *Exxon Valdez* event (ADNR 2009b).

4.4.10.3 Alaska – Arctic

Oil and gas production within the Arctic as a whole is not as developed as that in the GOM and Cook Inlet; however, this region includes the Beaufort Sea Planning Area, which has well-developed oil and gas industry infrastructure on adjacent land and in State waters. For instance, the Prudhoe Bay complex is located within the Beaufort Sea Planning Area. This is part of a large oil producing field, which contains extensive infrastructure (MMS 2007c).

As indicated in Table 4.4.1-4, oil production is anticipated to include 0.2 to 2.1 Bbbl within the Beaufort Sea and the Chukchi Sea. Therefore, a number of routine activities would be necessary to more fully develop this industry in order to provide for additional production within the Beaufort and Chukchi Seas region. As noted for the other areas, these activities have the potential to impact existing and future land use, development patterns, and infrastructure.

4.4.10.3.1 Routine Operations. Routine activities include exploration, development, production, and decommissioning. Impacts on land use, development patterns, and infrastructure within the Beaufort and Chukchi Seas regions from each of these activities are presented below.

Seismic Explorations and Exploratory Drilling. Activities associated with exploration typically include a seismic survey, exploratory well construction, and aircraft and vessel traffic.

Local Land Use/Comprehensive Planning and Development Patterns. Seismic explorations and exploratory drilling would not directly impact land use, development patterns, and infrastructure, because a majority of the activities would be located offshore. During this phase, existing and future land use categorizations would remain largely unchanged.

Loss of Use to Existing Landowners or Users. Activities associated with seismic explorations and exploratory drilling could potentially impact access or use of a particular land area, although to a minimal extent. Some temporary safety-related restrictions on access might be necessary both onshore and offshore; however, these restrictions likely would last only as long as the exploration activities.

For this area of Alaska, a scattered exploration pattern may be necessary due to the lack of existing oil and gas infrastructure. For this type of exploration pattern, more frequent and longer-duration helicopter and support boat trips would be needed than if a clustered pattern of exploration were utilized. For instance, platforms located beyond the landfast ice zone would require substantial helicopter support, especially during the developmental drilling phase, because they would be unreachable by ice roads. In addition, platforms located in the landfast ice zone could be served by vehicles traveling over ice roads (MMS 2007c). Local access to these transportation modes could be impacted, although to a minimal extent, to account for the additional trips and traffic associated with this type of exploration. This would result in a perceived loss of use for some people either living, visiting, or working within the area.

Perceived loss of land or use might also increase among tribal communities, local inhabitants, and visitors within the coastal areas of the Beaufort and Chukchi Seas. Since offshore exploration includes the placement of wells and the production of drilling muds and cuttings, which may be discharged into the marine environment, some people using the coastal area may perceive the effects of the drilling as a disruption to their regular activities. If the perceived disruption or "nuisance" becomes too intense, users may relocate to other parts of the coast in order to conduct their regular activities. Thus, the actual use of the land may be impacted, even if the intended land use designation or categorization is not altered.

For example, as indicated in Section 4.4.13.3, residents of the Chukchi Sea communities have noted a concern over the loss of a subsistence lifestyle and the imposition of additional demands on communities to maintain new infrastructure either directly or indirectly related to oil and gas exploration and eventual production. "Residents of the Chukchi Sea coastal communities have been remarkably consistent in their primary concerns during the more than 20 years of public hearings and meetings on State and Federal oil development on the North Slope" (BOEMRE 2010a, 2011k). Sections 4.4.13.3.1 and 4.4.14.3.1 provide additional information on the impacts to subsistence and tribal communities within the Arctic region resulting from oil and gas activities.

In addition, the use of individual properties in the vicinity of the exploration activities may be affected indirectly if excessive noise and air emissions were generated from equipment and onshore/offshore vehicular and air traffic (e.g., helicopters and automobiles), or if a small increase in the amount of trash and debris washing ashore were to result from the activities. These occurrences may cause disturbances or annoyance among particular landholders or users, thereby inhibiting the intended or actual use of a property. The level and extent of the indirect impacts would depend on the specific location within the Arctic region, but generally would be anticipated to be minimal to moderate (BOEMRE 2011k).

Physical and/or Infrastructural Composition. As noted in Table 4.4.1-4, approximately 6–20 exploration and delineation wells and 40–280 development and production wells would be drilled within the Arctic. Machinery and staging area improvements would be needed in order to accommodate equipment and workers associated with these exploration activities. The increase in physical infrastructure likely would be negligible to minimal at this stage of oil and gas development due to the temporary nature of the exploration activities and the anticipated use of existing facilities, where available.

Onshore and Offshore Construction. Similar to the exploration phase, onshore and offshore construction have the potential to impact local land use and comprehensive planning and existing and planned development; access and use of particular properties; and the physical and infrastructural composition of the Beaufort and Chukchi Seas.

As indicated in Figure 4.4.10-2, activities associated with this phase often include production well placement, pipeline placement, onshore construction, and aircraft and vessel traffic. Per the proposed development scenario within the Arctic region, approximately 1–5 platforms are anticipated, along with 16–130 km (10–80 mi) of onshore pipeline. No new pipeline landfalls or shore bases are anticipated. This section provides a discussion of impacts associated with land use as they pertain to onshore and offshore construction.

Local Land Use/Comprehensive Planning and Development Patterns. Due to the minimal level of current oil and gas development within the whole of the Beaufort and Chukchi Seas, existing land use plans and designations may not provide for areas that are able to accommodate new leases. Therefore, minimal to moderate impacts to land use and comprehensive planning decisions, such as a conditional use permit or zoning change, are predicted as a result of the leasing and subsequent development activities, including construction. The need to address existing land use would depend on the specific location selected for onshore construction and on the activity to be conducted (e.g., the construction of onshore pipeline routes or new transportation routes).

For instance, according to the North Slope Borough (NSB) comprehensive plan, five major zoning districts are present, including the Village, Barrow, Conservation, Resource Development, and Transportation Corridor (MMS 2007a). "All areas within the NSB are in the Conservation District, unless they are specifically designated within the limited boundaries of a village or Barrow, a unitized oil field within the Resource Development District, or within the Trans-Alaska Pipeline System (TAPS) corridor" (MMS 2007a). As indicated by this statement, major land uses generally are divided between subsistence use and petroleum-resource extraction (MMS 2007a).

Due to the recognition of oil and gas activities, all of the NSB land management regulations address oil and gas leasing activities, including onshore and offshore (MMS 2007a). Therefore, within the NSB, conditional use permits may be requested that would allow for specific, temporary activities; in some cases, the more permanent development associated with production would require that a master plan be prepared describing anticipated activities. In addition, use of non-Federal land within the NSB may require rezoning from the Conservation District to the Resource Development District or Transportation Corridor (MMS 2007a).

While not a direct cause and effect relationship, if changes to overall land use categorizations or planning initiatives were needed to begin construction and subsequent development of oil and gas facilities, future development patterns could be impacted. If onshore construction were to occur within the Arctic region, various government agencies and jurisdictions would be involved in the change. Land ownership within the North Slope area consists of overlapping ownership interests, at times vague boundary descriptions, and informal or unrecorded land transfers. Surface and subsurface ownership interests are held by the Federal Government, State government, the borough, villages, regional and village Native corporations, and private individuals, including Native allotments. As in many areas, surface and subsurface owners may differ, particularly in communities and Native allotments (URS Corporation 2005).

In addition, if new infrastructure would be needed onshore, some facilities and infrastructure would be subject to other local, State, and/or other Federal permitting and regulations, including provisions for the siting of facilities. Specific timelines and requirements would vary by location, as BOEM typically is not the permitting or regulating agency for development activities that occur onshore.

Loss of Use to Existing Landowners or Users. Onshore and offshore construction generally has the potential to interfere with or prevent use by existing owners or users within areas not already used for oil and gas activities (see Section 4.4.13.3 and 4.4.14.3 regarding impacts on subsistence activities). While the use of existing facilities generally is preferred over new construction, few of these facilities exist within the whole of the Arctic region as compared to the GOM and Cook Inlet. As previously indicated, the Chukchi Sea Planning Area has relatively little established infrastructure, while well-developed oil and gas facilities are located within the Beaufort Sea Planning Area, such as at the Prudhoe Bay complex. Therefore, during construction, a temporary loss of access to some users may occur. Restrictions on access may be put in place as safety precautions or to allow certain activities to occur. Depending on the location of the activities, these restrictions could be lifted after construction was completed.

Users of surrounding lands also may be inconvenienced by closure or restrictions on access routes or within areas used for subsistence activities during construction. For instance, if platforms were constructed in part onshore, some marine subsistence hunters may have to avoid or navigate around them when preparing their crafts from an onshore location. Another example would include the construction of temporary roads for exploration drilling or permanent roads that may be constructed as a result of proposed activities. While roads could increase access to previously inaccessible areas, they also could also create community-development, land use-planning, or fish and game-management problems (ADNR 2009). Consequently, the perceived impact associated with these restrictions or closures may weigh more heavily on communities using surrounding lands for subsistence activities than recreational users or tourists (see Sections 4.4.13.3.1 and 4.4.14.3.1 for additional information regarding subsistence activities).

In addition, the use of individual properties in the vicinity of the construction activities may be affected indirectly if excessive noise and air emissions were generated from equipment and onshore/offshore vehicular and air traffic (e.g., helicopters and automobiles), or if a small increase in the amount of trash and debris washing ashore were to result from the activities.

These occurrences may cause disturbances or annoyance among particular landholders or users, thereby inhibiting the intended or actual use of a property. The level and extent of impact would depend on the specific location within the Arctic, but generally would be anticipated to be minimal to moderate.

Physical and/or Infrastructural Composition. The physical presence of the shore-based and pipeline infrastructure within the Arctic region would represent an initial industrialization of the area and a long-term and significant change in land use patterns. This would result due to the change from an isolated and often pristine environment to one that supports oil and gas infrastructure. While new technologies and practices tend to be less damaging than those associated with past activities, the addition of these facilities has the potential to permanently alter the land use within the region (AMAP 2010).

In areas already developed with oil and gas infrastructure, such as in the Beaufort Sea Planning Area, the construction of oil and gas infrastructure would represent a continuation of industrial/commercial activity; however, in areas lacking existing infrastructure, it would account for a more substantial change in the industrial/commercial activity and diversity of individual villages (MMS 2007a). The extent of the impacts associated with these activities ultimately would depend on the specific location within the Arctic and the particular community in which facilities would be placed.

Impacts on infrastructural composition also would result from the development of onshore pipeline and a permanent road network in locations that do not already have existing oil and gas facilities. Depending on the location of a pipeline landfall, the path of an associated road to the Trans-Alaska Pipeline System (TAPS) might open up areas not previously reached by permanent roads. The positive benefits of this construction would be to aid future ice road and permanent road construction, as well as providing a connection to the North Slope communities (MMS 2007c). Some of the negative impacts of roadway construction would be the interference with subsistence uses and animal movement and the potential for increased traffic (see Sections 4.4.13.3.1 and 4.4.14.3.1 for more information).

Additional indirect impacts concern those associated with climate change. Siting of new facilities may account for potential changes resulting from rises in sea level, increased storm frequency and intensity, and temperature changes. One of the more noticeable effects would be the thawing of permafrost on land. In the Arctic, facilities often use permafrost as a solid foundation for buildings, pipelines, and roads, and for containing waste materials. Warming may degrade permafrost, which can harm existing facilities and prevent the use of permafrost in the future (AMAP 2007; MMS 2007c).

Consequently, indirect impacts on land use, development patterns, and infrastructure can include locating further inland and/or strengthening foundations or building materials of existing facilities. These actions potentially can increase costs associated with development or force the construction of new facilities rather than the reuse or expansion of existing properties associated with oil and gas production. These decisions also may be influenced by the potential for increased flooding and/or erosion.

Routine Operations. Routine operation activities would consist of production well operation, onshore facility operation, and vessel and aircraft traffic. It also would include the transport of oil from offshore to onshore locations using ships or pipelines (see Figure 4.4.10-3). As indicated in Section 4.4.1.3, the PEIS assumes that the most likely locations for the occurrence of activities would be in areas that already have been leased in recent sales. One to 15 helicopter trips and 1 to 15 vessel trips would be anticipated. Potential impacts associated with these activities would range in extent from negligible to moderate.

Local Land Use/Comprehensive Planning and Development Patterns. Once in operation,[17] negligible to minimal impacts are anticipated to result on land use, development patterns, and infrastructure, since a majority of the activities would be located offshore, and no additional construction would be anticipated. In general, the production of oil and gas would need to be consistent with Federal, State, and local planning initiatives.

Loss of Use to Existing Landowners or Users. Once in operation, an additional loss of use is not anticipated. At times, some access may be restricted within surrounding lands to accommodate a brief alteration in operations or a peak in normal activities, or to conduct maintenance.

During operation, the use of individual properties in the vicinity of the operating platforms may be affected indirectly if excessive noise and air emissions were generated from equipment and onshore/offshore vehicular and air traffic (e.g., helicopters and automobiles), or if a small increase in the amount of trash and debris washing ashore were to result from the activities. These occurrences may cause disturbances or annoyance among particular landholders or users, thereby inhibiting the intended or actual use of a property. The level and extent of impact would depend on the specific location within the Arctic, but generally would be anticipated to be minimal to moderate. For instance, in locations where subsistence activities occur, the impacts may be more noticeable and have a larger impact on certain communities as compared to other areas of the Arctic; a discussion of these impacts is provided in Sections 4.4.13.3.1 and 4.4.14.3.1.

Physical and/or Infrastructural Composition. To the extent possible, no new facilities would be built during normal operations. Therefore, the potential to create lasting changes to the physical and/or infrastructural composition of the Arctic region during the operation phase would be limited.

Decommissioning. When activities for oil and gas production operations become uneconomical to continue, or when a lease is expired, many of the structures built for production are dismantled, shut down, or converted to other uses. Decommissioning activities in the Arctic typically involve permanently plugging wells (with cement), removing wellhead equipment, and removing the processing module from the platform. Pipelines also must be decommissioned, which involves cleaning the pipeline, plugging the ends, and leaving it in place, buried within the seabed. Onshore pipelines may be used for other purposes, if not removed (MMS 2008b). All

---

[17] For the purposes of this evaluation, normal operations are considered exclusive of events leading up to the production of offshore oil and gas.

decommissioning activities would abide by Federal regulations. Due to the physical nature of these activities and the length of the leases, land use, development patterns, and infrastructure may be impacted directly. These impacts, however, generally would be site-specific. In some cases, pre-exploration and preconstruction conditions may not be able to be reestablished.

Local Land Use/Comprehensive Planning and Development Patterns. Depending on the location of the production wells and associated infrastructure, decommissioning activities onshore may be regulated by local land use, zoning, and comprehensive planning initiatives or requirements.

In turn, local planning initiatives often account for developments of this nature in future planning due to the length of operation. For instance, the continued use of the facilities after production could impact planned development in a positive manner, either by providing an opportunity for reuse of facilities or by allowing for the potential for additional or future oil and gas development.

Loss of Use to Existing Landowners or Users. No permanent loss of use is anticipated to occur during the decommissioning/reclamation phase. Some temporary loss may occur if road or area closures are necessary to accommodate equipment, workers, or specific activities associated with this type of process. Access to and the physical composition of the industrial/port areas typically would be restored to its preconstruction or operations state to the extent possible.

In addition, the use of individual properties in the vicinity of the decommissioning activities may be affected indirectly if excessive noise and air emissions were generated from equipment and onshore/offshore vehicular and air traffic (e.g., helicopters and automobiles), or if a small increase in the amount of trash and debris washing ashore were to result from the activities. These occurrences may cause disturbances or annoyance among particular landholders or users, thereby inhibiting the intended or actual use of a property. The level and extent of impact would depend on the specific location within the Arctic, but generally would be anticipated to be minimal.

Physical and/or Infrastructural Composition. In addition, potential changes to the physical and infrastructural composition of the Beaufort and Chukchi Seas would occur. Any equipment added may be removed; other defunct equipment also could be removed. These alterations would be site-specific and likely could range from negligible to minimal in the extent of their impact with regard to the existing composition of land use and infrastructure. Moreover, if any offshore or onshore infrastructure were deemed a visual intrusion within the landscape for the duration of the project, removal of the structure during decommissioning would remove the feature, and thus alleviate the intrusion (MMS 2003a).

4.4.10.3.2 Accidents. One anticipated effect of oil and gas development within the Arctic is to extend infrastructure (e.g., landfalls and platforms) and associated activities westward. As a result of this construction, new areas of Alaska adjacent to the Beaufort and Chukchi Seas would be exposed to the potential effects of crude oil spills. Approximately

3 large spills, 10 to 35 medium-sized spills, and 50 to 190 small spills are anticipated to occur with the proposed development of the Arctic Beaufort Sea (see Table 4.4.2-1). Consequently, crude oil spill-response equipment and personnel would be needed in those locations (MMS 2007c).

As with other areas of Alaska, potential indirect impacts on land use and infrastructure resulting from small, medium, or large spills would likely include moderate temporary stresses from the spill response on existing community infrastructure; oil contamination at a coastal area; increased boat and air traffic to respond to the spill and cleanup operations; and restrictions of access to a particular area while the cleanup is conducted (MMS 2007c). These occurrences could lead to a temporary loss of use of certain parcels for both their intended and actual uses.

Catastrophic Discharge Event. The PEIS analyzes a CDE as large as 1.4 to 2.2 million bbl in the Chukchi Sea and 1.7 to 3.9 million bbl in the Beaufort Sea (Table 4.4.2-2). A CDE would have similar types of impacts as spills of other magnitudes; however, the degree of impact would be more severe. For instance, the length of time in which the impacts would be experienced generally would be longer for this type of event (MMS 2007c; BOEMRE 2011k). Likewise, communities that are in close proximity to the event may experience a displacement of existing sociocultural patterns that could affect how they use the land (BOEMRE 2011k). In particular, this type of event would have major effects on communities using land for subsistence activities. These impacts are discussed in detail in Section 4.4.13.3.2.

4.4.10.4 Conclusion

The addition of new oil and gas leases within the GOM Planning Areas would result in negligible to minor impacts on land use, development patterns, and infrastructure. In general, the existing infrastructure would be expected to be sufficient to handle exploration and development associated with potential new leases.

Additional leases for oil and gas development would have a more noticeable impact on land use, development patterns, and infrastructure within Alaska. While Cook Inlet currently supports some oil and gas production, some minor impacts on land use, development patterns, and infrastructure would be anticipated to occur as a result of new leases. These impacts would vary in intensity dependent on specific location within the Inlet. The existing infrastructure would help to limit the intensity of the impacts as compared to Arctic locations, in which limited infrastructure is present and where communities are much smaller than within Cook Inlet.

Within the Arctic, minor to moderate impacts would be anticipated to result from the development of new oil and gas leases within the Beaufort and Chukchi Seas. Existing land use and infrastructure likely would be able to accommodate new leases. In general, land use changes would be needed only in locations where new onshore pipeline routes would be constructed, and in areas requiring new transportation networks (MMS 2007a).

In all three areas, the potential for accidents to occur would be present. These types of events could have both direct and indirect effects on land use, depending on the type, size, location, and duration of the incident. Impacts generally would be more intense in areas with little infrastructure in place to handle accidents and where a greater reliance is placed on coastal activities for subsistence and would be greater in the event of a CDE-level spill.

4.4.11 Potential Impacts on Commercial and Recreational Fisheries

4.4.11.1 Gulf of Mexico

4.4.11.1.1 Routine Operations.

Commercial Fisheries. Routine operations could affect commercial fisheries by causing changes in the distribution or abundance of fishery resources, reducing the catchability of fish or shellfish, precluding fishers from accessing viable fishing areas, or causing losses of or damage to equipment or vessels. Between 200 and 450 new platforms would be established under the proposed action, with up to 2,500 ha (6,177 ac) of seafloor likely to be disturbed by offshore platforms and up to 11,500 ha (28,417 ac) by pipelines. Impacts on commercial fishing activities would vary depending on the nature of a particular structure, the phase of operation, the fishing method or gear, and the target species group. Impacts would be higher for drifting gear such as purse nets, bottom longlines, and pelagic longlines than for trawls and handlines (MMS 2005). Nevertheless, areas in which commercial fishing would be affected are small relative to the entire fishing area available to surface longliners or purse seiners.

To avoid potential conflicts and to maintain safety at large deepwater structures, a safety zone for vessels longer than 30 m (100 ft) may be established up to 500 m (1,640 ft) around each production platform, which would encompass up to approximately 80 ha (198 ac) of surface area per platform. The Fisherman's Contingency Fund, established under OSCLA, can compensate fisherman for property and economic losses related to obstructions caused by oil and gas development in the OCS. The Fund is composed of assessments paid by offshore oil and gas operations and administered by the NMFS (see www.nmfs.noaa.gov/mb/financial_services/fcf.htm).

Federal regulations (30 CFR 250.702(I)) require that, during decommissioning, all wellheads, casings, pilings, and other obstructions be removed to a depth of at least 5 m (15 ft) below the mud line or to a depth approved by the District Supervisor; the size of the area left untrawlable due to abandoned components would represent only a fraction of the total area excluded by oil and gas operations. Longlining would still be possible following decommissioning and removal because surface waters would not be affected by the presence of the remaining underwater components.

The impact of oil and gas structures on commercial fisheries at various depth ranges can be estimated using data in the Offshore Environmental Cost Model (OECM) (BOEMRE 2010d). The model assumes that there will be buffer zones of up to 0.8 km (0.5 mi) around new oil and gas structures, decreasing the area of ocean available for fishing. Although harvesting levels are not affected by offshore structures and pipelines, as these levels are below federally mandated levels, it is assumed that fishing activity will continue in areas still open for fishing, with existing harvesting levels remaining, but that there will be an increase in fishing costs.

The impacts of oil and gas development on commercial fishing costs would vary considerably by planning region and placement depth (Table 4.4.11-1). In the Western Planning Area, the largest cost increases would occur with structures located in water between 150 and 300 m (492 and 984 ft) deep, with an annual increase of $93 in costs from a single structure; a single structure in each depth range would increase annual costs by $147. In the Central Planning Area, overall increases in costs would be much larger at $1,080 per year, with the largest increase coming with a single structure placed in water between 150 and 300 m (492 and 984 ft). Cost impacts in the Eastern Planning Area would be minimal, at $2 per year with a structure in each depth range. In each of the planning areas, single structures would have relatively insignificant impacts compared to fishery revenues in each depth range.

Under the proposed action alternative, between 44 and 80 platforms would be located in the depth range 0 to 60 m (0 to 197 ft) in the Western Planning Area, with between 122 and 257 such platforms in the Central Planning Area. Offshore oil and gas structures placed within this depth range would increase annual commercial fishing costs by between $1,993 and $3,819 in the Western Planning Area, while reducing costs by between $2,507 and $11,243 in the Central Planning Area. No data is currently available on the placement of offshore platforms in the Eastern Planning Area, and consequently, their impact on commercial fishing costs.

Recreational Fisheries. The level of impacts on recreational fisheries in the GOM due to routine operations under the proposed action would be similar to impacts during the previous lease period. Biological resources that serve as the basis for recreational fisheries in the GOM are expected to be only minimally affected by activities associated with routine operations. Construction activities would primarily affect soft bottom species such as red drum, sand sea trout, and spotted sea trout that are sought by anglers in private or charter/party vessels. Such conflicts would be temporary, however, as fishes would eventually return to disturbed areas. The presence of offshore platforms may have a positive effect on the availability of recreational fishing opportunities. During 1999, for example, approximately 20% of private boat fishing trips, 32% of charter boat fishing trips, and 51% of party boat fishing trips in the western and central GOM (Alabama, Mississippi, Louisiana, and Texas) took recreational fishers within 91 m (300 ft) of oil or gas structures (Hiett and Milon 2002), as the presence of structures is known to aggregate pelagic (e.g., king mackerels, tunas, and cobia) and reef-associated fish species (e.g., red snapper, gray triggerfish, and amberjack) that are targeted by many recreational fishers.

4.4.11.1.2 Accidents.

Commercial Fisheries. Under the proposed action, up to 8 large spills greater than 1,000 bbl, between 35 and 70 spills between 50 bbl and 1,000 bbl, and up to 400 small spills less than 50 bbl could occur within the northern GOM. Most of the fish species inhabiting shelf or oceanic waters of the GOM have planktonic eggs and larvae (Ditty 1986; Ditty et al. 1988; Richards and Potthoff 1980; Richards et al. 1993). Certain species, such as triggerfishes, deposit

TABLE 4.4.11-1 Impacts of Single Oil and Gas Structures on Commercial Fisheries, by Placement Depth ($2010)

	Western Planning Area		Central Planning Area		Eastern Planning Area	
Placement Depth Range	Fishery Revenue ($m)	Cost Impact ($)	Fishery Revenue ($m)	Cost Impact ($)	Fishery Revenue ($m)	Cost Impact ($)
0 to 60 m	103.4	41.24	153.5	–165.82	64.4	–0.52
60 to 150 m	22.6	16.73	40.4	21.00	17.7	0.24
150 to 300 m	8.3	92.89	26.1	916.09	9.4	–0.92
300 to 1,500 m	74.4	–5.95	180.3	224.17	22.3	2.15
More than 1,500 m	45.4	2.11	402.7	84.91	54.4	0.76
All depths	254.1	147.03	803.1	1,080.40	168.2	1.70

Source: BOEMRE 2010d.

demersal eggs but have larvae that take up residence in the water column, meaning that these species would also be affected by oil spills. Depending on the location and timing of particular spills, effects would be greater if local water currents retained planktonic larvae and floating oil within the same water mass for extended periods of time. In deepwater areas, adults of highly migratory fish species, including pelagic species such as tunas, sharks, and billfish, would move away from surface oil spills. Pelagic larvae and neuston would not be able to move away from the spilled oil on the surface and would most likely be killed or injured. However, these impacts are not expected to cause population reductions in most commercially exploited species. In coastal areas, moderate and long-term but temporary degradation of estuarine habitat could occur if a large coastal area was oiled following a large or very large oil spill. Although some wetland areas may not recover completely, it is anticipated that spills considered possible as a result of the proposed action are not likely to substantially threaten the overall viability of wetland habitats used by commercially important species. On the basis of the potential level of impacts on coastal habitats including wetlands and submerged seagrass beds under the proposed action, major declines in fish population are not likely to occur.

In general, the level of effects from accidental spills would depend on the location, timing, and volume of spills in addition to other environmental factors. Small spills would be unlikely to affect a large number of fish or commercial fishing before dilution and weathering reduced concentrations; therefore, they would not have long-term effects on commercial fisheries in the GOM. It is anticipated that any single large spill would affect only a small proportion of a given fish population within the GOM and that fish resources would not be permanently affected. However, localized effects on commercial fishing could result as a consequence of reduced catch, loss of gear, or loss of fishing opportunities during cleanup and recovery periods.

Recreational Fisheries. The magnitude of effects from accidental spills would depend on the location, timing, and volume of spills, in addition to other environmental factors. Small spills that may occur under the proposed action are unlikely to affect a large number of fish or have a substantial effect on recreational fishing before dilution and weathering reduced concentrations of oil in the water. Consequently, it is anticipated that small spills would not have substantial or long-term effects on recreational fishing in the GOM. Any single large spill would likely affect only a small proportion of a given fish population within the GOM, and it is unlikely that fish resources would be permanently affected. However, spills could have localized effects on recreational fishing as a consequence of contamination of fish tissues, degradation of aesthetic values that attract fishers, or temporary closure of fishing areas. A CDE, such as occurred following the DWH accident, could have more noticeable impacts on recreational fishing activity, as well as on individuals and firms that depend on angler spending. Spill effects can be mitigated to some extent through financial compensation and through policies of Federal and State fisheries management agencies. On the basis of the number and size of spills assumed for the proposed action, persistent degradation of shorelines and waters are not likely to occur; therefore, impacts on recreational fishing are not expected to be significant. Impacts of spills on subsistence resources are also discussed in Section 4.4.13 and 4.4.14.

Catastrophic Discharge Event. The PEIS analyzes a CDE that ranges in size from 0.9 to 7.2 million bbl (Table 4.4.2-2). The magnitude of effects from a CDE would depend on the location, timing, and volume of the oil associated with the event. Oil from a CDE could contact intertidal habitat and subsequently contaminate or reduce the abundance of commercial and recreational species that depend on nearshore habitat. However, it is likely that an event would only affect a small proportion of fish species population, and it is unlikely that fish resources would be permanently affected. In the short term, there would be local or regional effects on commercial fishing that as a result of reduced catch, loss of gear, or loss of fishing opportunities during cleanup and recovery periods, and on recreational fishing as a consequence of contamination of fish tissues, the degradation of aesthetic values that attract fishers, and the likely temporary closure of fishing areas.

4.4.11.2 Alaska – Cook Inlet

4.4.11.2.1 Routine Operations.

Commercial Fisheries. With one to three new platforms to be established under the proposed action, up to 4.5 ha (11 ac) of seafloor would be disturbed by offshore platforms, and up to 210 ha (519 ac) by pipelines. Impacts on commercial fishing activities would vary, depending on the nature of a particular structure, the phase of operation, fishing method or gear, and target species group. Routine operations could affect commercial fisheries by causing changes in the distribution or abundance of fishery resources, by reducing the catchability of fish or shellfish, by precluding fishers from accessing viable fishing areas, or by causing losses of or damage to equipment or vessels. It is anticipated that routine operations would not result in detectable effects on overall populations of fishery resources in Cook Inlet. Temporary displacement of fishery resources from localized areas could occur as a consequence of noise and activities associated with construction activities during development; however, these resources would be expected to return once construction disturbances have been terminated. Following platform construction, there could be some highly localized long-term changes in fish densities and species diversity in the vicinity of platforms due to attraction of some invertebrate and fish species.

Some exploration, development, and production activities have a potential to result in space use conflicts with commercial fishing activities. Seismic exploration vessels towing long cables have had a history of conflicts with the commercial fishing industry in Cook Inlet (MMS 2003a), including losses of crab pots, longlines, or other gear. In some cases, commercial fishing vessels could be excluded from normal fishing grounds to avoid the potential for gear loss. Such conflicts can sometimes be avoided by conducting seismic surveys during closed fishing periods or closed seasons. A potential also exists for loss of gear or access to fishing areas when floating drill rigs used for exploration are being moved and during other vessel operations.

Offshore construction of platforms could infringe on commercial fishing activities by excluding commercial fishing from adjacent areas due to safety considerations. It is assumed that up to three production platforms could be constructed as a consequence of leasing in the Cook Inlet Planning Area. If it is assumed that a safety zone of 500 m (1,640 ft) is maintained by larger vessels around each production platform, commercial fishing could be excluded from up to 160 ha (395 ac) of surface area within the planning area. Drilling discharges associated with exploration activities would likely affect only a small area near a drilling platform, and are not expected to interfere with commercial fishing. During development and production phases, potential effects of such discharges would cease because all muds, cuttings, and produced water would be discharged into wells instead of being released to open waters. Potential effects of platform construction and operation are expected to be highly localized. Because only a very small area of the Cook Inlet would be affected, interference with commercial fisheries is also expected to be small.

Construction of pipelines can result in entanglement hazards for some types of fishing gear. The presence of an offshore pipeline would not typically interfere with the use of longlines, purse seines, drift nets (MMS 2004a), or beach seines. However, a bottom trawl, such as those employed by the commercial groundfish industry in Cook Inlet, has a potential to become snagged on exposed pipelines. It is estimated that up to 241 km (150 mi) of additional offshore pipeline could result from lease sales in the Cook Inlet Planning Area, thereby increasing the potential for snagging on pipelines by bottom trawling equipment, unless subsea pipelines are buried in trenches.

It is anticipated that the small increase in vessel activity that could occur as a result of additional lease sales in Cook Inlet under the proposed action (up to six additional trips per week) would not measurably affect commercial fishing opportunities, catchability of fish and shellfish resources, or navigation by commercial fishing vessels.

The impact of oil and gas structures on commercial fisheries at various depth ranges can be estimated using data from the OECM (BOEMRE 2010d). The model assumes that there will be buffer zones of up to 0.8 km (0.5 mi) around new oil and gas structures, decreasing the area of ocean available for fishing. Although harvesting levels are not affected by offshore structures and pipelines, as these levels are below federally mandated levels, it is assumed that fishing activity will continue in areas still open for fishing, with harvesting levels remaining, but that there will be an increase in fishing costs.

The impacts of oil and gas development on commercial fishing costs would vary considerably by placement depth (Table 4.4.11-2). In the Kodiak area, the largest cost increases would occur with structures located in water between 300 and 1,500 m (984 and 4,921 ft) deep, with an annual increase of $34 in costs from a single structure; a single structure in each depth range would increase annual costs by $44. In the Cook Inlet area, the largest increase would come with a single structure placed in water between 150 and 300 m (492 and 984 ft), with an overall increase in costs of $57 per year. In each of the areas, single structures would have relatively insignificant impacts compared to fishery revenues in each depth range.

Recreational Fisheries. In general, routine operations associated with exploration, development, or production activities could affect recreational fisheries by causing changes in the distribution or abundance of fishery resources, by reducing the catchability of fish and shellfish, by precluding fishers from accessing viable fishing areas, or by causing losses of or damage to equipment or vessels. It is anticipated that routine operations would not result in detectable effects on overall populations of fishery resources in Cook Inlet. Temporary displacement of fishery resources from localized areas could occur as a consequence of noise and bottom-disturbing activities associated with routine operations. Following platform construction, there could be long-term localized changes in fish densities and species diversity due to the attraction of some invertebrate and fish species to platforms.

Seismic surveys could temporarily affect the behavior of some targeted species, thereby affecting catch rates in the immediate area of the surveys. Some recreational anglers could decide to avoid areas during seismic surveys due to the potential for loss of fishing gear, due to the increased vessel activity, or because of perceived or actual changes in catchability. It is estimated that new areas in the Cook Inlet Planning Area could be subjected to seismic surveys

TABLE 4.4.11-2 Impacts of Single Oil and Gas Structures on Commercial Fisheries, by Placement Depth ($2010)

	Kodiak		Cook Inlet	
Placement Depth Range	Fishery Revenue ($m)	Cost Impact ($)	Fishery Revenue ($m)	Cost Impact ($)
0 to 60 m	15.6	–3.34	7.3	–0.04
60 to 150 m	43.7	9.87	2.6	3.88
150 to 300 m	22.8	3.32	7.0	53.50
300 to 1,500 m	23.4	34.07	0.1	0.0
More than 1,500 m	1.3	0.26	0.0	0.0
All depths	106.9	44.18	17.0	57.35

Source: BOEMRE 2010d.

during the Program. However, given the relatively small proportion of the available Cook Inlet area that would be affected at any particular time, it is not anticipated that seismic surveys would greatly disrupt recreational fishing activities.

Offshore construction of platforms could infringe on some recreational fishing activities by excluding recreational fishing boats from adjacent areas for safety considerations. It is assumed that up to three production platforms could be constructed as a consequence of lease sales in the Cook Inlet Planning Area. However, the area lost to recreational fishing would be limited to the immediate footprint of the platforms plus a small safety zone surrounding each platform; only a very small proportion of available recreational fishing areas in Cook Inlet would be affected. The presence of such platforms could also benefit anglers by aggregating some pelagic or groundfish species.

Vessel traffic to provide support to OCS activities could increase by one to three trips per week. This would constitute a very small increase in overall vessel traffic in Cook Inlet. The potential increase in daily helicopter trips in the Cook Inlet area would not be expected to affect recreational fishing activities. Disturbances of recreational fishing opportunities from other activities associated with routine operations (e.g., pipeline construction) are also expected to be relatively minor and temporary.

4.4.11.2.2 Accidents.

Commercial Fisheries. Fisheries resources could become exposed to oil as a consequence of accidental oil spills. One large spill greater than 1,000 bbl, up to 3 spills between 50 and 1,000 bbl, and up to 15 small spills less than 50 bbl could occur in the Cook Inlet area from the proposed action.

Although pelagic fishes would be less likely to be affected than fishes in shallow subtidal or intertidal areas, oil spills could contaminate gear used for commercial fishing, such as purse seines and or drift nets. A large oil spill before or during the season when such fishing gears are in use could result in closures of some short-period, high-value commercial fisheries in order to protect gears or harvests from potential contamination. Lines from longline fisheries for halibut, Pacific cod, black cod, and other fish species could also be affected by oil. Some lines and buoys fouled with small amounts of oil could be unfit for future use. Although it is unlikely that a trawler would be operating in an oiled area, the trawl catches could be contaminated by oil and rendered unfit for consumption if the trawler did pass through such an area.

The bays and beaches of Cook Inlet have a number of setnet sites where gillnets are anchored to the beach or slightly offshore, and are used to harvest salmon and herring. Oil spills could damage setnet fisheries, as evidenced by the *Exxon Valdez* oil spill in 1989. While only a relatively small volume of weathered oil entered the lower Cook Inlet region as a result of the *Exxon Valdez* spill, the commercial salmon fishery was closed to protect both gear and the harvest from possible contamination.

Multiple small spills or a single large spill could cause declines in subpopulations of some species inhabiting the Cook Inlet Planning Area, although the level of effects would depend on a variety of factors. It is anticipated that there would be no long-term effects on overall fish populations in the central Gulf of Alaska. However, even localized decreases in stocks of fish could have effects on some commercial fisheries by reducing their catch or increasing the amount of effort or the distances that must be traveled to obtain adequate catches. Even if fish stocks are not reduced as a consequence of a spill, specific fisheries could be closed due to actual or perceived contamination of fish or shellfish tissues. Larger spills in Cook Inlet would probably result in the area being temporarily closed to commercial fishing until cleanup operations or natural processes reduced oil concentrations in fishery areas to levels considered safe. The Cook Inlet commercial shellfish industry is likely to be affected by closures because such a spill would be likely to affect shellfish in nearshore subtidal and intertidal areas. Fisheries for shellfish that occur in deeper waters, where oil residues seldom reach, are less likely to be closed. Shellfish from deeper areas could become commercially unacceptable for market due to actual or perceived contamination and tainting.

Closure of Cook Inlet to commercial fishing activities could result in considerable loss of income. Based on analyses conducted by MMS for Cook Inlet oil spills of the same sizes assumed for large spills in this analysis and assumptions about the value of commercial fisheries in Cook Inlet, it was estimated that a large oil spill in lower Cook Inlet could result in economic losses to commercial fisheries for up to 2 yr (MMS 2003a), and, depending on the timing and location of a spill, it was also considered possible that the fishery could be closed for a whole season, resulting in a 100% loss for a given year.

Recreational Fisheries. Recreational fishery resources could be exposed to oil as a consequence of accidental oil spills. Up to 1 large spill greater than 1,000 bbl, up to 2 spills between 50 and 1,000 bbl, and up to 10 small spills less than 50 bbl could occur in the Cook Inlet area from the proposed action.

While it is anticipated that these spills would not affect the overall populations of fishes in the central Gulf of Alaska, some fish stocks in localized areas of Cook Inlet could be affected. Populations of intertidal organisms could be depressed measurably for a year or more in intertidal areas contacted by spilled oil. Oil contacting beaches could affect clam gathering by depressing clam populations or tainting tissues of clams. The magnitude of such effects would depend upon many factors, including the volume of oil spilled, weather conditions, prevailing currents, locations, oil spill response actions, and whether the oil reached sensitive habitats for fishery resources. Declines in localized fish stocks could affect recreational fishing success and businesses associated with providing recreational and sport fishing opportunities.

An oil spill could result in a closure of ports in an effort to protect the ports and vessels from being oiled. Oil spills could potentially cause economic losses for boat owners and anglers by contaminating vessels and fishing gear. Oiled vessels would need to be cleaned and oiled gear either cleaned or replaced; potential individual costs are expected to be relatively small. It is anticipated that many anglers would choose to fish in alternate areas in the event of port closures. Charter operators could be inclined to temporarily avoid going out of port into Cook Inlet to avoid fouling their gear and vessels with oil. Public perception of oil spill damage could temporarily reduce the number of anglers. If so, anglers would likely target alternate fishing areas until they deemed that the quality of the fishing experience in the oil spill area had returned to previous conditions.

While charter operators could lose business in the event of a large spill, a report on the July 2, 1987, *Glacier Bay* tanker oil spill found "no measurable impacts" on sportfishing from that spill (Northern Economics 1990). It is estimated that 3,100 bbl of oil were spilled. Although several popular sportfishing runs had already ended when the spill occurred, the busiest season was beginning for the halibut charter boat fishery, and the second-run Kenai salmon sport fishing season was just opening for the year. The study found no evidence of losses in these sportfisheries due to oil-fouled boats or gear, loss of fishing opportunity, or harvest of oil-fouled fish that had to be discarded (with only one exception). In addition, the numbers of fish caught did not appear to be affected, and customers did not cancel reservations because of concerns about the spill. Very large oil spills could have greater impacts, especially if the oil reached large areas of intertidal habitat. Studies following the *Exxon Valdez* oil spill suggest that a very large oil spill could have the potential to reduce or contaminate populations of recreationally popular salmon and shellfish in heavily oiled areas for more than 10 yr. For example, pink salmon had elevated egg mortality for at least 4 yr after the spill (Peterson et al. 2003), and littleneck and butter clam populations were reduced for a decade after the spill, although much of the slow recovery may have resulted from cleanup methods used in intertidal areas (*Exxon Valdez* Oil Spill Trustee Council 2009a). Contamination of shellfish may persist even after populations recover. Species less dependent on intertidal soft sediments, such as rockfish, are less likely to be affected. Impacts of spills on subsistence resources are discussed in Section 4.4.13 and Section 4.4.14.

Catastrophic Discharge Event. The PEIS analyzes a CDE that ranges in size from 75 to 125 thousand bbl (Table 4.4.2-2). The magnitude of effects from a CDE would depend on the location, timing, and volume of the oil associated with the event. Oil from a CDE could contact intertidal habitat and subsequently contaminate or reduce the abundance of commercial and recreational species that depend on nearshore habitat. However, it is likely that an event would only affect a small proportion of fish species population, and it is unlikely that fish resources would be permanently affected. In the short term, there would be local or regional effects on commercial fishing that as a result of reduced catch, loss of gear, or loss of fishing opportunities during cleanup and recovery periods, and on recreational fishing as a consequence of contamination of fish tissues, the degradation of aesthetic values that attract fishers, and the likely temporary closure of fishing areas.

4.4.11.3 Alaska – Arctic

4.4.11.3.1 Routine Operations. There is a relatively small salmon fishery in Kotzebue Sound in Hope Basin, but there are no commercial fisheries in the Chukchi Sea Planning Area where routine operations would occur (MMS 2006b). Consequently, no impacts from routine operations are anticipated. The single commercial fishery in the Beaufort Sea is for cisco and whitefish on the Colville River during the summer and fall months. The potential for negative effects on this fishery would be related to the timing of exploration and development activities and the proximity of those activities to the mouth of the Colville River. Because exploration and development of this area has already occurred, it is considered unlikely that there would be substantial levels of additional development as a result of the proposed action. In addition, impacts would be limited in scope as a result of adherence to mitigation measures and compliance with Federal, State, and local requirements. Therefore, impacts on this fishery are also anticipated to be limited in scope. Similarly, impacts on recreational fisheries from routine operations are expected to be negligible, as little recreational fishing occurs in the Beaufort and Chukchi Sea Planning Areas (NPFMC 2009).

4.4.11.3.2 Accidents. Up to 3 large spills greater than 1,000 bbl, between 10 and 35 spills between 50 and 1,000 bbl, and up to 190 small spills of less than 50 bbl could occur in the Beaufort and Chukchi Sea areas from the proposed action.

Recreational fishing in the Beaufort and Chukchi Sea Planning Areas is very limited and generally occurs only at larger population centers. However, where and when recreational fishing does occur, an oil spill could reduce fishing activity or contaminate fishery resources. Commercial fishing in the Beaufort and Chukchi Sea Planning Areas is restricted to the Colville River. The occurrence of an oil spill near commercial fishing areas during the fishing season could have effects on particular fisheries and the local economies that depend on them. Oil spills typically result in the closure of fishing grounds and reduced or lack of harvest. Even if harvest continues, the perception of a tainted product could reduce the economic value of fish harvested in the vicinity of an oil spill or could even cause fish to be removed from markets.

Spills could foul fishing gear, result in fish contamination and mortality, and potentially close some fishing grounds or entire fisheries for one or more years. A large spill could also increase competition on alternative fishing areas that remain open, resulting in increased costs and/or reduced harvests for individual fishermen. There is a reduced chance of a spill occurring during pulse fisheries of short duration, such as those for salmon, herring, or whitefish, because of the relatively short period of time that such fisheries are open. However, if a spill were to occur during operation of such a fishery, potential impacts would include a total loss of commercial fishing harvest due to the inability to switch to an alternative fishing time or area. Impacts of spills on subsistence resources are discussed in Section 4.4.13 and Section 4.4.14.

Catastrophic Discharge Event. The PEIS analyzes a CDE that ranges in size from 1.4 to 2.2 million bbl in the Chukchi Sea Planning Area and from 1.7 to 3.9 million bbl in the Beaufort Sea Planning Areas (Table 4.4.2-2). The magnitude of effects from a CDE would depend on the location, timing, and volume of the oil associated with the event. Oil from a CDE could contact intertidal habitat and subsequently contaminate or reduce the abundance of commercial and recreational species that depend on nearshore habitat. However, it is likely that an event would only affect a small proportion of fish species population, and it is unlikely that fish resources would be permanently affected. Although commercial and recreational fishing in the Arctic region are of minor economic significance, in the short term, there would be local and regional economic impacts resulting from reduced catch, loss of gear, or loss of fishing opportunities during cleanup and recovery periods, and on recreational fishing as a consequence of contamination of fish tissues, the degradation of aesthetic values that attract fishers, and the likely temporary closure of fishing areas.

4.4.11.4 Conclusion

Routine operations could affect commercial fisheries by causing changes in the distribution or abundance of fishery resources, by reducing the catchability of fish or shellfish, precluding fishers from accessing viable fishing areas, or causing losses of or damage to equipment or vessels. No population-level effects or permanent loss of fishery resources are expected to result from routine operations in the GOM or Cook Inlet. Commercial and recreational fisheries in the Beaufort and Chukchi Sea Planning Areas are relatively small and localized. Impacts on these fisheries are unlikely, since OCS activities would not occur in the immediate area near these fisheries. Impacts to commercial and recreational fisheries from routine Program activities are expected to be minor.

The magnitude of effects from accidental spills would depend on the location, timing, and volume of spills, in addition to other environmental factors, and would be greatest in the event of a CDE-level spill. Small spills that may occur under the proposed action are unlikely to affect a large number of fish or have a substantial effect on recreational fishing before dilution and weathering reduced concentrations of oil in the water. Consequently, it is anticipated that small spills would have little effect on commercial and recreational fishing. Any single large spill would likely affect only a small proportion of a given fish population within the GOM, Cook Inlet, and Beaufort and Chukchi Seas, and it is unlikely that fish resources would be permanently affected. However, large spills could have localized effects on commercial fishing that could result as a consequence of reduced catch, loss of gear, or loss of fishing opportunities during cleanup and recovery periods, and on recreational fishing as a consequence of contamination of fish tissues, degradation of aesthetic values that attract fishers, or temporary closure of fishing areas. Oil from large or very large spills could contact intertidal habitat and subsequently contaminate or reduce the abundance of commercial and recreational species that depend on nearshore habitat. Impacts from a large spill could be long term, but are not expected to result in permanent loss of fishery resources. In the event of a CDE-level spill, fisheries recoveries could be impacted on a manner similar to that from a large spill. However, a larger proportion of a fish population could be affected, and impacts could be much more long-term on duration.

4.4.12 Potential Impacts to Tourism and Recreation

4.4.12.1 Gulf of Mexico

4.4.12.1.1 Routine Operations. In addition to the continuing use of existing onshore support and processing facilities, between 4 and 6 new pipeyards, less than 12 new pipeline landfalls, and as many as 12 new gas processing facilities are projected to be built as a result of the Program. Additional offshore construction could include increased noise and traffic, air and water pollution, impacts on residential property values, and land use changes. As it is likely that onshore facilities would be placed near other commercial areas zoned for such development, certain coastal areas could also be closed temporarily to accommodate the construction of new facilities, while underground pipeline construction could occur near important recreational areas. Routine operations would have limited effects on recreation and tourism, with potential adverse aesthetic impacts on beach recreation and sightseeing and potential positive impacts on diving and recreational fishing.

The proposed action is expected to result in 300 to 600 service-vessel trips and 2,000 to 5,500 helicopter operations weekly. Although service vessels are assumed to use established nearshore traffic lanes and helicopters are assumed to comply with areal clearance restrictions at least 90% of the time, additional helicopter and vessel traffic would add a low level of noise pollution that could affect beach users. Routine OCS traffic can cause minor disturbances to recreational resources, particularly beaches, through increased levels of noise, debris, and rig visibility. Although the proposed action has the potential to directly and indirectly impact recreational resources along the GOM coast, the small scale of OCS activities relative to the scale of the existing oil and gas industry is such that these potential impacts on recreational resources are likely to be minimal. There may also be minor space-use conflicts with recreational fishermen during the initial phases of the proposed action and low-level environmental degradation of fish habitat, which would negatively impact recreational fishing activity. However, these minor negative effects would likely be outweighed by the beneficial role that oil rigs serve as artificial reefs for fish populations. The degree to which oil platforms will become a part of a particular State's rigs-to-reefs program will be an important determinant of the degree to which the proposed action will impact recreational fishing activity in the long term.

The broader economic implications of the proposed action would be felt primarily on the GOM coast of Texas. The Texas coastline features an important barrier island system that supports a broad range of beach-related activity, and the visual, debris, and noise related issues could impact beach-related activity at these locations. However, given the expansive oil and gas industry already in place, as well as the distance oil platforms in Texas maintained from shore, beach-related disruptions due to OCS operations are expected to be minimal.

4.4.12.1.2 Accidents. Up to 8 large spills greater than 1,000 bbl, between 35 and 70 spills between 50 and 1,000 bbl, and up to 400 small spills less than 50 bbl could occur in the GOM from the proposed action. It is reasonable to expect that most of these spills will occur in deepwater areas located away from the coast, based on the established trend for oil and gas activity to move into deep waters located for the most part at a substantial distance from the coast.

Temporary impacts would occur if an oil spill reached a beach or other recreational use area. The magnitude of these impacts would depend on factors such as the size and location of the spill, and would likely be greatest if the spill occurred during the peak recreational season. A number of studies (see Section 3.1.3) have shown that there could be a one-time seasonal decline in tourist visits of 5 to 15% associated with a major oil spill.

Catastrophic Discharge Event. The PEIS analyzes a CDE that ranges from 0.9 to 7.2 million bbl (Table 4.4.2-2). The effects from a catastrophic discharge event would likely include beach and coastal access restrictions, including restrictions on visitation, fishing, or hunting while cleanup is being conducted, and aesthetic impacts associated with the event itself and with cleanup activities. These impacts are expected to be temporary, with the magnitude dependent on the location and size of the event and the effectiveness of cleanup operations. Longer-term impacts may also be substantial if tourism were to suffer as a result of the real or perceived impacts of the event, or if there were substantial changes to tourism and recreation sectors in the region as a result of the event.

4.4.12.2 Alaska – Cook Inlet

4.4.12.2.1 Routine Operations. Although no new pipe yards, pipeline landfalls, or gas processing facilities would be built as a result of the proposed 5-yr program, additional offshore construction could include increased noise and traffic, air and water pollution, impacts on residential property values, and land use changes. Oil and gas development under the proposed action in the south central Alaska region would occur in the vicinity of previous development. The additional development would not alter the character of the area, because similar infrastructure is already present. Effects on scenic quality would be temporary and localized, and would be most noticeable during heavy periods of industrial activity, such as during drilling or pipelaying. Temporary closure of certain areas to recreation would likely be necessary, but would be limited in size and duration. A small increase in the amount of trash and debris washing ashore may also occur as a result of the development. The frequency of helicopter and vessel traffic to and from the new platforms would be consistent with that of existing platforms, but would contribute marginally to the impact on scenic quality and add to the industrial noise. The magnitude of these impacts would be small and vary with the distance of these activities from existing parks and wildlife refuges, primary recreational use areas, and cruise line paths. During the short period of construction, the increased workforce could impact lodging accommodations for tourists during peak times; however, impacts would depend on the timing and location of the activities and the availability of a local workforce.

4.4.12.2.2 Accidents. One large spill greater than 1,000 bbl, up to 3 spills between 50 and 1,000 bbl, and up to 15 small spills less than 50 bbl could occur in the Cook Inlet area from the proposed action. These oil spills would be responded to primarily by existing response facilities along the coast and existing shore bases according to spill response protocols. Potential impacts on recreation and tourism resulting from an oil spill would likely include direct land use impacts (e.g., from oil contamination at a coastal area), access restrictions to a particular area (e.g., no fishing or hunting while cleanup is conducted), and aesthetic impacts of the spill itself and cleanup operations. These impacts are expected to be temporary, but could last an entire season. However, because of public perceptions resulting from the *Exxon Valdez* oil spill in

Prince William Sound, tourism in the region may respond more strongly than would tourism in other regions. The magnitude of the impacts would depend on the location and size of the spill and the effectiveness of cleanup operations.

Catastrophic Discharge Event. The PEIS analyzes a CDE that ranges in size from 75 to 125 thousand bbl (Table 4.4.2-2). The effects from a CDE would likely include beach and coastal access restrictions, including restrictions on visitation, fishing, or hunting while cleanup is being conducted, and aesthetic impacts associated with the event itself and with cleanup activities. These impacts are expected to be temporary, with the magnitude dependent on the location and size of the event and the effectiveness of cleanup operations. Longer-term impacts may also be substantial if tourism were to suffer as a result of the real or perceived impacts of the event, or if there were substantial changes to tourism and recreation sectors in the region as a result of the event.

4.4.12.3 Alaska – Arctic

4.4.12.3.1 Routine Operations. Although no new pipe yards, pipeline landfalls, or gas processing facilities would be built as a result of the proposed 5-yr program, additional offshore construction could include increased noise and traffic, air and water pollution, impacts on residential property values, and land use changes. Oil and gas development activities could result in minor impacts on recreation and tourism in the Arctic region. The main recreation and tourism activities that could be impacted by routine oil and gas operations would be sightseeing, hiking, and rafting. Fishing in this region is primarily a subsistence activity rather than a recreational activity. Impacts on sightseeing might be viewed as being negative, with adverse aesthetic impacts from offshore platforms and possible increases in construction projects for gas processing facilities and new offshore pipelines to connect to existing onshore pipelines in the Chukchi Sea area. Impacts on these recreational activities would depend on the proximity of the new construction to the recreational use areas (such as whether they are in view of existing parks and refuges).

The additional development would not alter the character of the area, as similar infrastructure is already present. Effects on scenic quality would be temporary and localized, and would be most noticeable during heavy periods of industrial activity, such as during drilling or pipelaying. Temporary closure of certain areas to recreation would likely be necessary, but would be limited in size and duration. A small increase in the amount of trash and debris washing ashore may also occur as a result of the development. The frequency of helicopter and vessel traffic to and from the new platforms would be consistent with that of existing platforms, but would contribute marginally to the impact on scenic quality and add to the industrial noise. The magnitude of these impacts would be small and vary with the distance of these activities from existing parks and wildlife refuges and primary recreational use areas. During the short period of construction, the increased workforce could impact lodging accommodations for tourists during peak times; however, impacts would depend on the timing and location of the activities and the availability of a local workforce.

4.4.12.3.2 Accidents. Up to 3 large spills greater than 1,000 bbl, up to 35 spills between 50 and 1,000 bbl, and up to 190 small spills of less than 50 bbl could occur in the Beaufort and Chukchi Sea area from the proposed action. These spills would be responded to primarily by existing response facilities along the coast and existing shore bases according to spill response protocols. Potential impacts to recreation and tourism resulting from an oil spill would likely include direct land use impacts (e.g., from oil contamination at a coastal area), access restrictions to a particular area (e.g., no fishing or hunting while cleanup is being conducted), and aesthetic impacts (e.g., view of spill and cleanup activities). These impacts are expected to be temporary, and the magnitude of the impacts would depend on the location and size of the spill and the effectiveness of cleanup operations. The greatest potential impacts would occur from large spills in shallow water. The potential for impact would likely decrease with decreasing spill size and increasing water depth.

Catastrophic Discharge Event. The PEIS analyzes a CDE that ranges from 1.9 to 2.2 million bbl in the Chukchi Sea Planning Area, and from 1.7 to 3.9 million bbl on the Beaufort Sea Planning Area (Table 4.4.2-2). The effects from a CDE would likely include beach and coastal access restrictions, including restrictions on visitation, fishing, or hunting while cleanup is being conducted, and aesthetic impacts associated with the event itself and with cleanup activities. These impacts are expected to be temporary, with the magnitude dependent on the location and size of the event and the effectiveness of cleanup operations. Longer-term impacts may also be substantial if tourism were to suffer as a result of the real or perceived impacts of the event, or if there were substantial changes to tourism and recreation sectors in the region as a result of the event.

4.4.12.4 Conclusion

Routine operations would have minor, short-term negative effects on recreation and tourism, with potential adverse aesthetic impacts on beach recreation and sightseeing and potential positive impacts on diving and recreational fishing in the GOM coast; sightseeing, boating, fishing, and hiking activities in the Cook Inlet area; and sightseeing, hiking, and rafting activities in the Chukchi Sea and Beaufort Sea Planning Areas.

Temporary impacts would occur if an oil spill reached a beach or other recreational-use area in the GOM or Cook Inlet. The magnitude of these impacts would depend on factors such as the size and location of the spill, and would likely be greatest if the spill occurred during the peak recreational season. In the event of a CDE-level spill, impacts to tourism and recreation would be long-term and substantial.

4.4.13 Potential Impacts to Sociocultural Systems

4.4.13.1 Gulf of Mexico

As discussed in Section 3.4.1.1, the counties in the GOM coastal commuting zone include a diverse mixture of social classes, cultures, ethnic groups, and communities. They also include a well-established oil and gas industry and support structure focused mainly in Louisiana and Texas. The activities covered under the Program would tend to maintain existing onshore facilities rather than require new ones (MMS 2006a, 2008a). While oil and gas facilities are dispersed along the central and western coast of the GOM, they are not spread evenly. Terrebonne, Plaquemine, and Lafourche parishes in Louisiana are the heart of the oil and gas support industry (MMS 2008a) with Port Fourchon catering to 90% of all GOM deepwater production (BOEMRE 2011a). Sociocultural impacts from routine operations would be small, while impacts from a low-probability catastrophic discharge event could be significant.

4.4.13.1.1 Routine Operations. Routine OCS gas and oil operations include exploration, development, operation, and decommissioning. Although tied to the shore by aircraft, supply vessels, and pipelines, these activities occur well offshore and in increasingly deeper water. The global nature of deepwater activities has contributed to cultural heterogeneity with the importation of migrant workers. A recent study reports that industry employers often hire foreign-born Mexican and Laotian workers in upstream support sectors such as ship and fabrication yards (Hemmerling and Colton 2004). The greater distance of deepwater platforms from coastal communities has resulted in workers being drawn from a wider range of locations in the GOM region, making the ties between local subcultural groups and the offshore industry less consistent. The move father offshore into deep water has also led to longer offshore work shifts and to more “on call” schedules for many workers, including technical experts and mariners (Austin et al. 2002). In the past, development of infrastructure within coastal wetlands has contributed to the shrinking of wetlands and loss of land in Louisiana, resulting in a loss of both subsistence and commercial harvesting areas. However, most new production will be able to tie into the existing pipeline system, so it is unlikely that many new pipeline channels will need to be dredged. Current practice is for pipeline channels to be backfilled, reducing wetland erosion and partitioning of habitat (Hemmerling and Colton 2004).

4.4.13.1.2 Accidents. Accidental spills, including oil spills, chemical spills, vessel collisions, and loss of well control, are possible under the Program (MMS 2008a) (see Section 4.4.2). Between 200 and 400 spills of 50 bbl or less, 35 to 70 spills between 50 and 1,000 bbl, and 8 large spills greater than 1,000 bbl are posited for the GOM Program. Most accidental spills on this scale are likely to be short term and localized. Those occurring well offshore are likely to be cleaned up or dissipate before reaching shore, and would thus have little effect on onshore communities (MMS 2006a). Those occurring in coastal waterways involving OCS support vessels or pipelines (BOEMRE 2011a) would have localized effects on wild resources harvested either commercially or for subsistence purposes. Intertidal and estuarian habitats, where shellfish are harvested and the juveniles of harvested species develop, are the most vulnerable. Most adult fish species seem to be better able to avoid oiled waters. Impacts from small and moderate coastal spills are likely to have localized and short-lived effects. Large spills (over 1,000 bbl) and especially spills of sufficient size to overwhelm cleanup and booming efforts, could significantly affect communities dependent on harvesting renewable wild resources either commercially or for subsistence purposes.

Catastrophic Discharge Event. The PEIS analyzes a CDE that ranges in size from 0.9 to 7.2 million bbl (Table 4.4.2-2). A CDE would have significant sociocultural consequences for populations employed in offshore oil and gas production and in commercial fishing and shrimping, and engaged in subsistence harvesting. A catastrophic discharge event would result in negative and long-lasting social effects (BOEMRE 2011b). Recent studies have shown that major oil releases result in negative and long-lasting social effects. Unlike devastation from hurricanes or other natural disasters that tend to bring communities together to face a common tragedy, oil spills tend to have divisive effects. Technical disasters such as oil spills are deemed as preventable, have a person or organization viewed as primarily responsible, and often can lead to litigation that can last for years (Picou et al. 2009). For example, during the DWH release, large areas of the GOM were closed to all shrimping and fishing (NMFS 2010, 2011). The loss of work placed financial stress on workers in that industry. Some, but not all, shrimpers and fishing boats were employed in the cleanup, creating a division between those who received some financial relief through the cleanup effort and those who did not. The loss of income and potential loss of some subsistence sources create emotional stress stemming from financial stress, often resulting in depression and post-traumatic stress disorder in those who depend on the renewable resources of the sea for their livelihood. An increase in sociological disorders such as domestic violence, substance abuse, and suicide was observed in communities affected by the *Exxon Valdez* spill (Picou and Arata 1997). Similar patterns appear to be emerging among populations that are heavily dependent on fishing along the GOM coast (Picou et al. 1999; Picou 2010), especially among fishing communities already hard hit by Hurricane Katrina (Yeoman 2010). Methods for mitigating social stress by creating a therapeutic community based on a model developed for the *Exxon Valdez* spill are being implemented in the GOM (SAMHSA 2010; MASGC 2011).

While only a small portion of those who live along the northern coast of the GOM are engaged in subsistence harvesting, if oil from a catastrophic discharge event were to reach the shore, it could affect the barrier islands and wetlands important to the harvesting of subsistence resources, including waterfowl, fish, shrimp, and shellfish. If coastal fisheries were contaminated or closed, it would have a significant effect on subsistence harvesting. As a result of the DWH event, close to 30,000 emergency advance payment claims were filed based on the loss of subsistence resources (BOEMRE 2011a). Loss of subsistence resources has economic, nutritional, and cultural consequences.

4.4.13.2 Alaska – Cook Inlet

Finding and developing oil and gas resources on the Cook Inlet OCS has the potential to create adverse effects on sociocultural systems and subsistence. Such effects would range from minor to major depending on the timing, location, and scale of the activity. Many negative consequences could be minimized through appropriate mitigation procedures. The most central of these is establishing and maintaining communication among Native villages, oil companies, and appropriate Federal agencies, including both government-to-government consultation in compliance with legal requirements and U.S. Department of the Interior (USDOI) policy (USDOI 2001) and ongoing dialogue leading to adaptive management of adverse effects.

The areas surrounding the Cook Inlet Planning Area are demographically diverse, including isolated subsistence-based Native villages, towns that rely primarily on commercial fishing, and ethnically and economically diverse cities partly dependent on the oil industry. There have been oil and gas operations in Cook Inlet since the late 1950s, and the surrounding area is home to a well-established gas and oil infrastructure that could accommodate much of any newly developed resource. As discussed in Section 4.4.1.2, under the proposed action, no new shore bases would be constructed, and one new pipeline landfall and possibly one new natural gas processing facility would be built.

Rural communities in the area benefit from oil and gas development throughout the State. However, currently the Federal Government does not share revenues from oil and gas leasing on the OCS with the States, although Alaska has received Federal Coastal Impact Assistance Program (CIAP) funding, because it is an OCS State (Hess 2011; BOEMRE 2011m). Benefits from revenue sharing would only occur if Congress authorizes the sharing of OCS revenues with the OCS States. If such sharing were to occur, OCS activities could be expected to have effects on Alaskan rural communities, through various State programs, proportionate to the percentage of the State budget that relies on revenues from OCS oil and gas production and that is allocated to the affected communities. For the period of the Program, the allocated revenues from OCS oil and gas production would be relatively small.

4.4.13.2.1 Routine Operations. Routine operations under the Program would include exploration for oil and gas resources, development of the resources including infrastructure, operation of the facilities, and decommissioning of the facilities. Each of these phases is characterized by different levels of activity, different extent, and different timing. Because the region as a whole has already undergone oil and gas development, each of these phases can take advantage of and tie into existing infrastructure and can draw on an existing pool of experienced workers (MMS 2003a). The Cook Inlet area has already experienced the impacts of oil and gas development, and would also experience both the positive and negative effects of increased population and employment from the proposed OCS activities. Most area communities are ethnically diverse, with Caucasian majority populations. Native communities tend to be more remote and more difficult to access than non-Native communities, and would be somewhat buffered from the impacts of the proposed action. Overall, impacts of routine operations on sociocultural systems are expected to be minor.

Exploration activities include seismic surveys and the drilling of test wells, activities that are typically conducted from self-contained vessels. Exploration crews would be drawn from an existing pool of trained oil and gas workers in the Cook Inlet area. In-migration for these jobs is expected to be minimal and to have little effect on the current ethnic composition or social structure of the area (MMS 2003a). Exploration activities would likely be supported from existing air and marine facilities on the Kenai Peninsula. No additional facilities would be required. Industrial activities associated with exploration would not be new to the area, but would continue existing operations. There would be very little in-migration for exploration jobs because of the existing trained labor pool and the fact that exploration rig crews are normally contracted with the vessel. Exploration activities are not expected to result in measurable changes in the availability or accessibility of subsistence resources.

Exploration activities could have temporary effects on subsistence harvesting, but are not expected to result in measurable changes in the availability or accessibility of subsistence resources. Cook Inlet personal use and subsistence fisheries are important to all residents of South Central Alaska. Since the Cook Inlet Planning Area lies outside of the Anchorage-Mat-Su-Kenai Peninsula Nonsubsistence Use Area, effects on personal use fishing are not expected. Most of upper Cook Inlet north of Ninilchik is included in the Anchorage-Mat-Su-Kenai Peninsula Nonsubsistence Use Area. While subsistence fishing is not authorized by the Alaska Board of Fisheries in this area, personal use fisheries, open to all Alaska residents who have lived in the state for at least a year, do exist on the Kenai and Kasilof Rivers and Fish Creek that provide an important food source for many families in the Mat-Su-Anchorage-Kenai area (SCADA 2011). More remote subsistence fisheries are accessible to rural communities where customary and traditional uses of fish and wildlife are a principal characteristic of the economy, culture, and way of life. These include Alaska Native communities (ADFG 2011), such as the community of Tyonek, on the west shore of Cook Inlet, and Port Graham and Nanwalek, located on the southern Kenai Peninsula and the Alaska Native communities along the northwestern shore of Kodiak Island.

The effects of exploration on subsistence fishing would be similar to the effects discussed for recreational and commercial fishing in Section 4.4.11.2. Seismic exploration vessels tow long lines that could be entangled with seines, gillnets, long lines, and other gear used by subsistence fishers (MMS 2003a), who may choose to avoid seismic vessels to prevent the loss of gear and thus be kept from their normal fishing grounds. Fishers may also choose to avoid floating exploratory drilling rigs being moved from one location to another for safety reasons and to prevent the loss of gear. Seismic surveys could temporarily affect the behavior of some targeted species, thereby temporarily affecting catch rates in the immediate area of the surveys. Some subsistence fishers could decide to avoid areas during seismic because of perceived or actual changes in catchability. New areas in the Cook Inlet Planning Area could be subjected to seismic surveys during the Program. However, given the relatively small proportion of the available Cook Inlet area that would be affected at any particular time, it is not anticipated that seismic surveys would greatly disrupt subsistence fishing activities. Platform installation activities associated with exploration could temporarily displace seals and possibly some whales from installation sites and because of the noise and movement of aircraft. It is estimated that displaced animals would return to normal behavior and distribution once the operation is complete (MMS 2003a). Effects on subsistence harvesting would vary with the size and duration of the operation.

There would be some direct effects on the subsistence harvest from noise and drilling discharges. Under Federal authority, limited sea mammal harvest and subsistence halibut (and some other non-salmon species) fishing can take place in Cook Inlet. Alaska Natives can hunt marine mammals under the MMPA. Traditionally, beluga whales have been one of the most important marine mammal subsistence resources taken from Cook Inlet at Tyonek. However, this population has experienced a sharp decline and is now endangered. Under current co-management agreements, subsistence harvesting has been suspended to allow the population to recover (Allen and Angliss 2011). After recovery, belugas would once again be available for the village of Tyonek to hunt. Proposed actions should have negligible effects upon this potential harvest. While belugas occasionally inhabit areas where exploration noise and disturbance could occur, in recent years their use of such areas appears to be low. In summer, belugas tend to be concentrated in the extreme upper inlet outside the planning area.

The drilling of exploratory wells would have minimal impact on fish species (see Section 4.4.7.3.2) and subsistence fishers. The estimated volume of drilling discharges from exploration wells would have no effect on fish other than bottom dwellers in the immediate area (within 100 m [328 ft]) of the well at the time of discharge (see Section 4.4.7.1). Drilling muds and cuttings may temporarily limit subsistence fishers to portions of traditional fishing grounds, since the fishers would be required to remain at least 500 m (1,640 ft) away from the drilling platform for safety reasons. Only a very small portion of the available subsistence fishing areas in Cook Inlet would be taken up.

Impacts on marine and coastal birds from exploration activities would be limited to the effects of helicopter flights on nesting or roosting individuals directly or in close proximity to regular flight paths. Effects could include abandonment of roosting or foraging areas, nest abandonment, and lower reproductive success. These effects could last from 1 to 2 years if birds adapt and for the life of the project if they fail to do so (MMS 2003a). Cook Inlet is an important seabird breeding area. All Alaska Native communities surrounding the Cook Inlet Planning Area report the harvesting of seabird eggs and marine and coastal birds including migratory waterfowl (Table 3.14.2-2). This localized, probably temporary displacement of bird populations from traditional subsistence harvest areas would affect subsistence bird and egg harvesters by reducing the availability of the resource and/or requiring harvesters to extend their harvesting range. It is not expected that any resource would become unavailable or that there would be an overall population decrease (MMS 2003a).

Sociocultural effects could result from development and production phases, if the resulting employment were to cause an in-migration into the area that is beyond the capacity of existing sociocultural systems to absorb, or if subsistence harvest patterns were changed. Although new development is likely to create jobs, many of these jobs could be filled from the reservoir of skilled petroleum industry workers in the Cook Inlet area (particularly on the Kenai Peninsula) or filled by others who would commute from outside the area and return home at the end of their shifts or contracted work assignments (MMS 2003a). The effect of job creation on population growth is thus likely to be small. The characteristics of any new population segment are likely to be compatible with the towns and cities in which they choose to reside. It is not likely that they will choose to reside in isolated Native villages, unless they are of Native heritage. Any in-migration should do little to change existing sociocultural patterns.

Because oil and gas industry infrastructure already exists in and around Cook Inlet, new construction would be limited to tying new production wells to the existing system. This could entail the construction of new offshore platforms, offshore and onshore pipelines, and a new landfall. Increased turbidity from the construction of platforms and pipelines could disturb pelagic fish important to subsistence fishers and commercial fishers alike, and displacing the fish from their preferred habitat and decreasing their catchability by subsistence fishers. However, disturbance or displacement should be short term — limited to the time of construction and a few hours or days thereafter. The drilling structures themselves may result in changes in species distribution as offshore structures attract and protect some species (MMS 2003a). Cuttings and fluids from production wells would be treated and disposed of in the well. Longlines and hand-held trolls used for bottom fishing and gear such as beach and purse seines could snag on submerged pipelines, causing some loss of gear for subsistence fishers.

A small increase in vessel activity to support platforms (up to six additional trips per week) is anticipated. This small increase should not measurably affect subsistence harvesting opportunities, catchability of fish and shellfish resources, or navigation by subsistence fishers.

Noise associated with drilling rig and support vessel traffic, helicopter flights, platform construction and operation, pipeline construction, and vessel traffic to and from drilling platforms could temporarily disturb belugas, particularly in the winter when they are more often in the lower inlet. While the beluga population in the inlet is in decline and the Cook Inlet stock is endangered, routine industry activities have not been found to contribute significantly to this decline (MMS 2003a). The effects of increased routine industry activity on beluga populations are assessed in Section 4.4.7.1.1.

Effects on marine and coastal birds important to subsistence harvesters would result from helicopter flights and would be similar to those described above for exploration activities.

Airborne and underwater noise would be the main sources of disturbance for marine mammals harvested by Native communities. Noise and disturbance would come from flights and vessel traffic to platforms, offshore pipelaying, platform installation, and very local costal habitat modification at the pipeline landfall. There would also be brief displacement of terrestrial mammals harvested by some communities (see Table 3.14.2-2) (e.g., brown bears, moose) on the Kenai Peninsula from helicopter flights and supply vessel traffic between platforms and onshore facilities.

Effects from well abandonment and decommissioning on wildlife important to subsistence harvesters would be similar to those from construction.

4.4.13.2.2 Accidents. The activities associated with the proposed action are susceptible to oil spills and natural gas releases. While developers are required to submit oil spill response plans, the *Exxon Valdez* oil spill has shown that a catastrophic discharge event can overwhelm existing plans and cause damage to resources important to subsistence harvesters, affect fish populations important to commercial fishers, and have sociological impacts in affected communities.

It is assumed that as many as 15 very small oil spills (50 bbl or less), 3 small oil spills between 50 and 1,000 bbl, and 1 large spill greater than 1,000 bbl and one catastrophic discharge event (250,000 bbl) could occur under the Program (see Section 4.4.2). While most small spills are likely to be contained, small spills may have effects on subsistence resources. Because small amounts of oil spread out rapidly over the ocean surface, forming a thin sheen, and tend to break up into small patches and streamers, an oil spill has to be at least several barrels, perhaps as many as 50, before birds important to subsistence hunters would be at risk. A limited number of birds would be lost. Small oil spills are estimated to have minor effects on mammals sought by subsistence hunters, such as harbor seals, other marine mammals, and terrestrial mammals, with perhaps the loss of a few individuals to oiling and some minor, transient, and local contamination. Subsistence harvesters would consider animals from an oiled context to be tainted and would be less likely to harvest them. Recovery from small spills would probably require no more than a year (MMS 2003a).

One large spill (over 1,000 bbl) is assumed here. Effects of a large spill are likely to be greatest in parts of the Cook Inlet Planning Area that are relatively confined, since oil is more likely to reach the shore and affect important intertidal zones that support the young of many fish species as well as shellfish that form a part of the subsistence harvest. Fishes most likely to be affected by large spills include many that are important to subsistence fishers. They include those that migrate extensively, such as the arctic cisco; those with strong ties to the streams where they were spawned, such as the Dolly Varden; and those tied to nearshore environments (see Section 4.4.7.2.3).

As the ongoing experience with the results of the *Exxon Valdez* oil spill and subsequent cleanup efforts has shown, a major oil spill in the waters of southern Alaska can have significant consequences for sociocultural systems (Fall 2009). Such effects could reduce the availability and/or accessibility of subsistence resources. Typically, this would last for a single season or less, but potentially for longer periods. Resources subject to such impacts include those that are most significant for the area — fish and shellfish — as well as marine mammals and, to some extent, terrestrial mammals. Birds and marine plants (seaweed) would also be at-risk resources that are used locally. A pipeline or platform spill in Cook Inlet could affect subsistence activities on the Kenai Peninsula, Kodiak Island, and the Alaska Peninsula. Lesser spills would have more confined and more limited impacts.

A large spill and cleanup effort can have long-lasting social and psychological repercussions. The sociocultural impacts of oil spills are of at least two types. The first is the result of direct effects upon resources that are used in some way by local residents (i.e., subsistence, tourism, recreation, and elements of quality of life). This includes economic losses for commercial fishers and support businesses.

The second is the impact of spill cleanup efforts in terms of short-term increases in population and economic opportunities, as well as increased demand on community services and increased stress to local communities. In communities based on commercial fishing, the increased demand on community services coincides with a decrease in tax revenues as income from commercial fishing declines. Competition for employment in the cleanup process creates division within communities (Picou et al. 2009).

As is evident from the *Exxon Valdez* event, cleanup efforts can be quite disruptive socially, psychologically, and economically for an extended period of time. While the magnitude of impacts declines rapidly in the first year or two after a large spill, long-term effects continue to be evident. Technological disasters, such as oil spills, have been shown to have more divisive community effects than those of natural disasters (Picou et al. 2009). Such effects can be reduced by the early implementation of coping and mitigation measures (Picou et al. 1999). One important coping measure is the establishment of, and local participation in, an effective spill-response effort that has been formulated into an explicit spill-response plan. Such local programs do have a number of benefits. They provide local employment, a sense of local empowerment, and a means for local resident/oil industry communication. Another coping measure is the establishment of intervention programs such as peer listening programs based on community participation (MMS 2003a; Picou et al. 1999, 2009; Picou 2010).

Oil spills have the potential for significant and long-lasting effects on subsistence-based Native villages and communities. However, Native communities have proven to be flexible and adaptive, mitigating to some extent immediate losses to subsistence harvest resources. Of major concern to Native wild food harvesters relating to oil spills is the contamination of the natural environment. After the *Exxon Valdez* spill, Alaska Natives were fearful that marine and near shore resources had been tainted, placing more trust in traditional environmental knowledge than government agencies. Harvesting of traditional resources dropped off and Alaska Natives relied on stored foods from previous seasons augmented by relief supplies of traditional foods supplied by unaffected villages with whom they had traditional ties and exchange relationships. Nonetheless, over time, social ties appear to have weakened. In the years following the spill, harvesting slowly rebounded, but the composition of the harvest changed, attributed both to long-term loss of resources and continuing fears of tainting (Fall 2009). Nanwalek Native Tom Evans reported in 2003 that “our resources have not recovered” (MMS 2003c). Other sociocultural effects included changes in wild food preferences, changes in traditional roles and status in the communities, disruption of the instruction of children in traditional subsistence knowledge and practices and thus the disruption of the transmission of Native culture, and conflicts with outsiders (MMS 2003a).

Cleanup efforts would also affect subsistence resources. While cleanup strategies would reduce the amount of spilled oil in the environment, thus mitigating negative effects to some extent, disturbance and displacement of subsistence resources would increase from cleanup activities such as offshore skimmers, workboats, barges, aircraft overflights, and *in situ* burning. Deflection of resources resulting from the combination of a large oil spill and cleanup efforts could persist beyond one season, perhaps lasting several years. The result could be a major effect on subsistence harvests and subsistence users, who would suffer nutritional and cultural impacts (MMS 2003a). In addition to effects on subsistence, during the *Exxon Valdez* cleanup, culturally important archaeological resources were damaged or stolen (Picou et al. 2009).

If a natural gas loss of well control occurred, with possible explosion and fire, subsistence resources such as fish, birds, and beluga whales in the immediate vicinity of the loss of well control could be killed, if the loss of well control occurred below or on the water surface. Natural gas and gas condensates that did not burn would be hazardous to any organism exposed to high natural gas and gas condensate concentrations. Natural gas vapors and condensates disperse rapidly and would not affect subsistence resources beyond the immediate area. High concentrations would not occur if the loss of well control occurred on the top of a platform where they would disperse more rapidly. Effects from losses of well control are likely to be short term and local, lasting a year or less and extending for about 1.6 km (1 mi) (MMS 2003a).

Catastrophic Discharge Event. The PEIS analyzes a CDE that ranges from 75 to 125 thousand bbl (Table 4.4.2-2). It is likely that a CDE would cause significant damage to resources important to subsistence harvesters, affect fish populations important to commercial fishers, and have sociological impacts in affected communities. Alaska Native subsistence harvesters would consider marine mammals from an oiled context to be tainted and would be less likely to harvest them. Since the waters of the Cook Inlet Planning Area are relatively confined, oil from a catastrophic discharge is likely to reach the shore and affect important intertidal zones that support the young of many fish species as well as shellfish that form a part of the subsistence harvest. Fishes most likely to be affected by large spills include many that are important to subsistence fishers. They include those that migrate extensively, such as the arctic cisco; those with strong ties to the streams where they were spawned, such as the Dolly Varden; and those tied to nearshore environments.

A CDE in the waters of south central Alaska and the resulting cleanup are likely to have significant consequences for sociocultural systems and can have long-lasting social and psychological repercussions. The sociocultural impacts would include effects upon resources that are used in some way by local residents (i.e., subsistence, tourism, recreation, and elements of quality of life), and economic losses for commercial fishers and support businesses. In past catastrophic discharge events, the loss of livelihood for both commercial and subsistence fishers can result in depression and an increase in suicide and other pathological behavior, as can participation in protracted litigation resulting from the spill (Picou et al. 2009, Fall et al. 2009).

Cleanup efforts resulting from a CDE would result in short-term increases in population and economic opportunities, as well as increased demand on community services and increased stress to smaller local communities. In communities based on commercial fishing, the increased demand on community services coincides with a decrease in tax revenues as income from commercial fishing declines. Competition for employment in the cleanup process creates division within communities (Picou et al. 2009).

Disturbance and displacement of subsistence resources would increase from cleanup activities such as offshore skimmers, workboats, barges, aircraft overflights, and *in situ* burning. Deflection of resources resulting from the combination of a large oil spill and cleanup efforts could persist beyond one season, perhaps lasting several years. The result could be a major effect on subsistence harvests and subsistence users, who would suffer nutritional and cultural impacts (MMS 2003a).

4.4.13.3 Alaska – Arctic

As was the case for Cook Inlet, finding and developing oil and gas resources on the arctic OCS has the potential for creating adverse effects on sociocultural systems and subsistence.

Such effects would range from minor to major depending on the timing, location, and scale of the activity. Many negative consequences could be minimized through appropriate mitigation procedures. The most central of these would be establishing and maintaining communication among Native villages, oil companies, and appropriate Federal agencies, including both government-to-government consultation in compliance with legal requirements and USDOI policy (USDOI 2001) and ongoing dialogue leading to adaptive management of adverse effects.

As discussed in Section 3.14.3.1, the northern and northwestern coasts of Alaska are the home of indigenous Iñupiat communities confronted with increasing industrialization tied to mineral extraction. While it is clear that industrialization in northern Alaska has had significant economic and social effects, until now, the industrial workforce building and operating the expanding oil and gas extraction facilities has been largely non-local and transient, residing in self-sufficient enclaves far removed from Native villages and, for the most part, placing little strain on village government resources. However, as expressed by Alaska Natives in scoping meetings (BOEMRE 2011c–f), as oil and gas production infrastructure expands both onshore and into the Arctic Ocean, the indigenous villagers feel their traditional subsistence-based lifeway is being constrained and their cultural values threatened.

As expressed by Carla Sims Kayotuk in the 2011 Kaktovik scoping meetings: "I do not want to see that [sociocultural] change for our community. It has changed some, but I don't want to see any more negative changes happen. And I strongly believe that if offshore development, even onshore development [continues], that's going to happen and our community will never be the same again. And I know change happens. Culture changes, traditions change, but I think it's going to be a very negative impact on us" (BOEMRE 2011c).

The Iñupiat are closely tied to the land and the sea. Subsistence harvesting and the distribution of the subsistence harvest through kin and social networks based on cultural ideals of community and sharing are core values of Iñupiat culture. To the extent that oil and gas activities in or close to Native villages adversely affect the subsistence harvest or limit cultural continuity, they have a negative impact on Iñupiat sociocultural systems. In addition, new development may result in an influx of outsiders who do not share Iñupiat values and mores, resulting in stress on indigenous sociocultural systems. For example, all Iñupiat villages on the North Slope are "dry," and in some of them the importation of alcohol is illegal. These values may not be shared by oil workers coming from outside Iñupiat communities.

The Iñupiat harvest a wide range of wild animal and plant resources including bowhead and beluga whales, seals, walrus, polar bears, fish, waterfowl, and caribou (see Section 3.14.3.1). For coastal communities, the most iconic harvests are the bowhead and beluga whale hunts. These lie at the heart of Iñupiat social system and sense of cultural identity.

"If you ever see this young kid as a young man [become] a whaler, it's like an individual that lives in [the city], has a dream of becoming a pilot or [having] a career of some sort. But when you are a Native, it's always been being a provider to the community, be a hunter. That's the culture of Iñupiat. Pass on the traditions that's been passed on to us for thousands of years," said Isaac Nukapigak from the village of Nuiqsut (BOEMRE 2011d).

Native Alaskans often refer to the Chukchi and Beaufort Seas as the Iñupiat garden or Garden of Eden and are extremely concerned about loss of resources from oil spills and pollution, and from changes in patterns of wildlife migration resulting from industrial activities. In the words of Raymond Aguvluk, a local resident, at the 2011 Wainwright scoping meeting for this PEIS "We eat from out there, you know. And [are] you guys going to send us chicken or steak? No way. We love our garden out there" (BOEMRE 2011e)

Marine mammals and fish are the resources of most concern, as they constitute a major part of the subsistence harvest and typically are the resources most likely to be directly affected by oil and gas activities on the OCS. Land mammals, particularly caribou, are also important subsistence resources, but would be affected more by transportation pipelines and other support infrastructure tied to OCS development than directly by oil and gas activities on the OCS. Oil spills that have occurred elsewhere in Alaska have resulted in negative consequences for subsistence resources and activities, but routine exploration, development, and operation could also potentially result in negative effects.

4.4.13.3.1 Routine Operations. Routine oil and gas operations may be divided into four categories or phases: exploration, development, operations, and decommissioning. Exploration on the OCS, whether using seismic surveys or test wells, is done from largely self-contained ocean-going vessels, and in the past has had little direct impact on the infrastructure of local communities (MMS 2007a, 2008b). Exploration ships do require onshore support facilities. Exploration in the Beaufort Sea using existing facilities at Prudhoe Bay/Deadhorse and Barrow would result in little new impact. Conversely, exploration plans filed for the Chukchi Sea include development of an onshore base in Wainwright that would use some village infrastructure and services. With a staff of 22 to 64 individuals, it would include a helipad, fuel storage, lift and hoist facilities near existing boat ramps, and temporary housing for vessel crews weathered in while being changed (Shell 2009a,b). The local village corporation has built is crew quarters (Burwell 2011; Anchorage Daily News 2010). Having the shore base in the village would likely increase interaction between transient workers and Wainwright Native Alaskans, with the potential for changing cultural dynamics, including conflicts arising from differing behavioral norms and the adoption of Western cultural traits by indigenous communities. The presence of the onshore base would also provide some employment opportunities for Native Alaskans (Shell 2009b). Cultural conflicts may be minimized through cultural awareness orientation stipulated in lease contracts so in-migrant workers are made aware of Native Alaskan cultural values including the importance of the subsistence harvest to local communities. Lease stipulations would require developers to submit plans that orient new in-migrant workers to the local Alaska Native culture, including subsistence, in advance (MMS 2007a).

Of great concern to local populations is the noise created by seismic survey air guns and test drilling rigs during exploration and their potential for disturbing or driving away the migratory sea mammals upon which subsistence communities depend. Iñupiat whalers generally agree that whales and other marine mammals are more sensitive to noise than Western scientific studies suggest and will avoid noise sources, and that they have been disturbed from their normal patterns of behavior by past seismic and drilling activities. According to Kaktovik whaling captain George Kaleak, Sr., "The sound can go over 50 miles, and whales can hear it" (BOEMRE 2011c). Noise and other associated activities can make whales less predictable and more dangerous to those who hunt them. They can be deflected from their usual migration routes into deeper, more dangerous waters, where they are more difficult to take and bring home successfully. Whalers from Barrow, Nuiqsut, and Kaktovik have been especially vocal on this issue, as they are most likely to be directly affected by such activities during the fall open water season.

Isaac Nukapigak, a Nuiqsut whaling captain explained at scoping meetings held in 2011: "At one point, I remember us being out there for 7 weeks and didn't meet our quota because of [oil and gas exploration] activities and weather prediction where our subsistence hunt and the whales were disrupted because of this heavy activity going on in the Beaufort. We had to go 30 miles north. That's where we finally were able to see whales because there was so much activity east of Cross Island. And that time we had no choice because a whale was got 35 miles north of Cross Island because of … safety [in] these small boats that we go out in to harvest, weather prediction got bad on us. We had no choice but to let go of the whale even though we didn't want to. And that year was so harsh because we didn't meet our quota. It was very noticeable in this community. There was no whale meat stored in our cellars. People were hurting" (BOEMRE 2011d).

According to Tom Albert, a former non-Iñupiat senior scientist for the North Slope Borough (NSB) Department of Wildlife Management, "When a captain came in to talk to me, I knew he was going to say that the whales are displaced [by noise] farther than you scientists think they are. But some of them would also talk about 'spookiness,' when the whales were displaced out there and when the whaler would get near them, they were harder to approach and harder to catch" (MMS 1997a).

That marine mammals are sensitive to noise disturbance is clear, although thresholds in terms of signal characteristics and distance for each species have not been established. Generally, such effects would be confined to the vicinity of the seismic vessel and to the actual time of operation. Seismic surveys would occur after July 1 in the open water season, and would thus not affect the spring whale hunt. Deferral of leasing from a corridor along the coast provides a sea mammal migration corridor in the Chukchi Sea. Villagers along the Beaufort coast have requested a similar deferral corridor (BOEMRE 2011d,f). Without mitigation in place, seismic surveys could affect the more important fall hunt and cause subsistence resources to be unavailable and have a major effect on subsistence harvesting. Lease stipulations for whaler-oil industry conflict avoidance agreements (CAAs) and other "non-disturbance" agreements have minimized such problems in the recent past so that noise and disturbance effects of single actions have been, and are expected to be, effectively mitigated. However, such agreements become more difficult to implement if multiple vessels are surveying at the same time. It is expected that required adaptive mitigation and management plans (AMMPs), the requirements of National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) incidental take authorizations, and required consultation with local communities would ensure that impacts on marine mammals would be minimal. Typical requirements include monitoring for the presence of sea mammals and ensuring that supply aircraft routinely fly above elevations that would disturb sea mammals (MMS 2007a, 2008b).

Development would involve the construction of onshore and offshore infrastructure including gravel drilling pads, onshore and offshore pipelines, landfalls, pumping stations, roads, and additional facilities to house an influx of construction workers. While construction has the potential of providing additional local employment, the noise and human presence associated with construction activities are likely to have temporary and localized effects on some subsistence resources and, depending on the location of construction worker enclaves, place stress on the infrastructure of local communities. Operation of the facilities may require fewer workers than construction, many of whom are likely to be transient shift-workers based in other parts of Alaska. The sociocultural impact of these transient workers would depend on the location of new shore-based facilities, and associated enclaves. With a shore-based facility for Chukchi Sea exploration and development is established at Wainwright, it is likely to expand beyond that required for exploration, further increasing the interaction between transient workers and the previously relatively isolated Alaska Native population.

The potential direct and indirect effects of development in the Arctic would result from noise, visual, and traffic disturbances from the construction of pipelines and other offshore and shore-based facilities. Construction activities, including the delivery of fuel and supplies, are limited in time and space and can be scheduled to minimize impacts to subsistence resources. In the past, they have been effectively limited in specified areas during critical periods on subsistence use through industry/subsistence user cooperation (MMS 2008b). The need to install additional platforms in the Arctic could increase the areas and times where either industry or subsistence activities are restricted. This would increase the possibility for significant harvest disruption. Disruption would be made worse if construction and production activities were concentrated in critical subsistence-use areas, which may include cabins and camps. Potential cumulative effects of multiple projects are discussed in Section 4.6.5.3.

Onshore pipeline effects on subsistence would occur during the 1- or 2-year construction period. The major onshore pipeline to be constructed for the proposed action would connect Chukchi Sea oil production with the TAPS or to a possible deepwater port at Kotzebue. Offshore pipeline effects on subsistence would generally be confined to the period of construction and could be mitigated through lease stipulations that would restrict industry activities during critical subsistence-use periods.

The potential disturbance effects of production operations may be more difficult to mitigate, because such activities would be longer term and operate year round. As with construction, the potential direct and indirect effects of routine OCS operations in the Arctic regions derive from noise, visual, and traffic disturbances from the operation of pipelines and other shore-based facilities.

Even when construction is complete, new infrastructure such as roads and pipelines could serve to restrict the movement of land mammals and the access by indigenous populations to onshore subsistence resources such as caribou herds. For example, a pipeline connecting the Chukchi Sea Planning Area with the TAPS would cross a large area that is currently undeveloped except for isolated and relatively small airstrips. This could restrict access by Nuiqsut subsistence hunters, who already could be restricted by oil and gas development in the Coleville River delta the westward expansion of the Prudhoe Bay facilities, and the potential for development to their west in the National Petroleum Reserve in Alaska (BOEMRE 2011d). The potential impact of the pipeline on subsistence resource-use patterns, while unavoidable, can be at least partially mitigated and minimized with proper pipeline design, location, and routing. Potential effects of a pipeline on subsistence users (perceptions of areas they wish to avoid or that are difficult for them to access for hunting) can be addressed with design considerations (for instance, by elevating or burying segments of the pipeline) and by including subsistence users early in the consultation process. The most difficult potential onshore pipeline effects to mitigate would be those related to pipeline servicing and access. If a service road is constructed for this purpose, it would greatly increase impacts on caribou movement and access to subsistence resources on the western part of the North Slope (MMS 2007a). This effect would be greater if such a road were eventually opened to public access, on the model of the Dalton Highway. Roads are also reported to impose substantial maintenance costs on subsistence equipment (snow machines and sleds) and to present some safety issues (Impact Assessment, Inc. 1990). Current practices aim to minimize the construction of new roads. If pipeline servicing was conducted using aircraft, and perhaps ice roads or other ground transport in winter, such potential access effects would be minimized. Increased aircraft traffic in the summer could have a moderate effect on subsistence uses, but such impacts could be reduced through coordination with subsistence users.

The potential effect of pipelines on subsistence resources themselves (in terms of population and behavior) are discussed in Section 4.4.7.13. With regard to caribou, onshore facilities and activities associated with the proposed offshore development program in northern Alaska should have temporary impacts on individual caribou but negligible effects on caribou herds, although development may change their migration patterns and make them less accessible or less desirable. Caribou habituation to gravel pads and oil field infrastructure alters the value of the caribou to subsistence users, who view these habituated caribou as contaminated and not behaving correctly. Frank Long, Jr., stated in the Nuiqsut Alpine Satellite Development Project scoping meeting: "We will have the same problem we did in the Prudhoe Bay and the Kuparuk area with our caribou. Right now, I call our caribou that are existing around here that don't go nowhere our 'industrial dope addict caribou.' They are already sick and nobody's doing anything about them" (MMS 2007a).

Fish are another important subsistence resource. Most petroleum industry activities would occur far from the freshwater or nearshore locations where subsistence harvests are concentrated. However, the construction of gravel causeways has the potential to affect fish migration routes. This can be mitigated by including culverts that allow the fish to pass through. Other effects would include potential reductions in fish populations (or health effects), which have been evaluated in Section 4.4.7.3.3.

Many Iñupiat villagers take the long view of their presence on the North Slope. The Iñupiat lived as subsistence hunters for centuries before the arrival of oil development and expect to remain after the oil and gas reserves have been depleted. They are concerned with decommissioning. The impacts of decommissioning are expected to be similar to those of the construction process. Likewise short-lived and spatially restricted, impacts of noise and traffic on subsistence resources can be mitigated through consultation and scheduling.

The principal sociocultural systems impacts of the proposed action in the Arctic would be due to developing a Shore Base within an Alaska Native community. Additional significant effects would be in the area of subsistence harvesting, with implications for health, population, and the economy. All of these topics, except for health, are discussed in other sections (see Sections 4.4.9, 4.4.10, and 4.4.14). Potential OCS activity would support these established trends. Activity under the proposed program could exert sociocultural effects at the Statewide, regional, and local levels. Income related to OCS development could be expected to support many of the preexisting State programs. At a regional level, OCS activity would constitute one component of continued economic development — primarily onshore and related to the Prudhoe Bay “oil patch” — which has become the prime source of support for most of the infrastructure and local economic development. At a local level, communities might experience adverse sociocultural impacts if development leads to the establishment of shore based facilities, new onshore access routes into the communities, an influx of oil industry personnel into local communities, or local economic benefits from increased local employment opportunities.

Social systems and cultures are seldom, if ever, static. Many changes viewed as sociocultural concerns could also be seen as adaptive change. What is often perceived as the “erosion of cultural values” may only be a transformation or change in the behavioral expression of those values (modes of sharing, expressions of respect). On the other hand, some behavioral changes are more important indicators of cultural and value change than others. That is perhaps why public testimony on the impacts of petroleum development in Arctic Alaska — especially that of Native Elders — has focused on subsistence resources and practices, the relationship of people to the land and its resources, health, increased social pathologies, and the use (and loss) of Native languages. While OCS activity from the proposed action would only contribute incrementally to these effects, it should be recognized that these activities would occur within this context.

Some of the vectors of sociocultural change that have been commonly noted in studies of Arctic Alaska, lease sale documents, or testimony during the lease sale process can be briefly summarized as follows (see MMS 2008b, p. 4-327, and reference therein):

- Changes in community and family organization (availability of wage-labor opportunities locally or regionally, ethnic composition, factionalism, household size);

- Institutional dislocation and continuity (introduction of new institutions, “loss” or de-emphasis of older or more traditional ones, and adaptation of new forms to old content or values, and vice versa);

- Changes in the patterns of overall subsistence activities (time allocation, access, effort, equipment, and monetary needs) and the potential disruption of subsistence harvest activities by industrial development;

- Changes in health measures (a combination of increased access to health care, changes in diet, increased exposure to disease, substance use and abuse, concern over possible exposure to contaminants of various sorts, and other factors);

- Perceived erosion of cultural values and accompanying behaviors (increased social pathologies such as substance abuse, suicide, and crime/delinquency in general; decreased fluency in Native languages; decreased respect for elders; less sharing); and

- Cultural "revitalization" efforts such as dance groups, Native language programs, and official and regular traditional celebrations (such as the reestablishment of *Kivgiq* [the Messenger Feast], for example, in the NSB and the NWAB).

While these are all in some sense generalizations and "analytical constructs," all are also supported by specific testimony of Native residents of the region. These dynamics are not generally viewed as specific to oil and gas development (let alone OCS), but rather as the overall context within which Iñupiat culture must continue to exist (MMS 2008b).

4.4.13.3.2 Accidents. The high degree of dependence of Arctic Native communities on the Beaufort and Chukchi Seas for their subsistence is reflected in the frequency and urgency with which they expressed their concerns over oil spills in the Arctic at public meetings. They are aware of the long-lasting consequences of the *Exxon Valdez* oil spill and of the scale of the effort that was required to cap and clean up after the DWH event in the GOM.

Oil spills have the most potential for adverse effects attributable to the proposed action. Negative effects on specific subsistence species, as well as on the more general patterns of subsistence resource use, persisted in Prince William Sound for years after the *Exxon Valdez* oil spill and the subsequent cleanup effort (Fall 2009).

The impacts of both large and small oil spills are expected to be significant in the Arctic, where oil is more likely to persist in the environment due to colder temperatures. An oil spill of more than 1,000 bbl could, depending on the time and location of the spill event, affect the subsistence use of marine mammals in the region where it occurs. In 1978, Thomas P. Bower, Sr., a whaler from Barrow, reported the results of a 1944 oil spill when a Liberty Ship, the *S.S. Jonathan Harrington*, ran aground southeast of Barrow and dumped fuel oil into the sea to lighten the ship:

According to Bower, about 25,000 gallons of oil were deliberately spilled into the Beaufort Sea in this operation. In the cold, arctic water, the oil formed a mass several inches thick on top of the water. Both sides of the barrier islands in that area — the Plover Islands — became covered with oil. "That first year … I observed how seals and birds who swam in the water would be blinded and suffocated by contact with the oil. It took approximately 4 years for the oil to finally disappear.… I observed that for 4 years after that oil spill, the whales made a wide detour out to sea from these islands" (MMS 2007a).

Although this episode shows that a species can recover after 4 years without cleanup, those years are remembered by subsistence harvesters as a time when subsistence harvest was severely reduced.

It is assumed that as many as 190 very small oil spills (50 bbl or less) and between 35 and 70 small oil spills (more than 50 bbl but no greater than 1,000 bbl) would be associated with the Program in the Arctic (see Section 4.4.2). While most small spills are likely to be contained, small spills may have effects on subsistence resources. Because small amounts of oil spread out rapidly over the ocean surface, forming a thin sheen, and tend to break up into small patches and streamers, an oil spill has to be at least several barrels, perhaps as many as 50, before birds important to subsistence hunters would be at risk. A limited number of birds would be lost. Small oil spills are estimated to have minor effects on mammals sought by subsistence hunters, such as harbor seals, other marine mammals, and terrestrial mammals, with perhaps the loss of a few individuals to oiling and some minor, transient, and local contamination. Subsistence harvesters would consider animals from an oiled context to be tainted and would be less likely to harvest them. Recovery from small spills would probably require no more than a year (MMS 2003a). The effects of prolonged exposure to elevated levels of petroleum hydrocarbons on fish are discussed in Section 4.4.7.3.3. The effects can be lethal or sublethal and have the greatest effect on eggs, larvae, and juveniles, particularly in intertidal zones.

As many as three large spills (over 1,000 bbl) could occur in the Beaufort Sea and Chukchi Sea Planning Areas under the proposed action. As the result of a large spill, the bowhead whale hunt could be disrupted, as could the beluga harvest and the more general and longer hunt for walrus west of Barrow. Animals could be directly oiled, or oil could contaminate the ice floes or onshore haulouts they use on their northern migration. Such animals could be more difficult to hunt because of the physical conditions. Animals could be "spooked" and/or wary, either because of the spill itself or because of the "hazing" of marine mammals, which is a standard spill-response technique in order to encourage them to leave the area affected by a spill. Oiled animals are likely to be considered tainted by subsistence hunters and would not be harvested, as occurred after the *Exxon Valdez* spill. This would also apply to terrestrial animals, such as bears that scavenge oiled birds and animals along the shore, or caribous that seasonally spend time along the shore or on barrier islands seeking relief from insects.

Although developers must submit oil spill response plans and have spill response vessels available, there has been little experience with under-ice or broken-ice oil spills. While the concern is most typically phrased in terms of the potential effects of oil spills on whales and whaling, it can be generalized to a concern for marine mammals and ocean resources in general. Fishes most likely to be affected by large spills include many that are important to subsistence fishers. They include those that migrate extensively, such as the arctic cisco; those with strong ties to the streams where they were spawned, such as the Dolly Varden; and those tied to nearshore environments, such as broad whitefish (see Section 4.4.7.3.3). Marine mammals and fish typically comprise 60% of a coastal community's diet. Pipeline and platform spills could also impact migrating anadromous fish in the river deltas, as well as species that use oiled coastal and nearshore habitat, such as nesting birds, breeding caribou, and the like. Overall, the impacts of oil spills on subsistence practices and resources are variable, ranging from minor to major, depending on the size, location, and timing of the spill. As shown by the results of the *Exxon*

Valdez spill, subsistence harvesters in unaffected areas are likely to share resources with impacted villages through established social networks. While local ties are regularly strengthened through mutual exchange, they can weaken when there is less to exchange (Picou et al. 2009).

Cleaning up a major spill is likely to have negative consequences as well. Cleanup activities and increased human presence could displace subsistence species from their usual harvesting locations. There are relatively few vessels on the northern coast that could participate in the cleanup of a major spill. It is likely that whaling boats and their crews would be diverted for this purpose. Depending on the timing of the spill, this would make them unavailable for the whale hunt. While local villagers would be employed in the cleanup, it is likely that many additional workers would be necessary, placing stress on village facilities. An influx of outsiders is likely to result in some cultural conflict, stressing the local sociocultural systems.

As is evident from the *Exxon Valdez* oil spill event, such cleanup efforts can be disruptive socially, psychologically, and economically for an extended period of time. While the magnitude of impacts declines rapidly in the first year or two after a large spill, long-term effects continue to be evident (Picou et al. 2009). Such effects can be reduced by the early implementation of coping and mitigation measures (Picou et al. 1999). One important coping measure is the establishment of, and local participation in, an effective spill-response effort that has been formulated into an explicit spill-response plan. Such local programs do have a number of benefits. They provide local employment, a sense of local empowerment, and a means for local resident–oil industry communication. Another possible coping measure would be the establishment of intervention programs, such as peer listening programs based on community participation (MMS 2003a; Picou et al. 1999, 2009; Picou 2010).

Catastrophic Discharge Event. The PEIS analyzes a CDE that ranges in size from 1.4 to 2.2 million bbl in the Chukchi Sea Planning Area, and for 1.7 to 3.9 million bbl in the Beaufort Sea Planning Area (Table 4.4.2-2). Local Alaska Natives have grave concerns over the possibility of a CDE. They are concerned that oil from such an event would spread quickly in the shallow Arctic waters, that oil companies lack the technology to clean up a spill in ice and lack an understanding of how dispersants would act in Arctic waters, and that there is not enough equipment nearby and insufficient infrastructure such as harbors and airports to handle a major spill. They are particularly concerned about the effects of a spill in the whale migration path and the resulting loss and/or contamination of a major food source. In the words of Waska Williams at the 2011 Barrow scoping meetings, “In the event that a major spill happens, our way of life is in jeopardy” (BOEMRE 2011f).

Depending on the time and place it occurred, a CDE could have significant effects on the marine mammals, fishes, migratory birds, and terrestrial mammals upon which Alaska Native subsistence harvesters depend. Oil is more likely to persist in the Arctic environment due to the colder temperatures prolonging the effects of such an event. As the result of a catastrophic discharge event, the economically, socially, and culturally important bowhead whale hunt could be disrupted, as could the beluga harvest and the more general and longer hunt for walrus west of Barrow. Animals could be directly oiled, or oil could contaminate the ice floes or onshore haulouts they use on their northern migration. Such animals could be more difficult to hunt because of the physical conditions. Animals could be "spooked" and/or wary, either because of the spill itself or because of the "hazing" of marine mammals, which is a standard spill-response technique in order to encourage them to leave the area affected by a spill. Oiled animals are likely to be considered tainted by subsistence hunters and would not be harvested, as occurred after the *Exxon Valdez* spill. This would also apply to terrestrial animals, such as bears that scavenge oiled birds and animals along the shore, or caribous that seasonally spend time along the shore or on barrier islands seeking relief from insects. The loss of subsistence harvest resources, particularly marine mammals, would have significant effects on Alaska native culture and society. As shown by the results of the *Exxon Valdez* spill (Picou et al. 2009), subsistence harvesters in unaffected areas are likely to share resources with impacted villages through established social networks. While local ties are regularly strengthened through mutual exchange, they can weaken when there is less to exchange.

Cleaning up a CDE would have negative consequences as well. Cleanup activities and increased human presence could displace subsistence species from their usual harvesting locations. There are relatively few vessels on the northern coast that could participate in the cleanup of a major spill. It is likely that whaling boats and their crews would be diverted for this purpose. Depending on the timing of the spill, this would make them unavailable for the whale hunt. While local villagers would be employed in the cleanup, it is likely that many additional workers would be necessary, placing stress on village facilities. An influx of outsiders is likely to result in some cultural conflict, stressing the local sociocultural systems. As is evident from the *Exxon Valdez* oil spill event, such cleanup efforts can be disruptive socially, psychologically, and economically for an extended period of time.

4.4.13.4 Conclusion

4.4.13.4.1 Gulf of Mexico. Few impacts on GOM sociocultural systems are anticipated from the proposed action. The oil and gas industry is well developed along the coast, and the proposed action is more likely to support the existing industry than to create industry growth. Any expansion of deepwater activities will result in jobs that require longer, unbroken periods of work offshore, specialized skills, and potential in-migration of part of the workforce. Such changes can affect workers, their families, and the communities in which they reside. Impacts to sociocultural systems from routine Program activities in the GOM planning areas are expected to be minor.

Impacts from small spills are likely to have small, localized, and short-lived effects. In the unlikely event of a CDE, there will be economic repercussions for the oil and gas industry, commercial fishers, and subsistence harvesters. These could result in social and cultural stress, leading to possible social pathologies.

4.4.13.4.2 Cook Inlet. Oil and gas exploration, development, and production activities are a continuation of long-time economic characteristics of the area. The proposed action would not introduce new kinds of activities to the area that would alter existing socioeconomic systems.

The relatively small number of new residents that would come into the area because of the proposed action should likewise not alter existing sociocultural systems. These activities are not likely to affect commercial fishing (see Section 4.4.11.2); however, they may periodically result in temporary and localized displacement of subsistence resources or limit subsistence access, making the subsistence harvest by Native Alaskans more difficult, but no resource would experience an overall decrease in population, and no harvest would be curtailed for part of the harvest season. Impacts to sociocultural systems from routine Program activities in the Cook Inlet Planning Area are expected to be minor.

A large oil spill could contact environmental resource areas where important subsistence resources are present. Some harvest areas and resources in these locations would be too contaminated to harvest. Some subsistence resource populations could suffer losses and, as a result of tainting, an even larger array of resources could be rendered unavailable for use. Tainting concerns in communities nearest the spill could seriously curtail traditional practices for harvesting, sharing, and processing resources and threaten pivotal practices of traditional Alaska Native culture. Harvesting, sharing, and processing of subsistence resources would continue but would be hampered to the degree these resources were contaminated. In the case of contamination, harvests would cease until such time as local subsistence hunters perceived resources as safe. In the event of a CDE-level spill, similar impacts would be incurred, although the extent, duration, and magnitude of impacts would be greater. Oil spill cleanup would increase overall effects by displacing subsistence species, altering or reducing subsistence hunter access, and altering or extending the normal period of the subsistence hunt (MMS 2003).

4.4.13.4.3 Arctic. Finding and developing oil and gas resources on the arctic OCS has the potential to create adverse effects on sociocultural systems and subsistence in the Arctic Planning Areas. Such effects would range from minor to major for the routine Program activities, depending on the nature, timing, location, and scale of the activity. Many potential effects are expected to be limited or mitigable. Of greatest concern to the Alaska Natives who inhabit the area are threats to their subsistence base and way of life. Not only does subsistence harvesting provide them with a substantial portion of their food supply, but subsistence-related activities are central to their cultural identity. For many, the most iconic subsistence activity is the whale hunt.

Lease sales on the Arctic OCS are likely to result in the search for and development of oil and gas resources. These activities could have direct and indirect effects on Alaska Native culture. Noise from seismic surveys and exploratory drilling has the potential to deflect whales and other marine mammals from their accustomed migration routes, making them more difficult to harvest. The effects can be reduced through cooperative scheduling and exploration design based on dialogue among the villages, oil companies, and Federal and State agencies. The noise and increased human presence resulting from the construction and operation of drilling pads, pipelines, and shore base facilities has the potential to disturb subsistence species. The increased presence of non-Natives in and around previously isolated villages increases the chance of cross-cultural misunderstanding and could result in financial and cultural stress on Native communities. Lease stipulations requiring conflict avoidance agreements between oil developers and Native villages, along with training of in-migrating work force, will reduce negative impacts.

Impacts on freshwater fish and terrestrial subsistence species such as caribou from onshore pipelines can be ameliorated by cooperative planning efforts that take subsistence needs into account. Effects are likely to be compounded by concern over cumulative effects, which are discussed in Section 4.6.5.3. Of greatest concern to the villagers are the effects of any oil spill. Potential impacts on sociocultural systems from accidents under the proposed action could vary greatly, depending on the size, location, and timing of a spill with greatest impacts occurring with a CDE-level spill. A catastrophic discharge event could prove challenging for existing response capacity and capability, especially if the spill were under ice or in broken ice.

4.4.14 Potential Impacts on Environmental Justice

4.4.14.1 Gulf of Mexico

4.4.14.1.1 Routine Operations. In addition to the continuing use of existing onshore support and processing facilities, between 4 and 6 new pipe yards, up to 12 new pipeline landfalls, and as many as 12 new gas processing facilities are projected to be built as a result of the proposed 5-yr program. Impacts of new onshore construction impacts could include increased noise and traffic, air and water pollution, impacts on residential property values, and land use changes. Air emissions from onshore facilities and helicopter and vessel traffic traversing coastal areas will be highest in the areas containing the greatest amounts of infrastructure, which again will be Texas and Louisiana. Lesser amounts will occur in Mississippi and Alabama. No onshore infrastructure supporting OCS operations currently exists in Florida, and none will be built as a result of the proposed program.

It is assumed that 75% of the activity from the proposed 5-yr program will occur in deep and ultra-deep waters, with offshore air emissions greatest in the coastal areas of Texas and Louisiana, the areas with the greatest amounts of oil and gas activity, and lesser amounts in occurring in Mississippi and Alabama. The coastal areas of Florida are located so far from OCS activities that no environmental justice issues from offshore air emissions are expected to impact the coastal parts of the State.

The effects of the OCS program on air quality have been analyzed in Section 4.4.4. This analysis concluded that routine operations associated with the proposed 5-yr program would result in NO_2, SO_2, PM_{10}, and CO levels that are well within the National Ambient Air Quality Standards (NAAQS). Coastal effects from offshore activities are expected to be small, based on the established and increasing trend toward movement of oil and gas activities into deeper waters of the GOM.

The proposed 5-yr program will result in levels of infrastructure use and construction similar to that which has occurred in the GOM coast region during previous programs. These activities are not expected to expose residents to notably higher risks than currently occur. While the distribution of offshore-related activities and infrastructure indicates that some places and populations in the GOM region will continue to be of environmental justice concern, the incremental contribution of the proposed OCS program is not expected to affect those places and populations.

4.4.14.1.2 Accidents. Up to 8 large spills greater than 1,000 bbl, between 35 and 70 spills between 50 and 1,000 bbl, and between 200 and 400 small spills less than 50 bbl could occur in the GOM from the proposed action. It is reasonable to expect that most of these spills will occur in deepwater areas located away from the coast, based on the established trend for oil and gas activity to move into deep waters located for the most part at a substantial distance from the coast. However, according to MMS (2002b), the probability of an offshore oil spill occurring and impacting coastal populations is low. While the location of possible oil spills cannot be determined and while low-income and minority populations reside in some areas of the coast, in general the coasts are home to more affluent groups. Low-income and minority groups are not more likely to bear more negative impacts than other groups.

Chemical and drilling-fluid spills may be associated with exploration, production, or transportation activities that result from the proposed action. Low-income and minority populations might be more sensitive to oil spills in coastal waters than is the general population because of their dietary reliance on wild coastal resources, their reliance on these resources for other subsistence purposes such as sharing and bartering, their limited flexibility in substituting wild resources with those purchased, and their likelihood of participating in cleanup efforts and other mitigating activities. With the exception of a catastrophic accidental event, such as that which occurred following the DWH accident, the impacts of oil spills, vessel collisions, and chemical/drilling fluid spills are not likely to be of sufficient duration to have adverse and disproportionate long-term effects for low-income and minority communities in the analysis area.

A CDE could have adverse and disproportionate effects for low-income and minority communities in the analysis area. Many of the long-term impacts of the DWH accident on low-income and minority communities are unknown. While economic impacts have been partially mitigated by employers retaining employees for delayed maintenance or through the Gulf Coast Claims Facility (GCCF) program's emergency funds, the physical and mental health effects on both children and adults within these communities could potentially unfold for many years. As studies of past oil spills have highlighted, different cultural groups can possess varying capacities to cope with these types of events (Palinkas et al. 1992). Likewise, some low-income and/or minority groups may be more reliant on natural resources and/or less equipped to substitute contaminated or inaccessible natural resources with private market offerings. Because lower income and/or minority communities may live near and be directly involved with spill cleanup efforts, the vectors of exposure can be higher for them than for the general population, increasing the potential risks of long-term health effects. To date, there have been no longitudinal epidemiological studies of possible long-term health effects for oil spill cleanup workers.

Catastrophic Discharge Event. The PEIS analyzes a CDE that ranges in size from 0.9 to 7.2 million bbl (Table 4.4.2-2). Although the magnitude of impacts of a CDE would partly depend on the location, size, and timing of the event, many of the long-term impacts of a CDE on low-income and minority communities are unknown. A spill as large as that which occurred following the DWH accident could have adverse and disproportionate effects for low-income and minority communities in coastal and inland areas. Different cultural groups would likely possess varying capacities to cope with catastrophic events, with some low-income and/or minority groups more reliant on subsistence resources and/or less equipped to substitute contaminated or inaccessible subsistence resources with those purchased in the marketplace. Because lower income and/or minority communities may live near and be directly involved with CDE cleanup efforts, the vectors of exposure can be higher for them than for the general population, increasing the potential risks of long-term health effects.

4.4.14.2 Alaska – Cook Inlet

4.4.14.2.1 Routine Operations. Although only one pipeline landfall and no new pipe yards or gas processing facilities would be built as a result of the Program, additional offshore construction could include increased noise and traffic, air and water pollution, impacts on residential property values, and land use changes. Much of the Alaska Native population resides in the coastal areas of Alaska. New offshore infrastructure resulting from this program could be located near areas where subsistence hunting occurs. The Program will result in levels of infrastructure use and construction similar to that which has occurred in the south central Alaska region during previous programs, and, in many of the same locations. These activities are not expected to expose residents to notably higher risks than those that currently occur.

Any adverse environmental impacts on fish and mammal subsistence resources from installation of infrastructure and routine operations of these facilities could have disproportionately higher health or environmental impacts on Alaska Native populations, particularly with regard to air quality impacts and impacts on animal species used for subsistence purposes.

Air emissions from onshore facilities and helicopter and vessel traffic traversing coastal areas will be highest in areas containing the greatest amounts of infrastructure. It is assumed that the majority of the activity from the Program will occur in deep and ultra-deep waters, with offshore air emissions greatest in the coastal areas with the greatest amounts of oil and gas activity, and lesser amounts occurring elsewhere. The effects of the OCS program on air quality have been analyzed in Section 4.4.4. This analysis concluded that routine operations associated with the proposed 5-yr program would result in NO_2, SO_2, PM_{10}, and CO levels that are well within the NAAQS. Coastal effects from offshore activities are expected to be small, based on the established and increasing trend toward movement of oil and gas activities into deeper waters.

Critical subsistence species that are most likely to be disturbed by noise-producing activities include bowhead and beluga whales, seals, fish, caribou, and birds. Noise disturbance would be associated with aircraft and vessel support of modifications to platform facilities, installation of oil and gas pipelines from platforms to shore, and the expansion of shore facilities. While OCS oil and gas activities are not expected to appreciably reduce any populations of subsistence species, it is possible that disturbance caused by these activities could alter the local availability of these resources to harvesters. These impacts would be considered short term and localized, and would not rise to the level of significant adverse effects.

4.4.14.2.2 Accidents. One large spill greater than 1,000 bbl, between 1 and 3 spills between 50 and 1,000 bbl, and up to 15 small spills less than 50 bbl could occur in the Cook Inlet area from the proposed action. It is reasonable to expect that most of these spills will occur in deepwater areas located away from the coast, based on the established trend for oil and gas activity to move into deep waters located for the most part at a substantial distance from the coast. The magnitude of impacts from such spills cannot be predicted, should they contact the coast, and depends on their location, size, and timing. However, according to MMS (2002b), the probability of an offshore oil spill occurring and impacting coastal populations is low. While the location of possible oil spills cannot be determined and while low-income and minority populations are resident in some areas of the coast, in general the coasts are home to more affluent groups. Low-income and minority groups are not more likely to bear more negative impacts than are other groups.

Subsistence activities of Alaska Native communities could be affected by accidental oil spills, with the potential health effects of oil spill contamination on subsistence foods being the main concern. After the 1989 *Exxon Valdez* spill, testing of subsistence foods for hydrocarbon contamination between 1989 and 1994 revealed very low concentrations of petroleum hydrocarbons in most subsistence foods, and the U.S. Food and Drug Administration concluded that eating food with such low levels of hydrocarbons posed no significant risk to human health (Hom et al. 1999). Human health risks can be reduced through timely warnings about spills, forecasts about which areas may be affected, and even evacuating people and avoiding marine and terrestrial foods that may be affected. Avoidance of shellfish, which accumulate hydrocarbons, would be recommended, and Federal and State agencies with health care responsibilities would have to sample the food sources and test for possible contamination.

Whether subsistence users will use potentially tainted foods would depend on the cultural "confidence" in the purity of these foods. Based on surveys and findings in studies of the *Exxon Valdez* spill, Natives in affected communities largely avoided subsistence foods as long as the oil remained in the environment. Perceptions of food tainting and avoiding use lingered in Native communities after the *Exxon Valdez* spill, even when agency testing maintained that consumption posed no risk to human health (MMS 2006b).

The assessment and communication of the contamination risks of consuming subsistence resources following an oil spill is a continuing challenge to health and natural resource managers. After the *Exxon Valdez* spill, analytical testing and rigorous reporting procedures failed to convince many subsistence consumers because test results were often inconsistent with Native perceptions about environmental health. Any effective discussion of subsistence resource contamination must understand the conflicting scientific paradigms of Western science and traditional knowledge in addition to the vocabulary of the social sciences in reference to observations throughout the collection, evaluation, and reporting processes. True restoration of environmental damage, according to Picou and Gill (1996), "must include the re-establishment of a social equilibrium between the bio-physical environment and the human community"

(Field et al. 1999; Nighswander and Peacock 1999; Fall et al. 1999). Since 1995, subsistence restoration resulting from the *Exxon Valdez* oil spill has improved by taking a more comprehensive approach by partnering with local communities and by linking scientific methodologies with traditional knowledge (Fall et al. 1999; Fall and Utermohle 1999).

Catastrophic Discharge Event. The PEIS analyzes a CDE that ranges in size from 75 to 125 thousand bbl (Table 4.4.2-20). Although the magnitude of impacts of a CDE would partly depend on the location, size, and timing of the event, many of the long-term impacts of a CDE on low-income and minority communities are unknown. A spill as large as that which occurred following the DWH accident could have adverse and disproportionate effects for low-income and minority communities in coastal and inland areas. Different cultural groups would likely possess varying capacities to cope with catastrophic events, with some low-income and/or minority groups more reliant on subsistence resources and/or less equipped to substitute contaminated or inaccessible subsistence resources with those purchased in the marketplace. Because lower income and/or minority communities may live near and be directly involved with catastrophic discharge event cleanup efforts, the vectors of exposure can be higher for them than for the general population, increasing the potential risks of long-term health effects.

4.4.14.3 Alaska – Arctic

4.4.14.3.1 Routine Operations. Although only one pipeline landfall and no new pipe yards or gas processing facilities would be built as a result of the Program, additional offshore construction could include increased noise and traffic, air and water pollution, impacts on residential property values, and land use changes. Much of the Alaska Native population resides in the coastal areas of Alaska. Any new onshore and offshore infrastructure resulting from this program could be located near these populations or near areas where subsistence hunting occurs. The Program will result in levels of infrastructure use and construction similar to what has occurred in the Arctic region during previous programs. These activities are not expected to expose residents to notably higher risks than currently occur.

Air emissions from onshore facilities and helicopter and vessel traffic traversing coastal areas will be highest in the areas containing the greatest amount of infrastructure. It is assumed that the majority of the activity from the Program will occur in deep and ultra-deep waters, with offshore air emissions greatest in the coastal areas with the greatest amounts of oil and gas activity, and lesser amounts in occurring elsewhere. The effects of the OCS program on air quality have been analyzed in Section 4.4.4. This analysis concluded that routine operations associated with the Program would result in NO_2, SO_2, PM_{10}, and CO levels that are well within the NAAQS.

Any adverse environmental impacts on fish and mammal subsistence resources from installation of infrastructure and routine operations of these facilities could have disproportionately higher health or environmental impacts on Alaska Native populations, particularly with regard to air quality impacts and impacts on animal species used for subsistence purposes.

The NSB Municipal Code defines subsistence as "an activity performed in support of the basic beliefs and nutritional needs of the residents of the borough and includes hunting, whaling, fishing, trapping, camping, food gathering, and other traditional and cultural activities" (ADNR 1997). While this is, at best, a partial view of the significance of these activities to the Iñupiat (and more generally to Alaskan Natives) as individuals, culturally it stresses subsistence as a primary cultural and nutritional set of activities upon which Alaskan Natives depend.

Critical subsistence species that are most likely to be disturbed by noise-producing activities include bowhead and beluga whales, seals, fish, caribou, and birds. Noise disturbance would be associated with aircraft and vessel support of modifications to platform facilities, installation of oil and gas pipelines from platforms to shore, and the expansion of shore facilities. While natural gas development and production are not expected to appreciably reduce any populations of subsistence species, it is possible that disturbance caused by these activities could alter the local availability of these resources to harvesters. These impacts would be considered short term and localized, and would not rise to the level of significant adverse effects.

4.4.14.3.2 Accidents. Up to 3 large spills greater than 1,000 bbl, between 10 and 35 spills between 50 and 1,000 bbl, and up to 190 small spills of less than 50 bbl could occur in the Beaufort and Chukchi Sea area from the proposed action. The magnitude of impacts from such spills cannot be predicted, should they contact the coast, and depends on their location, size, and timing. However, according to MMS (2002b), the probability of an offshore oil spill occurring and impacting coastal populations is low. While the location of possible oil spills cannot be determined, and while low-income and minority populations are resident in some areas of the coast, low-income and minority groups are not more likely to bear more negative impacts than are other groups.

Subsistence activities of Native communities could be affected by accidental oil spills, with the potential health effects of oil spill contamination of subsistence foods being the main concern. After the 1989 *Exxon Valdez* spill, testing of subsistence foods for hydrocarbon contamination between 1989 and 1994 revealed very low concentrations of petroleum hydrocarbons in most subsistence foods, and the U.S. Food and Drug Administration concluded that eating food with such low levels of hydrocarbons posed no significant risk to human health (Hom et al. 1999). Human health risks can be reduced through timely warnings about spills, forecasts about which areas may be affected, and even evacuating people and avoiding marine and terrestrial foods that may be affected. Avoidance of shellfish, which accumulate hydrocarbons, would be recommended, and Federal and State agencies with health care responsibilities would have to sample the food sources and test for possible contamination.

Whether subsistence users will use potentially tainted foods would depend on the cultural "confidence" in the purity of these foods. Based on surveys and findings in studies of the *Exxon Valdez* spill, Natives in affected communities largely avoided subsistence foods as long as the oil remained in the environment. Perceptions of food tainting and avoiding use lingered in Native communities after the *Exxon Valdez* spill, even when agency testing maintained that consumption posed no risk to human health (MMS 2006b).

The assessment and communication of the contamination risks of consuming subsistence resources following an oil spill is a continuing challenge to health and natural resource managers. After the *Exxon Valdez* spill, analytical testing and rigorous reporting procedures failed to convince many subsistence consumers, because test results were often inconsistent with Native perceptions about environmental health. Any effective discussion of subsistence resource contamination must understand the conflicting scientific paradigms of Western science and traditional knowledge in addition to the vocabulary of the social sciences in reference to observations throughout the collection, evaluation, and reporting processes. True restoration of environmental damage, according to Picou and Gill (1996), “must include the re-establishment of a social equilibrium between the bio-physical environment and the human community” (Field et al. 1999; Nighswander and Peacock 1999; Fall et al. 1999). Since 1995, subsistence restoration resulting from the *Exxon Valdez* oil spill has improved by taking a more comprehensive approach by partnering with local communities and by linking scientific methodologies with traditional knowledge (Fall et al. 1999; Fall and Utermohle 1999).

Catastrophic Discharge Event. The PEIS analyzes a CDE that ranges from 1.4 to 2.2 million bbl in the Chukchi Sea Planning Area and from 1.7 to 3.9 million bbl in the Beaufort Sea Planning Area (Table 4.4.2-2). Although the magnitude of impacts of a CDE would partly depend on the location, size, and timing of the event, many of the long-term impacts of a CDE on low-income and minority communities are unknown. A spill as large as that which occurred following the DWH accident could have adverse and disproportionate effects for low-income and minority communities in coastal and inland areas. Different cultural groups would likely possess varying capacities to cope with catastrophic events, with some low-income and/or minority groups more reliant on subsistence resources and/or less equipped to substitute contaminated or inaccessible subsistence resources with those purchased in the marketplace. Because lower income and/or minority communities may live near and be directly involved with catastrophic discharge event cleanup efforts, the vectors of exposure can be higher for them than for the general population, increasing the potential risks of long-term health effects.

4.4.14.4 Conclusion

The Program would result in levels of infrastructure use and construction similar to those that have already occurred along the GOM coast during previous programs. Routine Program operations are not expected to expose residents to notably higher risks than currently occur. While the distribution of offshore Program activities and infrastructure indicates that some places and populations in the GOM region will continue to be of environmental justice concern, the incremental contribution of the Program is not expected to affect those places and populations. Air emissions from the proposed program are not expected to result in air quality impacts on minority or low-income populations, with emissions from the proposed program not being expected to exceed the NAAQS in any affected area. Impacts to environmental justice from routine Program activities in the GOM Planning Areas are expected to be negligible. No environmental justice impacts from accidental oil spills are expected in the GOM because of the movement of oil and gas activities farther away from coastal areas and the demographic pattern of more affluent groups living in coastal areas.

In Alaska, much of the Alaska Native population resides in the coastal areas. Any new onshore and offshore infrastructure occurring under the Program could be located near these populations or near areas where subsistence hunting occurs. Any adverse environmental impacts on fish and mammal subsistence resources from Program infrastructure and routine operations could result in health or environmental justice impacts on Alaska Native populations although impacts are expected to be minor. A large oil spill, and especially a CDE-level spill, that contacts subsistence resources could also have disproportionately high impacts on the Alaska Native population, particularly if the subsistence resources were diminished or tainted as a result of the spill. In the event of a CDE, long-term impacts to subsistence resources may be expected, and these may lead to longer and greater environmental justice impacts. Mitigation measures, cooperative agreements between Native and industry groups, and government-to-government consultations are designed to limit the effects from oil spills and routine operations.

4.4.15 Potential Impacts to Archeological and Historic Resources

4.4.15.1 Gulf of Mexico

Archaeological resources in the GOM region that may be impacted by the proposed action include historic shipwrecks and inundated prehistoric sites offshore as well as historic and prehistoric sites onshore. Historic shipwrecks tend to concentrate in the shallow, nearshore waters of the GOM (CEI 1977; Garrison et al. 1989; Pearson et al. 2003); however, numerous recent discoveries of well-preserved historic shipwrecks in deepwater areas of the GOM have increased understanding of shipwreck potential on the OCS (Atauz et al. 2006; Church and Warren 2008; Church et al. 2004; Ford et al. 2008). BOEM has expanded its archaeological survey requirements to ensure the detection of these deepwater shipwrecks prior to approving bottom-disturbing activities in areas where it has reason to believe that archaeological resources might exist. Inundated prehistoric sites may exist on the continental shelf shoreward of about the 50-m (164-ft) isobath. The depth may increase as our understanding of the timing for the peopling of North America is pushed ever earlier.

Onshore historic properties include sites, structures, and objects such as historic buildings, forts, lighthouses, homesteads, cemeteries, and battlefields. Onshore prehistoric archaeological resources include sites, structures, and objects such as shell middens, earth middens, campsites, kill sites, tool manufacturing areas, ceremonial complexes, and earthworks. Adverse effects on historic properties require mitigation. The appropriate mitigation would be developed through consultation among BOEM, the appropriate SHPO, and any Native American tribes who have an interest in the resources.

All archaeological sites identified through surveys conducted for BOEM permitting activities require avoidance or evaluation for listing on the NRHP. Only archaeological and historic resources that are determined eligible for listing on the NRHP require consideration during Federal undertakings (36 CFR Part 800).

4.4.15.1.1 Routine Operations. Routine operations associated with offshore oil and gas fall into four stages: exploration, development, operations, and decontamination and decommissioning. Impacts can occur on archaeological and historic resources during any stage but would be most likely during the exploration and development stages when the seafloor is first altered by an activity. It is assumed that operations and decontamination and decommissioning would affect seafloor that had been previously altered by the earlier activities. The potential for impacting a cultural resource is dependent upon the specific activity and whether a cultural resource is present within the area of potential effect for that activity.

Routine activities associated with exploration and development that are likely to affect archaeological and historic resources include drilling wells, platform installation, and pipeline installation and anchoring, as well as onshore facility and pipeline construction projects. While the source of potential impacts will vary with the specific location and nature of the routine operation, the goal of archaeological resource management remains the protection and/or retrieval of unique information contained in intact archaeological deposits.

Direct impacts occur when permitted activities physically alter significant archaeological or historic resources. The result of direct impacts on shipwrecks would be the loss of archaeological data on ship construction, cargo, and the social organization of the vessel's crew, as well as loss of information on maritime cultures for the time period from which the ship dates. Other indirect impacts can result from the visual intrusion resulting from oil and gas development on the OCS and its effect on onshore historic properties. An indirect effect of oil and gas development on archaeological and historic resources is that metal debris from a permitted activity could settle near a shipwreck and could mask magnetic signatures of significant historic archaeological resources, making them more difficult to detect with magnetometers. Direct impacts from a routine activity on a prehistoric archaeological site could include destruction of artifacts or site features, as well as disturbance of the stratigraphic context of the site. This would result in the loss of archaeological data on prehistoric migrations, settlement patterns, subsistence strategies, and archaeological contacts for North America, Central America, South America, and the Caribbean.

Regulations in 30 CFR 250.194 allow the BOEM Regional Director to require that an archaeological report based on geophysical data be prepared, if there are indications that a significant archaeological resource may exist within a lease area. For historic resources, this decision can be based on whether a lease block falls within an area assessed as having a high potential for shipwreck occurrence, such as the entrances to historic ports and harbors, or on the Regional Director's determination that a survey is warranted. For prehistoric resources, a survey is required if there is the potential for landforms to be present that could contain prehistoric material. If the survey finds evidence of a possible archaeological resource within the lease area, the lessee must either move the proposed activity to avoid the possible resource or conduct further investigations to determine whether an archaeological resource actually exists at the location. If an archaeological resource is present at the location of proposed activity and cannot be avoided, BOEM procedures require consultation with the State Historic Preservation Office to develop mitigating measures prior to any exploration or development.

BOEM has used predictive models based on various parameters to determine when and where archaeological surveys should be required. Studies conducted between 2006 and 2008 suggest that the models used in the past are not adequate (Church and Warren 2008; Ford et al. 2008; Atauz et al. 2006). These studies document significant effects on shipwrecks resulting from routine activities that occurred in areas where wrecks were not anticipated. As a result of these discoveries, BOEM may require surveys in all areas outside those already identified as having the potential for archaeology that could be affected by a project.

Federal, State, and local laws and ordinances, including the National Historic Preservation Act provide a process to facilitate the consideration of known sites and as-yet-unidentified archaeological resources in the planning phases of a proposed project. Where there is reason to believe that an archaeological resource might exist in a lease area, regulations require archaeological surveys to be conducted prior to permitting any activity that might disturb a significant archaeological site. When required, these archaeological surveys have been found to be effective in locating most archaeological resources prior to any construction on the OCS; however, even with surveys, there is the potential that a shipwreck or an inundated terrestrial site could be missed due to sedimentation on the wreck or other factors, resulting in a routine activity contacting a shipwreck or site. Such an event could result in the disturbance or destruction of unique or significant historic archaeological information.

4.4.15.1.2 Accidents. Impacts on archaeological and historical resources from an accidental oil spill can result from either direct contact of crude oil with archaeological material or from effects caused by cleanup workers and their equipment (i.e., anchor drags, dredging of contaminated soils, or unauthorized collecting by cleanup workers). The following are discussions of the potential effects from an accidental oil spill on various resource types based on location and water depth.

Shipwrecks in shallow waters and coastal historic and prehistoric archeological sites could be impacted by an accidental oil spill. Archaeological resource protection during an oil spill requires specific knowledge of the resource's location, condition, nature, and extent prior to impact; however, the GOM coastline has not been systematically surveyed for archaeological sites. Existing information indicates that, in coastal areas of the GOM, prehistoric sites occur frequently along the barrier islands and mainland coast and the margins of bays and bayous. Thus, any spill that contacted the land would involve a potential impact on a prehistoric site.

Shipwrecks can be affected by contact with crude oil. Shallow water shipwrecks often serve as artificial reefs when they are covered by corals and other organisms. The organisms that attach to the wreck protect the wood from deterioration. An oil spill could destabilize a balanced ecosystem covering the wreck, thus potentially increasing deterioration of the wreck until the wreck comes into equilibrium with its new environment. Some terrestrial studies have suggested that, while oil contamination of wood initially restricts deterioration, it can later increase deterioration (Ejechi 2003). It is not known how this situation would be altered in a marine environment. It is also not known whether dispersants used to break up concentrations of oil have any effect on shipwrecks or the vegetation that forms on the wrecks (BOEMRE 2011a).

Should an oil spill contact a coastal historic site, such as a fort or a lighthouse, the major impact would be visual due to oil contamination of the site and its environment. Any effects from contact with oil to historic materials could be mitigated through cleaning of the historic material. The visual impact would most likely be temporary, lasting up to several weeks depending on the time required for cleanup. Gross crude oil contamination of shorelines is a potential direct impact that may affect archaeological site recognition. Heavy oiling conditions (Whitney 1994) could conceal intertidal sites that may not be recognized until they are inadvertently damaged during cleanup. Crude oil may also contaminate organic material used in ^{14}C dating, and, although there are methods for cleaning contaminated ^{14}C samples, greater expense is incurred (Dekin et al. 1993). An Alaskan study examining the effects of the 1989 *Exxon Valdez* oil spill on archaeological deposits revealed that oil in the intertidal zone had not penetrated the subsoil, apparently due to hydrostatic pressure (Dekin et al. 1993); however, because of the different environments, these results should not be translated into the GOM coastal environment without further study.

Spill Response and Cleanup. Cleanup activities have the potential to alter archaeological sites and shipwrecks. Inadvertent damage from anchors can greatly impact archaeological sites and shipwrecks (Church and Warren 2008). The potential amount of damage depends on several factors including the presence and density of shipwrecks and archaeological material in the area of activity, the number of vessels being employed in the cleanup activities, and whether offshore decontamination stations were needed and where these facilities were established. These types of impacts could be avoided or minimized if wreck locations are known. In 2007, 2,100 shipwrecks were reported to have been lost in the GOM; however, specific location information is known for only 233 of these wrecks (BOEMRE 2011a). This issue makes avoiding wrecks difficult.

Another source of potential impact from oil spills is the harm that could result from unmonitored shoreline cleanup activities. Unmonitored booming, cleanup activities involving vehicle and foot traffic, mechanized cleanup involving heavy equipment, and high-pressure washing on or near archaeological sites pose risks to the resources. Unauthorized collecting of artifacts by cleanup crew members is also a concern, albeit one that can be mitigated with effective training and supervision. As Bittner (1996) described in her summary of the *Exxon Valdez* oil spill, "Damage assessment revealed no contamination of the sites by oil, but considerable damage resulted from vandalism associated with cleanup activities and lesser amounts were caused by the cleanup process itself."

The National Response Team's *Programmatic Agreement on Protection of Historic Properties during Emergency Response under the National Oil and Hazardous Substances Pollution Contingency Plan* clarifies interagency and regulatory aspects of archaeological site protection during oil spill response. The agreement was followed during the DWH event and it is assumed that the agreement was effective; however, no reports on the utility of the agreement for that event are currently available.

Catastrophic Discharge Event. The PEIS analyzes a CDE that ranges in size from 0.9 to 7.2 million bbl (Table 4.4.2-2). A CDE could result in extensive impacts on a large number of archaeological and historic resources. Due to the large area affected by a catastrophic event, some resources such as coastal historic sites that are sensitive to prolonged contact with oil could be more heavily impacted. Cleanup crews would be needed in a greater number of locations. This could allow oil to be in contact with resources for a significant amount of time before cleanup efforts could be applied, which could result in impacts to these resources. A greater threat to archaeological and historic resources during a catastrophic discharge event would result from the larger number of response crews being employed. Historically most impacts to archaeological and historic resources during a spill response were the result of vandalism or physical damage from spill response activities (Bittner 1996). A catastrophic discharge event would result in major impacts to numerous archaeological and historic resources from response activities.

The Programmatic Agreement on Protection of Historic Properties during Emergency Response under the National Oil and Hazardous Substances Pollution Contingency Plan would be followed during the response to a CDE. As mentioned above, it is assumed that the process identified in the agreement would be effective; however, no assessments of the agreement's application during the DWH event are available.

4.4.15.2 Alaska – Cook Inlet

Archaeological and historic resources in the Alaska region include historic shipwrecks, submerged aircraft, inundated prehistoric sites offshore, and historic and prehistoric sites onshore. These resources have the potential to be affected by the proposed action. The locations of most of the cultural resources in Cook Inlet are currently unknown, but if any are discovered during OCS oil and gas activities, they would be subject to archaeological surveys, and other activities and mitigations required by applicable laws and BOEM policies. There is currently no archaeological baseline study for Alaska on which to base decisions concerning where cultural resources should be present. An archaeological baseline study was done for Alaska in the mid-1980s (Dixon et al. 1986); however, this research was never updated and should be assessed for its validity when compared with current research and scientific findings. Some research attempting to identify landforms that may contain archaeological remains has been done in the Beaufort and Chukchi Seas, but no new studies have been conducted in Cook Inlet. Research on historic shipwrecks has identified 108 shipwrecks in Cook Inlet (Tornfelt and Burwell 1992). As discussed in Section 3.16.2, portions of Cook Inlet are subject to high-energy tidal movements (MMS 2003a). This high-energy environment may have destroyed some of the archaeological evidence that once existed in Cook Inlet, but this can only be verified through science-based methods of inquiry.

4.4.15.2.1 Routine Operations. Routine activities associated with the proposed action that could affect cultural resources include well drilling, platform installation, pipeline installation, and onshore facility and pipeline construction projects that involve ground disturbance. Effects on cultural resources can be determined only on a case-by-case basis. Only through project-specific surveys can cultural resources be identified. The determination that a survey is required depends on several factors including the potential for landforms to exist that may contain archaeological sites (i.e., submerged coastlines) or archival records suggesting that shipwrecks could be present.

As previously discussed, regulations at 30 CFR 250.194 allow the BOEM Regional Director to require that an archaeological report based on geophysical data be prepared, if there are indications that a significant archaeological resource may exist within a lease area. For historic resources, this decision is based on whether a historic shipwreck is reported to exist within or adjacent to a lease area. For prehistoric resources, an analysis is completed prior to each lease sale to consider the relative sea level history, the depth of burial of the late Wisconsinan land surface (i.e., lands that could contain archaeological sites), the type and thickness of sediments burying the old land surface, and the severity of ice gouging at the present seafloor. Lease areas that are shown by this analysis to have the potential for prehistoric archaeological resources are required to have an archaeological survey prior to initiating exploration and development activities. If the survey finds evidence of a possible archaeological resource within the lease area, the lessee must either move the proposed activity to avoid the possible resource or conduct further investigations to determine whether an archaeological resource actually exists at the location. If an archaeological resource is present at the location of proposed activity and cannot be avoided, BOEM procedures require consultation with the State Historic Preservation Office to develop mitigation measures prior to any exploration or development.

Federal, State, and local laws and ordinances, including the National Historic Preservation Act and the Alaska Historic Preservation Act, provide a process to facilitate the consideration of known sites and as-yet-unidentified archaeological resources both onshore and offshore. Where there is reason to believe that an archaeological resource might exist in a lease area, regulations require archaeological surveys to be conducted prior to permitting any activity that might disturb a significant archaeological site. When required, these surveys have been found to be effective in locating most archaeological resources prior to any construction or offshore bottom-disturbing activity on the OCS. However, even with surveys there is the potential that a shipwreck or an inundated terrestrial site could be missed due to sedimentation on the wreck or other factors, resulting in a routine activity contacting a shipwreck or site. Such an event could result in the disturbance or destruction of unique or significant historic archaeological information. However, regulations in 30 CFR 250.194(c) require that if any archaeological resource is discovered, operations must be immediately halted in the area of the discovery and a report of the discovery must be made so that further investigation may determine the significance of the resource.

4.4.15.2.2 Accidents. Oil spills and their subsequent cleanup could impact the archaeological resources of the Alaska region directly and/or indirectly. The geologic history of specific shorelines generally affects the presence or absence, condition, and age of archaeological sites on or near Alaska region shorelines. However, some types of archaeological resources are present on or adjacent to nearly all Alaska region shorelines. Existing data indicate that archaeological resources are particularly abundant along Gulf of Alaska shorelines (Mobley et al. 1990).

Archaeological resource protection during an oil spill requires specific knowledge of the resource's location, condition, nature, and extent prior to impact. However, large portions of the Cook Inlet coastline have not been systematically surveyed for archaeological sites. While some response groups have compiled known archaeological site data in a form useful for mitigation during an emergency response (Wooley et al. 1997), these data have not been compiled for all areas of the Alaska region.

Gross crude oil contamination of shorelines is a potential direct impact that may affect archaeological site recognition. Heavy oiling conditions (Whitney 1994) could conceal intertidal sites that may not be recognized until they are inadvertently damaged during cleanup. Crude oil may also contaminate organic material used in ^{14}C dating, and, although there are methods for cleaning contaminated ^{14}C samples, greater expense is incurred (Dekin et al. 1993). However, many other anthropogenic sources of hydrocarbons and other possible contaminants also exist, so caution should always be taken when analyzing radiocarbon samples from coastal Alaska (see Reger et al. 1992). A study examining the effects of the 1989 *Exxon Valdez* oil spill on archaeological deposits revealed that oil in the intertidal zone had not penetrated the subsoil, apparently due to hydrostatic pressure (Dekin et al. 1993).

Spill Response and Cleanup. The major source of potential impact from oil spills resulting from the proposed action is the harm that could result from unmonitored shoreline cleanup activities. Cleanup activities could impact beached shipwrecks, or shipwrecks in shallow waters, as well as coastal historic and prehistoric archaeological sites. Unmonitored booming, cleanup activities involving vehicle and foot traffic, mechanized cleanup involving heavy equipment, and high-pressure washing on or near archaeological sites pose risks to the resources. Inadvertent damage from anchors can greatly alter archaeological sites and shipwrecks (Church and Warren 2008). The potential amount of damage depends on several factors including the presence and density of shipwrecks and archaeological material in the area of activity, the number of vessels being employed in the cleanup activities, and whether offshore decontamination stations were needed and where these facilities were established. These types of impacts could be avoided or minimized if wreck locations are known. Unauthorized collecting of artifacts by cleanup crew members is also a concern, albeit one that can be mitigated with effective training and supervision. As Bittner (1996) described in her summary of the 1989 *Exxon Valdez* oil spill, "Damage assessment revealed no contamination of the sites by oil, but considerable damage resulted from vandalism associated with cleanup activities, and lesser amounts were caused by the cleanup process itself."

The National Response Team's *Programmatic Agreement on Protection of Historic Properties during Emergency Response under the National Oil and Hazardous Substances Pollution Contingency Plan* clarifies interagency and regulatory aspects of archaeological site protection during oil spill response. The agreement also outlines the Federal On-Scene Coordinator's role in protecting archaeological resources, the type of expertise needed for site protection, and the appropriate process for identifying and protecting archaeological sites during an emergency response. The agreement was followed during the DWH event, and it is assumed that the agreement was effective; however, no reports on the utility of the agreement for that event are currently available.

Catastrophic Discharge Event. The PEIS analyzes a CDE that ranges from 75 to 125 thousand bbl (Table 4.4.2-2). A CDE could result in extensive impacts on a large number of archaeological and historic resources. Due to the large area affected by a catastrophic event some resources such as coastal historic sites that are sensitive to prolonged contact with oil could be more heavily impacted. Cleanup crews would be needed in a greater number of locations. This could allow oil to be in contact with resources for a significant amount of time before cleanup efforts could be applied, which could result in impacts to these resources. A greater threat to archaeological and historic resources during a catastrophic discharge event would result from the larger number of response crews being employed. Historically most impacts to archaeological and historic resources during a spill response were the result of vandalism or physical damage from spill response activities (Bittner 1996). A catastrophic discharge event would result in major impacts to numerous archaeological and historic resources from response activities.

The *Programmatic Agreement on Protection of Historic Properties during Emergency Response under the National Oil and Hazardous Substances Pollution Contingency Plan* would be followed during the response to a CDE. As mentioned above, it is assumed that the process identified in the agreement would be effective; however, no assessments of the agreement's application during the DWH event are available.

4.4.15.3 Alaska – Arctic

Archaeological and historic resources in the Alaska region include historic shipwrecks, submerged aircraft, inundated prehistoric sites offshore, and historic and prehistoric sites onshore. These resources have the potential to be affected by the proposed action. Several factors must be considered when assessing any potential impacts on offshore resources in Alaska. First, the locations of most of the cultural resources in the Arctic are currently unknown; this is especially true of submerged cultural resources. If any are discovered during OCS oil and gas activities, they would be subject to archaeological surveys and other activities and mitigations required by applicable laws and BOEM policies. The goal of much of the archaeological research being done in the Arctic is to identify locations and landforms that have the potential to contain archaeological and historic resources. The focus on submerged prehistoric resources in Alaska is due to the theory that North America was first populated by nomadic hunters following game across the submerged land mass known as Beringia that once linked Asia with North America (Hoffecker and Elias 2003). A second factor is that, unlike the GOM region, there is no current archaeological baseline study for Alaska on which to base decisions concerning where cultural resources should be present. A third factor is that sea levels have risen over the last 13,000 years. Human activity tends to concentrate on coasts. Regions that were once coastal are now submerged. The coastline that existed 13,000 years ago is now found at roughly the 50-m (164-ft) bathymetry line (Darigo et al. 2007). It is thought that people first came to North America approximately 13,000 years ago. A fourth factor is that natural processes such as ice gouging may have modified much of the ocean bottom to the extent that many cultural resources no longer exist. Studies conducted in 2007 suggest some nearshore locations may remain intact due to shorefast ice, which kept the ice which normally would scrape the sea floor away from the coast. Other factors such as the amount of sediment that has collected on a location may improve the potential for some resources to remain intact.

4.4.15.3.1 Routine Operations. Routine activities associated with the proposal that could affect cultural resources include well drilling, platform installation, pipeline installation, and onshore facility and pipeline construction projects that involve ground disturbance. Effects on cultural resources can be determined only on a case-by-case basis. Only through project-specific surveys can cultural resources be identified. The determination that a survey is required depends on several factors, including the potential for landforms to exist that may contain archaeological sites (i.e., submerged coastlines) or archival records suggesting that shipwrecks could be present.

Regulations at 30 CFR 250.194 allow the BOEM Regional Director to require that an archaeological report based on geophysical data be prepared if there are indications that a significant archaeological resource may exist within a lease area. For historic resources, this decision is based on whether an historic shipwreck is reported to exist within or adjacent to a lease area. For prehistoric resources, an analysis is completed prior to each lease sale to consider the relative sea level history, the depth of burial of the late Wisconsinan land surface (i.e., lands that could contain archaeological sites), the type and thickness of sediments burying the old land surface, and the severity of ice gouging at the present seafloor. Lease areas that are shown by this analysis to have the potential for prehistoric archaeological resources are required to have an archaeological survey prior to initiating exploration and development activities. If the survey finds evidence of a possible archaeological resource within the lease area, the lessee must either move the proposed activity to avoid the possible resource or conduct further investigations to determine whether an archaeological resource actually exists at the location. If an archaeological resource is present at the location of proposed activity and cannot be avoided, BOEM procedures require consultation with the State Historic Preservation Office to develop mitigation measures prior to any exploration or development.

Federal, State, and local laws and ordinances, including the National Historic Preservation Act and the Alaska Historic Preservation Act provide a process to facilitate the consideration of known sites and as-yet-unidentified archaeological resources both onshore and offshore. Where there is reason to believe that an archaeological resource might exist in a lease area, existing regulations require archaeological surveys to be conducted prior to permitting any activity that might disturb a significant archaeological site. When required, these archaeological surveys have been found to be effective in locating most archaeological resources prior to any onshore construction project or offshore bottom-disturbing activity; however, even with surveys there is the potential that a shipwreck or an inundated terrestrial site could be missed due to sedimentation on the wreck or other factors, resulting in a routine activity contacting a shipwreck or site. Such an event could result in the disturbance or destruction of unique or significant historic archaeological information.

4.4.15.3.2 Accidents. Oil spills and their subsequent cleanup could impact the archaeological resources of the Alaska region directly and/or indirectly. The geologic history of specific shorelines generally affects the presence or absence, condition, and age of archaeological sites on or near Alaska region shorelines; however, some type of archaeological resource is present on or adjacent to nearly all Alaska region shorelines. Existing data indicate that archaeological resources are particularly abundant along Gulf of Alaska shorelines (Mobley et al. 1990).

Archaeological resource protection during an oil spill requires specific knowledge of the resource's location, condition, nature, and extent prior to impact; however, large portions of the Alaska region coastline have not been systematically surveyed for archaeological sites. While some response groups have compiled known archaeological site data in a form useful for mitigation during an emergency response (Wooley et al. 1997), these data have not been compiled for all areas of the Alaska region.

Gross crude oil contamination of shorelines is a potential direct impact that may affect archaeological site recognition. Heavy oiling conditions (Whitney 1994) could conceal intertidal sites that may not be recognized until they are inadvertently damaged during cleanup. Crude oil may also contaminate organic material used in ^{14}C dating, and, although there are methods for cleaning contaminated ^{14}C samples, greater expense is incurred (Dekin et al. 1993). Many other anthropogenic sources of hydrocarbons and other possible contaminants also exist, so caution should always be taken when analyzing radiocarbon samples from coastal Alaska (see Reger et al. 1992). A study examining the effects of the 1989 *Exxon Valdez* oil spill on archaeological deposits revealed that oil in the intertidal zone had not penetrated the subsoil, apparently due to hydrostatic pressure (Dekin et al. 1993).

Spill Response and Cleanup. The major source of potential impact from oil spills resulting from the proposed action is the harm that could result from unmonitored shoreline cleanup activities. Cleanup activities could impact beached shipwrecks, or shipwrecks in shallow waters, as well as coastal historic and prehistoric archaeological sites. Unmonitored booming, cleanup activities involving vehicle and foot traffic, mechanized cleanup involving heavy equipment, and high-pressure washing on or near archaeological sites pose risks to the resource. Inadvertent damage from anchors can greatly alter archaeological sites and shipwrecks (Church and Warren 2008). The potential amount of damage depends on several factors, including the presence and density of shipwrecks and archaeological material in the area of activity, the number of vessels being employed in the cleanup activities, and whether offshore decontamination stations were needed and where these facilities were established. These types of impacts could be avoided or minimized if wreck locations are known. Unauthorized collecting of artifacts by cleanup crew members is also a concern, albeit one that can be mitigated with effective training and supervision. As Bittner (1996) described in her summary of the 1989 *Exxon Valdez* oil spill, "Damage assessment revealed no contamination of the sites by oil, but considerable damage resulted from vandalism associated with cleanup activities, and lesser amounts were caused by the cleanup process itself."

The National Response Team's *Programmatic Agreement on Protection of Historic Properties during Emergency Response under the National Oil and Hazardous Substances Pollution Contingency Plan* clarifies interagency and regulatory aspects of archaeological site protection during oil spill response. The agreement also outlines the Federal On-Scene

Coordinator's role in protecting archaeological resources, the type of expertise needed for site protection, and the appropriate process for identifying and protecting archaeological sites during an emergency response. The agreement was followed during the DWH event, and it is assumed the agreement was effective; however, no reports on the utility of the agreement for that event are currently available.

Catastrophic Discharge Event. The PEIS analyzes a CDE that ranges from 1.4 to 2.2 million bbl in the Chukchi Sea Planning Area and from 1.7 to 3.9 million bbl in the Beaufort Sea Planning Area (Table 4.4.2-2). A CDE could result in extensive impacts on a large number of archaeological and historic resources. Due to the large area affected by a catastrophic event some resources such as coastal historic sites that are sensitive to prolonged contact with oil could be more heavily impacted. Cleanup crews would be needed in a greater number of locations. This could allow oil to be in contact with resources for a significant amount of time before cleanup efforts could be applied, which could result in impacts to these resources. A greater threat to archaeological and historic resources during a catastrophic discharge event would result from the larger number of response crews being employed. Historically most impacts to archaeological and historic resources during a spill response were the result of vandalism or physical damage from spill response activities (Bittner 1996). A catastrophic discharge event would result in large impacts to numerous archaeological and historic resources from response activities.

The Programmatic Agreement on Protection of Historic Properties during Emergency Response under the National Oil and Hazardous Substances Pollution Contingency Plan would be followed during the response to a CDE. As mentioned above, it is assumed that the process identified in the agreement would be effective; however, no assessments of the agreement's application during the DWH event are available.

4.4.15.4 Conclusion

Assuming compliance with existing Federal, State, and local archaeological regulations and policies, most impacts on archaeological resources resulting from routine activities under the proposed action should be avoided. BOEM may alter its requirements for archaeological surveys because currently BOEM does not require the submission of archaeological reports based on high-resolution geophysical survey data in all lease sale areas. Without the data analysis included in the archaeological reports, it is impossible to assess whether a proposed activity may impact an unknown cultural resource in the area of potential effect. When required, archaeological reports based on high-resolution geophysical data are believed to provide the information needed by BOEM to develop appropriate avoidance or mitigation strategies to protect cultural resources within the area of potential effect from impacts associated with oil and gas activities on the OCS. Impacts to archeological and historic resources from routine Program activities are expected to range from negligible to major.

In the case of accidental oil spills, and especially CDE-level spills, some impacts could occur on coastal historic and prehistoric archaeological resources. Although it is not possible to predict the precise numbers or types of sites that would be affected, contact with archaeological sites would probably be unavoidable, and the resulting loss of information would be irretrievable. The magnitude of the impacts would depend on the number of resources affected and on the significance and uniqueness of the information lost. Impacts can result from both direct contact with oil and from cleanup operations. Based on experience gained from the *Exxon Valdez* oil spill, no or very limited impacts from direct contact with oil from even a CDE-level spill are expected, but some impacts are expected during cleanup activities. Response actions associated with a CDE-level spill have the greatest potential for adversely impacting archeological and historic resources

4.5 OTHER ALTERNATIVES

4.5.1 Alternative 2 – Defer the Eastern Planning Area for the Duration of the 2012-2017 Program

4.5.1.1 Description of Alternative 2

Under Alternative 2, no sales would be held in the Eastern GOM Planning Area under the Program, and there would be no change from the proposed action for the other planning areas. Under Alternative 2, the following would take place:

- Five area-wide lease sales in the Central GOM Planning Area;
- Five area-wide lease sales in the Western GOM Planning Area;
- One lease sale with a whaling deferral in the Beaufort Sea Planning Area;
- One lease sale with a 40-km (25-mi) buffer in the Chukchi Sea Planning Area; and
- One special interest lease sale in Cook Inlet.

4.5.1.2 Summary of Impacts

Excluding the Eastern GOM Planning Area from the Program would reduce the number of potential lease sales in the GOM from 12 to 10, and there would be no offshore and onshore oil and gas development activities in the Eastern GOM Planning Area. As a result, none of the localized impacts (short or long term) on water quality, air quality, marine and coastal biota and habitats, or archeological or historic resources that would be associated with development in the Eastern GOM Planning Area would be expected to occur. However, water and air quality, as well as marine and coastal biota and habitats, in some portions of the Eastern GOM Planning Area could be affected by oil and gas leasing and development in the eastern portions of the Central GOM Planning Area.

Because of the relatively small amount of development that would occur in the Eastern GOM Planning Area under the proposed action (no more than 1 installed platform, no more than 17 wells), the population, employment, and income impacts identified for the GOM under the proposed action would be only slightly reduced, and would remain unchanged in the other planning areas.

Under Alternative 2, potential impacts on natural, physical, and socioeconomic resources in Alaska would be the same as those identified from the proposed action.

Under Alternative 2, no oil spills from oil and gas development activities under the Program would occur directly in the Eastern GOM Planning Area. However, spills from development in the other planning areas (especially a large or very large spill in the Central Planning Area) could be carried by currents into the Eastern GOM Planning Area and affect marine and coastal resources, tourism and recreation, commercial fisheries, and local economies. The nature and magnitude of any such impacts on those resources (as described in earlier sections of this chapter) will depend on the location, size, and duration of a spill in the other GOM planning areas.

4.5.2 Alternative 3 – Defer the Western Planning Area for the Duration of the 2012-2017 Program

4.5.2.1 Description of Alternative 3

Under Alternative 3, no lease sales would be held in the Western Planning Area under the Program, and there would be no change from the proposed action for the other planning areas. Under Alternative 3, the following would take place:

- Five area-wide lease sales in the Central GOM Planning Area;
- One or two lease sales in the extreme western portion of the Eastern GOM Planning Area;
- One lease sale with a whaling deferral in the Beaufort Sea Planning Area;
- One lease sale with a 40-km (25-mi) buffer in the Chukchi Sea Planning Area; and
- One special interest lease sale in Cook Inlet.

4.5.2.2 Summary of Impacts

Excluding the Western GOM Planning Area from the Program would reduce the number of potential lease sales in the GOM from 12 to 7. Under the proposed action, there could be as many as 96 platforms and 534 wells (and associated pipelines, landfalls, and onshore processing facilities) developed in the Western GOM Planning Area. Under Alternative 3, this development would not occur, and as a result none of the short- or long-term localized impacts identified for the proposed action on water quality, air quality, marine and coastal biota and habitats, archeological or historic resources, or land use and infrastructure that would be associated with development and operation of this infrastructure and support activities (such as support vessel and helicopter traffic) in the Western GOM Planning Area would be expected to occur. However, water and air quality, as well as marine and coastal biota and habitats, in some portions of the Western GOM Planning Area could still be affected by oil and gas leasing and development in the western portions of the Central GOM Planning Area, especially if that development uses existing commercial infrastructure (such as shipyards, support centers, processing facilities) and shipping lanes in coastal areas of the Western GOM Planning Area.

Even though a relatively large amount of development would occur in the Western GOM Planning Area under the proposed action, the increases in population, employment, and income identified to occur under the proposed action would be only slightly reduced under Alternative 3, and would remain unchanged in the other planning areas.

Under Alternative 3, potential impacts on natural, physical, and socioeconomic resources in Alaska would be the same as those identified from the proposed action.

Under Alternative 3, no oil spills from oil and gas development activities would occur directly in the Western GOM Planning Area under the Program. However, spills that may occur under Alternative 3 from development in the other planning areas (especially large or very large spills in the Central Planning Area) could be carried by currents into the Western GOM Planning Area and affect marine and coastal resources, tourism and recreation, commercial fisheries, and local economies. The nature and magnitude of any such impacts on those resources (as described in earlier sections of this chapter) will depend on the location, size, and duration of any spills in the other GOM Planning Areas.

4.5.3 Alternative 4 – Defer the Central Planning Area for the Duration of the 2012-2017 Program

4.5.3.1 Description of Alternative 4

Under Alternative 4, no lease sales would be held in the Central Planning Area under the Program, and there would be no change from the proposed action for the other planning areas. Under Alternative 4, the following would take place:

- Five area-wide lease sales in the Western GOM Planning Area;

- One or two lease sales in the extreme western portion of the Eastern GOM Planning Area;

- One lease sale with a whaling deferral in the Beaufort Sea Planning Area;

- One lease sale with a 40-km (25-mi) buffer in the Chukchi Sea Planning Area; and

- One special interest lease sale in Cook Inlet.

4.5.3.2 Summary of Impacts

Excluding the Central GOM Planning Area from the Program would reduce the number of potential lease sales in the GOM from 12 to 7. Under the proposed action, the greatest amount of oil and gas development in the GOM would occur in the Central GOM Planning Area, with as many as 316 platforms and 749 wells (and associated pipelines, landfalls, and onshore processing facilities). Under Alternative 4, this development would not occur, and as a result none of the localized impacts (short or long term) on water quality, air quality, marine and coastal biota and habitats, archeological or historic resources, or land use and infrastructure that would be associated with development and operation of this infrastructure and support activities (such as support vessel and helicopter traffic) in the Central GOM Planning Area would be expected to occur. However, water and air quality, as well as marine and coastal biota and habitats could still be affected in some portions of the Central Planning Area by oil and gas activities in portions of the Western and Eastern GOM Planning Areas that abut the Central GOM Planning Area, especially if those activities use existing commercial infrastructure (such as shipyards, support centers, processing facilities) that are located in the Central GOM Planning Area.

Under Alternative 4, potential impacts on natural, physical, and socioeconomic resources in Alaska would be the same as those identified from the proposed action.

Even with the large amount of development that could occur in the Central GOM Planning Area under the proposed action, under Alternative 4 the increases in population, employment, and income likely to occur under the proposed action would be only slightly reduced, and would remain unchanged in the other planning areas.

Under Alternative 4, no oil spills from oil and gas development activities associated with the Program would occur directly in the Central GOM Planning Area. However, spills from development in the Western or Eastern GOM Planning Areas could be carried by currents into the Central GOM Planning Area and affect marine and coastal resources, tourism and recreation, commercial fisheries, and local economies. The nature and magnitude of any such impacts on those resources (as described in earlier sections of this chapter) will depend on the location, size, and duration of any spills in the other GOM planning areas.

4.5.4 Alternative 5 – Defer the Beaufort Sea Planning Area for the Duration of the 2012-2017 Program

4.5.4.1 Description of Alternative 5

Under Alternative 5, no lease sales would be held in the Beaufort Sea Planning Area under the Program, and there would be no change from the proposed action for the other planning areas. Under Alternative 5, there would be:

- Five area-wide lease sales in the Western GOM Planning Area;
- Five area-wide lease sales in the Central GOM Planning Area;
- One or two lease sales in the extreme western portion of the Eastern GOM Planning Area;
- One lease sale with a 40-km (25-mi) buffer in the Chukchi Sea Planning Area; and
- One special interest lease sale in Cook Inlet.

4.5.4.2 Summary of Impacts

Excluding the Beaufort Sea Planning Area from the Program would reduce the number of potential lease sales in the Arctic from 2 to 1. Under the proposed action, there could be as many as 4 platforms, 136 wells, 249 km (155 mi) of offshore pipeline, and 129 km (80 mi) of onshore pipeline developed in the Beaufort Sea Planning Area and adjacent coastal areas. Under Alternative 5 this development would not occur, and as a result none of the localized impacts (short or long term) on water quality, air quality, marine and coastal biota and habitats, archeological or historic resources, or land use and infrastructure that would be associated with development and operation of this infrastructure and any supporting activities (such as support vessel and helicopter traffic) in the Beaufort Sea Planning Area would be expected to occur. However, water quality, as well as marine and coastal biota and habitats in some portions of the Beaufort Sea Planning Area and adjacent coastal areas, could still be affected by oil and gas leasing and development in the eastern portions of the Chukchi Sea Planning Area.

Under Alternative 5, the increases in population, employment, and income likely to occur under the proposed action would be only slightly reduced, and would remain unchanged in the other planning areas.

Under Alternative 5, potential impacts on natural, physical, and socioeconomic resources in the GOM planning areas would be the same as those identified from the proposed action.

Under Alternative 5, no oil spills from oil and gas development activities associated with the Program would occur directly in the Beaufort Sea Planning Area. However, a spill that may occur under this alternative in the Chukchi Sea Planning Area could be carried by coastal currents into the Beaufort Sea Planning Area and affect marine and coastal resources, subsistence whaling, tourism and recreation, and local economies and communities. The nature and magnitude of any such impacts on those resources (as described in earlier sections of this chapter) will depend on the location, size, and duration of a spill in the Chukchi Sea Planning Area.

4.5.5 Alternative 6 – Defer the Chukchi Sea Planning Area for the Duration of the 2012-2017 Program

4.5.5.1 Description of Alternative 6

Under Alternative 6, no lease sales would be held in the Chukchi Sea Planning Area under the Program, and there would be no change from the proposed action for the other planning areas. Under Alternative 6, the following would take place:

- Five area-wide lease sales in the Western GOM Planning Area;
- Five area-wide lease sales in the Central GOM Planning Area;
- One or two lease sales in the extreme western portion of the Eastern GOM Planning Area;
- One lease sale with a whaling deferral in the Beaufort Sea Planning Area; and
- One special interest lease sale in Cook Inlet.

4.5.5.2 Summary of Impacts

Excluding the Chukchi Sea Planning Area from the Program would reduce the number of potential lease sales in the Arctic from 2 to 1. Under the proposed action, there could be as many as 5 platforms, 300 wells, and 402 km (250 mi) of offshore pipeline developed in the Chukchi Sea Planning Area. Under Alternative 6, this development would not occur, and as a result none of the localized impacts (short or long term) on water quality, air quality, marine and coastal biota and habitats, archeological or historic resources, or land use and infrastructure that would be associated with development and operation of this infrastructure and any supporting activities (such as support vessel and helicopter traffic) in the Chukchi Sea Planning Area would be expected to occur. However, water quality, as well as marine and coastal biota and habitats, and land use and infrastructure in some portions of the Chukchi Sea Planning Area and adjacent coastal areas, could still be affected by oil and gas leasing and development in the western portions of the Beaufort Sea Planning Area.

Under Alternative 6, the increases in population, employment, and income likely to occur under the proposed action would be only slightly reduced, and would remain unchanged in the other planning areas.

Under Alternative 6, potential impacts on natural, physical, and socioeconomic resources in the GOM planning areas would be the same as those identified from the proposed action.

Under Alternative 6, no oil spills from oil and gas development activities under the Program would occur directly in the Chukchi Sea Planning Area. However, spills from development in the Beaufort Sea Planning Area could be carried by coastal currents into the Chukchi Sea Planning Area and affect marine and coastal resources, subsistence whaling, tourism and recreation, and local economies and communities. The nature and magnitude of any such impacts on those resources (as described in earlier sections of this chapter) will depend on the location, size, and duration of a spill in the Beaufort Sea Planning Area.

4.5.6 Alternative 7 – Defer the Cook Inlet Planning Area for the Duration of the 2012-2017 Program

4.5.6.1 Description of Alternative 7

Under Alternative 7, no lease sales would be held in the Cook Inlet Planning Area during the Program, and there would be no change from the proposed action for the other planning areas. Under Alternative 7, the following leasing activities could take place:

- Five area-wide lease sales in the Western GOM Planning Area;
- Five area-wide lease sales in the Central GOM Planning Area;
- One or two lease sales in the extreme western portion of the Eastern GOM Planning Area;
- One lease sale with a whaling deferral in the Beaufort Sea Planning Area; and
- One lease sale with a coastal deferral in the Chukchi Sea Planning Area.

4.5.6.2 Summary of Impacts

Excluding the Cook Inlet Planning Area could result in one less potential lease sale in the Alaska Region. All offshore and onshore oil and gas activities and production associated with this sale would not occur. The small amount of oil assumed to be developed under Alternative 1 in Cook Inlet would be compensated for by imported oil. It is unlikely that the additional amount of imported oil that could occur under Alternative 7 will measurably affect the number of tanker oil spills that occur in other offshore areas in the United States.

The analyses of impacts of Alternative 1, the Proposed Action, in Cook Inlet showed in almost all cases temporary and localized impacts. Any disturbance to existing environmental conditions associated with routine operations or an oil spill would be expected to be ameliorated on a time scale of days to a year or two. Under Alternative 7, these short-term localized impacts would not occur. Under the Proposed Action, no population-level impacts were predicted for biological resources, although several endangered and/or threatened bird species would be vulnerable to mortality from oil spills. A moderate to large oil spill could affect a relatively large number of Steller's eiders, which overwinter in Cook Inlet. However, because the eider does not breed in Cook Inlet, the breeding populations would not be directly affected, although the number of eiders that arrive in the Arctic for breeding could be reduced. The endangered short-tailed albatross occurs uncommonly in Cook Inlet, so large numbers of birds would not be affected by a spill. Furthermore, the albatross breeds outside Cook Inlet, so the breeding population would not be affected. Kittlitz's murrelets, a candidate for listing under the Endangered Species Act, also occur in Cook Inlet and would be expected to come in contact with spilled oil while foraging. Impacts on these species under Alternative 1 would be contained within the Cook Inlet area and would not extend to other planning areas in Alaska where these species also occur during different life stages or seasons. Under Alternative 7, none of these localized impacts on protected species would occur from OCS activity.

While no long-term population-level impacts on terrestrial mammals in the Cook Inlet area are expected under Alternative 1, increased mortality of brown and black bears could occur if previously remote areas were converted to industrial use, resulting in increased conflict between bears and humans. A large oil spill that affected intertidal areas could lead to significant mortality of eggs and juvenile fish of pelagic species, such as the salmon, leading to reduced adult survival. The overall fish populations in South Alaska, however, would not be affected. A large spill could temporarily affect fisheries in the area that were contacted by the spill. While no long-term impacts on the fish populations are expected, economic impacts on commercial and recreational fisheries could result as a result of loss of gear, closings of affected areas, and unavailability of fishing areas during cleanup operations. These temporary and localized impacts in Cook Inlet, which are unlikely given the small amount of activity expected under Alternative 1, would be precluded under Alternative 3.

Impacts on air and water quality under Alternative 1 in Cook Inlet are expected to be short-term and localized because of the small amount of activity anticipated and the largely pristine quality of the air and water environments there. Therefore, Alternative 3 will not result in a major difference from Alternative 1 for these resources.

The analysis of archaeological resources indicated that existing BOEM requirements for archaeological surveys would be expected to eliminate most of the possible impacts on historic and prehistoric resources. Impacts were possible from cleanup operations after an oil spill. Given the small amount of liquid hydrocarbons expected to be produced under Alternative 1 in Cook Inlet, compounded with the requirement that the spill would have to contact areas with historic or prehistoric resources for impacts to occur, Alternative 3 is not expected to result in a significant difference from Alternative 1 with regard to the potential for archaeological resource impacts.

The population, employment, and income impacts anticipated under Alternative 1 in the Cook Inlet area would not occur under Alternative 3. Table 4.4.9-2 shows estimates of 4,520 jobs and $152 million in income resulting from Alternative 1 in the Cook Inlet area during the life of the Program.

4.5.7 Alternative 8 – No Action

The National Environmental Policy Act requires consideration of a No Action Alternative to every major Federal action that could result in significant impacts on the environment. In the context of the Program, the No Action Alternative is defined as the scenario in which BOEM holds no OCS oil and gas lease sales during the Program. Under this scenario, none of the potential environmental impacts associated with oil and gas related activities under the proposed action that have been evaluated in Section 4.4 would occur. These precluded impacts would include both the anticipated effects under the proposed action of routine operations and accidental discharges on ecological conditions and the effects of leasing on regional employment, regional income, and sociocultural stability. In addition, the oil and natural gas that would have been produced as a consequence of sales over the 5-yr program period would not be available to consumers, who would therefore need to obtain energy from other sources. The energy substitutes needed to replace the lost OCS production would be associated with their own potential environmental effects that could occur throughout the United States or the world depending on the mix of specific energy substitutes that would be used. The analysis that follows considers these factors to evaluate the overall effects of implementing the No Action Alternative. Information is first presented on the various uses of energy in the economy and on the current and projected uses of oil and gas compared to other fuel or alternate energy sources in each economic sector. Substantial discussions of the current status and projected developments in alternate energy sources for each sector of the economy are provided. A scenario of energy substitutes is then developed that projects the mix of energy substitutes that would be used to replace lost OCS production during the life of the program. This scenario is used to evaluate the anticipated broad effects of implementing the No Action Alternative in each program area as well as in other areas that could be affected by the energy substitutes used to replace lost OCS production.

4.5.7.1 Oil and Gas Uses and Alternatives

The primary energy sources used in the United States are petroleum, coal, natural gas, nuclear energy, and hydroelectric and non-hydroelectric power, the latter of which includes geothermal, wind, and solar power. The U.S. Energy Information Administration's *Annual Energy Review for 2009* reports that the largest portion (over 39%) of our energy comes from liquid fuels, primarily petroleum, and natural gas adds another 23% (EIA 2009a).

4.5.7.1.1 Transportation Sector. Total energy use in the transportation sector has grown by an average of just over 1% per year over the last 20 yr. As of 2008, the transportation sector accounted for an estimated 28% of all energy consumption in the United States, a proportion that has been slowly rising since the 1960s. The vast majority of this energy has come from oil — nearly three-fourths of all petroleum consumed in the United States in 2008 was used for transportation — with natural gas, electricity, and other alternatives playing much smaller roles (EIA 2008a). In this section, we discuss recent trends in the use of oil and gas in the transportation sector and the potential for substitutes for these energy sources within the time frame of the 40- to 50-yr life of the Program.

Uses of Oil and Gas in the Transportation Sector.

Ground Travel. Oil is the dominant energy source for ground travel. Approximately 141 billion gal of gasoline and 45 billion gal of diesel fuel were consumed for ground travel in 2007. Growth in consumption has been slow but steady in recent years, averaging about 1% per year from 2003 to 2007 (EIA 2007a). However, motor gasoline use fell by about 3% from 2007 to 2008, the first time total annual consumption has fallen since 1988–1991. Preliminary data show consumption remaining flat from 2008 to 2009 (EIA 2009b).

The use of natural gas as a vehicle fuel (in both compressed and liquid forms) has increased significantly in recent years, with an average annual growth rate of 8.5% from 2003 to 2007. However, natural gas still represents a small fraction of the total (just over 200 million gal of gasoline-equivalent in 2007, or about 1% of total vehicle fuel). In 2007, approximately 117,000 gas-fueled vehicles were in use, many of which were buses and other fleet vehicles (EIA 2007b).

Ethanol is currently the most used alternative fuel; consumption increased from 1.9 million gal of gasoline equivalent in 2003 to 4.7 million gal in 2007 (mostly as an additive in modest proportions to gasoline, although it is sometimes used as the dominant fuel source in an 85/15 ethanol-gasoline mix). Biodiesel use rose even more quickly over that period, but remains relatively modest overall at 470,000 gasoline equivalent gallons. Electricity, hydrogen, and other fuels contributed very little; electricity use for vehicle transportation actually declined slightly over this period (EIA 2007b).

Air Travel. Certified U.S. air carriers used 18.9 billion gal of fuel in 2008, which was 7.6% of the total consumed by the U.S. transportation sector. Fuel use for air travel has risen much faster than use for ground travel; total consumption rose by 4.6% per year from 2003 to 2007 before falling in 2008 (USDOT 2009c), indicating a strong linkage to larger economic factors. Petroleum-derived kerosene-style jet fuel accounts for nearly all of the fuel used for air travel.

Marine Travel. Marine travel accounts for a relatively small proportion of total oil consumption in the transportation sector and, as with air travel, there is no natural gas consumption. Total fuel consumption for marine travel was about 1,367 trillion Btu in 2007, roughly three-fourths the amount used by air travel and 6% of the total for the sector. Marine travel does show greater variation in fuels; residual fuel oil makes up about 70% of oil use, distillate and diesel fuel oil another 20%, with the remainder in gasoline. This mix has remained fairly consistent over time (USDOT 2010).

Total oil consumption for marine travel has shown no clear trend over time, with periods of sharp declines following years of growth, and vice versa. After dropping by nearly 30% from 2000 to 2003, fuel use increased nearly as dramatically to reach comparable levels by 2007. Consumption decreased in 2008. Taking a longer-term view does little to clarify the situation (USDOT 2010).

Rail Travel. Similar to marine travel, rail travel constitutes a small proportion of total oil consumption and virtually no natural gas consumption. Total oil use was 576 trillion Btu in 2007; the overwhelming majority of this was for freight transport, rather than passengers. Distillate and diesel are the fuels used (USDOT 2010).

Following a low of 414 trillion Btu in 1990, oil consumption for rail transportation grew steadily to 594 trillion Btu in 2006, before falling to 576 trillion in 2007 (USDOT 2010). Thus, it appears that fuel use for rail transportation is in the midst of a long-term increase, although the slide during the 1980s indicates that this is by no means inevitable.

Analysis of Energy Substitutes in the Transportation Sector. In this section we analyze the potential for substitution away from fossil fuels within the time frame of the 40- to 50-yr life of the Program. Our focus is primarily on ground transportation, which could demonstrate lower fuel consumption through efficiency improvements, a shift toward greater use of public transportation, or use of alternative fuels. We also discuss the potential for oil substitution in air travel through both efficiency improvements and fuel switching.

More Efficient Vehicles. Automobiles in the United States currently have a lifespan of about 14 years. While some individual vehicles will remain in use for a longer period of time, it seems safe to assume that the Nation's fleet will have turned over nearly in its entirety within 20 years. As of 2007, there were 254.4 million registered highway vehicles, of which 135.9 million were passenger cars, 7.1 million were motorcycles, and 111.3 million were other vehicles (primarily light- and heavy-duty trucks); population growth is likely to add substantially more vehicles, even if the number of vehicles per capita continues to fall (USDOT 2009d). Thus, there is huge potential for oil reductions through efficiency improvements in the Nation's automobiles. Since natural gas makes up such a small proportion of fuel used for transportation, we do not consider it further.

In the near term, the efficiency of the Nation's vehicle fleet is likely to be determined more by stricter regulatory requirements than by a demand from consumers for yet-more-efficient vehicles. CAFE standards currently stand at 27.5 mpg for passenger cars and 23.1 mpg for light trucks. Building on requirements in the 2007 Energy Policy Act, however, the Obama Administration has established stricter targets, setting a schedule that steadily raises the requirements to an end point of 35.7 mpg in 2015 for cars and 28.6 mpg for trucks. The new vehicles subject to these limits will replace older, retired vehicles manufactured in the late 1990s and early 2000s, whose fuel efficiency was, on average, about 8 mpg lower. This is equivalent to a 23% savings in fuel use for passenger cars, or a 28% savings for light trucks. If we hold the number of miles driven per vehicle steady at 2007 levels, we can expect a total savings of 12.3 billion gal of gasoline per year by 2015 as a result of the stricter vehicle standards.

Hybrid Vehicles. Hybrid vehicles are already fairly well established, with all of the major automakers now mass-producing hybrid models. While hybrids will remain somewhat more expensive than conventional cars in terms of the upfront cost, the premium will likely fall as technology improves and manufacturers continue to scale up production. With sufficiently strong tax incentives or other forms of policy support, hybrids could theoretically entirely replace conventional automobiles.

Rough calculations of the scale of the impacts that such a shift would entail suggest a large potential for reducing the consumption of gasoline. If population growth continues at its current pace, there will be about 393 million people in the United States in 2035; this will likely translate into roughly 300 million vehicles. Projecting a 30% savings per vehicle (based on the hybrid and traditional Toyota Camry models) would imply a total savings of 49 billion gal of gasoline — more than one-fourth of total current consumption for ground transportation. Clearly, this is a very rough, illustrative figure, but it nonetheless shows that hybrid vehicles have the potential to offset a significant fraction of oil use. While we do not discuss other types of fuel efficiency improvements (such as switching from trucks to cars or using more lightweight materials), the scope for potential gains would be similar.

Electric and Plug-in Vehicles. The impact of plug-in hybrid and electric vehicles is likely to be comparatively modest, even over a fairly long 25-year horizon. Plug-in hybrids use 20 to 55% less gasoline than traditional hybrids, depending on the mix of electricity and gasoline used (NRC 2010); electric vehicles, of course, use no oil at all. The existence of 40 million plug-in hybrids, the high estimate from the National Research Council (NRC), would imply a savings of about 12 billion gal of gasoline per year. While the NRC report did not consider all-electric vehicles, a similar number of electric vehicles (a very aggressive assumption) would save about 22 billion gal of gasoline per year. The 13 million vehicles considered a more likely figure would produce savings of 4 to 7 billion gal.

The keys to future rates of adoption of electric vehicles and plug-in hybrids are the batteries used to replace (in whole or in part) the gasoline-powered combustion engine. Both plug-in hybrids and electric vehicles currently use lithium-ion batteries; conventional hybrids use nickel-metal hydride technology, but are expected to switch over to lithium-ion batteries as well (Pike Research 2009). Within the broad characterization of lithium-ion batteries, there are several different subtypes, each of which can be evaluated on six basic criteria: energy storage capacity, power, safety, performance, life span, and cost. Significantly, none of the battery types currently in use performs well across all six criteria. As a result, the Boston Consulting Group concluded that, absent a major breakthrough, fully electric vehicles that are as convenient as conventional cars will likely not be available by 2020 (Boston Consulting Group 2010).

Similarly, a report from the NRC explored the prospects for plug-in hybrid vehicles by 2030. NRC estimates that, under optimistic assumptions, the maximum number of plug-in electric vehicles on the road at that time would be 40 million; cost and convenience factors suggest that 13 million may be more likely. The NRC report did not anticipate significant cost improvements in lithium-ion batteries in the foreseeable future (NRC 2010).

Ethanol Vehicles. Perhaps the single most important factor driving the long-term adoption of ethanol is the cost of producing cellulosic ethanol. Unlike traditional corn- or sugar-based ethanol, which is derived from starch, cellulosic ethanol uses cellulose as its basis, a structural component of plant cell walls and the most common organic compound on earth. A cost-effective method to produce cellulosic ethanol would allow for the use of a wide variety of feedstocks, including inedible crop residues and plants that grow on marginal agricultural land with little or no active cultivation. This would, in turn, enable far greater use of ethanol as a substitute for petroleum-based fuel.

At this time, cellulosic ethanol production is too expensive to justify large-scale use, due largely to the cost of producing enzymes to convert cellulose into a useable form. However, many observers expect significant cost reductions in the coming years. For example, Novozymes, the world's largest manufacturer of industrial enzymes, announced in February 2010 that it was launching a line of enzymes that it expects will lower overall production costs to under $2 a gallon, which is in line with costs for corn-based ethanol and gasoline (Leber 2010; Motavalli 2010).

If ethanol production costs fall below those of petroleum, further policy support may be unnecessary, as ethanol will become the preferred transportation fuel. Failing this, however, energy policy could play a major role in determining future levels of ethanol use. As was noted above, the Energy Independence and Security Act requires the use of 36 billion gal of ethanol in 2022, of which 16 billion is to be cellulosic ethanol. The U.S. Environmental Protection Agency (USEPA) has not yet established targets for later years (USEPA 2010a).

Another important consideration is whether there is sufficient agricultural capacity to support substantially greater reliance on biofuels — and to do so without causing an unacceptable rise in the price of basic foods, due to upward pressure on demand for agricultural land. A 2005 U.S. Department of Energy/U.S. Department of Agriculture (USDOE/USDA) report examined the feasibility of displacing 30% of the country's petroleum consumption with biomass-based energy, which the authors estimated would require a dry biomass potential of about 1 billion tons per year. That report identified the potential for 368 million dry tons biomass potential per year from forestlands and 998 million dry tons biomass potential from agricultural lands, with "relatively modest changes in land use and agricultural and forestry practices." Agricultural biomass would comprise a mix of crop residues, grains for biofuels, process residues, and dedicated perennial crops. Not all of this would be suitable for conversion to liquid fuels for transportation. Nonetheless, the report makes clear that the United States has the productive capacity to meet a significant portion, but not all, of its transportation fuel demand from biofuels (USDOE and USDA 2005).

The USDOE/USDA study cited above noted several potential environmental impacts from increased use of forest and agricultural land for biofuel production:

- Increased logging could result in greater soil erosion and elevated levels of sediment in surface waters.

- Removing crop residues could reduce soil quality, increase erosion, and release carbon from the soil into the atmosphere.

- In addition, removing the nutrients embodied in crop residues could lead to increased fertilizer use, leading to increased nutrients in water runoff and greater use of fossil fuels for fertilizer manufacture (USDOE and USDA 2005).

In addition, agriculture is relatively fuel-intensive; reliance on petroleum to power machinery and equipment, and to manufacture fertilizers and other inputs, could offset much of the potential for biofuels to reduce overall petroleum consumption. Cellulosic ethanol is expected to have a more favorable lifecycle profile than corn ethanol, but it will nonetheless be unable to reduce petroleum consumption on a 1-to-1 basis.

Overall, if cellulosic ethanol becomes cost-competitive with other liquid fuel sources, and/or if it is given sufficiently strong policy support, it will likely displace a significant amount of petroleum in the long term, possibly as much as 30% or more of total consumption. It is unlikely to have any appreciable impact on natural gas consumption.

Public Transportation. In the short term, cities that have established public transportation systems could see increased ridership on their existing routes. To expand the impact of public transportation over the longer term, cities could build new mass transit systems or expand existing systems, thereby allowing residents to reduce their use of gasoline-fueled automobiles. There are no firm rules regarding how much time is needed to develop new systems, but anecdotal information from cities that have recently created or expanded their transit networks suggests that a 10- to 15-yr time horizon should generally be sufficient for large cities to create or expand light rail systems. Bus-based systems could presumably be implemented in much shorter time frames.

Hydrogen and Fuel Cell Vehicles. Hydrogen has been discussed for some time as the "fuel of the future," touted as being advantageous because of its abundance as an element, its density as an energy carrier, and its lack of harmful emissions. In vehicles, hydrogen fuel can be used in two different ways: burning in an internal combustion engine, or in a chemical reaction in a fuel cell. The focus of this section is on the latter, which has the potential for greater efficiency in the long term. Fuel cells work by separating a chemical fuel, such as hydrogen, into negatively charged electrons and positively charged ions. The electrons are forced through a wire to create an electrical current and power the vehicle. The electrons are then reunited with the ions and oxygen to form pure water. Since there are no moving parts, fuel cells are exceptionally reliable and can last for a very long time.

While hydrogen is one of the most abundant elements on earth, it occurs only rarely in pure elemental form. Hydrogen for fuel must be gathered from another source. Currently, 95% of the hydrogen used in the United States is produced through steam reforming of natural gas, in which high-pressure steam reacts with methane to produce hydrogen, carbon monoxide, and a small amount of carbon dioxide (EERE 2008). A potentially more environmentally friendly, though more expensive, alternative is to split water molecules into hydrogen and oxygen through the process of hydrolysis. Since hydrolysis is powered by electricity, renewable power sources such as wind or solar power could theoretically be used to produce the hydrogen needed to fuel vehicles.

All of the technology needed for hydrogen-powered, fuel cell operated cars is already in existence, but not at a stage that would permit cost-effective widespread commercial deployment. Key areas of ongoing research include the materials and manufacturing process for fuel cells and, in particular, a reduction in the amount of platinum used. Another area of ongoing research is to develop a more efficient means of producing hydrogen through hydrolysis or from other non-fossil fuel sources, which would ultimately be more environmentally beneficial than production from natural gas.

Perhaps a more critical issue is the "chicken-and-egg" problem inherent in deploying hydrogen fuel on a wide scale. Widespread adoption of hydrogen vehicles will necessitate enormous investments in infrastructure, to make the fuel as widely available as gasoline is at present. However, it will be difficult to justify investment on the scale required until there are enough hydrogen-fueled cars on the road to create sufficient demand to support the industry. So long as there is a sufficient supply of petroleum or biofuels that can use existing infrastructure to meet the needs of the Nation's vehicle fleet, this will pose a serious problem. Sustained policy support will likely be necessary to establish adequate hydrogen fueling infrastructure.

The California Fuel Cell Partnership estimates that if fuel cell vehicles are introduced into the market on a limited scale over the next decade, as expected, they could be widely available by 2030. Due to the significant lag in vehicle turnover, then, it would likely be another 10 to 20 yr before hydrogen could replace oil as the dominant transportation fuel. Ultimately, hydrogen has the potential to replace substantially all of the petroleum used by the transportation sector, but only over a very long time horizon (NREL 2007).

Summary. The review of potential sources of oil and gas savings from the transportation sector showed that the ground transportation sector accounted for about 180 billion gal of gasoline and diesel fuel use in 2008. Air travel consumed roughly 19 billion gal of fuel; marine travel used somewhat less. Natural gas did not play a significant role as a transportation fuel.

In the near term, major sources of potential fuel savings include more efficient gasoline-powered automobiles and substitution of biofuels for gasoline in automobiles. These two sources could save approximately 17 billion gal of gasoline per year by 2015, or about 10% of the total for ground transportation. Hybrid and electric vehicles and increased use of public transportation could contribute more modest savings.

The potential for oil savings is greater in the longer term. Cellulosic ethanol could displace as much as 30% of total oil consumption. Hybrid and electric vehicles, increased use of public transportation, and more efficient planes could generate oil savings as well, albeit in more modest amounts (likely on the order of 9 billion to 14 billion gal gasoline-equivalent). Finally, if adopted on a wide scale, hydrogen fuel could replace substantially all of the petroleum used by the transportation sector, but only over a very long time horizon, beyond what is under consideration for the Program.

4.5.7.1.2 Electricity Generation Sector.

Uses of Oil and Gas in the Electricity Generation Sector. Petroleum plays a very modest role in electricity generation, and the proportion of U.S. electricity generation from oil-fired power plants has been on a steep decline since the late 1970s. For natural gas, the converse is true; gas-fueled electricity generation nearly doubled over the 10 years from 1997 to 2007. The electricity generation sector is second only to industrial use in terms of overall consumption of natural gas. This section analyzes the use of oil and gas for electricity generation. We begin with an examination of recent trends and current use of oil and gas in the sector, and then discuss the near- and long-term potential for substitutes. A particular focus is on the circumstances under which these fuels are used for electricity generation, and how this affects the ability of renewable energy sources to substitute for these fossil fuels.

Electricity generation consumed 81 million barrels of petroleum in 2008, or about 3.4 billion gal; this translates into total primary energy use of about 469 trillion Btu (EIA 2010c). This represents a steep decline from 2005, when electricity production consumed nearly three times as much oil. Prior to that, oil consumption had remained at approximately the same level since the mid-1980s. Oil consumption in the electricity generation sector peaked in 1977 at 3,900 trillion Btu, more than eight times the current level (EIA 2009c).

Within the electricity generation sector, petroleum is used primarily to fuel "peaker" plants — facilities that stand idle most of the time and are used only at times of very high demand. Generally, such plants are relatively cheap to build but expensive to operate, as the per-unit fuel costs are more expensive than other plants; thus, they are only used when all other options have been exhausted. As a result, oil provides the fuel for only a small fraction of electricity generated in the United States. Petroleum was used to produce 46 million megawatt-hours of electricity in 2008, about 1% of the 4,119 million megawatt-hour total. This was far less than the generation provided by coal, natural gas, nuclear, hydroelectric, or even biomass and wind resources (EIA 2010d).

Since most petroleum-fired plants are used relatively infrequently, these plants contribute a larger proportion of generating capacity to the total than they do actual generation. In 2008, oil-fired plants accounted for 57,445 MW of net summer generating capacity, or 5.7% of total U.S. capacity. This figure has remained fairly steady since 2002, despite the significant drop in petroleum-fueled electricity generation over that time period (during which overall peak electricity demand increased) (EIA 2008c, 2010d). What this indicates is that, for peaker plants in particular, there may not be a strong correlation over the short run between available capacity and actual use. Thus, oil price changes may be reflected to some degree in electricity generation, but it will take a longer time (and a more sustained price change) before total capacity of oil-fired plants is similarly affected.

The use of oil predominantly as a peak fuel means that most oil-fired plants are relatively small, and that there are a relatively high number of them in use. There were 1,205 oil-fired generating stations in 2008, with an average capacity of less than 50 MW each. By comparison, there were half as many coal-fired plants, with an average generating capacity of more than 500 MW.

Thermodynamically, the conversion of fossil fuels into electricity is not particularly efficient; that is, a significant amount of usable energy is lost as waste heat in the process. The use of 469 trillion Btu of petroleum products to produce 46 million megawatt-hours translates into an efficiency of about 34% (100% efficiency would require 3,412 Btu per kilowatt-hour). However, due to the nature of the technologies involved, there is relatively little room for efficiency gains using conventional combustion engines.

Much larger quantities of natural gas are used for electricity generation than petroleum. In 2008, 6,896 billion cubic feet of natural gas, or 7,089 trillion Btu, were consumed in electricity generation — an energy content 15 times greater than that supplied by petroleum. Natural gas use has risen sharply in recent years, growing by an average of 6.3% annually from 2003 to 2008. While that rate may seem modest, it was five times greater than the overall increase in electricity generation. Only coal supplied a larger share of the nation's electricity in 2008 (EIA 2010d).

In terms of generating capacity, natural gas ranks as the largest component of the electricity generation sector, producing 397 million MW in 2008, or 40% of the total. Growth in gas-fired capacity has outpaced overall capacity expansion in recent years (2.2% vs. 1.3% per year), albeit not to the same extent as has generation. Notably, gas generation expanded much more rapidly in the early years of the last decade than in later years, growing more than 16% per year from 1999 to 2003. This was largely in response to the relative flexibility of natural gas power plants, which can be used for baseload, intermediate, or peak generation, and the comparatively favorable environmental profile of such plants compared to coal or nuclear power. As of 2008, there were 1,653 gas-fired power plants in operation in the United States, with an average capacity of about 240 MW (EIA 2010d).

Electricity generation is somewhat more efficient using gas than oil, with an average 42.5% thermodynamic efficiency in 2008. This is partially due to the nature of the combustion engines used for each fuel; since gas engines are more expensive and run more frequently, there is a greater incentive for efficient combustion. However, efficiency has also been rising in recent years as the result of greater use of natural gas combined cycle plants. In a combined cycle plant, the exhaust gases from the gas turbine are used to heat steam which is used to turn a second turbine, thereby capturing the "waste" heat from the first cycle. As these secondary steam turbines are installed in new gas power plants or placed into existing ones, the efficiency of gas-fired electricity generation should continue to improve.

Analysis of Energy Substitutes in the Electricity Generation Sector. As of 2008, natural gas accounted for 40% of electricity generation and petroleum provided an additional 1.8%. Both oil and gas fossil fuel generators have an expected lifespan of about 20 to 25 years. In this time frame, therefore, we can expect a complete turnover of the Nation's oil and gas generators, as well as new additions necessitated by growth in demand. There is significant potential for substitution away from these fuels over that period, depending upon the availability and suitability of other power sources.

Biofuels represent the most obvious potential substitute for petroleum and gas in terms of fuel characteristics, although, as noted above, they are more likely to be used in the transportation sector, which represents a much larger source of demand. Even assuming significant scale-up of new biofuel production capabilities, the maximum amount available from domestic sources would likely not be enough to meet current levels of both transportation and electricity fossil fuel demand. We therefore exclude biofuels from further consideration here.

Wind and solar power are more likely alternatives to oil and gas as electricity sources.[18] Due to their status as intermittent resources (i.e., generating electricity on an irregular time frame according to the vagaries of weather), however, there are limits to the maximum amount of near-term penetration that these energy sources will likely achieve in a cost-effective manner. A report from the National Renewable Energy Laboratory (NREL) projected that wind power could achieve 20–30% penetration in the eastern United States by 2024, given sufficient investment in transmission upgrades; in the absence of such investment, this level of wind penetration would require significant curtailment (shutting down) of wind plants, with a high associated cost (EnerNex Corporation 2010). Furthermore, a similar study found that 30% wind penetration is technically feasible in the western United States as well, with some modifications to current practice by grid managers (GE Energy 2010). A substantial portion of the long-term wind potential also identified by NREL, 54 gigawatts, is to come from offshore wind. The U.S. has areas appropriate for offshore wind power development near large coastal urban areas. With growing electricity demand and space constraints on land-based electricity generation and transmission, offshore wind is favorably positioned to play a role in meeting future energy demand, though regulatory and permitting requirements may pose challenges in the near term (NREL 2010. In simple terms of magnitude, therefore, wind could theoretically entirely displace oil and gas for electricity generation. Wind is already reasonably cost-competitive with oil and gas, and will become more so if fuel prices rise and/or if climate policy results in a carbon tax or cap-and-trade mechanism. For wind, therefore, the most important constraint will be the ability of the electric grid to accommodate significant amounts of an intermittent resource as well as constructing sufficient transmission infrastructure. Much of the wind potential evaluated by NREL would come from the Great Plains, and while the report emphasizes the benefits of regional integration and coordination, this geographic dynamic suggests that a portion of the wind power is likely to be replacing coal rather than oil or gas.[19] For the coastal areas of the U.S. which rely more heavily on natural gas (and small amounts of oil) for electricity generation than the Midwest for example, any offshore wind development that does come about would help to further educe dependence on fossil fuels. In addition, some amount of oil or gas will be needed to balance the intermittency of wind resources. Nonetheless, wind power could potentially replace a major portion of oil- and gas-fired electricity generation.

---

[18] This is true in terms of electricity produced and thus fuel used on an ongoing basis; with regard to capacity, it is a more dubious proposition. Since wind and solar are not firm resources, a certain level of natural gas or oil capacity will generally be required as “backstop” resources to protect against grid problems in times when the supply of these renewables cannot meet the instantaneous demand for electricity.

[19] Although coal is a baseload power source, and thus not directly replaceable by a given wind plant, a widely dispersed network of wind plants could provide sufficiently firm power in the aggregate to eliminate the need for a portion of the region’s coal-fired capacity. The NREL report frames its results in terms of smaller increases in capacity of fossil plants, rather than absolute reductions, but it appears that it forecasts wind to displace a mix of coal and gas plants.

Solar power, although not expected to play a significant role in electricity generation over the next few years, could become more important, given the right mix of technological improvements and market or policy influences. A study by the research firm Clean Edge, Inc., and the non-profit Co-op America found that photovoltaic and concentrated solar power could reach 10% of electricity generation by 2025, although this would require a capital investment of hundreds of billions of dollars. As a resource that is generally available during times of peak demand (i.e., warm-weather periods), widespread use of solar power would imply significant displacement of both oil and gas. Such a scenario is dependent on significant cost decreases in the manufacturing process, to be driven both by the realization of economies of scale and by other technological improvements (Clean Edge, Inc. and Co-op America 2008).

All in all, given favorable conditions, solar and wind power could be used to replace a significant portion of oil and gas used for electricity generation. The technical constraints posed by their status as intermittent resources mean that these energy sources cannot be used to completely replace fossil fuels, however, even with investments in the transmission grid and/or in battery storage. While it is not the aim of this report to develop a detailed forecast, some simple math can illustrate the potential scope of the substitution. The EIA's 2010 Annual Energy Outlook forecasts electricity generation to grow at 1% annually over the next 25 yr (EIA 2009d). At that rate, total electricity generation would be approximately 5,389 billion MW-hr in 2035, up from 4,119 billion MW-hr in 2008. If wind is in fact able to reach 20% penetration, and solar to reach 10%, this would imply a total of about 1,078 and 539 billion MW-hr, respectively, produced from these sources. (By way of comparison, wind accounted for 1.34% of all generation in 2008, while solar was virtually zero.) If we assume that half of the growth in these renewables replaces oil and gas, and half coal, then this suggests that they could displace 772 billion MW-hr of oil- and gas-fired electricity annually. This could result in more than 80% of the current total produced from these sources, or roughly two-thirds of what would come from these fossil fuels in 2035 if they were to continue to hold their current proportions of total generation.

Nuclear power represents another potential substitute for natural gas. After years of no new construction, the Nuclear Regulatory Commission is actively reviewing applications for operating licenses for 22 new nuclear power plants; power companies are considering additional plants as well. However, since natural gas is used primarily as an intermediate or peak power source, whereas nuclear power is a baseload resource, the potential for substitution is limited. Furthermore, the extent to which nuclear power will be able to successfully compete with other baseload resources, such as coal or biomass, will depend on climate policy, the relative ease or difficulty of gaining regulatory approval, and fuel cost and availability.

Finally, we note that climate change and energy policy could have a significant effect on shaping the electricity sector. There are several means by which the industry could be shifted away from natural gas and oil. These include:

- *USEPA regulation of greenhouse gases as criteria pollutants under the CAA.* In April 2009, the USEPA declared CO_2 and five other greenhouse gases to be endangering public health and welfare, setting the stage for the agency to regulate them under the CAA. Electric utilities would be a likely first target for rules that would most likely either take the form of a cap-and-trade system similar to the SO_2 regime already in place or firm facility-level emissions limits. If put in place, such regulations would most likely have the greatest impact on coal, which is more greenhouse gas intensive, and could actually result in greater use of oil and gas as a result (as well as greater use of renewable power sources). The prospects for such regulation are unclear; Congress is considering legislation to preclude the USEPA from issuing such regulations.

- *A Nationwide renewable energy standard.* A renewable energy standard, such as that included in the Waxman-Markey climate bill passed by the House of Representatives, would require electric utilities to meet a minimum amount of electricity demand (e.g., 20%) through renewable sources. In this case, natural gas and oil would likely be impacted more heavily, since they are more expensive than coal and thus are more economically inefficient tradeoffs.

- *Subsidies for renewable energy production.* Finally, policymakers could continue existing incentives for generation from renewable sources, such as the production tax credit of 2.1 cents per kilowatt-hour for wind or the investment tax credit of 30% of the cost of solar installations. This would have largely the same effect (albeit on a more modest scale) as a renewable energy standard, making renewables more cost-competitive compared to other energy sources. Again, as higher-cost resources, natural gas and oil would likely be impacted more heavily than coal.

These or other policy measures will influence the mix of renewables, oil, gas, and other resources in the electricity sector, but they will be unlikely to change the maximum potential levels of substitution described above. Even over a 25-year time horizon, natural gas is likely to contribute a significant portion of electricity generation in the United States.

4.5.7.1.3 Oil and Gas Uses and Alternatives – Industrial Sector.

Current Use of Oil and Gas in the Industrial Sector. The industrial sector used 1.68 billion barrels of petroleum in 2008, with primary energy use of 8,586 trillion Btu. It consumed a similar 8,149 trillion Btu in natural gas, slightly more than was used for electricity generation. The industrial sector was therefore the second-largest petroleum-consuming sector of the economy after transportation and the highest gas-consuming sector (EIA 2009e, f).

Industrial oil use peaked in the United States in 1979 at just less than two billion barrels. More recently, levels of consumption have remained relatively steady from year to year; from 1998 to 2007, annual industrial petroleum use held between 1.77 and 1.91 billion barrels, a difference of less than 10%. Oil use was lower in 2008, likely due to the broad economic downturn in that year. What has changed over the past decades is the composition of the sector's petroleum inputs. Liquid petroleum gases, or LPGs, have steadily increased as a proportion of total petroleum, from 5% in 1950 to 24.2% in 1980 to 33.3% in 2008. As LPG use has grown, residual fuel oil has virtually disappeared, dropping from 33.4% of industrial oil in 1950 to just 1.7% in 2008 (EIA 2009g). Since LPGs are comparatively cleaner than residual fuel oil, this indicates that the net environmental impact of industrial oil use has moderated over time.

Natural gas use peaked in 1973 at 10,388 trillion Btu, industrial natural gas consumption fell sharply in the late 1970s and early 1980s, before climbing back during the 1990s. Natural gas use has been falling again in recent years, from 9,933 trillion Btu in 1997 to 8,149 trillion Btu in 2008 (EIA 2009f). This could reflect a response to a long-term trend of rising natural gas prices over that time period.

Oil and gas are used for three broad purposes within the industrial sector: (1) to generate heat and steam for industrial processes, either in boilers or in direct process heating; (2) for heating and air-conditioning of ambient air; and (3) as nonfuel feedstocks for a variety of products, including solvents, lubricants, plastics, asphalt, and various chemicals. Oil and natural gas are also used by many industrial facilities for cogeneration, which produces electricity as well as usable heat and steam to be consumed either onsite or by neighboring facilities. These end uses are discussed in greater detail below.

Process Heating. Process heating is the practice of heating particular materials used in manufacturing, including metals, plastics, and ceramics. Process heating softens, melts or evaporates materials, and may be used to catalyze chemical reactions. This can be accomplished through a variety of equipment types, including furnaces, ovens, dryers, and specially designed heaters for the process in question. Process heating systems may use fuel directly or may be electricity- or steam-based; we consider only direct fuel-burning equipment here.

Process heating is the largest industrial fuel use of natural gas. Excluding onsite transportation within industrial facilities, electricity generation, and unspecified uses, process heating accounted for 47% of industrial natural gas use in 2006. In 2002 (the date of EIA's previous Manufacturing Energy Consumption Survey [MECS]), this number stood at 49%. Total gas use for process heating dropped by 9% over that time period.

Process heating is also a major industrial use of petroleum, if nonfuel applications are excluded. Process heating represented 32% of industrial petroleum fuel use in 2006 (once again excluding transportation, electricity generation, and unspecified uses). Petroleum use for process heating dropped 23% from 2002, at which point it had accounted for 42% of industrial petroleum fuel use. If nonfuel applications are included, however, process heating accounted for less than 5% of total petroleum use in both 2002 and 2006 (EIA 2009h, i).

Boilers and Cogeneration. Boilers use a fuel source such as oil or gas to produce steam, which is, in turn, used to heat other materials and/or the ambient environment or to drive turbines. Conventional boilers accounted for 28% of industrial petroleum use for fuel in 2006, with cogeneration responsible for another 20%, a total of 48%. The numbers were somewhat lower for natural gas, at 24% and 16%, respectively, for a total of 40%. Again, these figures exclude onsite transportation, non-cogeneration electricity production, nonfuel applications, and unspecified uses. There was relatively little change in these proportions from 2002. Including nonfuel use has only a modest impact on natural gas, but drops the proportion of petroleum use for boilers and cogeneration dramatically, to 4% for boilers and 3% for cogeneration. Both natural gas and petroleum use for boilers and cogeneration were virtually unchanged in absolute terms from 2002 to 2006 (EIA 2009j, k).

Heating, Ventilation, and Air Conditioning (HVAC). After process heating and boilers and cogeneration, HVAC is the only significant industrial end use of petroleum and natural gas except use as chemical feedstocks. HVAC accounted for 4% of petroleum and 7% of natural gas fuel use in both 2002 and 2006. The proportion of petroleum use drops to less than 1% when nonfuel applications are factored in. Natural gas use for HVAC saw a modest decline in absolute terms from 2002, matching the overall pattern in industrial gas use, while petroleum remained constant (EIA 2009j, k).

Non-energy Uses. While nonfuel applications make up a relatively small proportion of industrial gas use — just 7% in 2006, down from 11% in 2002 — they account for nearly 90% of petroleum consumption. Thus, the use of petroleum products as chemical feedstocks deserves particular attention.

Over half of the nonfuel consumption of petroleum takes place at petroleum refineries. In addition to various forms of petroleum fuels, refineries also produce a range of petrochemicals, including lubricating oils, paraffin wax, and asphalt and tar; however, the information available is not sufficiently detailed to indicate petroleum use for each of these products (EIA 2009k).[20]

The next most significant source of demand is plastics materials and resins, which accounts for nearly 20% of nonfuel petroleum consumption (EIA 2009k). Plastics come in a wide variety of forms and are used for an equally wide variety of applications, but almost all plastics are composed of chains of carbon and hydrogen (sometimes with other elements included). This structure makes petroleum an ideal feedstock for plastics. Most plastic manufacturing processes have very little material waste and incorporate virtually all of the petroleum input into the final product (Graedel and Howard-Grenville 2005).

The other major consuming sectors of nonfuel petroleum are classified as "petrochemicals" and "other basic organic chemicals." Again, the information available does not provide any further detail. "Other basic organic chemicals" is also a major nonfuel user of natural gas. However, the most significant nonfuel consumer of natural gas is nitrogenous fertilizers, which are widely used throughout the agricultural sector (EIA 2009k).

Notably, nonfuel use of both petroleum and natural gas was significantly lower in 2006 than in 2002. The most significant decline for each came in chemicals. Detailed information was not available for petroleum. For natural gas, the decline was especially significant in

[20] The input source for this sector is classified as "other" in the MECS table regardless of the actual material type (petroleum, natural gas, coal). However, given the function of oil refineries, this energy is almost certainly taken from petroleum products. This discrepancy accounts for much of the "other" nonfuel consumption in the table above.

nitrogenous fertilizers (which fell by 40%), basic organic chemicals (which dropped by 54%), and plastics (83%). Although there is less detail, data from earlier years suggests this may be a sustained decrease rather than an isolated phenomenon. There was relatively little change in nonfuel consumption of petroleum at petroleum refineries or for plastics, the only major categories for which data are available for both years (EIA 2009k).

Analysis of Energy Substitutes in the Industrial Sector. Industrial equipment is typically long-lived. The Chartered Institute of Building Services Engineers (CIBSE) lists the "indicative life expectancy" for boilers at 15–25 yr, and gas- or oil-fired furnaces at 15 yr (CIBSE undated). In addition, such equipment often represents a significant expenditure. As a result, turnover rates are relatively low. Only in extreme circumstances would a change in fuel prices prompt a facility manager to replace petroleum- or gas-fired equipment significantly in advance of its planned retirement date. For that reason, we consider any form of fuel switching that would require replacing major equipment for industrial facilities as a long-term possibility.

The potential for biofuel production has already been discussed in the transportation section and is not repeated in detail here. Biofuels could displace a significant portion of petroleum use over the next 25 yr, perhaps up to 30% of total nationwide consumption, but most petroleum substitution will take place in the transportation sector. Most likely there is comparatively little room for expanded biofuel use in the industrial realm. Furthermore, due to the limits on potential biofuel supply (based on available land to dedicate to growing fuel crops), if overall biofuel use does approach the upper boundary of 30%, any substitution of biofuels for petroleum that did happen in the industrial sector would come at the expense of similar substitution elsewhere. This would be true for bio-based inputs for plastics manufacturing as well as for fuel use.

Industrial facilities could also use equipment powered by electricity instead of oil- and gas-fired equipment. Given that most industrial oil- and gas-using equipment is used simply to provide heat (e.g., for process heating or in boilers), such a move would generally be thermodynamically inefficient; while electricity generation and consumption produce considerable energy losses, combustion for heat is far more efficient at using embodied energy from a fuel source. Even so, electricity is a viable option, and if generated from renewable sources, it may result in lower environmental impacts.

For non-fuel uses such as plastics, there may be greater potential for substitution away from petroleum. The manufacture of bio-based plastics, mostly produced from starch, sugar, and cellulose, increased by 600% between 2000 and 2008, although they still represent a small proportion of total plastics (Ceresana Research 2009). Globally, demand for bio-plastics is forecast to grow at approximately 25% annually from 2010 to 2015 (Pira International 2010). This suggests the potential for bio-based plastics to replace a portion of conventional plastics.

Plastics manufacturing accounted for the equivalent of 1,198 trillion Btu of petroleum consumption in 2006. While it is not clear what proportion of total plastic produced in the United States currently derives from non-petroleum sources, 5–10% appears to be reasonable, based on global estimates (U.K. National Nonfood Crop Centre 2010; Nova Institute 2009). From this base, the projected growth rates in bio-plastic manufacture just reported would suggest that an additional 130–260 trillion Btu of petroleum for plastics manufacturing could be replaced by biological feedstocks over the next 5 years. This amounts to approximately 1.5–3% of total industrial petroleum use (EIA 2009g).

Increased plastic recycling would be a form of substitution away from industrial petroleum use. A recent report on the European plastics industry notes that Germany recycled the highest proportion of its post-consumer plastic waste of any European country, at 33.9%; an additional 60% of Germany's plastic waste was sent to waste-to-energy plants (PlasticsEurope, EuPC, EuPR, and EPRO 2010). Compared to the United States' current 7.1% recycling rate, this would constitute an ambitious goal. We therefore use it as an upper boundary on the potential for long-term recycling in the United States.

Thirty million tons of plastic waste was generated in the United States in 2009; this figure has held relatively constant in recent years (USEPA 2010b). If this level of waste production continues into the future, 33.9% recycling would represent an increase of 26.8% above current levels, or an additional 8 million tons of plastic. This level of recycling would save 192 trillion Btu of petroleum, or about 2.2% of total industrial petroleum use (EIA 2009g).

4.5.7.1.4 Residential and Commercial Sector.

Uses of Oil and Gas in the Residential and Commercial Sector. Oil and gas use in residences and commercial establishments is dominated by only a few particular end uses. There has been a long-term shift away from oil use and toward electricity in these applications, while natural gas use has not changed as dramatically. The potential substitutes for commercial and residential use of oil and gas are also similar to those for the commercial sector, consisting mainly of electricity and biogas, although efficiency could also be considered a feasible substitute in certain applications.

The commercial and residential sectors consume negligible amounts of petroleum compared to the transportation and industrial sectors, but contribute more substantially to gas consumption. Residences used 1,204 trillion Btu of petroleum in 2008; commercial buildings used another 638 trillion Btu, for a total of 1,842 trillion Btu (378 million barrels) (EIA 2009l, m). This amounts to just 5% of nationwide petroleum consumption (EERE 2011a). For natural gas, the residential sector consumed 4,989 trillion Btu in 2008 and the commercial sector consumed 3,211 trillion Btu, for a total of 8,200 trillion Btu (EIA 2009l). Combined, these sectors accounted for 34% of gas consumption, nearly equivalent to industrial levels and more than electricity generation (EERE 2011b).

Petroleum consumption has been falling steadily in both the residential and commercial sectors since the early 1970s. Residential petroleum consumption reached its highest point in 1972, at 2,856 trillion Btu, while commercial use peaked one year later at 1,604 trillion Btu. Overall oil use has fallen by nearly 60% for both sectors since that time (EIA 2009l).

Most residential petroleum and natural gas use is for space heating and water heating. To a lesser extent, these fuels are also used for appliances such as ranges, ovens, and refrigerators.

Similarly, commercial gas and oil use is dominated by space heating and water heating, with additional small amounts for cooking and miscellaneous other applications. Electricity was another major energy source for these applications.

Space Heating. Space heating is the most significant use of petroleum and natural gas in both the residential and commercial sectors. Space heating accounted for three-fourths of all residential oil use and 62% of residential gas use in 2005. Electricity use for space heating was comparatively small. A similar proportion of natural gas use in the commercial sector was for space heating in 2008 (63%), but oil use was minimal and electricity more substantial (EIA 2009n; EERE 2011c).

The proportion of homes with natural gas as their primary heating fuel has declined only slightly over the past several years. In 1980, 55% of homes used gas for space heating; in 2005 the number stood at 52%. The proportion of homes using oil has been cut nearly in half, from 20% to 12%. Perhaps surprisingly, given the low total amount of electricity used for residential space heating, 30% of homes used electricity as their primary heating type in 2005, a figure that has climbed steadily since 1980 (EIA 2009p). The apparent mismatch between total consumption and proportional use suggests that electricity is used for heating primarily in areas with mild winters, and thus low heating demand.

Water Heating. After space heating, water heating is the other most significant end use of oil and gas in the residential and commercial sectors, comprising 21% of residential oil use and 29% of residential gas use in 2005. In the commercial sector, water heating used negligible amounts of oil, but accounted for 18% of natural gas use in 2008 (EIA 2009n; EERE 2011c).

As might be expected, the proportion of homes that use natural gas for water heating is similar to space heating, 53% in 2005. This has remained essentially unchanged since 1980. Just 8% of homes use petroleum for water heating, down from 13%. The remaining 39% of homes relied on electricity for water heating in 2005, a modest increase from 33% in 1980. Less than 1% of homes used other energy sources, such as solar water heating (EIA 2009p).

Cooking and Appliances. Cooking and appliances represent the final major end uses of residential and commercial gas. About 9% of residential and 7% of commercial gas use went toward cooking and appliances; residences also used a small amount of petroleum for these purposes. There is no information readily available on the proportion of homes using oil, gas, and other fuels for these end uses. In absolute terms, however, natural gas for appliance applications grew by about 20% from 1980 to 2005, less than the rate of population growth. Meanwhile, oil use remained essentially unchanged and electricity use increased by 80% (EIA 2009n; EERE 2011c). The rise in total electricity use could be due in part to increased per-capita consumption, but it seems more likely that, matching the trend with space heating and water heating, an increasing proportion of homes are using electricity rather than oil or gas as their primary fuel. It would stand to reason that a home that used gas (or oil) for one major end use would be more likely to use it for others as well.

Analysis of Energy Substitutes in the Commercial and Residential Sector. Furnaces and boilers, water heaters, and cooking appliances — the equipment directly responsible for oil and gas consumption in the commercial and residential sectors – are durable, long-lived goods. Water heaters have an average life span of 13 years, while furnaces, boilers, and range/ovens typically last for 20 years or more (California Energy Commission undated a). Such items also represent significant investments for most buyers. Thus, similar to industrial consumers, residential and commercial consumers would be unlikely to replace their oil- or gas-fired equipment any earlier than necessary except under extreme conditions. For that reason, we consider any fuel-saving strategy that required major new equipment to be a long-term process. Commercial and residential consumers will have an opportunity to shift away from oil- and gas-fired equipment when their space and water heating equipment and appliances reach the end of their useful lifespan. Construction of new building stock and renovations of existing buildings allow further prospects for substitution.

The easiest mode of substitution would be to replace oil- or gas-fired space and water heating equipment and appliances with electric-powered units, which are readily available and widely used. As noted above, 30% of households used electricity as the primary energy source for space heating in 2005, and 39% used it for water heating. Both of these proportions have been growing over the past several years (EIA 2009p).

However, in most cases there is no clear advantage for any given residence or commercial building to switch to electricity, which is thermodynamically inefficient at delivering heat. The Federal Energy Management Program (FEMP) estimates the annual energy cost of a typical gas water heater as at approximately half the cost of an electric unit (EERE 2010), while the California Energy Commission reports that electricity usually costs three times as much as gas (California Energy Commission undated b). While gas water heaters are generally more expensive up front, the difference in fuel costs outweighs this initial price premium. Similarly, higher operating costs mean that electric furnaces and electric oven/ranges are generally uneconomical compared to gas or oil units (EERE 2011d; California Energy Commission undated c). Nonetheless, electricity remains a viable, if unlikely, substitute for these end uses. The associated environmental impacts would depend on the fuel mix used to produce the electricity. These issues have been discussed previously, and we do not repeat them here.

A second substitute comes in the form of renewable energy, and specifically, solar water heaters. Solar water heaters use collectors to gather solar energy, which is then used to heat water in a storage tank. Active solar water heaters contain a circulating pump, while passive systems do not. Although solar water heaters are most effective in warm, sunny areas such as Florida or California, they can be used in colder locations as well; Germany, for example, has more than 9,800 MW(t) of solar thermal capacity installed, while Austria has more than 3,200 MW(t); most, but not all, of this is for water heating (Eurobserv'er 2011). In the United States, all 50 States have some form of incentive for solar water heating systems, while the Federal Government provides a tax credit covering 30% of the installed cost of such systems (N.C. Solar Center and Interstate Renewable Energy Council, undated).

Solar water heaters usually have a gas or electric backup, to provide supplemental heating on cloudy days, in cold seasons, or in high-demand hours. As a result, they do not eliminate gas use entirely; the Solar Rating & Certification Corporation and the Energy Star program both estimate that typical solar water heaters cut gas consumption in half (Solar Rating and

Certification Corporation undated; USDOE and USEPA undated a). If applied nationwide, this would imply residential gas savings of 700 trillion Btu and an additional oil savings of 150 trillion Btu. Solar water heating in the commercial sector could contribute modest further savings. For example, a 10% adoption, with savings of 70 trillion and 15 trillion Btu, would represent an enormous increase over current levels (less than 1% of U.S. homes used solar water heaters in 2005) (EIA 2009p). However, this would require massive policy support; without generous tax credits or other incentives, the higher upfront cost of a solar water heating system would make it uneconomical for most consumers to purchase them, especially in less favorable climates, therefore, wide-spread adoption of the use of solar water heating is at present unlikely.

The other options for long-term substitution involve improvements to the building stock itself. Improved building envelope efficiency has already been discussed as a short-term option. We estimated above that if 200,000 homes per year are renovated, the resulting savings could reach 8.5 trillion Btu annually after 5 yr. Simply extending this trend to a 25-yr period would indicate that renovations to 5 million homes could save 42.5 trillion Btu in oil, gas, or electricity used for space heating. Of course, a more aggressive approach covering more homes would see proportionally greater impacts.

Over the long run, the building stock will also go through a more fundamental transformation, as new buildings are built to replace aging ones and to accommodate population growth. One well-regarded analysis estimates that 89 million new or replaced homes and 190 billion ft^2 of nonresidential building will be constructed by 2050, and that two-thirds of buildings that will exist at that time did not exist in 2007 (Ewing et al. 2008). For context, in 2005 there were an estimated 111 million households nationwide (EIA 2009p).

Given the massive scale of building expected, more efficient construction could produce substantial savings in oil and gas use for space heating (as well as electricity, for both heating and cooling). This could take the form of a greater number of high-efficiency buildings, such as those constructed to the Energy Star or Leadership in Energy and Environmental Design (LEED), managed by the EPA and the Department of Energy (USDOE and USEPA undated b), and the U.S. Green Building Council's LEED family of standards (U.S. Green Building Council 2011a). Further, improvements to building codes that raise minimum performance requirements for all buildings would contribute to substantial savings in oil and gas use for space heating.

Specifically, the Energy Star program reports that 14,475 commercial buildings are currently Energy Star-certified, which means they must be more efficient than 75% of comparable buildings nationwide. This is roughly equivalent to 25% less energy use. As of March 2011, there were just over 30,000 registered commercial LEED building projects A 2008 study found that, while there was considerable variation between projects, the average LEED-certified commercial building had energy use 25% below that of conventional buildings (Turner and Frankel 2008). Overall then, we can assume that new commercial buildings meeting either the LEED or the Energy Star standard will result in at least a 25% reduction in energy use below current levels.

Both Energy Star and LEED also have programs addressing homes. Energy Star homes must be at least 15% more efficient than the 2004 International Residential Code, but with the additional energy-saving features included, they are, again, typically 25–30% more efficient than standard homes. There are currently more than 1 million Energy Star homes in the United States (USDOE and USEPA undated c). The LEED for Homes program has not been as popular, with just under 50,000 registered homes as of March 2011. As with commercial buildings, LEED measures energy gains versus standard new buildings. It estimates an average of 30% energy savings for LEED-certified homes (U.S. Green Building Council 2011b).

We can safely assume that most if not all new residential and commercial buildings will meet the stricter minimum standards envisioned by the latest IECC and ASHRAE energy codes. Meanwhile, the overall impact of LEED, Energy Star, and other voluntary green building standards will depend on market penetration. While not attempting a definitive analysis, we can make some rough, order-of-magnitude approximations to demonstrate the scale of potential savings. If, over the next 25 years, half of all currently existing residences and commercial buildings are replaced, through new construction or retrofits, with buildings that are 25% more efficient in space heating (a conservative estimate, since space heating will likely account for a disproportionate level of total energy savings), this would translate into an aggregate 12.5% reduction in space heating energy demand, or about 564 trillion Btu of natural gas and 164 trillion Btu of oil. If 10% of these buildings met Energy Star and/or LEED standards and realized a further 25% improvement from the new baseline, they would save an additional 42 trillion Btu of natural gas and 12 trillion Btu of oil from space heating. In total, then, under these assumptions, more efficient new buildings could save approximately 782 trillion Btu of oil and natural gas per year within 25 years.

4.5.7.2 Analysis of the Environmental Effects of the No Action Alternative

The selection of the No Action Alternative would eliminate all oil and gas activities that were projected to occur under the Program. OCS-related activities could still occur, however, in these areas as a result of leasing activity during previous and future programs. At the same time, the No Action Alternative would require energy substitutes to replace the oil and gas production that would not occur as a result of the Program. The energy substitutions would be associated with their own potential environmental impacts that could occur within or outside program areas that were considered in the proposed action.

4.5.7.2.1 Energy Substitutions for OCS Oil and Gas. With less oil and gas available from the OCS under the No Action Alternative, consumers could obtain oil and gas from other sources, substitute to other types of energy, or consume less energy overall. Similarly, energy production may shift from OCS oil and gas to onshore oil and gas, overseas oil and gas production, or domestic production of oil and gas alternatives (e.g., coal). Each of these shifts in consumption and production relative to the proposed action yield environmental impacts that this section evaluates.

The process for calculating these impacts begins with the application of MarketSim, a multi-market equilibrium model that simulates the energy supply, demand, and price effects of OCS oil and gas production compared with baseline projections from the EIA's Annual Energy Outlook. In addition to simulating oil and natural gas markets, MarketSim includes separate modules for coal and electricity, enabling the model to capture the broad effects of the No Action Alternative across individual segments of the energy market. Modeling each of these sectors, MarketSim produces an estimate of the energy market's response to the absence of production that would occur as a result of the No Action Alternative.

Table 4.5.7-1 presents the changes in energy markets projected by MarketSim for the No Action Alternative. The table presents the quantities of the energy sources that would be used to replace the lost production of OCS hydrocarbons under the NAA. The quantities of domestic onshore production of both oil and natural gas is projected to increase but will make up for only a fraction of foregone OCS production. To ensure that demands for oil and gas are met, MarketSim projects a sharp increase in oil and gas imports under the No Action Alternative, via both tanker and pipeline. The model also projects that the reduction in OCS oil and gas production under the No Action Alternative will be replaced by an increase in domestic coal and electricity production and by energy conservation.

TABLE 4.5.7-1 Cumulative Energy Substitutions for Oil and Gas Under the No Action Alternative

Energy Sector	Quantity[a]	Replacement Percent (%)
Domestic Onshore Oil	53–402	1–3
Domestic Onshore Gas	759–2,326	13–17
Oil Imports	3,540–7,870	56–62
Gas Imports	458–1,224	8–9
Other	108–274	2
Coal	335–925	6–7
Electricity[b]	146–388	3
Reduced Demand[c]	330–814	6

[a] Quantities expressed as energy equivalents of a million bbl (Mbbl) of oil. Values derived from MarketSim output rounded to the nearest Mbbl. Range of values based on price assumptions of $60 and $160/bbl for oil and $4.27 and $11.39 per million cubic feet of gas. Quantities were calculated for a 40 year time period, which is slightly different than the 40-50 year assumed life of the program.

[b] Electricity generated from sources other than oil, gas or coal such as nuclear, hydro, solar and wind.

[c] Demand reductions resulting from energy conservation.

MarketSim projects that natural gas consumption will decline, while domestic consumption of oil, coal, and electricity will increase. Given that domestic oil production declines under the No Action Alternative, the increase in oil consumption may be somewhat unexpected. This increase in consumption reflects the fact that oil and gas are substitutes within the industrial sector and, to a lesser extent, the residential and commercial sectors. Therefore, as natural gas prices increase under the No Action Alternative, consumption of substitutes, including oil, increases. The increase in oil prices under the No Action Alternative may cause substitution in the opposite direction (i.e., from gas to oil), but the impact of increased gas prices is the more dominant of the two effects.

4.5.7.2.2 Impact Analysis.

Oil Spills. Table 4.5.7-2 shows the amount of oil projected to be developed in the planning areas considered in the Program and the amount of additional oil imported into planning areas that would be at risk from tanker spills because of their location relative to ports and terminals that would receive oil imports under the No Action Alternative. The table presents volumes of oil as a single quantity, rather than as a range of values, to simplify the comparison of quantities. The number of oil spills greater than 1,000 bbl that could result from import tanker accidents under the No Action Alternative and from accidents at OCS facilities and pipelines under the Proposed Action are presented. The number of spills was calculated by applying oil spill rates to the volume of OCS production and to the volume of import tankering projected under the two alternatives. Notably, the GOM is projected to experience four fewer large spills under the No Action Alternative. Part of this reduction is explained by the fact that the volume of oil imports under the No Action Alternative is smaller than the precluded volume of OCS oil that would have been produced under the No Action Alternative. Another factor is that tankering has a lower spill risk than OCS production in part because OCS production includes the risk of spills during both the production and the transportation phases, while tankering involves only risk during transportation. The production risk associated with oil import substitutes would occur in oil-exporting nations. It is interesting to note that while the Central GOM Planning Area accounts for most of the OCS oil production, and therefore would experience the greatest amount of reduction in oil spill risk under the No Action Alternative, the Western GOM Planning Area would experience the greatest amount of risk from the increased import tankering that is projected to occur.

Cook Inlet is projected to produce a small amount of oil under the proposed action and to import a small amount of oil as an energy substitute under the No Action Alternative. As a result, there would be no appreciable difference in oil spill risk between the two alternatives. Since there are no oil import ports or terminals in the Alaskan Arctic program area, the No Action Alternative would eliminate the risk from OCS sources without introducing any risk from oil tankers. It is important to keep in mind, however, that a reduction in the risk of oil spills from OCS production redistributes, rather than totally eliminates, the spill risk. As Table 4.5.7-2 shows, the Atlantic and Pacific coasts could each be exposed to an additional import tanker spill occurrence along these coasts under the No Action Alternative, whereas these areas would have no exposure to oil spill risk from OCS activities under the proposed action.

TABLE 4.5.7-2 Projected Large Spill Occurrences under the No Action Alternative

Planning Area	Volume of Oil at Risk for Spill[a] (Bbbl) Proposed Action	Oil Imports	Change in Spill Occurrence under the No Action Alternative[a]
Atlantic Coast	0	1.3	
North Atlantic	0	0.6	+1
Mid-Atlantic	0	0.5	
South Atlantic	0	0.1	
Straits of Florida	0	0.1	
Total Atlantic Coast	0	1.3	+1
Gulf of Mexico	4.1	2.7	
Central GOM	3.2	0.7	–2
Western GOM	0.8	1.9	1
Eastern GOM	<0.1	<0.1	0
Total GOM	4.1	2.7	-1
Pacific/South Alaska Coasts	0	1.6	
Southern California	0	0.4	+1
Central California	0	0.5	
Washington/Oregon	0	0.4	
Gulf of Alaska	0	0.2	
Shumagin	0	0.1	
Total Pacific/South Alaska Coasts	0	1.6	+1
Alaska Program Areas			
Cook Inlet	0.2	0.1	0
Arctic	1.6	0	–2
Alaska Program Area	1.8	0,01	-2

[a] OCS spill rate calculated as platform spill rate (0.25 spills/Bbbl) plus the pipeline spill rate (0.88 spills/Bbbl) since spills could occur at the platform or during transport. The tanker spill rate was calculated as 0.34 spills/Bbbl in lower 48 and 0.46 spills/Bbbl in Alaska.

Routine Operations. Routine OCS operations, such as installing offshore facilities and pipelines, transporting materials and personnel from the coast to offshore, and conducting seismic surveys, are associated with impact factors that could have potential environmental effects. The effects of noise, collisions with service vessels, air emissions, drilling and production discharges, and other impact factors associated with OCS activities were analyzed in Section 4.4 of this draft PEIS. With no new OCS activity occurring under the No Action Alternative, the potential for impacts from these factors would be eliminated within the program areas considered in the proposed action. The elimination of potential impacts in these program areas could redistribute a range of other environmental impacts that would result from the development and transportation of energy substitutions. These impacts could occur on or near the OCS, or elsewhere. While insufficient data are available for quantification of these substituted impacts, some issues of particular environmental concern from energy substitutions are listed below.

***Acid Mine Drainage from Coal Mining*.** Runoff from coal mining sites may increase the acidity of surface waters near and downstream from coal mining sites, adversely affecting habitat for aquatic organisms and limiting human recreational uses.

***Contamination of Groundwater from Oil and Gas Extraction*.** The extraction of oil and gas from onshore sources can, in some cases, lead to the contamination of local groundwater supplies. For example, focusing on shale gas extracted from wells in Pennsylvania and New York, Osborn et al. (2011) found that average methane concentrations in drinking water wells increased with proximity to the nearest gas well and were 17 times greater than wells not located near extraction sites (Osborn et al. 2011). In addition, oil and gas wells may lead to groundwater contamination from accidental spills, losses of well control, and/or pipeline leaks.

Water Discharges from Oil and Gas Operations.[21] To facilitate resource extraction from subsurface formations, oil and gas producers use water to develop pressure, causing oil and gas to rise to the surface (e.g., enhanced oil recovery and hydraulic fracturing). Producers must manage these waters as well as waters extracted from geologic formations during oil/gas extraction. The environmental impacts associated with this "produced water" vary based on the geologic characteristics of the reservoir that produced the water and the separation and treatment technologies employed by producers.

Coal Combustion Impacts. Coal consumed in place of gas under the No Action Alternative will result in environmental costs associated with diminished air quality and the disposal of coal combustion residuals. The combustion of coal in power plants or industrial boilers produces higher emissions of NO_x, SO_x, and PM than the combustion of natural gas and results in greater CO_2 emissions.[22] In addition, coal combustion residuals generated by power plants or coal-fired industrial boilers may pose a risk to local groundwater supplies when disposed in surface impoundments or landfills when such units are not properly maintained.

Socioeconomic and Sociocultural Effects. Sections 4.4.9.1 and 4.4.13.1 describe the effects of the proposed action on socioeconomic and sociocultural conditions, respectively, in the GOM. OCS oil- and gas-related activities have been an important source of employment and income in GOM coastal areas. According to Henry et al. (2002), the nature of blue-collar jobs in the oil and gas industry has been instrumental in the formation and persistence of Cajun culture in South Louisiana. The No Action Alternative would result in reduced employment and income opportunities and potentially could affect the stability and cohesion of communities and cultures. The No Action Alternative could also be interpreted as a boom-bust event. The infrastructure

[21] This discussion is based on USEPA (2008).

[22] For detailed emissions data for power plants, see USEPA (2010d).

and population of affected areas in the GOM have developed over decades in association with a regular occurrence of lease sales and resulting OCS activities. The No Action Alternative could result in situations in which local infrastructure and populations could not be maintained, resulting in out-migration and a reduction in public services. Furthermore, the No Action Alternative's disruption of a continuous process of activity in the GOM could affect future investments which would compound the social, economic, and cultural effects associated with the No Action Alternative.

Conclusion. No potential impacts from routine operations or from accidental discharges described in Section 4.4 would occur under the No Action Alternative. Most of the oil that was projected to be developed in the Arctic under the Proposed Action would be replaced by tanker imports that would offload at U.S. ports, none of which are located within the arctic area. Under the NAA, arctic program areas would therefore not receive any impacts from the Program or from energy substitutions such as tankering. The spill risk associated with replacing the lost OCS Arctic oil production would be transferred to other Planning Areas along the Atlantic, GOM, and Pacific coasts where increases in oil imports and associated risks of tanker spills would occur. The Pacific and Atlantic coasts would each be exposed to the risk of one additional tanker spill under the NAA. About two-thirds of the lost OCS production in the GOM would be replaced by tanker imports into GOM terminals. The spill risk from tankering would be greater in the Western GOM Planning Area than in the Central GOM based on the location of terminals. There would be effects of the NAA on socioeconomic conditions in the GOM and potential effects on community cohesion and levels of public services available there. The potential risk from impacts associated with routine OCS operations and activities removed under the NAA would be transferred to other areas within and beyond the OCS where energy substitutes such as imported and onshore oil and gas, and coal would be developed and transported.

4.6 ENVIRONMENTAL IMPACTS OF THE CUMULATIVE CASE

4.6.1 Cumulative Case Scenario

Cumulative effects are the impacts on the environment that result from the incremental impact of the proposed action when added to other past, present, and reasonably foreseeable future actions regardless of what agency, industry, or person undertakes the other actions. The cumulative analyses presented in this chapter evaluate OCS activities associated with the Program (the proposed action), as well as activities resulting from other past and future 5-yr OCS programs that could occur over the next 40 to 50 yr. It is reasonable to analyze cumulative impacts in the context of the proposed action (Alternative 1) because of all the action alternatives, it proposes the most geographically extensive lease sale scenario under the Program (and presumably, the most extensive potential impacts). The cumulative analyses also evaluate impacts from activities and processes that are not related to OCS development. These activities and processes will be identified in the following analyses where they apply. There are some activities and processes, however, that are pandemic actions (oil and gas programs in State waters and imported oil), emerging trends affecting multiple-use issues on the OCS (alternate energy), or phenomena that could affect the regional geophysical environment (climate change).

Because these activities have widespread importance as potential cumulative impacting factors, we describe them in this section to provide a framework for their inclusion in the appropriate cumulative analyses.

4.6.1.1 OCS Program Oil and Gas Activities

Tables 4.6.1-1 and 4.6.1-2 show the numeric estimates for all OCS program activities for the GOM and Alaska, respectively, that could occur on the OCS over the next 40 to 50 yr. These estimates include activities that will be part of the Program, as well as those from previous and future 5-yr programs. It should be noted that the cumulative scenario for the arctic planning areas reflects inherent uncertainty about the future of OCS oil and gas activities. To date, there have been no activities on the arctic OCS due largely to operational issues related to the extreme environmental conditions as well as legal issues associated with approving activities in the region. Table 4.6.1-2 presents the exploration and development scenarios for the cumulative case and the proposed action for Alaska; the values for the cumulative case reflect a small increase in activity in Alaska as a result of future leasing beyond the Program. These values are for analytical purposes only and are not intended as forecasts of future activity. At this time, future activity is unpredictable and could span a considerable range. Transportation and other scenario assumptions that were used in the proposed action explanation and development scenario and impact analyses (Section 4.4.1) also apply to the cumulative analyses.

Estimates of the assumed numbers of large and small oil spills that could result from all OCS oil and gas activities are presented in Table 4.6.1-3. The source and number of assumed OCS spills were based on the volume of anticipated oil production in each region, the assumed mode of transportation (pipeline and/or tanker), and the spill rates for large spills. Assumptions regarding the number of large oil spills from import tankers were based on the estimated level of crude oil imports and worldwide tanker spill rates. We assume that these spills would occur with uniform frequency over the life of the proposed action.

There are currently a total of 29,097 lease blocks in the GOM OCS Planning Areas; of these, 7,800 are active (Section 4.4.1.1). Shallow-water oil production in the GOM OCS has been in decline since 1997, and is expected to be offset by deepwater production over the life of the proposed action. Over the next 5 yr, BOEM projects that GOM OCS oil production will exceed 1.7 Mbbl/day (620 Mbbl annually). Gas production is expected to increase, then level off to about 8 Bcf/day (2,920 Bcf annually) (Karl et al. 2007).

The Cook Inlet Planning Area has had oil and gas operations in State waters since the late 1950s and currently has a well-established oil and gas infrastructure. The most recent sale in which leases were purchased occurred in 1997 (when two leases were purchased). A lease sale was held in 2004, but no leases were purchased (Section 4.4.1.2). There are currently no existing OCS activities in Cook Inlet.

There has been no oil and gas development activity in the arctic Program areas. Since 1979, 10 lease sales have been held in the Beaufort Sea Planning Area and three in the Chukchi Sea Planning Area, but no activity has resulted to date (Section 4.4.1.3).

TABLE 4.6.1-1 Offshore Exploration and Development Scenario for the OCS Program GOM Cumulative Case and Proposed Action[a]

Scenario Elements	Cumulative Case	Proposed Action
Years of activity	40–50	40–50
Oil (Bbbl)[b]	18–26	2.7–5.4
Gas (Tcf)[c]	76–112	12–24
Platforms	1,400–2,000	200–450
FPSOs[d]	1–6	0–2
No. of exploration and delineation wells	6,900–9,800	1,000–2,100
No. of development and production wells	8,500–12,000	1,300–2,600
Miles of pipeline	19,000–43,000	2,400–7,500
Service vessel trips/week	1,400–1,900	300–600
Helicopter trips/week	12,000–24,000	2,000–5,500
New pipeline landfalls	0–40	0–12
New natural gas processing facilities	0–14	0–12
Platforms removed with explosives	870–1,200	150–275
Drill Muds/Well (tons)		
Exploration and delineation wells	1,000	1,000
Development and production wells	1,000	1,000
Drill Cuttings/Well (tons)		
Exploration and delineation wells	1,200	1,200
Development and production wells	1,200	1,200
Produced Water/yr (Mbbl)[e]		
Oil well	19,000–27,000	73–140
Natural gas well	161–247	26–52
Bottom Area Disturbed (ha)[f]		
Platforms	960–12,000	150–2,500
Pipeline	9,500–69,000	2,000–11,500

[a] Values for the cumulative case represent the proposed action (under the 2012 to 2017 OCS program) and actions associated with ongoing and future OCS program oil and gas activities.

[b] Bbbl = billion barrels.

[c] Tcf = trillion cubic feet.

[d] FPSOs = floating, production, storage, and offloading systems.

[e] Based on 1.04 bbl produced water/bbl of oil, and 86 bbl produced water/1 Mcf gas (Clark and Veil 2009); Mbbl = million barrels. Calculations based on the total volume of oil or gas produced; actual discharges at a well are highly variable depending on geologic formation and age of well.

[f] Assumes 0.7–6 ha (1 ac) per platform and 0.5–1.6 ha (1.2–2.5 ac) per mile of pipeline.

TABLE 4.6.1-2 Offshore Exploration and Development Scenario for the OCS Program Alaska Cumulative Case and Proposed Action[a]

	Arctic Region				South Central Alaska Region	
	Beaufort Sea		Chukchi Sea		Cook Inlet	
Scenario Elements	Cumulative Case	Proposed Action	Cumulative Case	Proposed Action	Cumulative Case	Proposed Action
Years of activity	40–0	40–50	40–50	40–50	40–50	40–50
Oil (Mbbl)[b]	500–1,350	200–400	1,500–7,700	500–2,200	100–200	100–200
Gas (Tcf)[c]	0–7.0	0–2.2	0–31	0–8.0	0–0.68	0–0.68
Platforms	2–12	1–4	3–20	1–5	1–3	1–3
No. of exploration and delineation wells	12–48	6–16	12–66	6–20	6–12	6–12
No. of platform production wells	90–375	40–120	180–1,100	60–280	42–110	42–110
No. of subsea production wells	20–30	10	54–290	18–82	0	0
Miles of new offshore pipelines	50–520	30–155	150–1,300	25–250	25–150	25–150
Miles of new onshore pipelines	40–375	10–80	250–750	0	50–105	50–105
Service vessel trips/week[d]	1–18	1–12	1–23	1–15	1–3	1–3
Helicopter trips/week	1–18	1–12	1–23	1–15	1–3	1–3
New pipeline landfalls	0	0	0	0	0–1	0–1
New shore bases	0	0	0	0	0	0
New waste facilities	2–4	0	2–4	0	0	0
New natural gas processing facilities	2–4	0	2–4	0	0	0
Docks/causeways	2–4	0	2–4	0	0	0
Exploration well muds, cuttings, produced water	425 tons dry mud with 80% recycled; 525 tons dry rock cuttings, totaling 610 tons discharged at each well site.		425 tons dry mud with 80% recycled; 525 tons dry rock cuttings, totaling 610 tons discharged at each well site.		360 tons dry mud, with 80% recycled; 450 tons dry rock cuttings; totaling 522 tons per site.	
Development wells muds, cuttings, produced water	All muds, cuttings, and produced water treated and disposed of in wells.		All muds, cuttings, and produced water treated and disposed of in wells.		All muds, cuttings, and produced water discharged down hole.	
Bottom Area Disturbed (ha)[e]						
Platforms	1–72	1–24	2–180	1–30	1–18	1–18
Pipelines[f]	25–830	15–250	75–2,100	13–400	13–240	13–240

TABLE 4.6.1-2 (Cont.)

	Arctic Region				South Central Alaska Region	
	Beaufort Sea		Chukchi Sea[a]		Cook Inlet	
Scenario Elements	Cumulative Case	Proposed Action	Cumulative Case	Proposed Action	Cumulative Case	Proposed Action
Surface Soil Disturbed (ha)						
Pipeline	20–600	5–130	130–1,200	0	25–170	25–170

[a] Values for the cumulative case represent the proposed action (under the 2012 to 2017 OCS program) and actions associated with ongoing and future OCS program oil and gas activities. Because no OCS program oil and gas activities other than those associated with the 5-yr 2012–2017 OCS program are anticipated in the Cook Inlet Planning Area, the cumulative case scenario for the Cook Inlet Planning Area is the same as for the proposed action.

[b] Mbbl = million barrels.

[c] Tcf = trillion cubic feet.

[d] In the Arctic region, service vessel trips will only occur during open-water and broken-ice conditions (typically during August and September).

[e] Assumes 0.7–6 ha (1.7–15 ac) per platform and 0.5–1.6 ha (1.2–4.0 ac) per mile of pipeline.

[f] Value represents bottom area disturbance from offshore pipeline construction only.

TABLE 4.6.1-3 Large and Small Oil Spill Assumptions for the Cumulative Case

		Number of Spill Events[a]		
			Arctic Region	South Alaska Region
Scenario Elements	Assumed Spill Volume	Gulf of Mexico Region	Beaufort and Chukchi Seas	Cook Inlet
Oil Production (Bbbl)[b]		18–26	2–6	0.1–0.2
Large (bbl)	≥1,000			
Pipeline	1,700[c]	16–23	1–6	1 spill from either
Platform	5,000[d]	4–7	1–2	
Tanker	3,100–5,800[e]	5–10		
Small (bbl)[f]	≥50 to <1,000	230–330	25–80	1–3
	≥1 bbl to <50	1,350–1,950	150–450	7–15

[a] The assumed number of spills are estimated using the 1996–2010 spill rates in Anderson (in preparation). For the Alaska OCS region, the 1996–2010 spill rates were compared to fault-tree rates in Bercha Group, Inc. (2008a, b, 2006). The greater number of spills from Anderson (in preparation) is represented in Table 4.4.2-1. The values provided for the Arctic region are the combined totals for the Beaufort and Chukchi Seas.

[b] Bbbl = billion barrels.

[c] During the last 15 years (1996–2010), 7 oil spills ≥1,000 bbl occurred from U.S. OCS pipelines. The median spill size was 1,720 bbl. The maximum spill size between 1996 and 2010 from U.S. OCS pipelines was 8,212 bbl.

[d] During the last 15 years (1996–2010), 2 oil spills ≥1,000 bbl occurred from U.S. OCS platforms. During Hurricane Rita, one platform and two jack-up rigs were destroyed, and a combined total of 5,066 bbl were spilled. The median spill size, when not accounting for a decreasing trend in the rate of platform spills over 1964–2010, is 7,000 bbl. The low-probability very large spill occurrence, such as the DWH event, is represented as a catastrophic spill event.

[e] 3,100 bbl for tankers in the GOM; 5,800 bbl for TAPS tankers transporting Alaska OCS oil.

[f] The number of spills <1,000 bbl is estimated using a spill rate for both pipeline and platform spills.

4.6.1.2 Non-OCS Program Oil and Gas Activities

4.6.1.2.1 Offshore and Coastal Oil and Gas.

Gulf of Mexico. All the GOM States except Florida[23] have active oil and natural gas programs in both offshore State waters and on coastal lands. In 2009, oil and natural gas produced in GOM State waters totaled 503 million barrels (Mbbl) and 114 Bcf, respectively

[23] A drilling moratorium in Florida State waters has been in effect since July 1990 and there has been no leasing of tracts since the early 1980s (Lloyd et al. 1991).

(EIA 2010a, b). Offshore State oil and gas activity levels are highest in Texas and Louisiana, a long-established trend that will likely continue through the life of the Program.

Crude oil production in Texas has a long history, but has declined over the past decade (from approximately 449 Mbbl in 1999 to 404 Mbbl in 2009). During the same period, its offshore production increased from 475,000 to 897,000 bbl (EIA 2000, 2010a). From 2005 to 2009, the State's offshore gas withdrawals (from gas and oil wells) totaled 38 Bcf (EIA 2010b). Louisiana's offshore program produced 5.5 Mbbl of crude oil in 2009; from 2005 to 2009, its offshore gas withdrawals totaled 76 Bcf (EIA 2010a, b).

Although Mississippi ranked eleventh in the nation in both crude oil and natural gas production in 2009 (EIA 2010a, b), the State does not currently have an offshore program. Alabama did not produce crude oil from offshore waters in 2009; however, from 2005 to 2009 its offshore gas withdrawals totaled 109 Bcf (EIA 2010b).

Alaska. The Beaufort Sea and Cook Inlet are the only areas in Alaska with producing offshore leases. About 92% of Alaska's oil production takes place on the North Slope, and as of 2009 about 16,200 Mbbl of oil[24] have been produced from North Slope oil fields. Oil produced from the North Slope (including Beaufort Sea) is transported down the TAPS pipeline to Valdez, Alaska, where it is loaded onto tankers and exported. Significant volumes of natural gas (a net[25] of about 6.5 Tcf) have been produced along with oil recovery in North Slope fields; much of this gas has been reinjected into reservoirs (ADNR 2009c).

We assume that the North Slope fields will continue to account for most of Alaska's production during the life of the proposed action, although projections from the State of Alaska anticipate a 60% production decline by 2021 (ADNR 2000). Remaining North Slope oil reserves through 2050 are estimated by the State of Alaska to be about 5,200 Mbbl (ADNR 2009c). Over this period, almost half of the oil produced is expected to come from the Prudhoe Bay oil field (2,450 Mbbl) (ADNR 2009c). Natural gas reserves of 35 Tcf have been discovered within existing North Slope oil fields, with 93% located in four fields: Prudhoe Bay (23 Tcf), Point Thomson (8 Tcf), Lisburne (1 Tcf), and Kuparak (1 Tcf) (EIA 2009q). About 3.7 Tcf of natural gas from these reserves has been produced. This gas has been used as a fuel for facilities or has been reinjected into the hydrocarbon reservoir to enhance oil recovery.

There are also some leases in the Cook Inlet Planning Area. As of 2009, about 1,300 Mbbl of oil and 7,800 Bcf of natural gas (net) have been produced from reserves in Cook Inlet. Remaining reserves (including oil and natural gas liquids) through 2034 are estimated to be about 34 Mbbl, with annual production declining from 3.4 Mbbl in 2010 to about 0.52 Mbbl in 2034 (ADNR 2009c).

[24] Historic figures include both oil and natural gas liquids produced at Prudhoe Bay and surrounding fields.

[25] Net gas production is the difference between total gas injected (to enhance oil recovery) and total gas recovered.

4.6.1.2.2 Other Federal and Canadian Arctic Activities. The National Petroleum Reserve in Alaska (NPR-A) is a 9.3-million-ha [23-million-ac] site on the North Slope of Alaska that is managed by the BLM. The USGS has estimated that there is between 1.3 and 5.6 Bbbl and 39.1 and 83.2 Tcf of natural gas on Federal lands within the NPR-A. Integrated activity plans have been developed by BLM (2004, 2006a) that identify the lands within the NPR-A available for leasing, as well as those restricted from leasing, and identify stipulations and restrictions on surface activities in the lease areas of the NPRA. To date, there have been four lease sales in the NPR-A (in 1999, 2002, 2004, and 2006), and as a result of these sales, the BLM currently administers 381 Federal oil and gas leases on the NPR-A. To date, no production wells have been established in the NPR-A, although 23 exploration wells have been drilled within the reserve since 2000, and as many as an additional 11 exploration wells may be established by 2011 (BLM 2006b). It is uncertain at this time whether or not production facilities will be established within the NPR-A during the life of the Program.

Northern Canada contains about a quarter of Canada's remaining discovered resources of conventional petroleum and a third to a half of the country's estimated potential (Northern Oil and Gas Directorate 2007). This resource is distributed throughout northern Canada as follows:

- *Mackenzie Valley and onshore Yukon.* Twenty-six significant discoveries and three producing fields: the Norman Wells oil field produces oil at rates of 30,000 bbl per day (6.294 bbl = 1 m^3) with initial recoverable reserves of 235 Mbbl; the Kotaneelee and Pointed Mountain fields close to the British Columbia-Alberta border had produced 417 billion ft^3 (35.3 ft^3 = 1 m^3) of gas by the end of 1997.

- *Arctic Islands.* Nineteen significant discoveries after fewer than 200 exploration wells; the Bent Horn field in the Arctic Islands, which produced high-quality light oil for many years on a seasonal basis, has only recently been abandoned.

- *Mackenzie Delta/Beaufort Sea.* Discovered resources of in excess of 1 Bbbl of oil and 9 Tcf of gas in 53 significant discoveries. Four Tcf of marketable gas have been discovered in three onshore discoveries, and offshore discoveries include over 200 Mbbl in the Amauligak field. On the Mackenzie Delta, the Ikhil gas discovery is being developed to supply natural gas to the town of Inuvik, where it will replace imported diesel oil for power generation and domestic use.

4.6.1.2.3 Imported Oil. U.S. imports of crude oil and petroleum products grew steadily every year from 1981, when the annual total was 2.2 Bbbl, to a peak in 2005, when the annual total was 5.0 Bbbl. Since 2005, imports have been in decline, dropping to an annual total of 4.3 Bbbl in 2009 (its lowest point since 2000). The Gulf Coast district was the largest importer of crude oil, with a total of 1.9 Bbbl in 2009 (EIA 2010, 2011a). The USDOE estimates that crude oil imports will continue to decline from 2009 to 2035 as the growth in demand is met by domestic production (EIA 2011b). Canadian oil imports, representing about 21% of the total in

2009, are delivered by pipeline (EIA 2010a). The remaining oil arrives in the United States on tankers.

4.6.1.3 Mining Activity

Because mining is such a large component of the Alaskan economy (McDowell Group, Inc. 2006) and activity could occur in the future in areas potentially affected by OCS oil and gas activity, we have included a description of other mining activities. Alaska's mining industry includes exploration, mine development, and mineral production, and produces zinc, lead, gold, silver, and coal, as well as construction minerals such as sand, gravel, and rock (Research Development Council 2007). Approximately 73 open-pit, underground, mechanical placer, and suction dredge mines were in production in Alaska in 2005. In addition, there are at least 37 rock quarries and 71 active sand and gravel operations in the State (Research Development Council 2007). Two large mines, the Kensington Gold Project and the Pogo Gold Project, are expected to begin operation in 2007. The three largest mines in Alaska are the Red Dog, Ft. Knox, and Greens Creek mines. The Red Dog Mine, located in the Northwest Arctic Borough, is the world's largest zinc producer.

Among the large active mines currently operating in the State, only the Red Dog Mine is located adjacent to any of the Alaska OCS planning areas addressed in this PEIS. This mine, located in the DeLong Mountains approximately 88.5 km (55 mi) east of the Chukchi Sea, discharges treated water into Red Dog Creek, whose waters eventually feed into the Wulik River and drain into the Chukchi Sea.

In addition to the active and planned mine sites in the State, there are numerous exploration projects for gold, copper, nickel, silver, lead, zinc, and coal. In July 2006, BHP Billiton Energy Coal entered into an exploration agreement with the Arctic Slope Regional Corporation (ASRC) to conduct a 5-yr exploration program on corporation lands in the Northwest Arctic. Coal deposits in the Northwest Arctic run from the Colville River north to the Arctic Ocean. The coal reserves in the area are thought to be the largest coal resource in the United States and one of the largest worldwide, with estimated reserves of 5 billion tons of coal underlying 77,700 km^2 (30,000 mi^2). In early 2009, BHP Billiton suspended all exploration activities, and in the summer of 2009, the company terminated its agreement with ASRC. The company indicated that the decision was based on the current economic situation.

4.6.1.4 Alternate Energy

The Energy Policy Act of 2005 amended Section 8 of the Outer Continental Shelf Lands Act (OCSLA) (43 USC 1337) to give the Secretary of the Interior authority to issue a lease, easement, or ROW on the OCS[26] for activities that are not otherwise authorized by the OCSLA or other applicable law, if those activities:

[26] This excludes areas on the OCS within the exterior boundaries of any unit of the National Park System, National Wildlife Refuge System, National Marine Sanctuary System, or any National Monument.

- Produce or support production, transportation, or transmission of energy from sources other than oil and gas; or

- Use, for energy-related purposes or other authorized marine-related purposes, facilities currently or previously used for activities authorized under the OCSLA, except that any oil and gas energy-related uses shall not be authorized in areas in which oil and gas preleasing, leasing, and related activities are prohibited by a moratorium.

In response to this new authority, the BOEM of the USDOI, formerly the Minerals Management Service (MMS), established an Alternative Energy and Alternate Use Program on the OCS (now referred to as its Renewable Energy Program) to approve and manage these potential activities. The BOEM completed its PEIS to evaluate the potential environmental impacts of implementing the program and established initial policies and best management practices to mitigate these impacts in October 2007 (MMS 2007d). Each project developed under this new program will be subject to environmental reviews under the National NEPA, and each project may have additional project-specific mitigation measures. On April 22, 2009, the BOEM published its final regulations to establish an environmentally responsible Renewable Energy Program on the OCS. Documents and information related to the program can be found at http://www.boemre.gov/offshore/RenewableEnergy/index.htm.

While it is too early to predict the number and types of alternate uses and renewable energy projects that could be developed during the life of the Program, several OCS renewable energy projects have been proposed at the current time. Most of these are wind energy projects. The first commercial wind lease (Cape Wind off the coast of Massachusetts) was signed by the Secretary of the Interior in 2010 and its construction is expected to begin by the end of 2011 (BOEMRE 2011g). Noncompetitive leases for 14 lease areas off the coasts of New Jersey (6), Delaware (1), Georgia (3), and southeast Florida (4) have also been approved. These leases are for data collection and technology testing activities related to the development of wind and ocean current resources (BOEMRE 2011h). None of these leases are within the subject regions for this PEIS.

4.6.1.5 Climate Change

Because a growing body of evidence shows that climate change is occurring (Section 3.3), we have included it as an impacting factor in the cumulative analysis of some resources. The resources that include climate change as a cumulative impact factor meet one or both of the following two criteria:

- The resource is already experiencing impacts from climate change, so the effects are observable and not speculative. In Alaska, for example, the effects of climate change in recent decades have resulted in decreased extent and thickness of sea ice and other changes that could affect biological resources and subsistence.

- The resource will be directly affected by warming temperatures. An example of direct impacts of warming is increased melting of continental ice that leads to accelerated sea-level rise and inundation of coastal wetlands and beaches in the GOM.

We have not analyzed impacts from climatic and hydrologic changes that are the indirect result of temperature change because these indirect impacts are too uncertain to predict. For example, it is reasonable to expect changes in precipitation regimes as a result of climate change. Furthermore, it is also likely that precipitation changes would, in turn, affect the coastal salinity balance between freshwater flow and tidal influence in some areas, and that these changes would affect fisheries and fish populations in some way. Both the magnitude and direction of each factor in this sequence of occurrences, however, are uncertain. While we acknowledge that continuing climate change could result in changing regional ecological and socioeconomic patterns and distributions, at this stage of our understanding of underlying processes, the rates and directions of many of these changes are too speculative to include in the cumulative analyses that follow. A more in-depth discussion of climate change is provided in Section 3.3.

4.6.2 Marine and Coastal Physical Resources

4.6.2.1 Gulf of Mexico Region

4.6.2.1.1 Water Quality. Section 4.4.3 discusses water quality impacts in coastal, continental shelf, and deepwater environments in the GOM resulting from the proposed action (OCS program activities from 2012 to 2017). Cumulative impacts on water quality result from the incremental impacts of the proposed action (described in Section 4.4.3) when added to impacts from existing and reasonably foreseeable future OCS program activities (that are not part of the proposed action) and other non-OCS program activities. Table 4.6.1-1 presents the exploration and development scenario for the GOM cumulative case (encompassing the proposed action and other OCS program activities). Non-OCS program activities contributing to adverse cumulative impacts on water quality in the GOM are summarized in Table 4.6.2-1.

Ongoing and future routine OCS program activities, including those of the proposed action, involve vessel traffic, well drilling, pipelines (trenching, landfalls, and construction), chemical releases (drilling, operation discharges, and sanitary wastes), platforms (anchoring, mooring, and removal, except in deep waters), and onshore construction (coastal waters only). All of these have the potential to adversely affect water quality in the GOM. Accidental oil spills are also counted among OCS program-related activities; assumptions for oil spills under the cumulative case scenario are provided in Table 4.6.1-3.

OCS program-related marine vessel traffic in the GOM could be as high as 1,900 trips per week over the next 40 to 50 yr; vessel traffic associated with the proposed action (600 trips per week) represents about 30% of this traffic. Extensive non-OCS program marine traffic also

TABLE 4.6.2-1 Ongoing and Reasonably Foreseeable Future Non-OCS Activities Contributing to Cumulative Impacts on Water Quality

Type of Action	Associated Activities and Facilities (Impacting Factors)	Description
Marine vessel traffic	Discharges of bilge water and waste Accidental oil spills	Marine traffic includes crude oil and LNG tankers, commercial container vessels, military and USCG vessels, cruise ships, commercial fishing, and small watercraft. In 2009, a total 18,956 vessel calls were made in GOM ports, comprising about 34% of all U.S. vessel calls; U.S. vessel calls overall have been in decline in recent years (down 7% in 2009 from 5 yr earlier) (USDOT 2011b). It is estimated that about 60% of all crude oil imports into the United States are delivered by tanker ships entering through the GOM (VesselTrax 2007). See Section 4.6.1.2.2 on imported oil.
Wastewater discharge to coastal and marine waters	Permitted discharge points Pollutant releases via surface runoff (non-point discharges)	The major point sources of pollution include discharges (by discrete conveyances such as pipes or man-made ditches) from sewage treatment plants, industrial facilities, and power generating plants. Discharges are regulated through the NPDES permit program. Section 403 of the Clean Water Act (CWA) established the Ocean Discharge Criteria, which provide additional requirements for these types of discharges (USEPA 2011g). Non-point sources of pollution include rainfall, snowmelt, or irrigation water that runs over land or through the ground, entraining pollutants and depositing them into rivers, lakes, and coastal waters (including wetlands and estuaries). Pollutants such as fertilizers, herbicides, and insecticides; oil, grease, and toxic chemicals; sediment; and bacteria and nutrients can make their way to coastal waters and have harmful effects on drinking water supplies, recreation, fisheries, and wildlife. Non-point source management programs under Section 319 of the CWA regulate these pollutant sources. The USEPA and NOAA also co-administer State Coastal Non-Point Pollution Control Programs under Section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990 (USEPA 2011g).

TABLE 4.6.2-1 (Cont.)

Type of Action	Associated Activities and Facilities (Impacting Factors)	Description
		Excess nutrients (particularly nitrogen and phosphorus) released to the GOM have created an oxygen-depleted zone (the hypoxic zone) at the bottom of the continental shelf off Louisiana and Texas that is harmful to aerobic organisms. The USEPA predicts that the hypoxic zone will cover an average area of 24,400 km^2 (9,420 mi^2) in the summer of 2011, the largest area recorded since systematic mapping of the zone began. The hypoxic zone is attributed to the discharge of excess nutrients (from agricultural runoff) carried to the GOM from the Mississippi River and stratification (due to salinity and temperature differences across the water column) that prevents mixing of water (USEPA 2011f).
Dredging and marine disposal	Excavation of subaqueous sediments Transport of sediments (by dredger or pipeline) Relocation and disposal of sediments	The USEPA is responsible for designating and managing Ocean Dredged Material Disposal Sites as authorized by the Marine Protection, Research and Sanctuaries Act. Permits for ocean dumping of dredged materials are granted by the USACE, subject to USEPA review and concurrence, as authorized by Section 404 of the CWA (USEPA 2011c). There are currently 27 designated ocean dredged material disposal sites in the GOM, including 21 off the coast of Texas and Louisiana and in the Mississippi River GOM outlet (USEPA Region 6) and six off the coasts of Mississippi, Alabama, and Florida (USEPA Region 4) (USEPA 2011d, e). The largest quantities of disposed materials come from dredging of the Mississippi River bar channel (USACE 2011).

TABLE 4.6.2-1 (Cont.)

Type of Action	Associated Activities and Facilities (Impacting Factors)	Description
Liquefied \natural gas (LNG) terminals	Construction and operation of new LNG facilities on the OCS Increased risk of explosions and fires Increased LNG tanker traffic Cooled water releases	The United States is an importer and exporter of natural gas (EIA 2010b). The USDOE projects a significant increase in overall natural gas consumption between 2009 and 2035; estimates of LNG imports over this period are variable, ranging from 140 to 2,140 Bcf by 2035 (EIA 2011b). The United States currently operates five LNG import terminals, only one of which is located offshore (Gulf Gateway Deepwater Port off the coast of Louisiana). It is reasonably foreseeable that additional LNG terminals will be constructed in the GOM to offload LNG from tankers into the existing offshore natural gas pipeline system. Currently in the GOM, there are 16 applications for licenses to import LNG (seven licenses have been issued) (USDOT 2011a). See Section 4.3.1.1.2.
Oil and gas production in State-owned marine waters	Exploratory drilling and seismic testing Drilling of production wells Operation of infrastructure (pipelines and platforms) Transportation (by pipeline or tanker) Onshore refineries Hazardous spills/releases (e.g., loss of well control events) Decommissioning (plugging production wells and removing infrastructure)	Most of the historical production of oil and natural gas in State-owned marine waters in the GOM has occurred offshore of Texas and Louisiana. See Section 4.6.1.2.1.

TABLE 4.6.2-1 (Cont.)

Type of Action	Associated Activities and Facilities (Impacting Factors)	Description
Hard mineral mining	Vessel traffic Bottom sampling and shallow coring Mining	Hard minerals, such as quartz sand, sulfur, and sand, are currently being extracted for commercial purposes in the northern part of the GOM. Mineral resource deposits within coastal waters include phosphate, oyster shell, limestone, sand and gravel, and magnesium (Continental Shelf Associates 2004d). Mining from the cap rock of coastal and offshore salt domes has been active along the Texas–Louisiana coast since the 1890s (Kyle 2002). Currently, the Main Pass Block 299 mine, operated by Freeport-McMoRan, is leased to mine sulphur and salt in Federal waters of the GOM (lease OCS-G9372). The mine is located about 26 km (16 mi) offshore, east of Plaquemines Parish, Louisiana. It was closed in 2002 and proposed to be used as a disposal facility for exploration and production waste (67 FR 5847).
Oil- and gas-related infrastructure	Ports Oil and gas pipelines Tanker vessels Onshore fuel storage tanks and transfer stations Hazardous spills/releases	The oil and gas industry in the GOM is one of the most developed in the world. There are currently 3,172 active platforms in operation at water depths less than 61 m (200 ft) and 63 active platforms at water depths greater than 61 m (200 ft) (26 of which are in waters greater than 300 m [1,000 ft] deep). An estimated 41,843 km (26,000 mi) of oil and gas pipeline stretches across the seafloor. As of July 2011, there were more than 37,000 approved applications to drill in the GOM (BOEMRE 2011j; NOAA 2011c).
USDOD and U.S. Department of Homeland Security marine operations	Surface vessels Aircraft Aerial operations (e.g., flight training) Submarine operations	Numerous U.S. military bases are located along the GOM coast (see Section 4.3). Several U.S. Navy air stations serve as training bases in jet aviation, sea and air rescue, and coastal mine countermeasures, as well as home ports for various ships and operations. Some support U.S. Army and USCG activities. The USCG (part of the U.S. Department of Homeland Security) conducts routine missions, such as search, rescue, environmental protection, and homeland security on sea vessels and aircraft. The U.S. Air Force conducts training activities over the deepwater region of the GOM.

TABLE 4.6.2-1 (Cont.)

Type of Action	Associated Activities and Facilities (Impacting Factors)	Description
Renewable energy development	Wind, wave, and ocean current technologies Technology testing (bottom sampling, deep-tow sonar surveys, borings) Facility construction and operation Facility decommissioning (removal of facility)	To date, the United States has no offshore renewable energy projects, but the first commercial wind lease (Cape Wind off the coast of Massachusetts) was signed by the Secretary in 2010. See Section 4.3.1.1.3.

occurs in the GOM, one of the world's most concentrated shipping areas (USACE 2010). Non-OCS program traffic includes that related to crude oil and natural gas imports, commercial container vessels, military and USCG vessels, cruise ships, commercial fishing, and small watercraft. In 2010, the Port of New Orleans alone handled about 7,500 vessel calls (mainly tanker and dry bulk carrier), about 140 vessel calls per week (USDOT 2011b). Impacts on water quality from marine traffic arise from regular discharges of bilge water and waste, leaching of antifouling paints, and incidental spills (MMS 2001d), although operational discharges and spillage from marine vessels have declined substantially in the past few decades (NRC 2003b).

The number of production wells and oil platforms constructed over the period of the Program (at most 2,600 and 450, respectively) will be proportional to the amount of oil produced; these numbers represent about 21% of the total number of production wells and platforms (respectively) anticipated to be built in the GOM over the next 45 yr as part of the OCS program. The length of new pipeline (at most 12,070 km [7,500 mi]) added as part of the Program represents about 17% of that anticipated as part of the OCS program.

The area of disturbed sea bottom from construction of platforms and pipelines over the period of the Program (as much as 14,000 ha [34,600 ac] total) represents about 18% of that associated with the OCS program over the next 40 to 50 yr. Bottom disturbance degrades water quality by increasing water turbidity in the vicinity of the operations and adding contaminants to the water column. It also changes sediment composition as suspended sediments (and contaminants, if present) are entrained in currents and deposited in new locations.

An inventory conducted by NOAA found that there were about 766 major and 8,147 minor land-based point sources of pollution releasing to watersheds and coastal drainage areas of the GOM; these included discharges from industrial facilities (6,909), wastewater treatment plants (1,925), and power plants (79) — most of which were located in the watersheds of the Atchafalaya/Vermilion Bays and Galveston Bays at the time of the inventory (NOAA 1995). The kinds of contaminants released range from nitrogen (from organic chemicals, petroleum refining, industrial plants, and pesticide sources), phosphorus, metals (zinc, arsenic, cadmium, lead, and mercury), and oil and grease, to elevated suspended solids (turbidity) and biocides and heat (from power plant cooling water discharges). Nonpoint sources release pollutants to the GOM via rivers and on-land drainages and are primarily from urban and agricultural runoff (containing animal waste and residual fertilizer, in particular nitrogen and phosphorous compounds), but also originate from seepage from landfills and industrial facilities and various kinds of on-land spills. These sources (together with similar sources from Mexico) combine to degrade water quality in the GOM, especially in coastal waters. Coastal water quality is also adversely affected by the loss of wetlands (Section 3.7.1).

Activities taking place within GOM waters also contribute to the degradation of water quality in the GOM. These include sediment dredging and disposal (suspended sediments and contaminants), LNG terminal operations (biocide-laden, cooled water), and activities related to the oil and gas industry, which operates hundreds of platforms in State and Federal waters and discharges large volumes of drilling wastes, produced water, and other industrial waste streams into GOM waters. Hydrocarbon releases through natural oil seeps along the continental slope and accidental oil spills are additional sources of water and sediment contamination.

There are 27 designated ocean dredged material disposal sites in the GOM, including 21 off the coast of Texas and Louisiana and in the Mississippi River GOM outlet. Dredging operations are routinely conducted for channel construction and maintenance, pipeline emplacement, access to support facilities, creation of harbor and docking areas, and siting for onshore facilities. Offshore disposal, authorized under Title I of the Marine Protection, Research and Sanctuaries Act of 1972, as amended (33 USC 1401), and the Federal Water Pollution Control Act, as amended (33 USC 1251), consists primarily of dredged sediments but may also include fish wastes and vessels. The site management and monitoring plans for many of these sites are available on the USEPA's website (http://www.epa.gov). The USACE maintains an online database that tracks the projects (including quantities of materials, dredging and transport methods, and dumping frequency, size, and location) that dispose of materials at designated offshore disposal sites (http://el.erdc.usace.army.mil/odd). The direct impacts of dredging on water quality (increased turbidity and decreased dissolved oxygen at the dredge site) are fairly short lived; however, the long-term landscape-scale changes can have significant adverse impacts on aquatic organisms and their habitats (Nightingale and Simenstad 2001) (Sections 4.6.3 and 4.6.4).

Currently, there is only one offshore LNG terminal in the GOM (Gulf Gateway Deepwater Port off the coast of Louisiana). However, natural gas demand growth in the United States has accelerated since the 1980s, and LNG imports are expected to increase significantly to meet this demand. As a result, 25 LNG terminal proposals have been approved to serve the U.S. market (Parfomak and Vann 2009). At least seven new licenses have been issued for additional facilities in the GOM, and it is anticipated that more LNG facilities will be built over the coming decades (USDOT 2011c) (Section 4.6.1.5). The impacts of LNG transport and LNG receiving terminals are associated with explosions and fires and with the cryogenic and cooling effects of either an accidental release of LNG or the release of cooled water during the vaporization process.

The majority of oil released to the GOM comes from chronic releases, mainly from naturally occurring seeps and runoff from land-based sources (NRC 2003b). Oil seeps are estimated to contribute up to 62% of the oil input in U.S. marine waters overall; runoff from land-based sources, about 21% (NRC 2003b). As many as 350 crude oil and tar seeps have been identified in the GOM. Seepage rates for the northern part of the GOM (along the continental slope) have been estimated at about 73,000 tons (526,000 bbl) per year,[27] about twice that estimated for spills from the OCS program (based on a worst-case scenario of about 230,000 bbl per year, excluding catastrophic events; Table 4.6.2-3). Spills associated with the proposed action (based on a worst-case scenario of about 44,300 bbl per year, excluding catastrophic events (Table 4.4.2-1) represent a small fraction, about 6%, of the combined annual oil inputs from oil seeps and oil spills (from pipelines, platforms, and tankers/barges and incidental spills) from the OCS program over the next 40 yr. Natural gas seeps are also common, but little is known about their seepage rates (Kvenvolden and Cooper 2003).

---

[27] Total estimates for the GOM, taking into account oil seeping from the Campeche Basin offshore of Mexico in the southern part of the Gulf, run as high as 140,000 tons (1 Mbbl) per year (Kvenvolden and Cooper 2003).

The second largest contribution to oil releases in U.S. marine waters overall is related to oil consumption (about 32%): land-based runoff and river discharge (21%), recreational marine and non-tank vessels (2.6%), tank vessel operational discharges (<1%), atmospheric deposition (8.1%), and jettisoned aircraft fuel (<1%). Other important sources of oil releases include those associated with non-OCS program oil extraction/transportation activities (about 4.7% in total): platforms, produced water, atmospheric deposition, pipeline and tank vessel spills, operational discharges (cargo washings), and coastal facility spills (NRC 2003b).

Another issue of importance to the water quality in the GOM concerns the hypoxic zone in the GOM coast shelf waters (offshore of Louisiana and Texas to the west of the Mississippi Delta). The hypoxic zone is an area near the sea bottom that contains less than 2 ppm of dissolved oxygen, causing a condition of hypoxia that is inhospitable to fish and causes stress or death to benthic organisms (USGS 2011c). It is the second largest area of oxygen-depleted waters in the world, with an area of about 22,015 km^2 (98,500 mi^2) (in 2002). The hypoxic zone is attributed to water column stratification (driven by weather and river flow) and the decomposition of organic matter in bottom waters, as well as organic matter and nutrients (that fuel phytoplankton growth) carried by the Mississippi River. The USEPA predicts that the hypoxic zone will cover an average area of 24,400 km^2 (9,420 mi^2) in the summer of 2011, the largest area recorded since systematic mapping of the zone began (USEPA 2011f). The proposed action is not expected to have a large effect on the hypoxic zone, because inflows of contaminants causing hypoxia are mainly from Mississippi River waters discharging to the GOM.

Catastrophic oil spills are rare events, but their releases have a high potential to degrade water quality in both coastal and deep waters. The 2010 DWH event released an estimated 4.9 Mbbl. In response to the spill, 7,000 m^3 (1.84 million gal) of chemical dispersants were also released (Section 3.4.1.3). The short- and long-term impacts of the spill on water quality in the GOM are still being assessed, but as of January 2011, oiling was still present on many shorelines and on barrier islands. Although traces of oil and dispersant were found in the offshore and deepwater zones, water quality benchmarks (for oil- and dispersant-related chemicals) were not exceeded in samples collected. In its August 2010 assessment, the National Incident Command (NIC) estimated that half of the oil was removed from the water column either by direct recovery, by burning or skimming, or by evaporation and dissolution. Another 24% was dispersed. About 26% of the oil (an estimated 1.3 Mbbl) remained on or near the water surface, or was deposited onshore, or buried in sand and sediments. The Georgia Sea Grant Oil Spill Update, published on August 17, 2010, estimated that between 70 and 79% (2.9 and 3.2 Mbbl) of the oil spilled during the 2010 DWH event remains at or below the water surface. It recommended further assessment of dispersed and dissolved forms of oil to determine its potential threat to the ecosystem because such forms of oil remain highly toxic (Hopkinson 2010).

Climate change predictions are based on models that simulate all relevant physical processes under a variety of projected greenhouse gas emission scenarios (Section 3.3). Because the complexity of modeling global and regional climate systems is so great, uncertainty in climate projections can never be eliminated. The Intergovernmental Panel on Climate Change

(IPCC) projections relating generally to water and water quality over the next two decades include:

- Sea level will rise by 0.18 to 0.59 m (0.6 to 2 ft) by the end of the twenty-first century;

- Sea ice, glaciers, and ice sheets in polar regions will continue melting;

- Ocean pH will decrease by 0.14 to 0.35 over the twenty-first century;

- Tropical cyclones will become more intense (>66% likely);

- Precipitation will increase at high latitudes (>90% likely); and

- Annual river discharges (runoff) will increase by 10 to 40% at high latitudes and decrease by 10 to 30% in the dry regions at mid-latitudes.

The GOM region has already experienced increasing atmospheric temperatures since the 1960s. From 1900 to 1991, sea surface temperatures increased in coastal areas and decreased in offshore areas. Sea level rise along the northern coast is as high as 0.01 m/yr (0.03 ft/yr) and has contributed to the loss of coastal wetland and mangroves and increased the rates of shoreline erosion. Future sea level rise is expected to cause saltwater intrusion into coastal aquifers, potentially making some unsuitable as potable water supplies (Section 3.3.1).

Significant changes (increases or decreases) in precipitation and river discharges to the GOM would affect salinity and water circulation — which in turn affects water quality. Water quality impacts associated with increased river discharges result from increases in nutrients (nitrogen and phosphorous) and contaminants to estuaries, increases in harmful algal blooms, and an increase in stratification. Such changes could also affect dissolved oxygen content and the extent of the GOM hypoxic zone. Decreased discharge would diminish the flushing of estuaries and increase concentrations of pathogens.

Conclusion. Water quality in coastal and marine waters would be impacted by the following activities associated with the proposed action: vessel traffic, well drilling, pipelines (trenching, landfalls, and construction), chemical releases (drilling, operation discharges, and sanitary wastes), platforms (anchoring, mooring, and removal, except in deep waters), construction of shore-based infrastructure (coastal waters only), and accidental oil spills. Coastal water in the GOM is also affected by numerous other factors, including river inflows, urbanization, agricultural practices, municipal waste discharges, and coastal industry. Non-OCS program activities likely to contribute to cumulative impacts include marine vessel traffic, wastewater discharge to coastal and marine waters, dredging and marine disposal, oil and gas production in State-owned marine waters, hard mineral mining, oil- and gas-related infrastructure, military operations, and renewable energy development. Natural seepage of oil along the continental slope is also significant. The cumulative impacts on GOM water quality from all OCS and non-OCS activities in the GOM over the next 40 to 50 yr are expected to be moderate, and the incremental contribution of the routine Program activities to water quality impacts would be small (see Section 4.4.3.1).

The USEPA, in collaboration with other Federal and coastal State agencies, has assessed the coastal conditions of each region of the United States, including the GOM coast, by evaluating five indicators of condition, one of which was water quality, based on such parameters as dissolved oxygen, chlorophyll *a*, nitrogen, phosphorus, and water clarity.[28] The most recent assessment found the overall condition of the coastal waters of the GOM coast region to be fair to poor, with an overall condition rating score of 2.2 (on a 5.0-point scale) and an individual indicator score of 3.0 for water quality. Parameters such as dissolved oxygen and water clarity vary in relation to climatic factors (e.g., annual rainfall) (USEPA 2008b).[29] In addition, the hypoxic zone is predicted to cover a larger area of the GOM shelf than in any other year since it has been measured.

The number of accidental spills in GOM waters for most activities associated with the proposed action would represent only a small increase over the number of expected spills from ongoing OCS and non-OCS program activities, and a very small increase relative to releases from naturally occurring oil seeps (except for catastrophic spills). The incremental increase in adverse water quality impacts from these spills would depend on the weather and sea conditions at the spill location, the type of waves and tidal energy at the spill locations, the type of oil spilled (very light to very heavy), the depth of the spill event (deep water, shallow water, or surface water), and the volume and rate of spillage. Spill response and cleanup activities (e.g., *in situ* burning and use of chemical dispersants) could contribute to these impacts. A more detailed discussion of the effects of oil spills on water quality in the GOM is presented in Section 4.4.3.1.2.

4.6.2.1.2 Air Quality. Section 4.4.4 discusses air quality impacts on onshore and offshore areas of the GOM resulting from the proposed action (OCS program activities from 2012 to 2017). Cumulative impacts on air quality result from the incremental impacts of the proposed action (described in Section 4.4.4) when added to impacts from existing and reasonably foreseeable future OCS program activities (that are not part of the proposed action) and other non-OCS program activities. Table 4.6.1-1 presents the exploration and development scenario for the GOM cumulative case (encompassing the proposed action and other OCS program activities). Non-OCS program activities also contribute to adverse cumulative impacts on air quality in the GOM; they are discussed below.

Ongoing and future routine OCS program activities, including those of the proposed action, involve production platforms, exploration wells, platform construction and removal,

---

[28] Other indicators used to assess coast conditions include sediment quality (toxicity, contaminants, and total organic carbon), benthic community condition, coastal habitat loss, and fish tissue contaminants. The assessment found sediment quality in the Gulf coast region also to be poor (with sediments containing pesticides, metals, PCBs, and PAHs) (USEPA 2008b).

[29] The water quality score does not include the impact of the hypoxic zone in offshore Gulf coast waters or the recent DWH oil spill (USEPA 2008b).

marine vessels (pipelaying, support, and survey), helicopters, and tanker and barge transport. All these activities have the potential to adversely affect air quality in the GOM. Accidental oil spills are also counted among OCS program-related activities; assumptions for oil spills under the cumulative case scenario are provided in Table 4.6.1-3. Other emission sources on the OCS that are not associated with oil and gas development activities include commercial marine vessels, commercial and recreational fishing, tanker lightering, military vessels, and natural sources such as oil or gas seeps. Onshore emission sources include power generation, industrial processing, manufacturing, refineries, commercial and home heating, on-road vehicles, and non-road engines (e.g., aircraft, locomotives, and construction equipment).

Criteria Pollutants. Over the past 20 yr, the USEPA has promulgated a series of measures to reduce regional and nationwide emissions from fuel combustion sources (e.g., diesel marine engines), and the beneficial effects of these measures are evident in the data collected in 2006 (the most recent year for which data are reported). NO_x emissions, mainly from transportation and fuel combustion sources, decreased nationwide by about 29% between 1990 and 2006. Most of the reductions in NO_x emissions occurred between 1998 and 2006 and are attributed to implementation of the Acid Rain Program and the NO_x State Implementation Plan (SIP) Call. SO_2 emissions, mainly from fuel combustion, industrial processes, and transportation sources, also decreased nationwide by about 38% between 1990 and 2006. During this same period, emissions from $PM_{2.5}$, PM_{10}, and CO decreased by 14, 30, and 38%, respectively (USEPA 2008c). At the State level, data collected between 1990 and 2002 indicate overall emissions have also declined in the five GOM coast States (Alabama, Florida, Louisiana, Mississippi, and Texas) in total: NO_x, down by 31%; SO_2, down by 15%; PM_{10}, down by 34%; and VOCs, down by 8%. Increases were observed only in Florida (NO_x up by 15% and VOCs up by 20%) and Alabama (VOCs up by 2%) during this period (USEPA 2011h).

Table 4.6.2-2 lists the estimated annual emissions associated with all ongoing and future OCS oil and gas activities in the GOM over the next 40 to 50 yr. These emissions were estimated by BOEM using emission factors from the *2008 Gulfwide Emission Inventory Study* (Wilson et al. 2010). In terms of absolute amounts, the largest emissions would be NO_x, followed by CO, with lesser amounts of VOC, SO_x, PM_{10}, and $PM_{2.5}$, in order of decreasing emissions. Under both the high and low scenarios, support vessels would be the largest source of NOx, SOx, and PM; production platforms would be the largest source of VOC and CO. Emissions from the Program (proposed action) generally represent about 27% of the cumulative case emissions.

Table 4.6.2-2 also presents the emissions calculated from an inventory of all non-OCS activities collected by Wilson et al. (2010) in calendar year 2008. The non-OCS program emissions estimates are based on the same source categories as for the OCS oil and gas program, but also include biogenic/geogenic sources; commercial fishing, marine, and military vessels; the Louisiana offshore oil port; and vessel lightering. The estimated OCS program annual emissions for the cumulative case are greater than those measured for non-OCS program activities in calendar year 2008 for all pollutants except SO_x. Many OCS and non-OCS program activities (e.g., support, commercial, and military marine vessel trips) are expected to increase in the future; however, emissions related to these activities are expected to be reduced by meeting USEPA standards.

TABLE 4.6.2-2 Estimated Total Air Emissions for OCS and Non-OCS Program Activities for the Gulf of Mexico Cumulative Case

	Pollutant (tons/yr)[a]					
Activity	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO	VOC
Well drilling (E&D)	34,865–44,826	4,437–5,705	615–791	606-779	8,385–10,780	830-1,067
Well drilling (D&P)	33,924-48,418	4,318–6,162	599–854	590-841	8,158–11,644	807–1,152
Platform installation/removal	1,257–1,842	176–258	29–42	29-42	159–234	29–42
Pipeline installation	10,925–23,762	1,855–4,035	412–897	412-897	2,268–4,932	412–897
Production platforms	71,080–104,176	1,738–2,547	661–969	656-961	79,611–116,680	45,404–66,545
Support vessels	127,954–187,532	17,242–25,270	2,216–3,248	2,216-3,248	12,188–17,863	2,216–3,248
Helicopters	1,054–1,545	260–381	205–301	205-301	12,903–18,911	2,548–3,735
Tankers loading	0-536	0-261	0-58	0-58	0-318	0-10,935
Tankers in transit	0-33,114	0-4,014	0-502	0-502	0-2,759	0-10,184
Tankers unloading	0-1,534	0-261	0-58	0-58	0-318	5,497
Total (Cumulative OCS)	281,059–448,283	30,026–44,619	4,738–7,720	4,714-7,687	123,672–181,361	52,247–87,621
Total (Proposed Action)[b]	60,019-125,167	6,765-14,440	1,058-2,268	1,051-2,268	8,907-22,692	23,510-45,853
Year 2008 non-OCS emissions[c]	100,880	52,022	7,004	6,481	8,432	22,442

[a] The range of values reflects the low and high end of the exploration and development scenarios for the cumulative scenario.

[b] Values from Table 4.4.4-1.

[c] Emissions are from inventory collected in calendar year 2008 and reported in Wilson et al. (2010).

The USEPA's Acid Rain Program (established under Title IV of the 1990 CAA amendments) sets a permanent cap on the total amount of SO_2 that can be released from the electric power sector, with the final 2010 cap set at 8.95 million tons (about half of the emissions from the electric power industry in 1980). NO_X emissions from coal-fired boilers were also limited under the program (to about 8.1 million tons). Between 1980 and 2008, SO_2 emissions were reduced by about 52% compared to 1990 levels. In 2008, SO_2 emissions had already fallen below the emissions cap set for 2010 and monitoring data indicated the national composite average of SO_2 mean ambient concentrations declined by 71% between 1980 and 2008. NO_X emissions from the electric power sector in 2008 were also greatly reduced (by as much as 63% relative to projected levels in 2000 without the program). The USEPA also reports significant improvements in acid deposition indicators (wet sulfate and nitrogen deposition) (USEPA 2011i).

The Cross-State Air Pollution Rule was finalized in 2011 (replacing the USEPA's 2005 Clean Air Interstate Rule) and will take effect in 2012. The rule requires 27 States in the eastern half of the United States (including all of the GOM coast States) to reduce power plant emissions contributing to ozone and/or fine particulate pollution in other States by mandating significant reductions in SO_2 and NO_x emissions from power plants. The USEPA estimates that these actions will reduce SO_2 and NO_x emissions by 73% and 54%, respectively, from 2005 levels (USEPA 2011j).

The MMS (currently BOEM) performed a cumulative air quality modeling analysis of platform emissions in a portion of the GOM in 1992 (MMS 1997b). The modeling incorporated a 40% increase in emissions above the 1992 levels to account for growth in oil and gas development. Predicted concentrations were well within the NAAQS and the Prevention of Significant Deterioration (PSD) Class II maximum allowable increases. An inventory study in the Breton National Wilderness Area (BNWA), a Class I area under the USEPA's PSD regulations, was conducted by the MMS to estimate the contribution of OCS and non-OCS program emissions to concentrations of NO_x and SO_2 in the BNWA[30] (Billings and Wilson 2004). A recent modeling-based cumulative increment analysis for SO_2 and NO_2, conducted by MMS, considered the cumulative effect of all onshore and offshore emission sources in the area with respect to the baseline year (Wheeler et al. 2008). The model results are summarized as follows:

- The increase in the 3-hr SO_2 concentration within the BNWA since 1977 (the baseline year) ranges from 0.42 to 1.70 µg/m^3; the maximum increment of 25.0 µg/m^3 has not been exceeded within the BNWA but a small portion of the increment may have been consumed. The largest change within a 50-km (31-mi) radius of the BNWA is 2.6 µg/m^3 and occurs to the south and east of Breton Island.

- The increase in the 24-hr SO_2 concentration within the BNWA since 1977 ranges from 0.11 to 1.18 µg/m^3; the maximum increment of 5.0 µg/m^3 has not been exceeded within the BNWA but a portion of the increment may have been consumed. The maximum 24-hr average SO_2 has increased over most of the GOM since 1977; it has increased or decreased over land, depending on location. For example, it has decreased as much as 7.7 µg/m^3 near Mobile, Alabama. In areas east of the Chandeleur Islands and southeast of the Breton Islands, it has increased between 1.0 and 1.64 µg/m^3.

- The annual SO_2 concentration within the BNWA has decreased by 1.07 to 1.89 µg/m^3 since 1977. The decrease in annual SO_2 is less than 0.5 µg/m^3 over much of the GOM and is greatest (more than 1.5 µg/m^3) near the GOM coast and inland over south Mississippi, Alabama, and eastern Louisiana.

[30] Under the CAA, water quality degradation is limited in Class I areas by establishing stringent "increment" limits for NO_x and SO_2. These increments are the maximum increases in ambient pollutant concentrations allowed over baseline concentrations (Billings and Wilson 2004).

Isolated increases at grid points in Louisiana and the GOM are likely due to local additions of SO_2 point sources since 1977.

- The maximum increase in annual NO_2 concentration within the BNWA since 1988 (the baseline year) is 0.10 µg/m^3, well below the maximum allowable increment of 2.5 µg/m^3. Only a very small portion of the increment has been consumed. Since 1988, annual NO_2 concentrations have decreased over land where controls have been implemented, but have increased over the GOM due to the addition of offshore NO_x emission sources. The boundary between decreased onshore concentrations and increased offshore concentrations follows the southern Louisiana coastline then turns northeastward away from the Louisiana coast and over the GOM where it crosses the BNWA and runs through the northern part of the Chandeleur Island chain. Part of the BNWA has experienced an increase in NO_2 concentrations since 1988. Larger increases are observed in areas within 75 km (47 mi) of the BNWA boundaries.

The BOEM continues to consult with the USFWS, which manages the BNWA, on any plans within 100 km (62 mi) of the BNWA.

Ozone Formation. In the Nation's ozone (O_3) nonattainment areas, emissions of NO_x and VOCs are being reduced through the SIP process in order for those areas to achieve compliance with the national O_3 standard. Prior to the revocation of the 1-hr O_3 standard in 2004, the Houston-Galveston-Brazoria (Texas) and Baton Rouge (Louisiana) areas were classified as severe nonattainment; the Beaumont-Port Arthur (Texas) nonattainment classification was serious. While the 1-hr O_3 standard no longer applies, the same emission controls will remain in effect while each State develops its plan to reach compliance with the new 8-hr standard. In October 2008, the USEPA reclassified the Houston-Galveston-Brazoria O_3 nonattainment area from a moderate 8-hr O_3 attainment area to a severe 8-hr O_3 nonattainment area and required the State to submit a revised SIP addressing the severe O_3 requirements of the CAA (73 FR 56983). In September 2010, the USEPA published a notice that the Baton Rouge moderate 8-hr O_3 attainment area had attained the 1997 8-hr O_3 NAAQS (75 FR 54778); the Beaumont-Port Arthur area was also designated an attainment area for the 1997 8-hr O_3 NAAQS in 2010 (75 FR 64675). There are no O_3 nonattainment areas in Alabama, Florida, or Mississippi.

Ozone levels in the southeast Texas have been in a steady downward trend since 1995. The maximum observed fourth highest 8-hr O_3 concentration in the Houston-Galveston area decreased from about 0.140 parts per million (ppm) in 1995 to around 0.100 ppm in 2005. Ozone levels in the Baton Rouge area remained steady over the same period, but the number of exceedances of the O_3 standard decreased. This data indicates that emission-reduction measures have been effective in reducing O_3 levels.

Modeling studies were performed using the preliminary emissions inventory prepared by Wilson et al. (2004) to examine the O_3 impacts with respect to the 8-hr O_3 standard of 80 parts per billion (ppb). One modeling study focused on the coastal areas of Louisiana extending eastward to Florida (Haney et al. 2004). This study showed that the impacts of OCS emissions on onshore O_3 levels were very small, with the maximum contribution at locations where the standard of 1 ppb or less was exceeded. Another study, conducted by Yarwood et al. (2004), evaluated O_3 levels in southeast Texas. The results of this study indicated a maximum contribution to areas exceeding the standard of 0.2 ppb or less. The projected emissions for the cumulative case would be about the same as the emissions used in these modeling studies. The contributions to O_3 levels would therefore be similar. As emissions within the nonattainment areas are expected to decrease further in the future, the cumulative impacts from the OCS oil and gas program on O_3 levels would likely be reduced.

Visibility Impairment. Gaseous and fine particulate matter in the atmosphere can potentially degrade atmospheric visibility. Existing visibility in the eastern United States, including the GOM coast States, is impaired due to fine particulate matter containing primarily sulfates and carbonaceous material. High humidity is an important factor in visibility impairment in the GOM coastal areas. The absorption of water by the particulate matter makes them grow to a size that enhances their ability to scatter light and reduce visibility. The estimated natural mean visibility in the eastern United States is 97 to 129 km (60 to 80 mi) (Malm 1999).

Based on data presented by Malm (2000), the observed mean visual range in coastal Louisiana, Mississippi, and Alabama is about 38 to 48 km (24 to 30 mi). In the Texas coastal areas, the average visibility is about 48 to 64 km (30 to 40 mi). In the GOM coast States, about 60 to 70% of the human-induced visibility degradation (impairment) is attributed to sulfate particles, while about 20% is from organic or elemental carbon particles. About 8% of the visibility degradation is attributed to nitrate particles (Malm 2000; USEPA 2001).

Visibility degradation in large urban areas, such as Houston, can be especially pronounced during air pollution episodes. In some severe cases, it may hinder navigation by boats and aircraft. Degraded visibility also adds to the perception by the observer of bad air quality even when monitors do not record unhealthful pollutant levels.

A study of visibility from platforms off Louisiana revealed that significant reductions in Louisiana coastal and offshore visibility are almost entirely due to transient occurrences of fog (Hsu and Blanchard 2005). Episodes of haze are short-lived and affect visibility much less. Offshore haze often appears to result from plume drift generated from coastal sources. The application of visibility screening models to individual OCS facilities has shown that the emissions from a single facility are not large enough to significantly impair visibility. It is not known to what extent aggregate OCS sources contribute to visibility reductions; however, the effects from OCS sources are likely to be very minor because offshore emissions are substantially smaller than the onshore emissions.

In July 1999, the USEPA published its Regional Haze Regulations Final Rule to address visibility impairment in the Nation’s National Parks and Wilderness Areas (64 FR 35714). These regulations established goals for improving visibility in Class I areas through long-term strategies for reducing emissions of air pollutants that cause visibility impairment. The rule requires States to establish goals for each affected Class I area to improve visibility on the haziest days and to ensure no degradation occurs on the clearest days. Since visibility impairment involves considerable cross-boundary transport of air pollutants, States are encouraged to coordinate their efforts through regional planning organizations. Texas and Louisiana are part of the Central States Regional Air Planning Association. Mississippi, Alabama, and Florida are members of the Visibility Improvement State and Tribal Association of the Southeast. The USEPA provides funding to the regional planning organizations to address regional haze by developing regional strategies to reduce emissions of particulate matter and other pollutants that lead to haze (USEPA 2011k).

The Regional Haze Regulations along with the rules on ozone and acid rain should result in a lowering of regional emissions and improvement in visibility. Projected emissions from all cumulative OCS program activities are not expected to be substantially different from year 2000 emissions. The contribution of OCS program-related emissions to visibility impairment is expected to be very minor.

Conclusion. The effects of various USEPA regulations and standards are expected to result in a steady, downward trend in future air emissions. This trend should be realized in spite of continued industrial and population growth along the GOM coast. Previous O_3 nonattainment areas in the GOM coast region (Beaumont-Port Arthur, Texas, and Baton Rouge, Louisiana) were reclassified as attainment areas in 2010. States such as Texas are required to implement SIPs to reduce emissions in their O_3 nonattainment areas. The overall cumulative impacts on air quality in the GOM over the next 40 to 50 yr are expected to be minor to moderate, and the incremental contribution of the routine Program activities to air quality impacts would be small (see Section 4.4.4.1).

The OCS program contributes slightly to onshore levels of NO_2, SO_2, and PM_{10}, but concentrations are well within the national standards and PSD increments. The effects from future OCS program activities are expected to remain about the same as in previous years. Portions of the GOM coast region have O_3 levels that exceed the Federal standard, but the contribution from all OCS program activities to ozone levels is very small (about 1%; see Section 4.4.4.1.1). Ozone levels are on a declining trend due to air pollution control measures that have been implemented by the States. This trend is expected to continue as a result of local as well as nationwide control efforts. The contribution of the Program to onshore O_3 would therefore remain very small. The GOM coast region has significant visibility impairment from anthropogenic emission sources. However, visibility is expected to improve somewhat as a result of regional and national programs to reduce emissions. The contribution from OCS program activities to visibility impairment, therefore, is expected to remain small.

Impacts from the evaporation of accidental oil spills for the cumulative case would be similar to those for the Program (see Section 4.4.4.1.2). Since impacts from individual spills would be localized and temporary (due to the spreading of oil and action by winds, waves, and currents that disperse volatile compounds to extremely low levels over a relatively larger area), the magnitude of their impacts would be no different from those associated with the proposed action. However, as many as 330 small (greater than 50 bbl and less than 1,000 bbl) and 40 large oil spills (greater than 1,000 bbl; with the largest spills from tanker vessels) are projected to occur over the 40 to 50 yr. Impacts from fires would also be localized and short in duration.

A more detailed discussion of the effects of oil spills on air quality in the GOM is presented in Section 4.4.4.1.2.

4.6.2.1.3 Acoustic Environment. Section 4.4.5.1 discusses impacts on the acoustic environment in the GOM resulting from the proposed action (OCS program activities from 2012 to 2017). Section 4.4.7 evaluates the direct and indirect impacts of noise on marine fauna (mammals, birds, and fish), and Section 4.6.4 addresses the cumulative impacts of noise on marine fauna. Cumulative impacts on the acoustic environment result from the incremental impacts of the proposed action when added to impacts from existing and reasonably foreseeable future OCS program activities (that are not part of the proposed action) and other non-OCS program activities. Table 4.6.1-1 presents the exploration and development scenario for the GOM cumulative case (encompassing the proposed action and other OCS program activities). Ongoing and reasonably foreseeable non-OCS program activities contributing to adverse cumulative impacts on the acoustic environment in the GOM include marine subsurface and surface vessel traffic, aircraft traffic (helicopters and fixed-wing aircraft), dredging, construction of onshore and offshore facilities (e.g., production platforms and drilling rigs in State waters), LNG facility operations, renewable energy projects (foreseeable), marine geophysical (seismic) surveys, active sonars, underwater explosions, ocean science studies, and mining operations. This section addresses the quality of the acoustic environment only; the cumulative impacts of noise on GOM marine fauna are discussed in Section 4.6.4.1.

Ambient (background) noise has numerous natural and man-made sources that vary with respect to season, location, depth of occurrence, time of day, and noise characteristics (e.g., frequency and duration).[31] Natural sources of ambient noise include wind and waves, surfs (produced by waves breaking onshore), precipitation (rain and hail), lightning, volcanic and tectonic noise, and biological noise (from fishes, shrimp, and marine mammals). Vessels are the greatest man-made contributors to overall marine noise in the GOM. Underwater explosions in open water are the strongest point sources of man-made sound. Baseline acoustic conditions in the GOM are discussed in more detail in Section 3.6.1.

Ongoing and future routine OCS program activities, including those of the proposed action, that generate noise include operating air gun arrays (during marine seismic surveys), drilling, pipeline trenching, and onshore and offshore construction and decommissioning of platforms and drilling rigs. Vessel and aircraft traffic (including those associated with emergency-response and cleanup activities in the event of a spill), accidental releases (e.g., loss of well control events), and vessel collisions also contribute to noise. A preliminary study of the noise impacts of OCS-related geophysical surveys found that marine seismic surveys have the greatest impact on marine mammals, sea turtles, fish, and commercial and recreational fisheries (MMS 2004a). Noise generated from OCS and non-OCS program activities would be transmitted through both air and water, and may be transient or more extended (occurring over the long term).

[31] Higher frequencies are attenuated with distance from the source more rapidly than lower frequencies. Traffic noise generated in deep water contributes to background noise levels at greater distances than traffic noise generated in shallow water.

Conclusion. The quality of the acoustic environment in the GOM would continue to be adversely affected by ongoing and future OCS program and non-OCS program activities. Activities under the proposed action would contribute to adverse cumulative impacts on the quality of the acoustic environment in the GOM. The magnitude of cumulative impacts in the GOM is time- and location-specific and could range from minor to major, depending on the ambient acoustic conditions and the nature and combination of all OCS and non-OCS program activities in the GOM over the next 40 to 50 yr, and the incremental contributions due to noise generated by routine Program activities (minor impacts) would also vary with time and location and would depend on the characteristics of noise sources present (e.g., their frequency and duration). The cumulative impacts of noise on marine fauna are discussed in Section 4.6.4.

4.6.2.2 Alaska Region – Cook Inlet

4.6.2.2.1 Water Quality. Section 4.4.3.2 discusses water quality impacts in coastal and marine waters in the Cook Inlet resulting from the proposed action (OCS program activities from 2012 to 2017). Cumulative impacts on water quality result from the incremental impacts of the proposed action when added to impacts from reasonably foreseeable future non-OCS program activities. Table 4.6.1-2 presents the exploration and development scenario for the Cook Inlet cumulative case. Non-OCS program activities contributing to adverse cumulative impacts on water quality in Cook Inlet are summarized in Table 4.6.2-3.

OCS program activities (i.e., those of the proposed action; there are no existing OCS program activities) involve vessel traffic, chemical releases (permitted discharges), and disturbance of bottom sediments. Accidental oil spills are also counted among OCS program-related activities; assumptions for oil spills under the cumulative case scenario are provided in Table 4.6.1-3. All these activities have the potential to adversely affect water quality in Cook Inlet.

OCS program-related marine vessel traffic in Cook Inlet could be as high as one to three trips per week over the next 40 yr, all of which are associated with the proposed action. Extensive non-OCS program marine traffic also occurs in Cook Inlet. Non-OCS program traffic includes that related to crude oil and finished product transport, LNG and ammonia carriers (at the Nikiski industrial complex), commercial fishing boats, and cruise ships. Fuel barge traffic is minimal since much of the refined oil for regional consumption is transported to Anchorage by a pipeline from the Tesoro refinery in Nikiski. An estimated 704 large vessels (other than fuel barges on domestic trade) called at Cook Inlet ports between January 1, 2005, and July 15, 2006. About 65% of these were made by container vessels, roll-on/roll-off cargo ships, or ferries; 29% were gas or liquid tank ships calling at Nikiski. The remaining traffic consisted of bulk carriers, general cargo ships, tugs, and fishing and passenger vessels. Impacts on water quality from vessel traffic in Cook Inlet result mainly from oil and gasoline spills when vessels run aground, collide, catch fire, or sink (Eley 2006).

The number of production wells and oil platforms constructed over the period of the Program (at most, 114 and 3, respectively) will be proportional to the amount of oil produced

TABLE 4.6.2-3 Ongoing and Reasonably Foreseeable Future Non-OCS Activities Contributing to Cumulative Impacts on Water Quality – Cook Inlet

Type of Action	Associated Activities and Facilities (Impacting Factors)	Description
Marine vessel traffic	Accidental oil spills	Large vessel calls at marine facilities and terminals totaled 704 between January 1, 2005, and July 15, 2006. Most of these calls (65%) were container vessels, roll-on/roll-off cargo ships, or ferries; 29% were gas or liquid tankships. Another 6% were bulk carriers and general cargo; another 2% were tugs and fishing and passenger vessels. Facilities in Cook Inlet include the Nikiski industrial complex terminals (between Homer and Anchorage), the Port of Anchorage docks, and the Drift River terminal (37 km [23 mi] west-southwest of Nikiski) (Eley 2006).
Nikiski industrial complex	Permitted discharge points Pollutant releases via surface runoff (non-point discharges) Accidental oil or chemical spills Increased risk of explosions and fires Cooled water and biocide releases (LNG plant)	The LNG plant on the East Foreland peninsula of Cook Inlet (at Nikiski) is currently the only LNG export operation in the United States; it exported about 30 Bcf of gas in 2010. The USDOE has extended the plant's export license to 2013; however, in February 2011, ConocoPhillips announced it would close the plant, citing concerns over the gas supply and the deteriorated LNG market in Asia (Bradner 2011).
	Increased vehicle and marine traffic	See entry under "Oil- and gas-related activities and infrastructure" (this table).
Wastewater discharge to Cook Inlet	Permitted discharge points Pollutant releases via surface runoff (non-point discharges)	The major point sources of pollution in Cook Inlet include discharges (by discrete conveyances such as pipes or man-made ditches) from municipal wastewater treatment plants (e.g., Anchorage), seafood processors, and the petroleum industry (MMS 1995a). Most of these activities would remain at present levels for the foreseeable future and are not expected to affect the overall water quality in Cook Inlet. Discharges are regulated through the USEPA NPDES permit program. Section 403 of the CWA established the Ocean Discharge Criteria, which provide additional requirements for these types of discharges. The Alaska Department of Environmental Quality issues all NPDES permits in Alaska except for those related to oil and gas, munitions, cooling water, pesticides, and offshore seafood processors, and

TABLE 4.6.2-3 (Cont.)

Type of Action	Associated Activities and Facilities (Impacting Factors)	Description
		those on tribal lands. Current NPDES permits in Alaska are available on the USEPA website at http://yosemite.epa.gov/r10/water.nsf/NPDES+Permits/CurrentAK822. Non-point sources of pollution include stormwater and snowmelt that runs over land or through the ground, entraining pollutants and depositing them into the inlet. (The Cook Inlet watershed is home to two-thirds of Alaska's population; therefore, the quality of runoff in the watershed is heavily influenced by human activity.) The most common forms of pollution in Alaska's urban runoff include fecal coliform, sedimentation, and petroleum. Snow disposal into the marine environment also introduces oil, grease, antifreeze, chemicals, trash, animal wastes, salt, and sediments (sand, gravel, suspended and dissolved solids) (ADEC 2007b). Non-point source management programs under Section 319 of the CWA regulate these pollutant sources. The USEPA and NOAA also co-administer State Coastal Non-Point Pollution Control Programs under Section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990 (USEPA 2011).
Dredging and marine disposal	Excavation of subaqueous sediments Transport of sediments (by dredger or pipeline) Relocation and disposal of sediments	The USACE currently has dredging projects in Anchorage Harbor, Homer Small Boat Harbor, and Ninilchik Harbor (Anderson 2010).

TABLE 4.6.2-3 (Cont.)

Type of Action	Associated Activities and Facilities (Impacting Factors)	Description
Oil- and gas-related activities and infrastructure	Port of Anchorage Nikiski industrial complex Exploration wells Oil and gas pipelines Tanker vessels Onshore fuel storage tanks and transfer stations Hazardous spills/releases	Except for the Beaver Creek Unit, all other oil-producing fields in Cook Inlet are in State waters (MMS 2003a). There are 15 active offshore production platforms in the inlet. Crude oil production is handled through the Trading Bay facility and the Tesoro refinery in Nikiski; natural gas is consumed locally and processed through several plants in Nikiski. There is also a LNG plant (Phillips Marathon) at Nikiski (slated to close in 2011. Most of Cook Inlet's oil reserves have been produced; oil production in the region, therefore, has been in decline since 1970. The Port of Anchorage stages all of the refined petroleum products from Fairbanks and facilitates petroleum deliveries from refiners on the Kenai Peninsula and in Valdez (it does not receive foreign crude oil imports). The port is currently undergoing expansion that would likely begin in 2013 (Municipality of Anchorage 2011).

and reflects the total number of production wells and platforms anticipated to be built in Cook Inlet over the next 40 to 50 yr as part of the OCS program. The length of new pipeline (at most 241 km [150 mi] offshore and 169 km [105 mi] onshore) added as part of the Program represents all of that anticipated over the next 40 yr as part of the OCS program.

The area of sea bottom disturbed from construction of platforms and pipelines over the period of the Program (as much as 260 ha [640 ac] total) also represents that associated with the OCS program over the next 40 to 50 yr. Bottom disturbance degrades water quality by increasing water turbidity (i.e., suspended sediment concentration) in the vicinity of the operations and adding contaminants to the water column. It also changes sediment composition as suspended sediments (and contaminants, if present) are entrained in currents and deposited in new locations.

As summarized in Section 3.4.2, the principal point sources of pollution in Cook Inlet include municipal discharges, as well as discharges from seafood processors and the petroleum industry. Point-source pollution is rapidly diluted by the energetic tidal currents in Cook Inlet, and the USEPA *National Coastal Condition Report III* has rated the coastal waters of south central Alaska, including Cook Inlet, as good (although water clarity in upper Cook Inlet was rated poor because of very high loadings of glacial river sediments) (USEPA 2008b). Non-point sources release a range of contaminants via rivers and on-land drainages and are primarily from urban runoff (related to land development); forest practices (e.g., timber harvest operations); harbors and marinas; roads, highways, and bridges; hydromodification (related to dams, channel modification, and stream bank erosion); mining; and agriculture (ADEC 2007). Point-source discharges are anticipated to remain at present levels for the foreseeable future; non-point-source discharges should improve as a result of Alaska's water pollution control strategy (as outlined in ADEC 2007). Low concentrations of hydrocarbons are found throughout the waters of Cook Inlet and are attributed to natural sources — natural oil seeps, river discharges carrying carbon compounds of biogenic origin, and the deposition of fuel and natural organic matter (e.g., from fires) (MMS 2003a).

Activities taking place within Cook Inlet waters also contribute to the degradation of water quality. These include oil spills associated with vessel traffic, sediment dredging and disposal in local harbors (suspended sediments and contaminants), and activities related to the oil and gas industry, which operates platforms in State waters and discharges drilling wastes, produced water, and other industrial waste streams into Cook Inlet waters (MMS 2003a).

Most of the oil released to Cook Inlet is from commercial and recreational vessels (MMS 2003a). Smalls spills (less than 1,000 bbl) from commercial and recreational vessels or from OCS program activities (e.g., accidental releases) are not expected to affect the overall quality of Cook Inlet water (because they would be localized and short in duration); however, large spills (greater than 1,000 bbl) could temporarily degrade the overall quality of its water (MMS 2003a). Oil spills in ice-covered waters during winter months are generally contained within a much smaller area (compared with spills in open waters) because oil weathering (i.e., spreading, evaporation, and migration) is much slower and some oil may solidify. While such factors have proven to be favorable for most response strategies, the presence of ice can also complicate response efforts. Spills on ice are fairly easy to detect and map, unless there is fresh snowfall at the time of the spill; however, oil spilled within and under the ice can be hidden from view. Broken ice also makes spilled oil difficult to detect and map, and it can reduce the effectiveness of conventional recovery systems (MMS 2009b; DF Dickens Associates, Ltd. 2004).

Climate change predictions are based on models that simulate all relevant physical processes under a variety of projected greenhouse gas emission scenarios (Section 3.3). Because the complexity of modeling global and region climate systems is so great, uncertainty in climate projections can never be eliminated. The IPCC projections relating generally to water and water quality over the next two decades include:

- Sea level will rise by 0.18 to 0.59 m (0.6 to 2 ft) by the end of the twenty-first century;

- Sea ice, glaciers, and ice sheets in polar regions will continue melting;

- Ocean pH will decrease by 0.14 to 0.35 over the twenty-first century;

- Precipitation will increase at high latitudes (>90% likely); and

- Annual river discharges (runoff) will increase by 10 to 40% at high latitudes and decrease by 10 to 30% in the dry regions at mid-latitudes.

Alaska has experienced extensive regional warming since the 1960s, with a rise in annual temperature of about 3°C (5°F) since the 1960s. The general effects of warming include the extensive melting of glaciers, thawing of permafrost, and increased precipitation (Section 3.3). Modeling studies of warming in Cook Inlet project very large warming trends, ranging from 4°C to 10°C (7°F to 18°F) by the year 2100; precipitation is projected to increase by 20 to 25% (Kyle and Brabets 2001).

Conclusion. Water quality in Cook Inlet would be impacted by the following activities associated with the proposed action: vessel traffic, chemical releases (sanitary wastes), disturbance of bottom sediments, and accidental oil spills (from vessels and the oil and gas industry). Water quality is also affected by many other factors, including river inflows, urbanization, forest practices, mining, and agriculture. Non-OCS program activities likely to contribute to cumulative impacts include marine vessel traffic, wastewater discharge to the inlet, dredging and marine disposal, and oil and gas related activities, as well as infrastructure in State-owned marine waters. Natural seepage of oil along the west part of the inlet may also significant. The cumulative impacts on Cook Inlet water quality from all OCS and non-OCS activities in Cook Inlet over the next 40 to 50 yr are expected to be minor to moderate, and the incremental contribution of the routine Program activities to water quality impacts would be minor. These impacts may lessen with time since oil and gas production in the Cook Inlet is currently on the decline (see Section 4.4.3.2).

The USEPA, in collaboration with other Federal and coastal State agencies, has assessed the coastal conditions of each region of the United States, including Cook Inlet, by evaluating five indicators of condition, one of which was water quality, based on such parameters as dissolved oxygen, chlorophyll *a*, nitrogen, phosphorus, and water clarity. The most recent assessment found the overall condition of the coastal waters of south-central Alaska, including Cook Inlet, good (although water clarity in upper Cook Inlet was rated poor). Point source discharges are anticipated to remain at present levels for the foreseeable future; non-point source discharges should improve as a result of Alaska's water pollution control strategy. Low concentrations of hydrocarbons are found throughout the waters of Cook Inlet and are attributed to natural sources.

The number of accidental spills in Cook Inlet waters for most activities associated with the proposed action would represent only a small increase over the number of expected spills from ongoing non-OCS program activities. The incremental increase in adverse water quality impacts from these spills would depend on the weather and sea conditions at the spill location (e.g., whether ice is present), the type of waves and tidal energy at the spill locations, the type of oil spilled (very light to very heavy), the depth of the spill event (deep water, shallow water, or surface water), and the volume and rate of spillage. A more detailed discussion of the effects of oil spills on water quality in Cook Inlet is presented in Section 4.4.3.2.2.

4.6.2.2.2 Air Quality. Section 4.4.4.2 discusses air quality impacts in onshore and offshore areas of Cook Inlet resulting from the proposed action (OCS program activities from 2012 to 2017). Cumulative impacts on air quality result from the incremental impacts of the proposed action when added to impacts from other reasonably foreseeable future OCS program activities.[32] Table 4.6.1-2 presents the exploration and development scenario for the Cook Inlet cumulative case. Non-OCS program activities may also contribute to adverse cumulative impacts on air quality in the Cook Inlet region; they are discussed below.

OCS program activities, i.e., those of the proposed action (there are no existing OCS program activities), involve production platforms, exploration wells, platform construction and removal, marine vessels (pipelaying, support, and survey), helicopters, and tanker and barge transport. All these activities have the potential to adversely affect air quality in the Cook Inlet region via direct emissions or other releases to air (e.g., volatile components of fuel). Accidental oil spills are also counted among OCS program-related activities; assumptions for oil spills under the cumulative case scenario are provided in Table 4.6.1-3. Existing emission sources in the Cook Inlet Planning Area include oil production activities in State waters, onshore petroleum processing and refining, onshore oil and gas production, marine terminals, and commercial shipping.

Except for a few population centers such as Anchorage, Fairbanks, and Juneau, the existing air quality in Alaska is relatively pristine, with pollutant concentrations well within ambient standards (Section 3.5.2.2). The primary industrial emissions in the Cook Inlet region are associated with oil and gas production, power generation, small refineries, paper mills, and mining. Other sources include vessel traffic in Cook Inlet and emissions from on-land motor

[32] Currently, there are no existing OCS activities in Cook Inlet and no future activities other than those planned for the 2012-2017 OCS program.

vehicles and refuse burning (MMS 2003a). While some growth of these activities is likely to take place in the future, overall emissions are expected to remain low. More stringent emission standards on motor vehicles and new USEPA standards on non-road engines and marine vessels would result in a downward trend in emissions.

Modeling studies of proposed OCS production facilities in the Cook Inlet show that concentrations of NO_2, SO_2, and PM_{10} are within the PSD Class II and Class I maximum allowable increments and the NAAQS. Pollutant concentrations within the Tuxedni NWA, the only Class I area adjacent to the Cook Inlet Planning Area, exceed the Class I significance levels. As a consequence, any proposed facilities that would exceed the Class I significance levels, would need a comprehensive PSD increment consumption analysis done before permitting (MMS 2003a).

The baseline conditions and impacts from OCS activities on ozone and visibility are discussed in Sections 3.5.2.2 and 4.4.4.2, respectively. Because conditions in Alaska are seldom favorable for significant O_3 formation, the contribution of leasing activity associated with the Program to O_3 levels in the Cook Inlet region is expected to be small. OCS emission sources affecting visibility are also small; however, preliminary visibility screening for the Tuxedni NWA suggests sources within about 50 km (30 mi) may result in a plume visible from the site (MMS 2003a).

Accidental oil spills are sources of gaseous emissions. No more than one large spill (greater than 1,000 bbl) and 15 small spills (less than 50 bbl) are projected for the Cook Inlet Planning Area cumulative case as a result of the OCS program. Most accidental spills in the Cook Inlet region are of non-crude products caused by onshore train derailments, pipeline failures, and leaks (crude oil comprises about 4% of all product spills) (ADEC 2007). Since 1976, there have been nine major crude oil spills in the inlet, ranging in volume from 10,000 to 396,000 gal (with the largest of these coming from construction barges, offshore platforms, and jet fuel releases); the last major oil spill occurred in 1997 as a result of a loss of well control incident at the Steelhead Platform (State of Alaska 2011). Oil spills cause localized increases in VOC concentrations (proportional to the size of the spill) due to evaporation. Most of these emissions would be expected to occur within a few hours of the spill and decrease (by dispersion) drastically after that period (MMS 2003a). However, oil spills in ice-covered waters during winter months would be contained within a much smaller area (compared with spills in open waters) because oil weathering (i.e., spreading, evaporation, and migration) is much slower and some oil may solidify (MMS 2009b). A more detailed discussion of the effects of oil spills on air quality in Cook Inlet is presented in Section 4.4.4.2.

Catastrophic events at well locations may result in fires; *in situ* burning is also a preferred technique for cleanup and disposal of oil spills (documented in soil spill contingency plans). Smoke generated from such fires would be expected to reach shore quickly (within a day), but would be limited in geographic extent (MMS 2003a). A discussion of the effects of fires on air quality in the Arctic region is presented in Section 4.4.4.2.

Conclusion. OCS program activities in combination with other oil and gas exploration, development, and production activities in the Cook Inlet Planning Area could affect air quality in the region over the next 40 to 50 yr. Air pollutant concentrations associated with offshore and onshore emission sources are expected to remain well within applicable State and Federal standards over the life of the Program. Therefore, the overall cumulative impacts on air quality in Cook Inlet from all OCS and non-OCS activities in the GOM over the next 40 to 50 yr are expected to be minor to moderate, and the incremental contribution of the routine Program activities to air quality impacts would be small (see Section 4.4.4.2).

Impacts from the evaporation of accidental oil spills for the cumulative case would be similar to those for the Program (see Section 4.4.4.2.2). Since impacts from individual spills would be localized and temporary (due to the spreading of oil and action by winds, waves, and currents that disperse volatile compounds to extremely low levels over a relatively larger area or solidification of oil during winter months), the magnitude of their impacts would be no different from those associated with the proposed action. However, as many as three small (greater than 50 bbl and less than 1,000 bbl) and one large oil spills are projected to occur over the next 40 to 50 yr. Impacts from fires would also be localized and short in duration. A more detailed discussion of the effects of oil spills on air quality in Cook Inlet is presented in Section 4.4.4.2.2.

4.6.2.2.3 Acoustic Environment. Section 4.4.5.2 discusses impacts on the acoustic environment in Cook Inlet resulting from the proposed action (OCS program activities from 2012 to 2017). Section 4.4.7 evaluates the direct and indirect impacts of noise on marine fauna (mammals, birds, and fish), and Section 4.6.4 addresses the cumulative impacts of noise on marine fauna. Cumulative impacts on the acoustic environment result from the incremental impacts of the proposed action when added to impacts from reasonably foreseeable future OCS program activities (that are not part of the proposed action) and other non-OCS program activities.[33] Table 4.6.1-1 presents the exploration and development scenario for the Cook Inlet cumulative case (encompassing the proposed action and other OCS program activities). Ongoing and reasonably foreseeable non-OCS program activities contributing to adverse cumulative impacts on the acoustic environment in the Cook Inlet include aircraft overflights, vessel activities and traffic, construction and decommissioning of onshore and offshore facilities (e.g., related to ongoing oil and gas exploration and development in State waters), and other activities (e.g., seismic surveys) conducted as part of the existing oil and gas industry in the inlet. This section addresses the quality of the acoustic environment only; the cumulative impacts of noise on Cook Inlet marine fauna are discussed in Section 4.6.4.2.

Ambient (background) noise has numerous natural and man-made sources that vary with respect to season, location, depth of occurrence, time of day, and noise characteristics (e.g., frequency and duration).[34] Natural sources of ambient noise include wind and wave action, strong tidal fluctuations, currents, ice, precipitation (rain and hail), lightening, volcanic and tectonic noise, and biological noise (from marine mammals and coastal birds). Vessels (e.g., tankers, supply ships, tugboats, barges, and fishing boats) are the greatest man-made

[33] Currently, there are no existing OCS program activities in Cook Inlet.

[34] Higher frequencies are attenuated with distance from the source more rapidly than lower frequencies. Traffic noise generated in deep water contributes to background noise levels at greater distances than traffic noise generated in shallow water.

contributors to overall marine noise in Cook Inlet. Baseline acoustic conditions in Cook Inlet are discussed in more detail in Section 3.6.2.

Ongoing and future routine OCS program activities, including those of the proposed action, that generate noise include operating air gun arrays (during marine seismic surveys), drilling, pipeline trenching, and onshore and offshore construction of platforms and drilling rigs. Vessel and aircraft traffic (including that associated with emergency response and cleanup activities in the event of a spill), accidental releases (e.g., loss of well control events), and vessel collisions also contribute to noise. A preliminary study of the noise impacts of OCS-related geophysical surveys found that marine seismic surveys have the greatest impact on marine mammals, sea turtles, fish, and commercial and recreational fisheries (MMS 2004a). Noise generated from OCS and non-OCS program activities would be transmitted through both air and water, and may be transient or more extended (occurring over the long term).

Conclusion. The quality of the acoustic environment in Cook Inlet would continue to be adversely affected by ongoing and future non-OCS program activities and by future OCS program activities (currently there are no existing OCS activities). Activities under the proposed action would contribute to adverse cumulative impacts on the quality of the acoustic environment in the inlet. The magnitude of cumulative impacts due to noise in Cook Inlet from all OCS and non-OCS activities in Cook Inlet over the next 40 to 50 yr is time- and location-specific and could range from minor to major, depending on the ambient acoustic conditions and the nature of activities taking place. The incremental contribution of the routine Program activities (minor impacts) would also vary with time and location and would depend on the characteristics of noise sources present (e.g., their frequency and duration). The cumulative impacts of noise on marine fauna are discussed in Section 4.6.4.

4.6.2.3 Alaska Region – Arctic

4.6.2.3.1 Water Quality. Section 4.4.3.3 discusses water quality impacts in coastal and marine waters in the Beaufort and Chukchi Seas resulting from the proposed action (OCS program activities from 2012 to 2017). Cumulative impacts on water quality result from the incremental impacts of the proposed action when added to impacts from existing and reasonably foreseeable future OCS program activities (that are not part of the proposed action) and other non-OCS program activities.[35] Table 4.6.1-2 presents the exploration and development scenario for the Arctic region cumulative case. Non-OCS program activities contributing to adverse cumulative impacts on water quality in Beaufort and Chukchi Seas are summarized in Table 4.6.2-4.

[35] Currently, there are no existing OCS program activities in the Beaufort Sea and Chukchi Sea Planning Areas, but it is assumed that exploration and development activities as a result of Sale 193 (Chukchi Sea) will have occurred before commencement of the exploration and development activities associated with the proposed action (Section 4.4.1.3).

TABLE 4.6.2-4 Ongoing and Reasonably Foreseeable Future Non-OCS Activities Contributing to Cumulative Impacts on Water Quality – Arctic Region

Type of Action	Associated Activities and Facilities (Impacting Factors)	Description
Marine vessel traffic	Discharges of bilge water and waste Accidental oil spills	Current level of vessel traffic is low, consisting mainly of vessels supporting the oil and gas industry (e.g., cargo vessels, tugs/barges, service vessels, spill-response vessels, and hovercraft. Other vessels include those used by the military, arctic researchers (icebreakers), and by local communities for hunting and between-village transportation during the open water period. As open water season begins earlier and ends later, vessel traffic is likely to increase for shipping, research, and cruise-ship tourism (MMS 2008b). There is substantial international vessel traffic in the Bering Strait (the narrow international strait that connects the north Pacific Ocean to the Arctic Ocean) and Chukchi Sea; activity in this region increased from 245 marine vessel transits in 2008 (in the Bering Strait) to 325 transits in 2010. This trend is expected to continue with ongoing exploration and drilling activities on the U.S. and possibly the Russian portion of the Chukchi shelf (USCG 2011).
Wastewater discharges	Permitted discharge points Pollutant releases via surface runoff (non-point discharges)	Point-source discharges to the Beaufort and Chukchi Seas include those from facilities related to the oil and gas industry, hard-rock and placer mining, military operations, and seawater treatment (ADEC 2010; USEPA 2010c). Most of these activities would remain at present levels for the foreseeable future and are not expected to affect the overall water quality in these regions. Discharges are regulated through the USEPA NPDES permit program. Section 403 of the CWA established the Ocean Discharge Criteria, which provide additional requirements for these types of discharges. The Alaska Department of Environmental Quality issues all NPDES permits in Alaska except for those related to oil and gas, munitions, cooling water, pesticides, and offshore seafood processors, and those on tribal lands. Current NPDES permits in Alaska are available on the USEPA Web site at http://yosemite.epa.gov/r10/water.nsf/NPDES+Permits/CurrentAK822.

TABLE 4.6.2-4 (Cont.)

Type of Action	Associated Activities and Facilities (Impacting Factors)	Description
		Non-point sources of pollution include stormwater and snowmelt that run over land or through the ground, entraining pollutants and depositing them into Arctic waters. The most common forms of pollution in Alaska's urban runoff include fecal coliform, sedimentation, and petroleum. Snow disposal into the marine environment also introduces oil, grease, antifreeze, chemicals, trash, animal wastes, salt, and sediments (sand, gravel, suspended and dissolved solids) (ADEC 2007b). Non-point source management programs under Section 319 of the CWA regulate these pollutant sources. The USEPA and NOAA also co-administer State Coastal Non-Point Pollution Control Programs under Section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990.
Dredging and marine disposal	Excavation of subaqueous sediments Transport of sediments (by dredger or pipeline) Relocation and disposal of sediments	Mechanical and hydraulic dredges have been used to excavate materials to construct artificial islands (drilling platforms), helipads, and coastal harbors/shipping corridors in the Beaufort Sea. All past dredging activities have been conducted to support the oil and gas industry — in the 1950s and 1960s, it was for shipping and transportation; in the 1970s and 1980s, it was mainly for the construction of islands (30 islands were built during this time). Most dredging occurred during the open water season in water depths less than 50 m (150 ft). Harbors, channels, and mooring basins were dredged in MacKinley Bay, Tuft Point, and Tuktoyaktuk. Several regulations govern the dredging operations in arctic waters (IMG Golder Corp. 2004). The likelihood of future dredging projects is not known but is considered to be low.

TABLE 4.6.2-4 (Cont.)

Type of Action	Associated Activities and Facilities (Impacting Factors)	Description
Oil- and gas-related activities and infrastructure	Ports and terminals Exploration wells Oil and gas pipelines Tanker vessels Onshore fuel storage tanks and transfer stations Hazardous spills/releases	Thirty-five oil-producing fields and satellites have been developed on the North Slope and nearshore areas of the Beaufort Sea. Industrial development centers on Prudhoe Bay; infrastructure includes roadways, pipelines, production and processing facilities, gravel mines, and docks. After 30 yr of leasing in the Alaska OCS, there are no commercial oil or gas facilities located on Federal OCS lands. Most projects are located offshore in the State waters of the Beaufort Sea (MMS 2008b). Two large diesel fuel spills have occurred in the Beaufort Sea — one of 2,440 bbl from a diesel tank on an eroded gravel island in the Canadian Beaufort Sea (September 1985) and one of 1,600 bbl from a punctured barge delivering fuel to Kaktovik (August 1988) (MMS 2008b). There were 4,481 spills of seawater, produced water, crude oil, diesel, and drilling muds on the Alaska North Slope subarea between 1995 and 2005 (totaling 45,000 bbl); 98% of the volume released resulted from spills greater than 99 gal. Oil exploration and production facilities were responsible for more than 90% of the spills and about 90% of the volume. Over the past 20 yr, most large spills were of diesel fuel and occurred in local villages (ADEC 2007a; MMS 2008b).

TABLE 4.6.2-4 (Cont.)

Type of Action	Associated Activities and Facilities (Impacting Factors)	Description
Red Dog Mine	Transport by barge	The Red Dog Mine, operated by Teck Cominco Alaska, is one of the largest lead and zinc mines in the world and the only base-metal lode mine currently in production in northwest Alaska. The open-pit mine (with processing mill, tailings impoundment, and support facilities) is located in the DeLong Mountains about 130 km (82 mi) north of Kotzebue and 74 km (46 mi) inland from the Chukchi seacoast; it has produced more than a million tons of zinc and lead concentrates annually but is estimated to be mined out by 2012. Teck Cominco Alaska is proposing to mine an adjacent deposit (Aqqaluk Deposit) and continue its operations until 2031 (ADNR 2011; USEPA 2009). Processed ore (concentrate) is transported from the Red Dog Mine by an 84-km (52-mi) road to the DeLong Mountain Terminal, a port facility located on the Chukchi Sea. The terminal consists of a housing unit, six diesel storage tanks, two concentrate storage buildings, a laydown area, and a concentrate conveyor/ship loading system. Although concentrate is shipped from the mine to the terminal year-round, shipping of concentrate by barge (to deep sea cargo ships) occurs only during months when the waters are ice-free (generally from July through October). The port site also includes a small domestic wastewater treatment system that discharges to the Chukchi Sea under a NPDES permit (USEPA 2009). The Red Dog Mine may be a source of trace metals in the Chukchi Sea (Section 3.4.3).
Gold (placer mining) on Seward Peninsula (Chukchi Sea)	Use of mercury for amalgamation	Mining of placer gold in beach deposits and bench gravels continued through 1900 and could present a risk of contamination to nearby water and sediments.

Ongoing and future routine OCS program activities (i.e., those of the proposed action and existing OCS program activities) involve vessel traffic, waste disposal, chemical releases (permitted discharges), and disturbance of bottom sediments. All these activities have the potential to adversely affect water quality in the Beaufort and Chukchi Seas. Accidental oil spills are also counted among OCS program-related activities; assumptions for oil spills under the cumulative case scenario are provided in Table 4.6.1-3.

OCS program-related marine vessel traffic in the Beaufort and Chukchi Seas could be as high as 41 trips per week (up to 18 in the Beaufort Sea and 23 in the Chukchi Sea) over the next 40 to 50 yr; vessel traffic associated with the proposed action represents about 66% of this traffic but would occur only during open-water and broken ice conditions (typically during August and September). Non-OCS program traffic in the Beaufort and Chukchi Seas is relatively low and includes that related to the oil and gas industry (e.g., cargo vessels, spill response vessels, and hovercraft), military operations, and arctic research. Small vessels are used by local communities for hunting and between-village transportation during the open water period (MMS 2008b). Impacts on water quality from marine traffic arise from regular discharges of bilge water and waste, leaching of anti-fouling paints, and incidental spills (MMS 2001).

In the Beaufort Sea Planning Area, the number of production wells and oil platforms constructed over the period of the Program (at most 120 and 4, respectively) will be proportional to the amount of oil produced; these numbers represent about 32 and 33% (respectively) of the total number of production wells and platforms anticipated to be built in the planning area over the next 40 to 50 yr as part of the Program. The lengths of new onshore and offshore pipeline (at most 129 km [80 mi] and 250 km [155 mi], respectively) added as part of the Program represent about 21 and 30%, respectively, of that anticipated as part of the OCS program.

In the Chukchi Sea Planning Area, the number of production wells and oil platforms constructed over the period of the Program (at most 280 and 5, respectively) will be proportional to the amount of oil produced; these numbers represent about 25% (for each) of the total number of production wells and platforms anticipated to be built in the planning area over the next 40 yr as part of the OCS program. The lengths of new onshore and offshore pipeline (at most 0 km [0 mi] and 402 km [250 mi], respectively) added as part of the Program represent about 0 and 19%, respectively, of that anticipated as part of the OCS program.

The area of sea bottom disturbed from construction of platforms and pipelines over the period of the Program (as much as 430 ha [1,100 ac] in the planning areas combined) represents about 19% of that associated with the OCS program over the next 40 yr. Bottom disturbance degrades water quality by increasing water turbidity in the vicinity of the operations and adding contaminants to the water column. It also changes sediment composition as suspended sediments (and contaminants, if present) are entrained in currents and deposited in new locations.

As summarized in Section 3.4.3, the water quality in the Beaufort and Chukchi Seas is relatively uncontaminated by anthropogenic pollutants (compared to other regions that typically receive pollutants from industrial, agricultural, and municipal discharges and related runoff). The principal point sources of pollution are facilities related to the oil and gas industry, hard-rock and placer mining, military operations, and seawater treatment. Non-point sources release a range of contaminants via rivers and onland drainages that could include contaminated runoff related to mining operations (e.g., gold mining on the Seward Peninsula). Most of these activities would remain at present levels for the foreseeable future and are not expected to affect the overall water quality in these regions.

Activities taking place within arctic waters also contribute to the degradation of water quality. These include oil spills associated with vessel traffic, sediment dredging and disposal in local harbors (suspended sediments and contaminants), and activities related to the oil and gas industry, which operates platforms in State waters and discharges drilling wastes, produced water, and other industrial waste streams into the Beaufort Sea (MMS 2008b; ADEC 2007a).

Most of the oil released to arctic waters is from leaks related to the oil industry (ADEC 2007a). Smalls spills (less than 1,000 bbl) from commercial and recreational vessels or from OCS program activities (e.g., accidental releases) are not expected to affect the overall quality of the Beaufort or Chukchi Seas because they are localized and short in duration; however, large spills (greater than 1,000 bbl) could temporarily degrade the overall quality of their water (MMS 2003a). Oil spills in ice-covered waters are generally contained within a much smaller area (compared with open-water spills) because in the cold arctic environment, oil weathering (i.e., spreading, evaporation, and migration) is much slower and some oil may solidify. While such factors have proven to be favorable for most response strategies, the presence of ice can also complicate the response strategy. Spills on ice are fairly easy to detect and map, unless there is fresh snowfall at the time of the spill; however, oil spilled within and under the ice can be hidden from view. Broken ice also makes spilled oil difficult to detect and map, and it can reduce the effectiveness of conventional recovery systems (MMS 2009b; DF Dickens Associates, Ltd. 2004).

Climate change predictions are based on models that simulate all relevant physical processes under a variety of projected greenhouse gas emission scenarios (Section 3.3). Because the complexity of modeling global and region climate systems is so great, uncertainty in climate projections can never be eliminated. Changes to the arctic climate include:

- Atmospheric temperature increases of 1 to 2°C (2–4°F) since the 1960s and continuing increases at a rate 1°C (2°F) per decade in winter and spring;

- Precipitation increases at a rate of about 1% per decade;

- Decreases in sea ice extent at a rate of about 3% per decade (since the 1970s);

- Multi-year ice decreases at a rate of about 9% per decade (since the 1980s);

- Temperatures increases at the top of the permafrost layer by up to 3°C (5°F) since the 1980s; and

- Thawing of the permafrost base at a rate of up to 0.04 m/yr (0.13 ft/yr).

The retreat of sea ice is increasing impacts on coastal areas from storms. In areas where permafrost has thawed, coastlines are more vulnerable to erosion from wave action.

Conclusion. Water quality in the Beaufort and Chukchi Seas would be affected by the following activities associated with the proposed action: vessel traffic, waste disposal, chemical releases (permitted discharges), disturbance of bottom sediments, and accidental oil spills (from vessels and the oil and gas industry). Non-OCS program activities likely to contribute to cumulative impacts include marine vessel traffic, wastewater discharge, dredging and marine disposal, oil-related, and gas-related activities and infrastructure in State-owned marine waters, and activities related to the Red Dog Mine. The cumulative impacts on arctic water from all OCS and non-OCS activities in the Arctic over the next 40 to 50 yr are expected to be moderate and the incremental contribution of the routine Program activities (such as non-OCS program oil and gas activities to water quality impacts would be minor to moderate (see Section 4.4.3.3). The number of large spills in arctic waters for most activities associated with the proposed action would represent only a small increase over the number of expected spills from ongoing OCS and non-OCS program activities. The incremental increase in adverse water quality impacts from these spills would depend on the weather and sea conditions at the spill location (e.g., whether ice is present), the type of waves and tidal energy at the spill locations, the type of oil spilled (very light to very heavy), the depth of the spill event (deep water, shallow water, or surface water), and the volume and rate of spillage. A more detailed discussion of the effects of oil spills on water quality in arctic waters is presented in Section 4.4.3.3.2.

4.6.2.3.2 Air Quality. Section 4.4.4.1 discusses air quality impacts on onshore and offshore areas of the Arctic region resulting from the proposed action (OCS program activities from 2012 to 2017). Cumulative impacts on air quality result from the incremental impacts of the proposed action when added to impacts from existing and reasonably foreseeable future OCS program activities (that are not part of the proposed action) and other non-OCS program activities.[36] Table 4.6.1-2 presents the exploration and development scenario for the Arctic region cumulative case (encompassing the proposed action and future OCS program activities). Non-OCS program activities also contribute to adverse cumulative impacts on air quality in the region; they are discussed below.

Ongoing and future routine OCS program activities, including those of the proposed action, involve production platforms, exploration wells, platform construction and removal, marine vessels (pipelaying, support, and survey), helicopters, and tanker and barge transport. All these activities have the potential to adversely affect air quality in the Beaufort and Chukchi Seas. Accidental oil spills are also counted among OCS program-related activities; assumptions for oil spills under the cumulative case scenario are provided in Table 4.6.1-3. Existing emission sources in the Beaufort and Chukchi Sea Planning Areas include oil and gas exploration, development, and production activities in State waters (Beaufort Sea only); onshore petroleum

[36] Currently, there are no existing OCS program activities in the Beaufort and Chukchi Sea Planning Areas, but it is assumed that exploration and development activities as a result of Sale 193 (Chukchi Sea) will have occurred before commencement of the exploration and development activities associated with the proposed action (Section 4.4.1.3).

processing and refining; marine terminals (e.g., DeLong Mountain Terminal on the Chukchi Sea); aircraft traffic; and vessel traffic.

Except for a few population centers such as Anchorage, Fairbanks, and Juneau, the existing air quality in Alaska is relatively pristine with pollutant concentrations well within ambient standards (Section 3.5.2.3). This is also the case in the Chukchi and Beaufort Seas and the North Slope area, with the exception of "arctic haze," which is attributed to combustion sources in Russia (MMS 2010). The primary industrial emissions in the Beaufort and Chukchi Sea Planning Areas are associated with onshore oil development and production, offshore oil development and production (in State waters), power generation, mining (Red Dog Mine), and marine transportation. While some growth of these activities is likely to take place in the future, overall emissions are expected to remain low. More stringent emission standards on motor vehicles and new USEPA standards on non-road engines and marine vessels would result in a downward trend in emissions.

On the Alaska North Slope, the main sources of air emissions are associated with onshore oil production from the Prudhoe Bay, Kuparuk River, Colville River, Oooguruk, Milne Point, and Badami fields and oil production in State waters (Northstar and Duck Island fields). As of 2009, about 16.2 Bbbl[37] of oil have been produced from North Slope reservoirs, including the Beaufort Sea (ADNR 2009). Production from the region peaked at about 730 Mbbl in 1988 and has been in decline since then (EIA 2011c). The USDOE projects that the annual production of oil will continue to decline, from about 234 Mbbl in 2010 to 37 Mbbl in 2050 (EIA 2009q). There are a number of planned and potential future oil development projects, both onshore and in State and Federal waters in the Beaufort Sea Planning Area. There are very few other emission sources in the Chukchi Sea Planning Area.

Air monitoring at a number of sites in the Kuparuk and Prudhoe Bay fields has shown that concentrations of NO_2, SO_2, and PM_{10} are well within the NAAQS. Modeling studies for the Liberty project indicate that emissions from these areas have little effect on ambient concentrations in other locations (with maximum concentrations occurring within 100 to 200 m [330 to 660 ft] from the facility boundary and considerably lower concentrations at a distance of 1 km [0.62 mi]) (MMS 2010). For this reason, it is anticipated that emissions from new facilities would be small and localized with little interaction between facilities.

The baseline conditions and impacts from OCS activities on ozone and visibility are discussed in Sections 3.5.2.3 and 4.4.4.3, respectively. Because conditions in Alaska are seldom favorable for significant O_3 formation, the contribution of leasing activity associated with the Program to O_3 levels in the Beaufort and Chukchi Sea Planning Areas is expected to be small. OCS emission sources affecting visibility are also small.

Accidental oil spills are a source of gaseous emissions. No more than six large spills (of volume greater than 1,000 bbl) and 450 small spills (of volume less than 50 bbl) are projected for the Beaufort and Chukchi Sea Planning Areas cumulative case as a result of the OCS program (Table 4.6.1-3). Most of the accidental spills in the North Slope region are of non-crude

[37] Historic figures include both oil and natural gas liquids produced at Prudhoe Bay and surrounding fields.

products during fuel transfer operations at remote villages (ADEC 2007a). While there is no discernable trend in the annual number of spills or total volume released, there is a seasonal pattern to spill events, with increases occurring during winter months (likely coinciding with increased exploration activities). Since 1976, there have been no major crude oil spills in arctic waters (State of Alaska 2011). Oil spills cause localized increases in VOC concentrations (proportional to the size of the spill) due to evaporation. Most of these emissions would be expected to occur within a few hours of the spill and decrease (by dissipation) drastically after that period (MMS 2010). However, oil spills in ice-covered waters during winter months would be contained within a much smaller area (compared with spills in open waters) because oil weathering (i.e., spreading, evaporation, and migration) is much slower and some oil may solidify (MMS 2009b). A more detailed discussion of the effects of oil spills on air quality in the Arctic region is presented in Section 4.4.4.3.

Catastrophic events at well locations may result in fires; *in situ* burning is also a preferred technique for cleanup and disposal of oil spills (documented in oil spill contingency plans). Smoke generated from such fires would be expected to reach shore quickly (within a day), but would be limited in geographic extent (MMS 2003a). A discussion of the effects of fires on air quality in the Arctic region is presented in Section 4.4.4.3.

Conclusion. OCS program activities in combination with other oil and gas exploration, development, and production activities in the Beaufort and Chukchi Sea Planning Areas could affect air quality in the region. Air pollutant concentrations associated with offshore and onshore emission sources are expected to remain well within applicable State and Federal standards over the life of the Program. Therefore, the overall cumulative impacts on air quality in the Beaufort and Chukchi Sea Planning Areas are expected to be minor to moderate, and the incremental contribution of routine Program activities to air quality impacts would be small (see Section 4.4.4.3).

Impacts from the evaporation of accidental oil spills for the cumulative case would be similar to those for the Program (see Section 4.4.4.3.2). Since impacts from individual spills would be localized and temporary (because in the cold arctic environment oil weathering is slower and some oil may solidify), the magnitude of their impacts would be no different from those associated with the proposed action. However, as many as 80 small (greater than 50 bbl and less than 1,000 bbl) and eight large oil spills are projected to occur over the next 40 to 50 yr. Impacts from fires would also be localized and short in duration. A more detailed discussion of the effects of oil spills on air quality in the Arctic region is presented in Section 4.4.4.3.2.

4.6.2.3.3 Acoustic Environment. Section 4.4.5.3 discusses impacts on the acoustic environment in the Arctic region resulting from the proposed action (OCS program activities from 2012 to 2017). Section 4.4.7 evaluates the direct and indirect impacts of noise on marine fauna (mammals, birds, and fish), and Section 4.6.4 addresses the cumulative impacts of noise on marine fauna. Cumulative impacts on the acoustic environment result from the incremental impacts of the proposed action when added to impacts from reasonably foreseeable future OCS program activities (that are not part of the proposed action) and other non-OCS program activities.[38] Table 4.6.1-1 presents the exploration and development scenario for the Beaufort Sea and Chukchi Sea Planning Areas cumulative case (encompassing the proposed action and other OCS program activities). Ongoing and reasonably foreseeable non-OCS program activities contributing to adverse cumulative impacts on the acoustic environment in the Arctic region include aircraft overflights, vessel activities and traffic, construction of onshore and offshore facilities (e.g., related to ongoing oil and gas exploration and development in State waters), and other activities (e.g., seismic surveys) conducted as part of the existing oil and gas industry in the Beaufort and Chukchi Seas. This section addresses the quality of the acoustic environment only; the cumulative impacts of noise on marine fauna in the Beaufort and Chukchi Seas are discussed in Section 4.6.4.3.

Ambient (background) noise has numerous natural and manmade sources that vary with respect to season, location, depth of occurrence, time of day, and noise characteristics (e.g., frequency and duration).[39] Natural sources of ambient noise include wind and wave action, currents, ice, precipitation (rain and hail), lightening, and biological noise (from marine mammals and coastal birds). Vessels (e.g., tankers, supply ships, tugboats, barges, and fishing boats) are the greatest man-made contributors to overall marine noise in the Arctic region. Baseline acoustic conditions in the region are discussed in more detail in Section 3.6.3.

Ongoing and future routine OCS program activities, including those of the proposed action, that generate noise include operating air gun arrays (during marine seismic surveys), drilling, pipeline trenching, and onshore and offshore construction and decommissioning of platforms (including artificial islands and causeways), and drilling rigs. Vessel and aircraft traffic (including that associated with emergency response and cleanup activities in the event of a spill), accidental releases (e.g., loss of well control events), and vessel collisions also contribute to noise. A preliminary study of the noise impacts of OCS related geophysical surveys found that marine seismic surveys have the greatest impact on marine mammals, sea turtles, fish, and commercial and recreational fisheries (MMS 2004a). Noise generated from OCS and non-OCS program activities would be transmitted through both air and water, and may be transient or more extended (occurring over the long term).

Conclusion. The quality of the acoustic environment in the Beaufort and Chukchi Seas would continue to be adversely affected by ongoing and future non-OCS program activities and by future OCS program activities (currently there are no existing OCS activities). Activities under the proposed action would contribute to adverse cumulative impacts on the quality of the acoustic environment in the Arctic region. The magnitude of cumulative impacts due to noise in the Beaufort and Chukchi Seas from all OCS and non-OCS activities in the Arctic over the next 40 to 50 yr is time- and location-specific and could range from minor to major, depending on the ambient acoustic conditions and the nature of activities taking place. The incremental

[38] Currently, there are no existing OCS program activities in the Beaufort Sea and Chukchi Sea Planning Areas, but it is assumed that exploration and development activities as a result of Sale 193 (Chukchi Sea) will have occurred before the proposed action (Section 4.4.1.3).

[39] Higher frequencies are attenuated with distance from the source more rapidly than lower frequencies. Traffic noise generated in deep water contributes to background noise levels at greater distances than traffic noise generated in shallow water.

contribution due to noise generated by the routine Program activities (minor impacts) would vary with time and location and would depend on the characteristics of noise sources present (e.g., their frequency and duration). The cumulative impacts of noise on marine fauna are discussed in Section 4.6.4.

4.6.3 Marine and Coastal Habitats

4.6.3.1 Gulf of Mexico Region

4.6.3.1.1 Coastal and Estuarine Habitats. A number of activities associated with the proposed action could result in impacts on coastal and estuarine habitats (Section 4.4.6.1). These activities include construction of pipelines and shoreline facilities, maintenance dredging of inlets and channels, and vessel traffic. Impacts associated with these activities could include (1) losses of beach and dune habitat and indirect effects that contribute to reductions in beach habitat in areas of ongoing shoreline degradation; and (2) elimination of wetland habitat and indirect effects that contribute to reductions in wetland habitat. Similar activities will be occurring from previous and future sales during the life of the Program (see Table 4.6.1-1). Excluding the estimated number of offshore pipelines installed, which is not relevant to this analysis, the activities associated with the proposed action will be about 15–30% of the total amount of OCS program activity that will occur during the life of the Program.

Barrier Beaches and Dunes. Impacts on barrier beaches and dunes primarily result from factors that reduce sediment input to downdrift areas or that directly contribute to increased erosion of beaches and dunes. Construction projects may reduce the sediment contribution to the GOM barrier landforms from inflowing rivers, or they may restrict the movement of sediments to downdrift areas and natural replenishment of barrier beaches. Other activities may disturb barrier dune vegetation, thereby promoting dune erosion, or directly disturb beach and dune substrates, resulting in increased erosion of beaches and dunes. Increases in wave action can also contribute to beach erosion.

Ongoing non-OCS activities that could affect barrier beaches and dunes include those related to State oil development, commercial shipping, coastal development, and recreation. These activities can be reasonably expected to continue into the future. A number of activities reduce the sediment supply to barrier beaches and dunes. Past activities that have contributed to sediment deprivation and submergence of coastal lands have contributed to erosion and land losses, particularly along the Louisiana coast, and are expected to continue into the foreseeable future. Channelization and diversion of Mississippi River flows, as well as the construction of Mississippi River dams and reservoirs, and subsequent reductions in sediment supply to deltaic areas to the west have resulted in the continued extensive erosion of coastal habitats. Past construction of dams on other rivers discharging to the western GOM has also resulted in a reduction in sediments delivered to the coast, which, along with natural causes of sediment supply reductions, have resulted in ongoing land loss along the Texas coast. The emplacement of groins, jetties, and seawalls for beach stabilization in much of the GOM contributes to the reduction of sediment inputs and the acceleration of coastal erosion in downdrift areas. Maintenance dredging of barrier inlets and bar channels, in combination with channel jetties, has resulted in impacts on adjacent barrier beaches down-current due to sediment deprivation, especially on the sediment-starved coastal areas of Louisiana. Maintenance dredging is an ongoing practice and is expected to continue to be an impacting factor into the future; this includes, for example, efforts to accommodate larger cargo vessels. The past construction of canals for pipelines and navigation has resulted in losses of coastal barrier habitat. Although new navigation canals from the GOM to inland areas are unlikely to be needed and current pipeline construction methods result in little, if any, impacts on barrier landforms, existing pipeline canals are expected to continue to be sediment sinks and to promote the reduction of adjacent barrier island dunes and beaches. However, the replenishment of barrier beaches with sand obtained from OCS sources and the beneficial use of dredged material are expected to continue to aid in the restoration of barrier islands. The impacts on barrier beaches and dunes from sediment removal activities associated with maintenance dredging under the proposed action would represent a very small contribution to the past, ongoing, and expected future degradation of barrier beaches and dunes from non-OCS activities.

Although coastal barrier islands in most of the Central GOM Planning Area generally receive minimal recreational use, most barrier beaches in Texas, Alabama, and Florida are accessible and extensively used for recreation. Pedestrian and vehicular traffic on beaches and dunes can destabilize substrates, either by reducing vegetation density—and thus increasing erosion by wind, waves, and traffic—or by directly disturbing or displacing substrates. In addition, considerable private and commercial development has occurred on many barrier islands in the GOM, resulting in losses of beach and dune habitat. The impacts on barrier beaches and dunes from substrate-disturbance activities associated with pipeline construction under the proposed action are expected to be greatly minimized by non-intrusive construction techniques and would not be expected to appreciably add to the cumulative effects of other substrate-disturbing activities.

Activities that increase wave action along barrier beaches and dunes can contribute to their erosion. The construction of seawalls, groins, and jetties in Texas and Louisiana has contributed to coastal erosion in part by increasing or redirecting the erosional energy of waves. Vessel traffic related to shipping and transportation can result in wake erosion of channels between barrier islands. A large number of vessels use the navigation channels near the GOM coast. A portion of the impacts related to vessel traffic would be associated with the proposed action; however, activities conducted under the proposed action would contribute a relatively small number of vessel trips to the total.

Barrier beaches and dunes could be impacted by accidental spills of oil or petroleum products resulting from cumulative OCS activities (Section 4.6.1.1). Although the majority of these spills would be small (less than 50 bbl), catastrophic releases can impact extensive areas of shoreline. Oil released into coastal waters as a result of the DWH event, April–July 2010, affected more than 1,046 km (650 mi) of the GOM coastal habitat, from the Mississippi River delta to the Florida panhandle, with the Louisiana, Mississippi, Alabama, and Florida coasts all affected (OSAT-2 2011; National Commission 2011). The greatest impacts were in Louisiana. More than 209 km (130 mi) of coastal habitat were moderately to heavily oiled, with only 32 km

(20 mi) occurring outside of Louisiana (National Commission 2011). Little or no oil affected Texas coastal habitats. Heavy to moderate oiling occurred along a substantial number of Louisiana beaches, with the heaviest oiling on the Mississippi Delta, in Barataria Bay, and on the Chandeleur Islands (OSAT-2 2011). The majority of Mississippi barrier islands had light oiling to trace oil, although heavy to moderate oiling occurred in some areas. Some heavy to moderate oiling also occurred on beaches in Alabama and Florida, with the heaviest stretch of oiling extending from Dauphin Island, Alabama, to near Gulf Breeze, Florida (OSAT-2 2011). Light to trace oiling occurred from Gulf Breeze to Panama City, Florida. Deposition of oil occurred in the supratidal zone (above the high tide mark), deposited and buried during storm events; intertidal zone; and subtidal zone, there remaining as submerged oil mats (OSAT-2 2011). On Grand Isle, Louisiana, and Bon Secour, Alabama, oil was found up to 105 cm (41 in.) below the surface (OSAT-2 2011). Although much of the oil remaining after cleanup is highly weathered, several constituents have the potential to cause toxicological effects (OSAT-2 2011). Non-OCS activities, such as the domestic transportation of oil, foreign crude oil imports, and State oil development may also result in accidental spills that could potentially impact coastal barrier beaches and dunes. The amount of oil contacting barrier islands from a spill would depend on a number of factors such as the location and size of the spill, waves and water currents, and containment actions. Naturally occurring seeps may also be a source of crude oil introduced into GOM waters (NRC 2003b; Kvenvolden and Cooper 2003). The magnitude of resulting impacts and the persistence of oil would depend on factors such as the amount of oil deposited, remediation efforts, substrate grain size, and localized erosion and deposition patterns. In areas of barrier beach erosion, such as Louisiana, remediation would likely include the minimization of sand removal or replacement of removed sand. The impacts of potential oil spills associated with the proposed action would be expected to add a small contribution to the impacts of other sources of oil.

Indirect effects on coastal barrier beaches and dunes could result from global climate change. Factors associated with global climate change include changes in temperature and rainfall, alteration in stream flow and river discharge, sea level rise, changes in hurricane frequency and strength, sediment yield, mass movement frequencies and coastal erosion, and subsidence (Yanez-Arancibia and Day 2004). Potential thermal expansion of ocean water and melting of glaciers and ice caps could result in a global rise in mean sea level (Section 4.6.1.6). Recent rates of sea level rise have been approximately 3 mm/yr (0.12 in./yr), but this rate may increase to 4 mm/yr (0.16 in./yr) by 2100 (Blum and Roberts 2009). Sea-level rise could result in increased inundation of barrier beaches and increases in losses of beach habitat. Effects of sea level rise include damage from inundation, floods and storms; and erosion (Nicholls et al. 2007). Effects of increased storm intensity include increases in extreme water levels and wave heights; increases in episodic erosion, storm damage, risk of flooding, and defence failure (Nicholls et al. 2007). Patterns of erosion and accretion can also be altered along coastlines (Nicholls et al. 2007). The small tidal range of the GOM coast increases the vulnerability of coastal habitats to the effects of climate change.

Hurricanes and other severe storm events can affect coastal barrier beaches and dunes. Increased wave action and intensity on barrier habitats may result in increased erosion and changes in beach and dune topography or losses of habitat. Hurricanes and tropical storms are inherent components of the GOM ecosystem that have long influenced coastal habitats and are expected to continue to be sources of impacts. Anthropogenic impacts on barrier beaches and dunes may be greatly exacerbated by severe storm events such as hurricanes. In 2005, Hurricanes Katrina and Rita caused extensive erosion of barrier landforms in the central and western GOM. Extreme storms such as these can result in relatively permanent change to these habitats, particularly in areas that are already experiencing erosion and retreat as a result of sediment deprivation, sea level rise, and coastal development.

Wetlands. Factors that affect coastal wetlands include the direct elimination of wetland habitat by excavation or filling, the reduction of sediment inputs, the erosion of wetland substrates, and the degradation of wetland communities by reduced water quality or hydrologic changes. Construction projects may fill wetlands for facility siting or excavate wetlands for the construction of canals or pipelines. Other projects may reduce the sediment delivered to coastal wetlands from inflowing rivers. A number of activities may degrade wetlands or promote wetland losses indirectly by causing changes to wetland hydrology or introducing contaminants. Routine OCS operations could have direct impacts on wetlands as a result of direct losses of habitat from construction activities, pipeline landfalls and channel dredging, and indirect impacts as a result of altered hydrology caused by channel dredging.

Ongoing non-OCS activities that could affect coastal wetlands include those related to State oil and gas development, commercial shipping, coastal development, dredging operations, discharge of municipal wastes and other effluents, domestic transportation of oil and gas, and foreign crude oil imports. These activities can be reasonably expected to continue into the future. A number of these activities result in the localized destruction of wetlands. The construction of pipelines and navigation channels would result in direct losses of wetlands that are crossed, due to excavation. In addition, the creation of spoil banks along canals would bury wetland habitat. Large areas of coastal wetlands are also lost by drainage and filling, due to urban development and agricultural use (Gosselink et al. 1979; Bahr and Wascom 1984). Although activities that impact wetlands are regulated by State and Federal agencies, construction of industrial facilities, commercial sites, and residential developments would be expected to result in continued wetland losses. Pipeline installation and vessel traffic outside of established traffic routes could have short-term impacts on seagrass communities, which are primarily located in the eastern GOM. The direct impacts on coastal wetlands from pipeline, navigation canal, or facility construction under the proposed action would represent a small contribution to the past, ongoing, and expected future losses of wetlands from non-OCS activities.

Indirect impacts on wetlands from non-OCS activities are expected to continue to contribute to wetland degradation and conversion of wetlands to open water. A major factor that has contributed to the ongoing loss of coastal wetlands, particularly in the Mississippi River Delta region of Louisiana, is the reduction in sediments provided to coastal marshes. Reductions in sediment supply, in combination with natural subsidence, have contributed significantly to the conversion of coastal marsh to open water. The construction of dams and levees and channelization along the Mississippi River restrict the sediment supply and overbank flow of floodwaters, limiting the release of sediments and fresh water to coastal marshes (LCWCRTF 1998, 2003; USACE 2004).

Coastal wetlands are also lost due to the effects of large storm events, and the continuing erosion of barrier islands reduces their capacity to act as buffers for coastal wetlands (LCWCRTF 2001). Construction of canals for pipelines and navigation would result in future continuing progressive losses from canal widening and failure of mitigation structures, which would contribute to the conversion of wetlands to open water. Canal construction and maintenance dredging of navigation canals result in hydrologic changes, primarily high levels of tidal and storm flushing and draining potential of interior wetland areas. Such alterations of water movement can result in erosion of marsh substrates and increase inundation levels, and can result in substantial impacts on the hydrologic basin. Construction and maintenance of canals through coastal wetlands can increase the impacts of coastal storms, such as hurricanes, in the conversion of wetlands to open water. Saltwater intrusion results from canal construction and reduced freshwater inputs due to river channelization, and causes considerable deterioration of coastal wetlands. Wetland losses due to subsidence have also been attributed to extraction of oil in some portions of the Mississippi River Delta, or the withdrawal of groundwater along the Texas coast. Changes in wetland hydrology, as well as increases in turbidity and sedimentation, as a result of construction projects, can affect wetlands.

Degradation of wetlands can result from water quality impacts due to stormwater discharges and discharges of waste water from vessels, municipal treatment plants, and industrial facilities. Water quality may also be impacted by waste storage and disposal sites. The direct and indirect impacts on coastal wetlands under the proposed action would represent a small contribution to the past, ongoing, and expected future impacts on wetlands from non-OCS activities.

Accidental spills of oil or petroleum products from OCS activities (Section 4.4.6.1) could impact coastal wetlands. The majority of these spills would be small (less than 50 bbl). Should spills occur in shallow water from vessel accidents and pipelines, they could contact and affect coastal wetlands. Most spills that occur in deep water would be unlikely to contact and impact wetlands. Catastrophic releases in deep water, however, can impact extensive areas of shoreline. Oil released into coastal waters as a result of the DWH event, April–July 2010, affected more than 1,046 km (650 mi) of the GOM coastal habitat, from the Mississippi River delta to the Florida panhandle, with the Louisiana, Mississippi, Alabama, and Florida coasts all affected (OSAT-2 2011; National Commission 2011). Non-OCS activities, such as State oil development, the domestic transportation of oil, and foreign crude oil imports, may also result in accidental spills that could potentially impact coastal wetlands. Naturally occurring seeps may also be a source of crude oil that could potentially affect coastal wetlands. The amount of oil contacting wetlands, the magnitude of resulting impacts, and the length of time for recovery would depend on a number of factors such as the location and size of the spill, containment actions, waves and water currents, type of oil, types of remediation efforts, amount of oil deposition, duration of exposure, season, substrate type, and extent of oil penetration. Impacts from oil spills would be expected to range from short-term effects on vegetation growth to permanent loss of wetlands and conversion to open water. The impacts of potential oil spills associated with the proposed action would be expected to constitute a small addition to the impacts of all other sources of oil in the GOM.

Global climate change could result in indirect effects on coastal wetlands. Factors associated with global climate change include changes in temperature and rainfall, alteration in stream flow and river discharge, wetland loss, salinity, sea level rise, changes in hurricane frequency and strength, sediment yield, mass movement frequencies and coastal erosion, and subsidence (Yanez-Arancibia and Day 2004). Effects of sea level rise include damage from inundation, floods and storms; erosion; saltwater intrusion; rising water tables/impeded drainage; and wetland loss and change (Nicholls et al. 2007). Effects of increased storm intensity include increases in extreme water levels and wave heights; increases in episodic erosion, storm damage, risk of flooding, and defence failure (Nicholls et al. 2007). Patterns of erosion and accretion can also be altered along coastlines (Nicholls et al. 2007). The small tidal range of the GOM coast increases the vulnerability of coastal habitats to the effects of climate change. A study of coastal vulnerability along the entire U.S. GOM coast found that 42% of the shoreline mapped was classified as being at very high risk of coastal change due to factors associated with future sea level rise (Thieler and Hammar-Klose 2000). A revised coastal vulnerability index study of the coast from Galveston, Texas, to Panama City, Florida, indicated that 61% of that mapped coastline was classified as being at very high vulnerability, with coastal Louisiana being the most vulnerable area of this coastline (Pendleton et al. 2010). Potential thermal expansion of ocean water and melting of glaciers and ice caps could result in a global rise in mean sea level (Section 4.6.1.6). Sea level rise would result in greater inundation of coastal wetlands and likely result in an acceleration of coastal wetland losses, particularly in Louisiana, as wetlands are converted to open water. In addition, large changes in river flows into the GOM could affect salinity and water circulation in estuaries, which, in turn, could impact estuarine wetland communities.

Hurricanes and other severe storm events impact coastal wetlands through increased wave action and intensity, resulting in increased erosion of wetland substrates and conversion of coastal wetlands to open water. Hurricanes and tropical storms are inherent components of the GOM ecosystem that have long influenced coastal habitats and are expected to be continuing sources of impacts. However, impacts on wetlands as a result of human activities, such as those that create marsh openings that enhance tidal and storm-driven water movements, may be amplified by severe storm events such as hurricanes. In 2005, Hurricanes Katrina and Rita caused extensive impacts on wetlands in the Central and Western GOM. For example, up to 259 km^2 (100 mi^2) of coastal wetlands in Louisiana may have been converted to open water as a result of the storms, and up to 60,700 ha (150,000 ac) of coastal wetlands and bottomland forests were damaged in national wildlife refuges along the GOM coast (FWS 2006). It is possible that extreme storms such as these could result in relatively permanent change to these habitats, particularly in areas that are already experiencing erosion and conversion of wetlands to open water as a result of sediment deprivation, sea-level rise, channelization, and coastal development.

Seagrass Beds. As identified in Section 4.4.6.1, the principal OCS activities under the proposed action that could potentially affect seagrass beds include placement of structures (e.g., pipelines) and vessel traffic within the vicinity of the beds. In addition, coastal development associated with OCS oil and gas activities could contribute to cumulative impacts on submerged seagrass beds. Most of the seagrass beds in the GOM are in the Eastern GOM Planning Area, where no OCS activities are proposed during the Program.

Non-OCS activities that may contribute to cumulative effects on seagrass habitats include anchoring, fishing/trawling, offshore shipping, diving, and continued onshore development. The extensive seagrass beds located in the eastern GOM may be susceptible to impacts from non-OCS activities such as dredging and onshore development that contribute to increased sedimentation, turbidity, nutrient input, and various types of point and non-point source contamination.

As noted in Section 4.4.6.1, oil spills reaching coastal areas could affect submerged seagrass beds. The majority of these spills would be small (less than 50 bbl). Should spills occur in shallow water from vessel accidents and pipelines, they could contact and affect seagrass beds. Most spills that occur in deep water would be very unlikely to contact and impact seagrasses; however, catastrophic releases can impact extensive areas of shoreline. As identified in Table 4.6.1-3, it is assumed that up to 40 large oil spills (>1,000 bbl), up to 330 small-sized spills 50 to 999 bbl, and up to 1,950 small oil spills of less than 50 bbl could occur as a result of ongoing and currently planned OCS activities. A catastrophic spill event would have an assumed spill size of 4,000,000 bbl. As discussed previously, non-OCS activities and oil seeps could also contribute substantially to releases of oil in the GOM. Oil spills in shallow water in the GOM from OCS and non-OCS activities could have significant effects on submerged seagrass beds. The magnitude and severity of potential effects on seagrass beds from oil spills would be a function of the location, timing, duration, and size of the spill; the proximity of the spill to seagrass beds; and the timing and nature of spill containment and cleanup activities. Releases that occur in the shallow portions of the eastern GOM have the potential to be of greatest significance, due to the more extensive growth of seagrasses along that coastline. It is unlikely that OCS spills would contact the extensive seagrass areas offshore Florida and along its coast because of the great distance between these resources and locations in the Central and Western GOM Planning Areas where leasing will occur.

Conclusion. Ongoing OCS and non-OCS program activities in combination with naturally occurring events have resulted in considerable losses of coastal and estuarine habitats in the GOM; cumulative impacts on these resources, therefore, are considered to be moderate to major. Operations under the proposed action would result in small localized impacts, primarily due to facility construction, pipeline landfalls, channel dredging, and vessel traffic; however, the incremental contribution of routine Program activities to cumulative impacts would be small (see Section 4.4.6.1.1).

The cumulative impacts of past, present, and future oil spills and natural seeps on submerged seagrass beds would be moderate to major. The incremental impacts of accidental oil spills associated with the proposed action on seagrass beds would be small to large, depending on the location, timing, duration, and size of the spill; the proximity of the spill to seagrass beds; and the timing and nature of spill containment and cleanup activities (see Section 4.4.6.1.1). The majority of these spills would be small (less than 50 bbl). Large oil releases that occur in or reach shallower nearshore areas have the greatest potential to affect coastal and estuarine habitats. Most spills would be unlikely to contact and affect coastal and estuarine habitats. Large oil spills and catastrophic discharge events, however, can affect extensive areas of shoreline.

4.6.3.1.2 Marine Benthic and Pelagic Habitats. Cumulative impacts could result from the combination of the proposed action and past, present, and reasonably foreseeable future OCS and non-OCS activities. Impacts on marine benthic and pelagic habitat resulting from ongoing and future routine OCS program activities, including those of the proposed action, could result from noise (vessel, seismic surveys, and construction), well drilling, pipeline placement (trenching, landfalls, and construction), platform placement (anchoring, mooring, and removal, except in deep waters) and routine discharges (drilling, production, platform, and vessel). Accidental oil spills are also counted among OCS program-related activities.

Up to 12,000 development and production wells and 2,000 oil platforms are anticipated to be built in the GOM under the cumulative scenario (Table 4.6.1-1). In addition, up to 69,200 km (43,000 mi) of offshore pipeline could be added. The construction of platforms and pipelines would disturb as much as 81,000 ha (200,200 ac) in total over the next 40 to 50 yr (Table 4.6.1-1). Bottom disturbance resulting from the proposed action may degrade water quality by increasing water turbidity in the vicinity of the operations and adding contaminants to the water column. It also changes sediment composition as suspended sediments (and contaminants, if present) are entrained in currents and deposited in new locations. The increased amount of drilling anticipated under the proposed action will result in OCS discharges of drill muds, cuttings, and produced waters. Impacts of OCS routine operations (exploration, production and decommissioning activities) on marine benthic and pelagic habitat are discussed in detail in Sections 4.4.6.2.1 and 4.4.6.3.1. Overall, routine operations represent a negligible to moderate long-term disturbance, with the severity of the impacts generally decreasing dramatically with distance from the well site.

Non-OCS activities with a potential to impact marine benthic and pelagic habitats in the GOM include sediment dredging and disposal, sand mining, anchoring, fishing/trawling, and tankering of imported oil. Anchoring by non-OCS vessels could cause significant chronic disturbance the benthic habitat and biota and temporarily reduce water quality by generating turbidity in the water column. Anchoring could involve boats used for recreational and commercial fishing or scuba diving, and commercial ship traffic. The amount of damage that could result from anchoring activity would depend upon vessel size, the size of the anchor and chain, sea conditions at the time of anchoring, and the location or position of the anchor on the feature. Areas damaged by anchors may take more than 10 years to recover, depending upon the severity of the damage. Due to a lack of regulation of non-OCS activities on these features, there is a likelihood of damages increasing due to heavier usage of the resources in the future. Sand mining and dredging operations in conjunction with ship channel maintenance and construction, pipeline placement and burial, and support facility access occur throughout the GOM as part of non-OCS activities. Sediments dredged and sidecast or transported to approved dredged material disposal sites would alter bottom habitat and communities and remove, injure, or kill local biotic communities in addition to generating turbidity over the length of the water column. Similarly, bottom trawling degrades benthic habitats and temporarily increases the turbidity of the water (Jones 1992).

Other non-OCS activities with a potential to impact marine benthic and pelagic habitats include offshore marine transportation, and pollutant inputs from point and non-point sources. Vessel traffic is a source of chronic noise that could temporarily and episodically reduce local habitat quality by disturbing pelagic and shallow water benthic organisms. Multiple contaminant sources exist from nearshore point sources and contaminants can also be delivered to the continental shelf during storms and high river discharge. A primary example is the cultural eutrophication of the GOM, which has resulted in a large seasonal hypoxic zone off the coasts of Louisiana and Texas and restricts the use of benthic and bottom water habitat by marine biota over a wide area. In addition to non-point source pollution, LNG terminal operations (biocide-laden, cooled water), and activities related to the oil and gas industry, which operates hundreds of platforms in State and Federal waters, discharges large volumes of drilling wastes, produced water, and other industrial waste streams to GOM waters. Pollutant inputs into the GOM and their impact on water quality are discussed in Section 4.6.2.1. The impacts of these activities on marine pelagic habitat can be temporary or long term and could result in reduced habitat quality for marine biota.

In the benthic and pelagic habitats of the GOM, climate change may cause the temporal variability of key chemical and physical parameters — particularly hydrology, dissolved oxygen, salinity, and temperature — to change or increase, which could significantly alter the existing structure of the benthic and phytoplankton communities (Rabalais et al. 2010). For example, freshwater discharge into the GOM has been increasing and is expected to continue to increase as a result of the increased rainfall in the Mississippi River Basin (Dai et al. 2009). Such changes could result in severe long-term or short-term fluctuations in temperature and salinity that could reduce or eliminate sensitive species. Such changes are most likely to occur in the Mississippi Estuarine Ecoregion, where freshwater inputs are highest. In addition, greater rainfall may increase inputs of nutrients into the GOM, potentially resulting in more intense phytoplankton blooms that could promote benthic hypoxia (Rabalais et al. 2010). Hypoxic or anoxic conditions can reduce or eliminate the suitability of benthic habitat for marine organisms.

Marine benthic and pelagic habitat and biota could be affected by oil spills from both OCS program activities and non-OCS activities such as the domestic transportation of oil, the import of foreign crude oil, and State development of oil. Storms, operator error, and mechanical failures may result in accidental oil releases from a variety of non-OCS related activities. Assumptions for oil spills under the cumulative case scenario are provided in Table 4.6.2-3, and for catastrophic spills, in Table 4.4.2-2. Large and potentially catastrophic spills could result from pipeline ruptures, tanker spills associated with an FPSO system, or loss of well control. In addition, crude oil enters the environment of the GOM from naturally occurring seeps. At least 63 seeps have been identified in the GOM (mostly off the coast of Louisiana) (MacDonald et al. 1996), and more than 350 naturally occurring and constant oil seeps that produce perennial slicks of oil at consistent locations may be present in the GOM (MacDonald and Leifer 2002, as cited in Kvenvolden and Cooper 2003). Seeps in the northern GOM have been estimated to discharge more than 28,000 bbl of crude oil annually to overlying GOM waters (MacDonald 1998b).

For both OCS and non-OCS oil spills, it is assumed that the magnitude and severity of the potential effects on benthic and pelagic habitat would be a function of the location, timing, duration, and size of the spill and the timing and nature of spill containment and cleanup activities. Detailed discussion of the impacts of OCS accidental hydrocarbon releases on marine benthic and pelagic habitat can be found in Sections 4.4.6.2.1 and 4.4.6.3.1.

Coral Reefs and Hard-Bottom Habitat. Sensitive coral reef and hard-bottom benthic habitats in the GOM may be more susceptible to OCS impacts and take longer to recover if impacts were to occur. Consequently, these habitats receive special protection. Four coral reef and hard-bottom habitats are designated for the various protections: (1) banks offshore of Texas and Louisiana (including the FGBNMS), (2) the Pinnacle Trend off the Louisiana-Alabama coast, (3) seagrass and low-relief live-bottom areas primarily located in the Central and Eastern Planning Areas, and (4) potentially sensitive biological features of moderate to high relief that are not protected by (1) and (2). As identified in Section 4.4.6.2.1, NTL No. 2009-G39 has several protections in place to minimize and mitigate the adverse effects of oil and gas exploration and development on coral reefs and hard-bottom habitat.

Cumulative impact factors for coral reef and hard-bottom habitat include both OCS and non-OCS cumulative activities. Impacts of OCS exploration, production and decommissioning activities on coral reefs and hard-bottom habitat could result from noise, well drilling, pipeline placement (trenching, landfalls, and construction), chemical releases (drilling discharges, operation discharges, and sanitary wastes), and platforms placement (anchoring, mooring, and removal, except in deepwaters). Impacts of OCS exploration, production and decommissioning activities on marine benthic and pelagic habitat are discussed in detail in Section 4.4.6.2.1. Overall, impacts on coral reef and live-bottom habitat from routine activities should be minimized by the protection stipulated by NTL 2009-G39. However, low-relief or small, isolated, unmapped live-bottom could be affected by direct mechanical damage and turbidity and sedimentation.

Non-OCS activities with a potential to impact these habitats include anchoring by non-OCS activity vessels, fishing/trawling, discharges by non-OCS offshore marine transportation, and tankering of imported oil. Anchoring could involve boats used for recreational and commercial fishing or scuba diving, and commercial ship traffic. The amount of damage that could result from anchoring activity would depend upon vessel size, the size of the anchor and chain, sea conditions at the time of anchoring, and the location or position of the anchor on the feature. Recovery of areas damaged by anchors may be long term, depending upon the severity of the damage. Due to a lack of regulation of non-OCS activities on these features, there is a likelihood of damages increasing due to heavier usage of the resources in the future.

Trawling activities are another source of damage to coral and hardbottom habitat. Because anchoring and collection activities by scuba divers on the living reef areas of the Flower Garden Banks are prohibited, biota associated with the Flower Garden Banks are unlikely to be significantly affected by these activities. Similarly, use of spiny lobster and stone crab traps may also damage bottom substrate such as seagrasses and corals. Strings of traps deployed without buoys are sometimes retrieved by dragging 18-kg (40-lb) grapnels and chains across the bottom until the trap string is hooked, potentially damaging bottom habitats in the process.

Impacts could also occur due to discharges from other non-OCS activities, including tankers or other marine traffic passing in the vicinity of coral reef and hard-bottom habitat. Because water depths are typically greater than 20 m (66 ft) at the tops of most of the banks, dilution of discharges would greatly reduce concentrations of potentially toxic components before they could come in contact with these features; consequently, it is assumed that discharges from such activities would not be concentrated enough to reduce habitat quality.

Climate change has the potential to profoundly affect coral communities on coral and hard-bottom features in several ways including (Section 3.7.1.1.4):

- Increased frequency of bleaching as a stress response to warming water temperatures (Hoegh-Guldberg et al. 2007);

- Excessive algal growth on reefs and an increase in bacterial, fungal, and viral agents (Boesch et al. 2000; Twilley et al. 2001);

- Greater frequency of mechanical damage to corals from greater severity of tropical storms and hurricanes (Janetos et al. 2008);

- Decreases in the oceanic pH and carbonate concentration are expected to reduce the reef formation rate, weaken the existing reef structure, and alter the composition of coral communities (Janetos et al. 2008); and

In addition, climate change may allow the range expansion of non-native species. Many of the decommissioned platforms will be converted into artificial reefs. By acting as stepping stones across the GOM, oil platforms have been implicated in the introduction of a non-native coral species (*Tubastraea coccinea*) and fishes such as sergeant majors (*Abudefduf saxatilis*) and yellowtail snapper (*Ocyurus chrysurus*) into the FGB (Hickerson et al. 2008).

Oil spills from both OCS and non-OCS activities could affect coral reef and hard-bottom habitat and biota. Detailed discussion of the impacts of OCS accidental hydrocarbon releases on hard-bottom and coral reef habitat can be found in Section 4.4.6.2.1. It is assumed that accidental oil releases from most non-OCS activities would be at the surface or located sufficiently far from coral reef and hard-bottom habitat and biota that they would be unlikely to greatly affect these habitats. The magnitude and severity of potential effects on coral reef and hard-bottom habitat and biota from such exposure would be a function of the location, timing, duration, and size of the spill; the proximity of the spill to the features; and the timing and nature of spill containment and cleanup activities. Depending upon location, spills from non-OCS sources and releases from natural seeps could contribute to the overall exposure of communities associated with topographic features in the GOM OCS planning areas to oil, with corresponding lethal or sublethal effects.

High Density Deepwater Communities (HDDC). High density deepwater communities (HDDCs) include coldwater corals and chemosynthetic communities. Cumulative impact factors for HDDCs include both OCS and non-OCS cumulative activities. Potential impacts on HDDCs resulting from ongoing and future routine OCS program activities, including those of the proposed action, could result from noise, well drilling, pipeline placement (trenching, landfalls, and construction), chemical releases (drilling discharges, operation discharges, and sanitary wastes), and platform placement (anchoring, mooring, and removal, except in deep waters). Mitigation measures instituted to protect these HDDCs include Notice to Lessee (NTL) 2009-

G40, which requires the avoidance of HDDCs or areas that have a high potential for supporting these community types, as interpreted from geophysical records. Impacts of OCS exploration, production, and decommissioning activities on HDDCs are discussed in detail in Section 4.4.6.2.1. Overall, impacts on HDDCs from exploration and site development activities are expected to be minimal because of the provisions in NTL 2009-G40 that protect HDDCs from oil and gas development activities. However, small and unmapped HDDCs may be completely or partially destroyed by bottom-disturbing activities. In such cases, recovery would likely be long term, although permanent loss of the affected feature is also possible.

Non-OCS activities that have the potential to adversely affect HDDCs include fishing/trawling, anchoring, and offshore marine transportation. Due to the water depths of these areas and the widely scattered nature of these habitats, such activities are unlikely to greatly affect HDDCs in the GOM. However, deepwater trawling could destroy HDDCs and recover could be long term or may not occur at all. Generally, commercially important deepwater fish species use *Lophelia* reefs as juveniles (SAFMC 1998).

As climate change has the potential to affect warm water corals, it could affect coldwater *Lophelia* reefs (Section 3.7.2.1.7). The saturation depth of aragonite (the primary carbonate formed used by hard corals) appears to be a primary determinant of deepwater coral distribution, with reefs forming in areas of high aragonite solubility (Orr et al. 2005). The depth at which the water is saturated with aragonite is projected to become shallower over the coming century, and most coldwater corals may be in undersaturated waters by 2100 (Orr et al. 2005). Consequently, the spatial extent, density, and growth of deepwater corals may decrease, diminishing their associated ecosystem functions (Orr et al. 2005). There is evidence that oil and gas extraction reduces the natural release of hydrocarbons that support deep-sea chemosynthetic communities (Quigley et al. 1999). Unlike chemosynthetic communities, *Lophelia* corals do not depend on hydrocarbon seepage to meet their metabolic requirements (Becker et al. 2009) and presumably would not be affected.

Oil spills from both OCS and non-OCS activities could affect HDDCs. Detailed discussion of the impacts of OCS accidental hydrocarbon releases can be found in Section 4.4.6.2.1. The magnitude and severity of potential effects on biota associated with topographic features from such exposure would be a function of the location, timing, duration, and size of the spill, the proximity of the spill to the features, and the timing and nature of spill containment and cleanup activities. It is assumed that most accidental oil releases would be at the surface or located sufficiently far from HDDCs that they would be unlikely to greatly affect communities associated with the topographic features.

Conclusion. Impacting factors for marine benthic and pelagic habitats include both OCS and non-OCS activities. For OCS activities, planning and permitting procedures and stipulations that promote identification and avoidance of sensitive habitats should minimize the potential for direct impacts on sensitive seafloor areas during routine OCS activities. In the GOM, stipulations that are currently in place restrict OCS activities in the immediate vicinity of seafloor areas containing important topographic features, live bottom habitat, and HDDC, and there is relatively little likelihood that cumulative OCS activities will affect overall viability of ecological resources in such areas. Non-OCS activities with a potential to impact marine benthic and pelagic habitats in the GOM include oil and gas production in State waters, sediment dredging and disposal, sand mining, anchoring, fishing/trawling, and tankering of imported oil. Disturbances from these activities such as noise, vessel discharges, and bottom disturbance would occur in addition to similar impacts from OCS Program activities. Cumulative impacts to major topographic features, live bottom habitats and HDDC as a result of OCS and non OCS Program activities would be minor, either because impacts would occur to relatively small proportions of the available habitats or because there are various restrictions in place to limit the potential for impacts. The incremental contribution of routine Program activities to these impacts would be small (see Section 4.4.6.2.1).

Oil spills could result from both OCS and non-OCS activities. The cumulative impacts of past, present, and future oil spills on seafloor habitats would be minor to major. The incremental impacts of accidental oil spills associated with the proposed action on these resources would be small to large, depending on the location, timing, duration, and size of spills; the proximity of spills to particular habitats; and the timing and nature of spill containment and cleanup activities (see Section 4.4.6.2.1). Spills in deeper water, whether from OCS or non-OCS sources, are unlikely to have overall community-level effects on seafloor habitats because of the relatively small proportion of seafloor area that would come in contact with released oil at concentrations great enough to elicit toxic effects. Catastrophic oil spills that affect shallow and intertidal habitats have the potential to be of greatest significance. Although pelagic habitat is likely to recover quickly following an oil spill, the recovery time for intertidal and shallow subtidal benthic habitat directly impacted by oil spills could be long term.

4.6.3.1.3 Essential Fish Habitat. This section identifies activities that could affect fish resources in the GOM, including non-OCS activities and current and planned OCS activities that would occur during the life of the Program, and the potential incremental effects of implementing the proposed action. Cumulative effects on EFH could occur from a variety of OCS and non-OCS activities that have a potential to directly kill managed fish species, disturb ocean bottom habitats, increase sediment suspension, degrade water quality, or affect the food supply for fishery resources.

Cumulative impacting factors for EFH include both OCS and non-OCS activities. Impacts on marine benthic and pelagic habitat resulting from ongoing and future routine OCS program activities, including those of the proposed action, could result from noise, well drilling, pipeline placement (trenching, landfalls, and construction), platform placement (anchoring, mooring, and removal, except in deep waters) and routine discharges (drilling, production, platform, and vessel). Accidental oil spills are also counted among OCS program-related activities.

Routine OCS activities could disturb bottom areas due to the installation of platforms and pipelines and the anchoring of vessels and structures. Up to 12,000 production wells and 2,000 oil platforms are anticipated to be built in the GOM under the cumulative scenario (Table 4.6.1-1). In addition, up to 69,200 km (43,000 mi) of offshore pipeline could be constructed. The construction of platforms and pipelines over the period of the Program would disturb as much as 81,000 ha (200,200 ac) in total (Table 4.6.1-1). Under the cumulative scenario, it is anticipated that less than 40 new pipeline landfalls could occur in the GOM (Table 4.6.1-1) with up to 12 of these resulting from the proposed action. As discussed in Section 4.4.6.4, deposition of drilling muds and cuttings could potentially affect EFH by altering grain-size distributions and chemical characteristics of sediments such that benthic prey of some managed fish species would be affected in the immediate area surrounding drill sites. Produced water will also be released into the GOM during the production phase.

Platform removals using explosives will likely kill some fish, including managed species for which EFH has been established, and would remove platform-associated fouling communities that serve as prey for managed species. Up to 280 platforms may be removed under the proposed action compared with up to 1,200 platforms removed using explosives as a result of cumulative OCS activities during the life of the Program. If large numbers of fish are killed as the result of removal of platforms using explosives, there could be effects on managed species and their prey in the immediate vicinity of the removed platforms. Once a platform is removed, the fouling community that serves as a food source for some managed and prey fish species in the vicinity would no longer be available, and the associated fishes would be forced to relocate to other foraging areas. However, given the relatively small area that would be affected by such removals, Gulfwide effects on managed species are not anticipated.

See Section 4.4.6.4.1 for a detailed discussion of the impacts of routine operations on EFH and managed species in the GOM. Overall, it is expected that the cumulative impacts of exploration and site development activities on marine EFH would be moderate, and impacts are not expected to permanently reduce the EFH available to managed species or result in population-level impacts to managed species. The most sensitive benthic habitats, such as those associated with hard bottoms and topographic features, should not be affected by routine operations, and effects would be minimized or eliminated by existing lease stipulations.

There are also State oil and gas activities that can affect EFH. Louisiana and Texas have experienced substantial oil and gas development within their coastal areas including exploratory drilling, production platform installation, and pipeline installation. Factors that could affect EFH from these activities would be similar to those described above for OCS activities. However, the effects from non-OCS oil and gas activities could possibly be more severe than the effects from routine OCS activities because the activities are closer to shore and in shallower environments. As a consequence, more benthic EFH may be damaged, and resulting changes in sedimentation and turbidity could affect a greater proportion of the water column.

Other non-OCS activities that influence EFH may include commercial fishing, commercial shipping (tanker transportation), land development, water quality degradation, dredge and fill and dredge disposal operation, and construction of channel stabilization structures such as jetties could affect EFH (GMFMC 1998). As discussed below, these non-OCS activities when combined with OCS activities could result in cumulative impacts on EFH over time, especially if these impacts occur frequently or are of sufficient magnitude that habitat recovery times are prolonged.

Barges carrying cargo arrive and depart through ports and travel through the GOM Intracoastal Water Way, which serves as a major route for needed goods and supplies.

Discharges of treated wastes or hazardous chemicals could negatively affect water quality (Section 4.6.2.1.1), a component of EFH, as well as aquatic vegetation. Pollutants generated from boat maintenance activities on land and water could also negatively impact water quality. Oil and grease are commonly found in bilge water, especially in vessels with inboard engines, and these products may be discharged during vessel pump out (USEPA 1993).

Sand mining and routine dredging operations for channel construction and maintenance, pipeline emplacement, and creation of harbor and docking areas can affect EFH in the GOM by suspending sediments and affecting water quality. As suspended sediments settle to the bottom, the benthic prey of some managed fish species could be smothered. In most cases, benthic organisms would recolonize such areas unless maintenance dredging operations are repeated frequently. Dumping sites for dredge spoils in the GOM, most of which are located within State waters, could also alter water quality and affect benthic organisms that serve as prey for some managed fish species.

See individual sections on water quality, coastal habitats, and marine and pelagic habitats for a discussion of the effects of climate change on EFH in the GOM. One primary impact expected to result from climate change is the loss of wetland habitat, which is an important EFH for many larval and juvenile stages of managed species. Wetland loss could be caused by several factors including erosion, sea level rise, discharging nutrient-laden waters to the environment, reduced sediment load of the Mississippi River, and human-induced subsidence from groundwater withdrawals, among others. Cumulative effects on wetlands are discussed in Section 4.6.3.1.1.

Commercial and recreational fisheries in the GOM also impact EFH. For example, most of the wild shrimp caught are harvested using bottom trawls. The nets are held open with bottom sled devices made from wood or steel. In addition to capturing and killing some nontarget fish and invertebrate species, the sleds, or “doors,” drag along the bottom, potentially digging up sediments and hard substrate. Such activities could disrupt the benthic community and increase the turbidity of the water (Jones 1992). Similarly, use of spiny lobster and stone crab traps may also damage bottom substrate such as seagrasses and corals.

Other events, including hurricanes, turbidity plumes, and hypoxia, could also affect various managed fish or their habitat, although the GOM fish community as a whole should be adapted to such events. For example, a hurricane or a series of hurricanes could temporarily degrade the quality of large areas of wetlands that serve as nursery and feeding areas for a variety of managed fish and invertebrate species.

Oil spills from OCS and non-OCS activities may cumulatively affect several resources that contribute to EFH, including sediments, water quality, fish resources, coastal habitats, and seafloor habitats and benthic communities (see Sections 4.6.2 and 4.6.3). Large, potentially catastrophic spills could result from pipeline ruptures, tanker spills associated with an FPSO system, or loss of well control. Other potential sources of oil spills that could affect EFH include non-OCS oil development activities and non-OCS tankering activities. Spills from import tankers could occur offshore in shipping lanes or in coastal waters as tankers prepare to make landfall.

Oil from shallow-water spills could impact life stages of managed fish species that use surface waters as part of their lifecycle, especially those that release pelagic eggs and have pelagic larvae. Unlike adult fish that can move away from oiled waters, pelagic eggs and larvae are largely transported by wind and water currents. Those that come into contact with surface oil could be injured or killed through smothering or an accumulation of oil on the gills. Thus, oiled surface waters would temporarily reduce the amount of EFH available for these life stages. Detailed discussion of the impacts of oil spills on fish can be found in Section 4.4.7.3.1.

In marine waters, several individual reefs and banks located offshore of the Louisiana-Texas border have been designated HAPCs by the GMFMC (NMFS 2010a). As identified in Section 4.4.6.2.1, NTL No. 2009-G39 has several protections in place to minimize and mitigate the adverse effects of oil and gas exploration and development on these banks. However, large or catastrophic spills could adversely affect hard-bottom HAPC by causing lethal or sublethal impacts to corals (Section 4.4.6.2.1). The HAPC for bluefin tuna extends from the 100 m (328 ft) isobath seaward to the EEZ. The HAPC could also be affected by oil spills, and population-level impacts to bluefin tuna could result from catastrophic spills. Habitat areas of particular concern in nearshore areas include intertidal and estuarine habitats with emergent and submerged vegetation, sand and mud flats, and shell and oyster reefs that may provide food and rearing for managed juvenile fish and shellfish. Shallow-water spills may reach these coastal EFH areas and have negative impacts. Shallow-water wave action could increase entrainment of oil and tar balls in the water column. This could temporarily diminish the quality and quantity of benthic EFH. Settled tar balls may be ingested by bottom-feeding fishes and may harm or prove fatal to them. During a spill, aquatic vegetation, which provides habitat for juveniles and for prey of some managed species, could become coated with oil. In such cases, organisms that are sessile or that have limited ability to avoid spills could be killed. These areas represent important nursery areas for fishes and invertebrates that contribute to estuarine, coastal, and shelf food webs. Loss of such habitat by oil spills would be compounded by the existing high natural loss of wetlands.

The actual locations of the spills will determine the degree to which EFH would be affected. The HAPC in the Eastern Planning Area that could be affected by oil spills from the Central or Western Planning Areas include the Florida Middle Grounds, the Madison-Swanson Marine Reserve. Pulley Ridge, and Tortugas North and South Ecological Reserve are also located in the southern tip of Florida, and are unlikely to be contacted by oil. Spills have the greatest potential to harm EFH resources if they occur in shallow waters, where benthic habitats or wetlands can be affected, or if they occur when large numbers of pelagic eggs and larvae of managed species are present. If the location of a spill coincided with the location of eggs and larvae, large numbers of these organisms would be injured or killed. Oil reaching the surface from deepwater pipeline spills and deepwater tanker spills could affect EFH for the eggs and larvae of federally managed pelagic fish species, neuston prey species, and *Sargassum* and its associated fauna. Pelagic eggs and larvae contacting the spilled oil would be smothered, and *Sargassum* within affected areas would be fouled and potentially killed.

Conclusion. Impacting factors for EFH include both OCS and non-OCS activities. Non-OCS activities with a potential to impact EFH in the GOM include oil and gas production in State waters, sediment dredging and disposal, and vessel traffic. Impacts from OCS activities would be limited by specific lease stipulations. Cumulative impacts to EFH as a result of OCS and non-OCS program activities would be minor, due to the small proportion of EFH area that would likely be affected. The incremental contribution of routine Program activities to these impacts would be small (see Section 4.4.6.3.1).

Accidental releases of oil and gas from OCS and non-OCS facilities could also have effects on EFH. The cumulative impacts of past, present, and future oil spills on EFH would be minor to moderate. The incremental impacts of accidental spills associated with the proposed action on EFH would be small to large, depending on the location, timing, duration, and size of spills; the proximity of spills to particular fish habitats; and the timing and nature of spill containment and cleanup activities (see Section 4.4.6.3.1). While most accidents related to OCS activities assumed under the cumulative spill scenario would be small and would have relatively small incremental impacts on EFH, spills that reach coastal wetlands could have more persistent impacts and could require remediation. Spills in deeper water, whether from OCS or non-OCS sources, are unlikely to have overall population-level effects on fish resources because of the relatively small proportion of similar available fish habitats that would come in contact with released oil at concentrations great enough to elicit toxic effects. Oil spills that have the greatest potential to impact EFH and managed species are those that occur in shallower subtidal and intertidal areas and spills that reach areas at the same time where substantial numbers of eggs or larvae of managed species are present.

4.6.3.2 Alaska – Cook Inlet

4.6.3.2.1 Coastal and Estuarine Habitats. A number of activities associated with the proposed action could result in impacts on coastal and estuarine habitats in the Cook Inlet Planning Area (Section 4.4.6.1.2). These activities include construction of pipelines and pipeline landfalls and operation of service vessels and existing facilities. Impacts could include losses of beach and wetland habitat and indirect effects that contribute to reductions in these habitats or impacts on biota. There are no past or ongoing OCS activities in the Cook Inlet Planning Area.

Pipeline landfalls could directly disturb tidal marshes, beaches, rocky shores, or other coastal habitats, depending on the location of the landfalls. Sedimentation from physical disturbance of substrates may affect biota in intertidal or shallow subtidal habitats. In addition, accidental spills may impact shoreline habitat.

Ongoing non-OCS activities that could affect coastal and estuarine habitats include those related to State oil and gas development, commercial shipping and other marine vessels, coastal development, discharge of municipal wastes and other effluents, domestic transportation of oil and gas, and logging. These activities can be reasonably expected to continue into the future.

Factors that impact coastal wetlands include the direct elimination of wetland habitat by excavation or filling and the degradation of wetland communities by reduced water quality or hydrologic changes. The construction of pipelines, docks, or shorebases associated with State oil and gas exploration and development could result in direct losses of habitat. Habitats and associated biota within the Cook Inlet Planning Area could also be impacted by routine discharges from marine vessels, discharges of municipal and industrial wastewater, or sedimentation from upland areas, including erosion from logging operations within the Cook Inlet watershed. Activities that increase wave action along beaches could contribute to their erosion. Barge and service vessel traffic supporting State oil and gas development may result in wake erosion. The direct and indirect impacts on wetlands from pipeline construction, service vessel operation, and operation of existing facilities under the proposed action would represent a very small contribution to the past, ongoing, and expected future impacts on coastal and estuarine habitats from non-OCS activities.

Accidental spills of oil or other liquid hydrocarbons, resulting from activities conducted under the proposed action, could impact shoreline habitats. As under the proposed action, the majority of these spills would be small (less than 50 bbl). Spills from onshore pipelines and facilities could impact freshwater wetlands, or tidal wetlands if carried to coastal habitats by streams. Non-OCS activities, such as State oil and gas development, domestic transportation of oil or refined petroleum products, including LNG from Cook Inlet and the Alaska Peninsula, the production and storage of petroleum products and LNG, and commercial shipping, may also result in accidental spills that could potentially impact shoreline habitats. Oil spills have resulted in past impacts on beaches and other intertidal habitats, as in the case of the *Exxon Valdez* oil spill. Spills can result in short- or long-term effects on vegetation growth and changes in the composition of intertidal or shallow subtidal communities, or extensive mortality of biota associated with shoreline habitats, and may persist in substrates for decades. The amount of oil contacting shoreline habitats from a spill depends on a number of factors such as the location and size of the spill, waves and water currents, and containment actions. Naturally occurring seeps may also be a source of crude oil introduced into nearshore waters (Kvenvolden and Cooper 2003). The magnitude of resulting impacts and the persistence of oil would depend on factors such as the amount of oil deposited, remediation efforts, substrate grain size, and localized erosion and deposition patterns. Recovery of affected wetlands could require several decades. The impacts of potential spills associated with the proposed action would be expected to add a small contribution to the impacts of other sources of oil in the planning area.

Indirect effects on coastal and estuarine habitats could result from global climate change. Potential thermal expansion of ocean water and melting of glaciers and ice caps could result in a global rise in mean sea level (Section 4.6.1.6). Sea-level rise could result in increased inundation of shorelines and erosion of beach habitat and conversion of wetlands to open water. In addition, large changes in river flows into nearshore marine waters could affect salinity and water circulation in estuaries, which, in turn, could impact estuarine wetland communities.

Conclusion. Future OCS program and ongoing and future non-OCS program activities in combination with naturally occurring events have resulted in losses of coastal habitats in Cook Inlet; cumulative impacts on these resources, therefore, are considered to be moderate to major. Operations under the proposed action would result in small localized impacts, primarily due to facility construction, pipeline landfalls, channel dredging, and vessel traffic; however, the incremental contribution of routine Program activities to cumulative impacts would be small (see Section 4.4.6.2.2).

The cumulative impacts of past, present, and future oil spills on coastal and estuarine habitats would be moderate. The incremental impacts of accidental oil spills associated with the proposed action on these resources would be small to large, depending on the location, timing, duration, and size of the spill; the proximity of the spill to particular habitats; and the timing and nature of spill containment and cleanup activities (see Section 4.4.6.2.2). The majority of these spills would be small (less than 50 bbl). Large oil releases that occur in or reach shallower nearshore areas have the greatest potential to affect coastal and estuarine habitats. Most spills would be unlikely to contact and affect coastal and estuarine habitats. Large oil spills and catastrophic discharge events, however, can affect extensive areas of shoreline.

4.6.3.2.2 Marine Benthic and Pelagic Habitats. Cumulative impacting factors for marine benthic and pelagic habitats in Cook Inlet Planning Area include both OCS and non-OCS activities. Potential impacts on marine benthic and pelagic habitat resulting from ongoing and future routine OCS program activities, including those of the proposed action, could result from noise (vessel, seismic surveys, construction, operations), well drilling, pipeline placement (trenching, landfalls, and construction), platform placement (anchoring, mooring, and removal), and discharges (drilling, vessel and platform). All these activities have the potential to adversely affect marine benthic habitats in the Cook Inlet Planning Area. Accidental oil spills are also counted among OCS program-related activities; assumptions for oil spills under the cumulative case scenario are provided in Table 4.6.2-3, and catastrophic spill assumptions are provided in Table 4.4.2-2.

Because there is no OCS activity in Cook Inlet Planning Area, the new OCS activities under the proposed action represent a 100% increase in all associated OCS activities in Cook Inlet. Over the life of the Program, up to 114 production wells and up to three oil platforms are anticipated. In addition, up to 241 km (150 mi) of new offshore pipeline is anticipated. Bottom disturbance resulting from OCS program activities degrades water quality by increasing water turbidity in the vicinity of the operations and adding contaminants to the water column. It also changes sediment composition as suspended sediments (and contaminants, if present) are entrained in currents and deposited in new locations. Construction of platforms in areas previously lacking hard substrate could have localized effects on the biodiversity and distribution of benthic communities by favoring organisms that prefer a hard substrate. Impacts of OCS routine operations (exploration, production and decommissioning activities) on marine benthic and pelagic habitat in the Cook Inlet Planning Area are discussed in detail in Sections 4.4.6.2.2 and 4.4.6.3.2. Overall, routine operations represent a negligible to moderate long-term disturbance, with the severity of the impacts generally decreasing dramatically with distance from the well site.

The increased amount of drilling in Cook Inlet anticipated under the proposed action will result in OCS discharges of drill muds and cuttings from exploration and delineation wells. Drilling muds and cuttings from production wells as well as all produced waters will be disposed of in the well rather than discharged into Cook Inlet. The OCS discharges of drill muds, cuttings, and produced waters could potentially affect benthic and pelagic habitat by increasing turbidity and altering grain size distributions and chemical characteristics of sediments. The impacts of drilling discharges on benthic and pelagic habitats are discussed in detail in Sections 4.4.6.2.3 and 4.4.6.3.3.

Various non-OCS activities in Cook Inlet, including State oil and gas programs, dredging and disposal of dredging spoils in OCS waters, anchoring, and commercial or sportfishing activities, and commercial shipping (including imported oil) could contribute to cumulative effects on pelagic and seafloor habitats. Drilling of wells in State waters could also require construction of platforms and pipelines in waters of Alaska. Effects on seafloor and pelagic habitat and biota would be similar to those described above for OCS oil and gas programs (Sections 4.4.6.2.2 and 4.4.6.3.2). Dredging operations in conjunction with ship channel maintenance and construction, pipeline placement and burial, and support facility access occur throughout the Cook Inlet Planning Area as part of non-OCS activities. Non-OCS dredging and marine disposal activities would involve excavation of nearshore sediments and subsequent disposal in offshore or nearshore areas, thereby disturbing seafloor habitats and generating temporary turbidity in the water column. Sediments dredged and sidecast or transported to approved dredged material disposal sites could cause smothering and some mortality of sessile animals in the vicinity of the activity. Anchoring of non-OCS activity vessels on these features could cause significant chronic disturbance to benthic and bottom water habitat and biota. Anchoring could involve boats used for recreational and commercial fishing and commercial ship traffic. The amount of damage that could result from anchoring activity would depend upon vessel size, the size of the anchor and chain, sea conditions at the time of anchoring, and the location or position of the anchor on the feature. Similarly, some fishing methods, such as trawling and shellfish dredging, could damage seafloor habitats and increase the turbidity of the water column (Jones 1992). The effects of dredging, anchoring, and trawling activities on marine benthic and pelagic habitats are expected to be similar to those described for OCS bottom disturbing activities (Sections 4.4.6.2.2 and 4.4.6.3.2). Impacts on pelagic habitat would be localized and temporary, while benthic habitat damaged by anchors may take more than 10 years to recover, depending upon the nature of the habitat and severity of the damage.

As a heavily river influenced system, climate change may cause the temporal variability of key chemical and physical parameters the Cook Inlet Planning Area — particularly hydrology, dissolved oxygen, salinity, and temperature. These changes could significantly alter the existing benthic and pelagic habitat and biota. A predicted increase in river discharge could change the salinity, temperature, and turbidity regimes in nearshore areas and alter the composition of existing phytoplankton and benthic communities. Other changes could result from:

- Ocean acidification from increasing CO_2 inputs into the ocean that may reduce the availability of calcite and aragonite to calcifying marine organisms.

- The expected reduction in landfast ice extent and duration resulting from rising temperatures may reduce the scouring of intertidal and shallow subtidal habitats on the western side of Cook Inlet.

- Warmer temperatures may also increase phytoplankton productivity, potentially resulting in greater food inputs to benthic habitats and subsequent increases in the productivity of benthic biota.

Oil spills from both OCS and non-OCS activities could affect benthic and pelagic habitat in Cook Inlet. The total number of oil spills and the extent of affected seafloor habitat would likely increase under the cumulative scenario, in conjunction with increased levels of petroleum exploration and production. Accidental hydrocarbon releases can occur at the surface from tankers or platforms or at the seafloor from the wellhead or pipelines. Non-OCS activities, such as oil and gas development in State waters, domestic transportation of oil or refined petroleum products, and commercial shipping, may also result in accidental spills that could affect benthic and pelagic habitats within the Cook Inlet Planning Area.

For both OCS and non-OCS oil spills, it is assumed the magnitude and severity of potential impacts on benthic and pelagic habitat would be a function of the location (including habitats affected), timing, duration, and size of the spill and containment and cleanup activities. It is anticipated that most small to medium spills would have limited effects because of the relatively small areas likely to be exposed to high concentrations of hydrocarbons and the short period of time during which potentially toxic concentrations would be present. Oil spills would likely have the greatest impacts on benthic habitat and communities in shallow subtidal waters and in intertidal areas. Although pelagic habitat is likely to recover quickly following an oil spill, the recovery time for intertidal and shallow subtidal benthic habitat directly impacted by oil spills could be long term (Section 4.4.6.2.2). Multiple spills would further contribute to cumulative effects. Detailed discussion of the impacts of OCS accidental hydrocarbon releases on marine benthic and pelagic habitat can be found in Sections 4.4.6.2.2 and 4.4.6.3.2.

Conclusion. Impacting factors for marine benthic and pelagic habitats include both OCS and non-OCS activities. Non-OCS activities in Alaskan waters, including oil and gas development in State waters, commercial fishing and sportfishing, sediment dredging and disposal, anchoring, and tankering of imported oil, could also contribute to cumulative effects on seafloor habitats. Disturbances from these activities including noise, vessel discharges, and bottom disturbance would occur in addition to similar impacts from OCS activities. Cumulative impacts to marine benthic and pelagic habitats, as a result of OCS and non-OCS program activities, would be minor, either because of the limited time frame over which most individual activities would occur or the small proportion of available habitats that would be affected during a given period. The incremental contribution of routine Program activities to these impacts would be small (see Section 4.4.6.2.2).

Oil spills could result from both OCS and non-OCS activities. The cumulative impacts of past, present, and future oil spills on seafloor habitats would be moderate. The incremental impacts of accidental oil spills associated with the proposed action on these resources would be small to large, depending on the location, timing, duration, and size of spills; the proximity of spills to particular seafloor habitats; and the timing and nature of spill containment and cleanup activities (see Section 4.4.6.2.2). Oil from catastrophic spills that reach shallow and intertidal habitats have the potential to be of greatest significance. Although pelagic habitat is likely to recover quickly following an oil spill, the recovery time for intertidal and shallow subtidal benthic habitat directly impacted by oil spills could be long-term.

4.6.3.2.3 Essential Fish Habitat. This section identifies activities that could affect fish resources in Cook Inlet, including non-OCS activities and current and planned OCS activities that would occur during the life of the Program, and the potential incremental effects of implementing the proposed action. Cumulative effects on EFH could occur from a variety of OCS and non-OCS activities that have a potential to directly kill managed fish species, disturb ocean bottom habitats, increase sediment suspension, degrade water quality, or affect the food supply for fishery resources.

Cumulative impacting factors for EFH include both OCS and non-OCS activities. Impacts on marine benthic and pelagic habitat from ongoing and future routine OCS program activities, including those of the proposed action, could result from noise, well drilling, pipeline placement (trenching, landfalls, and construction), platform placement (anchoring, mooring, and removal), and routine discharges (drilling, platform, and vessel). Accidental oil spills are also counted among OCS program-related activities.

Because there is no OCS activity in Cook Inlet Planning Area, the new OCS activities under the proposed action represent a 100% increase in all associated OCS activities in Cook Inlet. Over the next Program life, up to 114 production wells and up to three oil platforms are anticipated. In addition, up to 241 km (150 mi) of new offshore pipeline are anticipated. Implementation of the proposed action would also result in seismic survey activity and the release of drilling muds and cuttings to offshore areas (Table 4.6.2-2).

Although there are is no oil and gas development in OCS waters, oil and gas operations have existed in State waters of Cook Inlet for decades. Impacting factors from OCS and non-OCS oil and gas activities would be similar. Overall, it is expected that the cumulative impacts of exploration and site development activities on marine EFH would be moderate, and impacts are not expected to permanently reduce the EFH available to managed species or result in population-level impacts on managed species. The most sensitive benthic habitats, such as those associated with hard-bottoms and kelp communities, should not be affected by routine operations, and effects would be minimized or eliminated by existing protections. The construction of all platforms and pipelines would disturb bottom habitats to some degree. Deposition of drilling fluids and cuttings could potentially affect EFH by altering grain size distributions and chemical characteristics of sediments such that benthic prey of some managed fish species or water quality in offshore areas would be affected in the immediate area surrounding drill sites. Although muds and cuttings from exploration and delineation wells could be discharged to surrounding waters, it is assumed that muds, cuttings, and produced waters from production wells would be discharged into wells and not released to open waters. See Section 4.4.6.4.2 for a detailed discussion of the impacts of routine operations on EFH and managed species in Cook Inlet Planning Area.

Freshwater areas used by salmon and other anadromous fish are considered to be EFH and could be affected by nearshore OCS and non-OCS oil and gas activity such as pipeline dredging or by onshore pipelines that cross bodies of water, especially streams. The primary effects of pipeline crossings would be increasing turbidity and sedimentation of the benthic environment during construction and blocking migration of anadromous fish following construction. As a consequence, crossings of anadromous fish streams would be minimized and consolidated with other utility and road crossings of such streams. In addition, onshore pipelines would be designed, constructed, and maintained to reduce risks to fish habitats from a spill, pipeline break, or construction activities. Other non-OCS activities, such as logging, road construction, and development in general could also contribute to water quality degradation and blockage of fish passage in anadromous fish streams.

Other non-OCS activities that could impact fish communities include land use practices, point and non-point source pollution, logging, dredging/ and disposal of dredging spoils in OCS waters, anchoring, and commercial or sportfishing activities, and commercial shipping (including imported oil). Many of these activities would result in bottom disturbance that would affect bottom dwelling fishes as well as their food sources in a manner similar to those described for OCS activities (Section 4.4.7.3.2). These non-OCS activities when combined with OCS activities could over time result in cumulative impacts on EFH and managed species especially if these impacts occur frequently or are of sufficient magnitude that habitat recovery times are prolonged. See Section 4.6.3.2.1 and Section 4.6.3.2.2 for a discussion of impacts of these non-OCS activities on benthic and pelagic EFH.

Logging could also degrade riverine habitats that are important reproductive and juvenile habitat for managed migratory fish species. Erosion from areas undergoing commercial logging could increase the silt load in streams and rivers, which could reduce levels of invertebrate prey species and adversely affect spawning success and egg survival. The introduction of fine sediments into spawning gravels may render these habitats unsuitable for salmon spawning. Logging could also remove riparian canopies along some streams, which could increase solar heating of freshwater habitats. Downed timber could physically block salmon migrations. Because of past damage inflicted by commercial logging, improved forestry practices have been initiated, and timber harvests have been curtailed. Continued implementation of effective forest management techniques should help mitigate the adverse effects of logging in the future. Cumulative impacts on migratory species could also occur as a result of activities that obstruct fish movement in marine environments during migration periods.

Commercial fishing practices that are indiscriminate, such as trawling and pots, are responsible for significant amounts of bycatch that can injure or kill juveniles of many fish species. These types of fishing practices could damage future year classes, reduce available prey species, and damage benthic habitat for many Cook Inlet fish resources. A wide variety of methods are used to target numerous species of fishes and shellfishes, including longlines, seines, setnets, trawls, and traps. Some fisheries target particular fish species returning to their natal stream or river, while other fisheries take place in pelagic waters and target mixed stocks of fishes or shellfishes.

As a consequence of the pressure commercial fishing places on fishery resources, appropriate management is required to reduce the potential for depletion of stocks due to overharvesting. Fisheries in Alaskan waters and in adjacent offshore areas are managed by the Alaska Department of Fish and Game and the North Pacific Fishery Management Council of the National Marine Fisheries Service through implementation of fishing regulations such as fishing seasons and harvest limits and through hatchery production of some fishery resources (primarily salmon). Even with management, the possibility of overfishing still exists. Occasionally fisheries are closed when stocks are considered insufficient to support harvesting, and will sometimes remain closed for multiple seasons before stocks are deemed sufficient. While occasional or sustained declines in fishery stocks may not be fully attributable to commercial fishing, it appears that commercial fishing is an important factor in the abundance, or lack thereof, of fishery resources.

Although the magnitude of harvests is considerably smaller than for commercial fisheries (Fall et al. 2009), sportfishing also contributes to cumulative effects on the abundance of some fishery resources. Recreational fisheries are managed to prevent overharvesting, but recreational harvests can be a substantial portion of fisheries landings. Consequently, recreational fishing activities have a potential to result in overharvest of managed species over the life of the Program. However, recreational fishing methods are less destructive of EFH compared to commercial fisheries.

Subsistence fishing may also contribute to the cumulative effects on the abundance of some fishery resources. Alaska State law defines subsistence as the "noncommercial customary and traditional uses" of fish and wildlife. The Alaska Department of Fish and Game defines subsistence fishing to include "the taking of, fishing for, or possession of fish, shellfish, or other fisheries resources by a resident of the State for subsistence uses with gill net, seine, fish wheel, long line, or other means defined by the Board of Fisheries." These fishing methods have more limited impacts on EFH compared to commercial fishing methods. Subsistence fishing is subject to harvest limits that reduce the potential for overfishing and much of Cook Inlet is defined as a nonsubsistence area, and subsistence fishing is therefore not authorized. Consequently, subsistence fishing makes a relatively minor contribution to the reduction in fish stocks compared to commercial fishing (Fall et al. 2009).

Another source of cumulative impacts to fishery resources are personal use fisheries which are a legally defined as "the taking, fishing for, or possession of finfish, shellfish, or other fishery resources, by Alaska residents for personal use and not for sale or barter, with gill or dip net, seine, fish wheel, long line, or other means defined by the Board of Fisheries." In the Cook Inlet Planning Area, there are areas designated for personal use fisheries for salmon, tanner crab, herring, and eulachon, all of which are managed species. All personal use fisheries are subject to harvest limits that reduce the potential for overfishing. Personal use fishing makes a relatively minor contribution to the reduction in fish stocks compared to commercial fishing.

See individual sections on water quality, coastal habitats, and marine and pelagic habitats for a discussion of the effects of climate change on EFH in the Cook Inlet Planning Area. As a heavily river-influenced system, climate change may cause the temporal variability of key chemical and physical parameters, which could significantly alter the existing benthic and pelagic habitat and biota. A predicted increase in river discharge could change the salinity, temperature, and turbidity regimes in nearshore areas and alter the composition of existing phytoplankton and benthic communities. Other changes could result from ocean acidification, reduction in landfast ice extent and duration, and increase phytoplankton productivity.

The total number of oil spills and the extent of affected EFH areas would likely increase under the proposed action in conjunction with increased levels of petroleum exploration and production. The proposed action would contribute 100% of the OCS spills in the Cook Inlet Planning Areas. See Table 4.6.2-3 for oil spill assumptions for Alaska. Catastrophic spills assumptions are provided in Table 4.4.2-2. Non-OCS activities, such as oil and gas development in State waters, domestic transportation of oil or refined petroleum products, and commercial shipping, may also result in accidental spills that could potentially impact fish resources within the Cook Inlet Planning Area. While effects on EFH resources would depend on the timing, location, and magnitude of specific oil spills, it is anticipated that most small to medium spills that occur in OCS waters would have limited effects on EFH, due to the relatively small areas likely to be exposed to high concentrations of hydrocarbons and the short period of time during which potentially toxic concentrations would be present. See Section 4.4.6.4 for a detailed discussion of the impact of oil spills on EFH.

Because of the high concentrations of individuals likely to be present, EFH for anadromous salmon are at higher risk from an OCS oil spill in the Cook Inlet Planning Areas. The greatest potential for damage to salmon stocks would be if a spill were to occur along migration routes. However, because of the limited area affected by even large oil spills relative to the wide pelagic distribution and migratory patterns of salmonids, it is anticipated that most impacts would be limited to small fractions of exposed salmon populations. Oil spills occurring at constrictions in migration routes would have an increased potential for adversely affecting salmon. Adverse effects of oil spills on EFH for groundfishes of southern Alaska would also be a function of spill magnitude, location, and timing. Adult groundfishes are primarily demersal and would generally be subjected only to the insoluble oil and water-soluble fractions of oil that reach deeper strata. Insoluble oil fractions would sink to the bottom and be distributed diffusely as tar balls over a wide area, and would be unlikely to produce a reduction in the population of adult fishes. Egg and larval stages would be at greater risk of exposure to oil spills because spawning aggregations of many groundfish species (e.g., walleye pollock) produce pelagic eggs that could come into contact with surface oil slicks. Herring are also potentially susceptible to oil spills because they spawn in nearshore waters for protracted periods of time.

Managed shellfish stocks (such as tanner, snow, and red king crab) are unlikely to be exposed to surface oil. However, oil reaching shallow subtidal and intertidal shellfish or crab habitat could measurably reduce crab populations. Pelagic crab larvae could also be affected if a large surface oil spill occurred during the spring spawning season. However, because the area affected by most spills would be expected to be small relative to overall distributions of crab larvae, overall population levels are unlikely to be noticeably affected.

Conclusion. Impacting factors for EFH include both OCS and non-OCS activities. Non-OCS activities with a potential to impact EFH in the Cook Inlet Planning Area include oil and gas production in State waters, coastline development, commercial and recreational fishing, sediment dredging and disposal, and vessel traffic. Impacts from OCS activities would be limited by specific lease stipulations. Cumulative impacts to EFH as a result of OCS and non-OCS program activities would be minor to moderate, proportional to the EFH area affected. The incremental contribution of routine Program activities to these impacts would be small (see Section 4.4.6.3.2).

Accidental releases of oil and gas from OCS and non-OCS facilities could also have effects on EFH. The cumulative impacts of past, present, and future oil spills on EFH would be minor to moderate. The incremental impacts of accidental spills associated with the proposed action on EFH would be small to large, depending on the location, timing, duration, and size of spills; the proximity of spills to particular fish habitats; and the timing and nature of spill containment and cleanup activities (see Section 4.4.6.3.2). While most accidents related to OCS activities assumed under the cumulative spill scenario would be small and would have relatively small incremental impacts on EFH, oil that reaches coastal wetlands could have more persistent impacts and could require remediation. Spills in deeper water, whether from OCS or non-OCS sources, are unlikely to have overall population-level effects on fish resources because of the relatively small proportion of similar available fish habitats that would come in contact with released oil at concentrations great enough to elicit toxic effects. Oil spills that have the greatest potential to impact EFH and managed species are those that occur in shallower subtidal and intertidal areas and spills that reach areas at the same time substantial numbers of eggs or larvae of managed species are present.

4.6.3.3 Alaska Region – Arctic

4.6.3.3.1 Coastal and Estuarine Habitats.

Coastal Barrier Beach and Dunes. Vessel traffic associated with the proposed action could result in indirect impacts on coastal barrier beaches and dunes in the Arctic region (Section 4.4.6.1.3). Onshore pipeline construction may impact sand beaches and dunes on the margins of lakes and rivers on the Arctic Coastal Plain (ACP). Similar activities are associated with current and planned OCS sales in the Alaska region and would occur during the life of the Program (see Table 4.6.1-2). In the Beaufort and Chukchi Sea Planning Areas, vessel traffic associated with the proposed action would represent approximately 25–35% of such OCS activities, and onshore pipelines associated with the proposed action would represent approximately 30% for the Beaufort Sea Planning Area.

Impacts on barrier beaches and dunes primarily result from factors that contribute to increased erosion of beaches and dunes. Activities may disturb dune vegetation, thereby promoting dune erosion, or directly disturb beach and dune substrates, resulting in increased erosion of beaches and dunes. Increases in wave action could also contribute to the erosion of beaches. Sedimentation from physical disturbance of substrates or erosion may affect biota in intertidal or shallow subtidal habitats. In addition, accidental spills may impact beach or dune habitat.

Ongoing non-OCS activities that could affect barrier beaches and dunes include those related to State oil and gas development, commercial shipping and other marine vessels, and coastal development. These activities can be reasonably expected to continue into the future.

The construction of pipelines, docks, causeways, or shorebases associated with State oil and gas exploration and development could result in direct losses of beach or dune habitat.

Construction of facilities on barrier islands could impact beach, dune, or tundra habitat. Erosion of beach or dune substrates adjacent to these constructions may result in additional habitat losses. Intertidal and shallow subtidal organisms in nearby areas may be buried by excavated materials or indirectly impacted by turbidity and sedimentation. Sand beaches and dunes along lagoon shorelines and on the margins of lakes and rivers on the ACP may also be impacted by pipeline construction. The impacts on barrier beaches and dunes from substrate-disturbance activities associated with construction under the proposed action would represent a small contribution to the past, ongoing, and expected future impacts on barrier beaches and dunes from non-OCS activities. Vegetated dunes in the Arctic region may be impacted by vehicles associated with seismic activities (ADNR 2009). Beaches and associated biota within the Beaufort and Chukchi Sea Planning Areas could also be impacted by routine discharges from marine vessels, discharges of municipal and industrial wastewater, or sedimentation from upland areas.

Activities that increase wave action along barrier beaches and dunes could contribute to their erosion. Barge and service vessel traffic supporting State oil and gas development may result in wake erosion along barrier islands in the Beaufort and Chukchi Sea Planning Areas. A portion of the impacts related to vessel traffic would be associated with the proposed action; however, activities conducted under the proposed action would contribute a relatively small number of vessel trips to the total.

Accidental spills of oil or other liquid hydrocarbons, resulting from activities conducted under the proposed action, could impact beaches and dunes. Such spills would represent approximately 20–40% of the spills resulting from ongoing OCS activities and planned future sales in the Beaufort and Chukchi Sea Planning Areas (Table 4.6.1-3). As under the proposed action, the majority of these spills would be small (less than 50 bbl). Non-OCS activities, such as State oil and gas development, domestic transportation of oil or refined petroleum products, and commercial shipping, may also result in accidental spills that could potentially impact coastal barrier beaches and dunes. Spills can result in short- or long-term changes in the composition of intertidal or shallow subtidal communities, or extensive mortality of biota associated with coastal habitats, and may persist in substrates for decades. The amount of oil contacting beaches from a spill depends on a number of factors such as the location and size of the spill, waves and water currents, and containment actions. Naturally occurring seeps may also be a source of crude oil introduced into nearshore waters (Kvenvolden and Cooper 2003). The magnitude of resulting impacts and the persistence of oil would depend on factors such as the amount of oil deposited, remediation efforts, substrate grain size, and localized erosion and deposition patterns. The impacts of potential spills associated with the proposed action would be expected to add a small contribution to the impacts of other sources of beach degradation in the Arctic region.

Indirect effects on coastal barrier beaches and dunes could result from global climate change. Potential thermal expansion of ocean water and melting of glaciers and ice caps could result in a global rise in mean sea level (Section 4.6.1.6). Sea-level rise could result in increased inundation of barrier landforms and erosion of beach habitat. In the Arctic, greater wave activity during storms due to decreases in sea-ice cover, as well as changes in permafrost due to temperature increases, could result in increased coastal erosion.

Wetlands. A number of activities associated with the proposed action could result in impacts on coastal wetlands in the Alaska region (Section 4.4.6.1.3). These activities include construction of pipelines, road construction, and facility maintenance, and activities that result in poorer water and air quality and altered hydrology. Impacts associated with these activities could include elimination of wetland habitat and indirect effects that contribute to reductions in wetland habitat. Similar activities are associated with current and planned OCS lease sales in the Beaufort and Chukchi Sea Planning Areas, and would occur during the life of the Program (see Table 4.6.1-2). In the Beaufort Sea Planning Area, the activities associated with the proposed action would represent approximately 30% of such OCS activities; the proposed action does not include new onshore pipelines in the Chukchi Sea Planning Area.

Factors that impact coastal wetlands include the direct elimination of wetland habitat by excavation or filling and the degradation of wetland communities by reduced water or air quality or hydrologic changes. Construction projects may fill wetlands for facility siting or excavate wetlands for the construction of pipelines, causeways, or shore bases or for gravel mining. A number of activities may degrade wetlands or promote wetland losses indirectly by causing changes to wetland hydrology or introducing contaminants.

Ongoing non-OCS activities that could affect coastal wetlands include those related to State oil and gas development, commercial shipping and other marine transportation, coastal development, discharge of municipal wastes and other effluents, and domestic transportation of oil and gas. These activities can reasonably be expected to continue into the future.

A number of these activities result in the localized destruction of wetlands. The construction of pipeline landfalls, docks, or shorebases associated with State oil and gas exploration and development could result in direct losses of tidal wetlands. The construction of onshore facilities to support State oil and gas development and the exploration of oil reserves on the National Petroleum Reserve-Alaska on the ACP have impacted freshwater wetlands, and future impacts associated with oil and gas development are expected to continue. The construction of buried pipelines results in direct impacts on wetlands due to excavation, and the construction of gravel pads and gravel roads eliminates wetland habitat by filling. Current technology allows for smaller and fewer drilling pads, and some new developments in the Arctic region would not include interconnecting roads. On the ACP, gravel has been used in support of oil development to construct pads for camps, drilling sites, operations and maintenance facilities, airports, and roads for facility access as well as the Dalton Highway/haul road, offshore islands, and causeways (MMS 2003a). Gravel mining operations often result in the excavation of wetland habitat in and near rivers and other water bodies. Over 730 ha (1,800 ac) of tundra have been removed by gravel mining on the ACP (MMS 2003a). The construction of vertical support members for elevated pipelines also contributes to small localized wetland losses. Although activities that impact wetlands are regulated by State and Federal agencies, construction of industrial facilities, commercial sites, and residential developments would be expected to result in continued wetland losses. On the ACP, over 3,900 ha (9,600 ac) of tundra habitat, most of which is wetland, have been impacted by oil development activities (MMS 2002b, 2003a). The direct impacts on coastal wetlands from pipeline construction under the proposed action would represent a very small contribution to the past, ongoing, and expected future losses of wetlands from non-OCS activities.

Indirect impacts of many activities have also resulted in wetland losses. The construction of gravel roads and pads has resulted in altered hydrology in some areas, by blocking natural drainage patterns, converting vegetated wetlands to open water, or drying wetlands by restricting water inflow. Snow accumulations adjacent to pads and roads can result in vegetation changes and thermokarst. Windblown dust near gravel pads and roads causes changes in plant communities, reduction of vegetation, and thermokarst, leading to wetland losses. Sedimentation from gravel pads, roads, gravel mining operations, and vehicular impacts on streambanks adversely affect wetlands and may result in losses of vegetation or other associated biota. Ice roads in the Arctic could result in compression of vegetation, microtopography, and tundra soils, altering wetland communities. Vehicles used for seismic surveys could compress microtopography and cause changes in the vegetation community. Organisms in wetland areas near construction activities may be buried by excavated materials or indirectly impacted by turbidity and sedimentation. Degradation of wetlands could result from water quality impacts due to discharges of waste water from vessels, municipal treatment plants, and industrial facilities, and stormwater discharges. Water quality may also be impacted by waste storage and disposal sites. Spills of produced water could kill vegetation and other biota in freshwater wetlands. Impacts on air quality near construction sites or industrial facilities could result in local effects on wetland vegetation, and may include sources such as fugitive dust, off-gassing from processing facilities, or exhaust emissions. Indirect impacts on wetlands from non-OCS activities are expected to continue to contribute to wetland degradation and losses in the Arctic region. The indirect impacts on wetlands from pipeline construction under the proposed action would represent a very small contribution to the past, ongoing, and expected future impacts on wetlands from non-OCS activities.

Accidental spills of oil or petroleum products as a result of activities conducted under the proposed action could impact tidal or freshwater wetlands (see Section 4.4.6.1.3). Such spills would represent approximately 20–40% of the spills resulting from ongoing OCS activities and planned future sales in the Beaufort and Chukchi Sea Planning Areas (Table 4.6.1-3). Most of these spills (1,350–1,950) would be small (less than 50 bbl), as under the proposed action. Spills in shallow water, primarily those from vessel accidents and pipelines, would be most likely to affect coastal wetlands, whereas deepwater spills, such as those from platforms, would be less likely to impact wetlands. Spills from onshore pipelines and facilities could impact freshwater wetlands or tidal wetlands if carried to coastal habitats by streams. Non-OCS activities such as State oil and gas development, the domestic transportation of oil or refined petroleum products, the production and storage of petroleum products, and commercial shipping may also result in accidental spills that could potentially impact wetlands. Naturally occurring seeps may also be a source of crude oil that could potentially affect coastal wetlands. The amount of oil contacting wetlands, the magnitude of resulting impacts, and the length of time for recovery would depend on a number of factors such as the location and size of the spill, containment actions, waves and water currents, type of oil, types of remediation efforts, amount of oil deposition, duration of exposure, season, substrate type, and extent of substrate penetration. Impacts from oil spills would be expected to range from short-term effects on vegetation growth to extensive mortality. Recovery of affected wetlands could require several decades. The impacts of potential oil spills associated with the proposed action would be expected to constitute a small addition to the impacts of all other sources of oil in the Arctic region.

Global climate change could result in indirect effects on coastal wetlands. Potential thermal expansion of ocean water and melting of glaciers could result in a global rise in mean sea level (Section 4.6.1.6). Sea-level rise would result in greater inundation of coastal wetlands, and likely result in conversion of wetlands to open water. In addition, large changes in river flows into nearshore marine waters could affect salinity and water circulation in estuaries, which, in turn, could impact estuarine wetland communities.

Conclusion. Future OCS program and ongoing and future non-OCS program activities in combination with naturally occurring events have resulted in losses of coastal habitats in the Arctic region; cumulative impacts on these resources, therefore, are considered to be moderate to major. Operations under the proposed action would result in small localized impacts, primarily due to facility construction, pipeline landfalls, channel dredging, and vessel traffic; however, the incremental contribution of routine Program activities to cumulative impacts would be small (see Section 4.4.6.1.3).

The cumulative impacts of past, present, and future oil spills on coastal and estuarine habitats would be moderate. The incremental impacts of accidental oil spills associated with the proposed action on these resources would be small to large, depending on the location, timing, duration, and size of the spill; the proximity of the spill to particular habitats; and the timing and nature of spill containment and cleanup activities (see Section 4.4.6.1.3). The majority of these spills would be small (less than 50 bbl). Large oil releases that occur in or reach shallower nearshore areas have the greatest potential to affect coastal and estuarine habitats. Most spills would be unlikely to contact and affect coastal and estuarine habitats. Large oil spills and catastrophic discharge events, however, can affect extensive areas of shoreline.

4.6.3.3.2 Marine Benthic and Pelagic Habitats. Cumulative impacting factors for marine benthic and pelagic habitats in Beaufort and Chukchi Sea Planning Areas include both OCS and non-OCS activities. Potential impacts on marine benthic and pelagic habitat resulting from ongoing and future routine OCS program activities, including those of the proposed action, could result from noise (vessel, seismic surveys, construction, operations), well drilling, pipeline placement (trenching, landfalls, and construction), discharges (drilling, vessel and platform), and platform placement (anchoring, mooring, and removal). All these activities have the potential to adversely affect marine benthic and pelagic habitats in the Beaufort and Chukchi Sea Planning Areas. Accidental oil spills are also counted among OCS program-related activities; assumptions for oil spills under the cumulative case scenario are provided in Table 4.6.2-3, and catastrophic spill assumptions are provided in Table 4.4.2-2.

Potential environmental impacts associated with the building and operation of OCS facilities such as platforms, subsea wells, artificial islands, and pipelines would increase in conjunction with the increased number of wells (approximately 9 ha [22 ac] for artificial islands versus less than 1.5 ha [3.7 ac] for platforms) and complete burial of existing substrates during construction. Under the cumulative scenario, it is anticipated that up to 1,795 production wells, up to 32 oil platforms, and up to 2,900 km (1,820 mi) of new offshore pipeline would be constructed in the Beaufort and Chukchi Sea Planning Areas. Bottom substrates would be significantly altered by the construction of artificial islands. Marine benthic and pelagic habitats would be affected by bottom disturbance, by temporary increases in turbidity, and by deposition of disturbed sediment. Construction of artificial islands would result in a more complete loss of benthic habitat, due to larger footprints. Bottom disturbance degrades water quality by increasing water turbidity in the vicinity of the operations and adding contaminants to the water column. It also changes sediment composition as suspended sediments (and contaminants, if present) are entrained in currents and deposited in new locations. Construction of platforms and artificial islands in areas previously lacking hard substrate could have localized effects on the biodiversity and distribution of benthic communities by favoring organisms that prefer a hard substrate. Impacts of OCS routine operations (exploration, production and decommissioning activities) on marine benthic and pelagic habitat in the Beaufort and Chukchi Sea Planning Areas are discussed in detail in Sections 4.4.6.2.3 and 4.4.6.3.3. Regulations and mitigating measures should preclude construction of platforms or artificial islands and placements of pipelines or wells in environmentally sensitive areas, such as the Stefansson Sound Boulder Patch in the Beaufort Sea (Section 4.4.6.2.3). Overall, routine operations represent a negligible to moderate long-term disturbance, with the severity of the impacts generally decreasing dramatically with distance from the well site.

The increased amount of drilling anticipated under the proposed action will result in OCS discharges of drill muds and cuttings from exploration and delineation wells. Deposition of drilling fluids and cuttings could potentially affect benthic and pelagic habitat by increasing turbidity and altering grain size distributions and chemical characteristics of sediments. The impacts of drilling discharges on benthic and pelagic habitats are discussed in detail in Sections 4.4.6.2.3 and 4.4.6.3.3.

Various non-OCS activities, including oil and gas activities in State waters, commercial shipping (including tanker vessels), dredging and disposal of dredging spoils in OCS waters, and anchoring could contribute to cumulative effects on pelagic and seafloor habitats in the Beaufort and Chukchi Sea Planning Areas. Drilling of wells and oil and gas activities in State waters could also require construction of artificial islands, platforms, and pipelines in waters of Alaska. Effects on seafloor and pelagic habitat and biota would be similar to those described above for OCS oil and gas programs (Sections 4.4.6.2.3 and 4.4.6.3.3). Dredging operations in conjunction with ship channel maintenance and construction, pipeline placement and burial, and support facility access occur throughout the Beaufort and Chukchi Sea Planning Areas as part of non-OCS activities. Dredging and marine disposal activities would involve excavation of nearshore sediments and subsequent disposal in offshore or nearshore areas and could cause temporary turbidity in the water column and smothering of sessile animals in the vicinity of the activity. Anchoring of non-OCS activity vessels on these features could cause significant chronic disturbance to benthic and bottom water habitat and biota. The amount of damage that could result from anchoring activity would depend upon vessel size, the size of the anchor and chain, sea conditions at the time of anchoring, and the location or position of the anchor on the feature. The effects of dredging, anchoring, and trawling activities on marine benthic and pelagic habitats are expected to be similar to those described for the installation of pipelines (Sections 4.4.6.2.2 and 4.4.6.3.2). Impacts on pelagic habitat would be localized and temporary, with recovery time depending upon the nature of the habitat and severity of the damage.

Climate change is expected to have multiple effects on the Beaufort and Chukchi Sea Planning Areas that could impact benthic and pelagic habitat. Increased river discharge could alter the salinity, temperature, and turbidity regimes in nearshore areas (Hopcroft et al. 2008). Several rivers flow into the Beaufort shelf, and this region may be more heavily affected than the western Chukchi shelf. The increase in total suspended solids due to coastal erosion and the greater riverine sediment loading could increase turbidity in the water column and consequently decrease the penetration of photosynthetically active radiation available for kelp production (Hopcroft et al. 2008).

Climate change is expected to decrease the spatial extent and temporal duration of sea ice and make the ice thinner. Several possible consequences could result, including:

- Reduction in the spatial and temporal extent of subtidal and intertidal benthic scouring, but an increase in wave generated subtidal and intertidal disturbance;

- An increase in the sloughing of sediments from shoreline during storms, adding to the sediment loads and changing water chemistry in nearshore areas;

- An overall increase in biological productivity in the open water with increasing temperature and ice retreat and a shift to a pelagic-based rather than a benthic-based food web (Hopcroft et al. 2008); and

- Reduction in the amount and seasonal availability of sea ice algae.

In addition, ocean acidification from increasing CO_2 inputs into the ocean is also predicted to continue in arctic waters, which may reduce the availability of calcite and aragonite to calcifying marine organisms in the sediment and water column.

Oil spills from both OCS and non-OCS activities could affect benthic and pelagic habitat in the Beaufort and Chukchi Sea Planning Areas. The total number of oil spills and the extent of affected seafloor habitat would likely increase under the cumulative scenario, in conjunction with increased levels of petroleum exploration and production. Accidental hydrocarbon releases can occur at the surface from tankers or platforms or at the seafloor from the wellhead or pipelines. The total number of oil spills and the extent of affected seafloor habitat would likely increase under the cumulative scenario, in conjunction with increased levels of petroleum exploration and production. Non-OCS activities, such as oil and gas development in State waters and domestic transportation of oil, may also result in accidental spills that could affect benthic and pelagic habitats within the Beaufort and Chukchi Sea Planning Areas.

For both OCS and non-OCS oil spills, it is assumed the magnitude and severity of potential impacts on benthic and pelagic habitat would be a function of the location (including habitats affected), timing, duration, and size of the spill and containment and cleanup activities. It is anticipated that most small to medium spills would have limited effects because of the relatively small areas likely to be exposed to high concentrations of hydrocarbons and the short period of time during which potentially toxic concentrations would be present. Oil spills would likely have the greatest impacts on benthic habitat and communities in shallow subtidal waters and in intertidal areas. Although pelagic habitat is likely to recover quickly following an oil spill, the recovery time for intertidal and shallow subtidal benthic habitat directly impacted by oil spills could be long term. If a large amount of oil from a spill were to sink and inundate sensitive boulder communities, the recovery of sensitive species could be long term (Section 4.4.6.2.3). Detailed discussion of the impacts of accidental hydrocarbon releases on marine benthic and pelagic habitat potentially resulting from the Program in the Beaufort and Chukchi Sea Planning Areas can be found in Sections 4.4.6.2.3 and 4.4.6.3.3.

Conclusion. Impacting factors for marine benthic and pelagic habitats include both OCS and non-OCS activities. Non-OCS activities with a potential to impact marine benthic and pelagic habitats in the Beaufort and Chukchi Sea Planning Areas include oil and gas production in State waters, sediment dredging and disposal, and vessel traffic. Disturbances from these activities including noise, vessel discharges, and bottom disturbance would occur in addition to similar impacts from OCS activities. For OCS activities, planning and permitting procedures should minimize the potential for direct impacts on sensitive boulder habitats during routine OCS activities. Cumulative impacts to marine benthic and pelagic habitats as a result of OCS and non-OCS program activities would be minor, either because of the limited time frame over which most individual activities would occur or the small proportion of available habitats that would be affected during a given period. The incremental contribution of routine Program activities to these impacts would be small (see Section 4.4.6.2.3).

Oil spills could result from both OCS and non-OCS activities. The cumulative impacts of past, present, and future oil spills on seafloor habitats would be moderate. The incremental impacts of accidental oil spills associated with the proposed action on these resources would be small to large, depending on the location, timing, duration, and size of spills; the proximity of spills to particular seafloor habitats; and the timing and nature of spill containment and cleanup activities (see Section 4.4.6.2.3). Spills in deeper water, whether from OCS or non-OCS sources, are unlikely to have overall community-level effects on seafloor habitats because of the relatively small proportion of seafloor area that would come in contact with released oil at concentrations great enough to elicit toxic effects. Catastrophic oil releases that affect shallow and intertidal habitats have the potential to be of greatest significance. Although pelagic habitat is likely to recover quickly following an oil spill, the recovery time for intertidal and shallow subtidal benthic habitat directly impacted by oil spills could be long-term.

4.6.3.3.3 Essential Fish Habitat. This section identifies activities that could affect EFH resources in the Beaufort and Chukchi Sea Planning Areas, including non-OCS activities and current and planned OCS activities that would occur during the life of the Program, and the potential incremental effects of implementing the proposed action. Cumulative effects on EFH could occur from a variety of OCS and non-OCS activities that have a potential to directly kill managed fish species, disturb ocean bottom habitats, increase sediment suspension, degrade water quality, or affect the food supply for fishery resources.

Cumulative impacting factors for EFH include both OCS and non-OCS activities. Impacts on marine benthic and pelagic habitat resulting from ongoing and future routine OCS program activities, including those of the proposed action, could result from noise, well drilling, pipeline placement (trenching, landfalls, and construction), subsea production well and platform placement (anchoring, mooring, and removal), and routine discharges (drilling, platform, and vessel). Accidental oil spills are also counted among OCS program-related activities.

Under the cumulative scenario it is anticipated that up to 1,795 production wells, up to 32 oil platforms, and up to 2,900 km (1,820 mi) of new offshore pipeline would be constructed in the Beaufort and Chukchi Sea Planning Areas over the period of the Program. Drilling muds and cuttings from exploration wells would also be released in to OCS waters.

Overall, it is expected that the impacts of exploration and site development activities on marine EFH would be moderate, and impacts are not expected to permanently reduce the EFH available to managed species or result in population-level impacts on managed species. The most sensitive benthic habitats, such as those associated with hard-bottoms and kelp communities, should not be affected by routine operations since impacts would be minimized or eliminated by existing protections. Although construction of platforms, artificial islands, and pipelines would all disturb bottom habitats to some degree, artificial islands (Beaufort and Chukchi Seas only) would result in a more complete loss of benthic habitat due to larger footprints (approximately 9 ha [22 ac] for artificial islands versus less than 1.5 ha [3.7 ac] for platforms) and complete burial of existing substrate. Deposition of drilling muds and cuttings could potentially affect EFH by altering sediment characteristics such that benthic prey of some managed fish species, certain stages of the managed species themselves, or water quality in offshore areas would be affected in the immediate area surrounding drill sites. See Section 4.4.6.4.3 for a detailed discussion of the impacts of routine operations on EFH and managed species in the Arctic.

Various non-OCS activities, such as subsistence fishing, commercial shipping (including tankers), coastal modifications, hardrock mining, dredging and disposal of dredging spoils in OCS waters, and anchoring could contribute to cumulative effects on pelagic and seafloor EFH in the Beaufort and Chukchi Sea Planning Areas. Commercial fishing does not occur in the Beaufort and Chukchi Sea Planning Areas and sportfishing is minor in the Arctic but could increase if regulations change and if warming temperatures allow an increase in vessel traffic. Impacts from these non-OCS activities including noise, vessel discharges, and bottom disturbance would occur in addition to similar impacts from OCS activities. Many of these activities would result in bottom disturbance that would affect bottom dwelling fishes as well as their food sources in a manner similar to those described for OCS activities (MMS 2008; ADEC 2007a; Section 4.4.7.3.3).

EFH and managed species in the Beaufort and Chukchi Sea fall in the Kotzebue Sound and Northern Subsistence fishing areas (http://www.adfg.alaska.gov/index.cfm?adfg= subsistence.main). Subsistence fishing may contribute to the cumulative effects on the abundance of some fishery resources. Alaska State law defines subsistence as the "noncommercial customary and traditional uses" of fish and wildlife. The Alaska Department of Fish and Game defines subsistence fishing to include "the taking of, fishing for, or possession of fish, shellfish, or other fisheries resources by a resident of the State for subsistence uses with gill net, seine, fish wheel, long line, or other means defined by the Board of Fisheries." These fishing methods have more limited impacts on EFH compared to commercial fishing methods. In addition, subsistence fishing is subject to harvest limits that reduce the potential for overfishing. Consequently, subsistence fishing makes a relatively minor contribution to the reduction in fish stocks.

Cumulative impacts on anadromous or diadromous managed species could also occur as a result of activities that obstruct fish movement in marine environments during migration periods. For example, some structures along the Beaufort Sea mainland (e.g., the West Dock) have been shown to block the movements of diadromous fishes, particularly juveniles, under certain meteorological conditions (Fechhelm 1999; Fechelm et al. 1999). Causeways such as the 40 m (131 ft) wide and 60 m (197 ft) long structure associated with the Red Dog Mine may impede coastal movement either by directly blocking fish or by modifying nearshore water conditions to the point where they might become too cold and saline for some species (Fechhelm et al. 1999). Although the presence of causeways has been an issue associated with oil development activities in the Beaufort Sea, the small size of the Red Dog causeway would likely have little effect on the coastal movements and distributions of Chukchi Sea fishes and shellfishes. However, it is anticipated that proper placement and design considerations for future causeway construction along the North Slope would alleviate the potential for such effects on fish movement.

There are several contaminant sources in the Beaufort and Chukchi Sea Planning Areas. The Red Dog Mine in Alaska is the largest lead and zinc mine in the world, and is presently the only base-metal lode mine operating in northwest Alaska. A study for the National Park Service (Hasselbach et al. 2004) showed extensive airborne transport of cadmium and lead from Red Dog Mine; although the study was focused only on the limits of the Cape Krusenstern National Monument, these contaminants are probably carried out into the Chukchi Sea. There are also natural sources of metals and hydrocarbons. Sediments, peats, and soils from the Sagavanirktok, Kuparuk, and Colville Rivers are the largest source of dissolved and particulate metals and saturated and polycyclic aromatic hydrocarbons in the development area. However, background concentrations in fish sampled in the Arctic Planning Areas are typically at background levels (Neff & Associates 2010).

There are also State oil and gas activities that can affect EFH in the Beaufort and Chukchi Seas. Factors that could affect EFH from these activities would be similar to those described above for OCS activities including underwater noise, habitat loss and disturbance, seismic survey and exploratory drilling, as well as other ancillary activities. However, the effects from non-OCS oil and gas activities could possibly be more severe than the effects from routine OCS activities because the activities are closer to shore and in shallower environments. As a consequence, more benthic EFH may be damaged, and resulting changes in sedimentation and turbidity could affect a greater proportion of the water column.

Freshwater areas used by salmon and other anadromous fish are considered to be EFH and could be affected by nearshore OCS and non-OCS oil and gas activities such as pipeline dredging or by onshore pipelines that cross bodies of water, especially streams. The primary effects of pipeline crossings would be increasing turbidity and sedimentation of the benthic environment during construction and blocking migration of anadromous fish following construction. Any pipeline route would be required to comply with various Alaska Coastal Management Program policies. As a consequence, crossings of anadromous fish streams would be minimized and consolidated with other utility and road crossings of such streams. In addition, onshore pipelines would be designed, constructed, and maintained to reduce risks to fish habitats from a spill, pipeline break, or construction activities.

See individual sections on water quality, coastal habitats, and marine and pelagic habitats for a discussion of the effects of climate change on EFH in the Beaufort and Chukchi Sea Planning Areas. As a heavily river-influenced system, increased river discharge could alter the salinity, temperature, and turbidity regimes in nearshore areas (Hopcroft et al. 2008). Climate change is also expected to decrease the spatial extent and temporal duration of sea ice as well as make the ice thinner, an overall increase in biological productivity in the open water, and a shift to a pelagic-based rather than a benthic-based food web (Hopcroft et al. 2008). In addition, ocean acidification may reduce the availability of calcite and aragonite to marine organisms.

The total number of oil spills and the extent of affected EFH areas would likely increase under the proposed action in conjunction with increased levels of petroleum exploration and production. See Table 4.6.2-3 for oil spill assumptions for Alaska. Non-OCS activities, such as oil and gas development in State waters, domestic transportation of oil, and commercial shipping, may also result in accidental spills that could potentially impact fish resources within the Arctic. While effects on EFH resources would depend on the timing, location, and magnitude of specific oil spills, it is anticipated that most small to medium spills that occur in OCS waters would have limited effects on EFH, due to the relatively small areas likely to be exposed to high concentrations of hydrocarbons and the short period of time during which potentially toxic concentrations would be present. Large or catastrophic spills could result in long-term impacts to EFH habitat quality and managed species populations. See Section 4.4.6.4 for a detailed discussion of the impact of oil spills on EFH.

Arctic fishes could also be susceptible to adverse effects of oil spills (see Section 4.4.6.4.2). Most offshore spills would be small and likely have little effect on overall populations, since the areas with significant hydrocarbon concentrations would be localized relative to the broad distributions of most marine and anadromous fishes of the Beaufort and Chukchi Seas. However, population level effect could occur if large amounts of oil from a catastrophic spill were to reach shallow subtidal and intertidal sediments. Some anadromous species of the Alaskan North Slope could be at greater risk because of their unique life-history cycles. Juveniles of some species of whitefish (including broad whitefish, humpback whitefish, and least cisco) are intolerant of highly saline marine conditions. During their summer feeding dispersals in the Beaufort Sea, these species tend to remain within a narrow band of warm, low-salinity water along the coast. Offshore barrier islands offer additional protection by helping to maintain low-salinity corridors. Thus, unlike most subarctic fishes, whitefish along the North Slope have a reduced capacity to bypass localized disruptions to their migration corridor by moving offshore and around the impasse. An oil spill, even one of limited area, could block the narrow nearshore corridor and prevent fishes from either dispersing along the coast to feed or returning to their overwintering grounds in rivers of the North Slope. If a spill were localized in the sensitive nearshore zone, its location would also make it more amenable to cleanup by environmental response teams. There is no tanker traffic on the North Slope, which eliminates the possibility of a collision spill in that area.

Oil from spills occurring under the ice in the Beaufort and Chukchi Seas could remain trapped there throughout the winter unless removed, which, while difficult, could be done. Water quality would be negatively impacted, and overwintering eggs, larvae, and invertebrate prey would likely be killed in affected areas. Surface spills occurring in the summer months would temporarily reduce EFH for surface-dwelling eggs, larvae, and pelagic prey species. Oil reaching nearshore areas could travel short distances upriver in anadromous fish streams as a result of tidal water movements, and some oil could become trapped in the interstitial spaces of the sediments. In such cases, EFH for salmon eggs and larvae could be affected. See Section 4.4.3.3 for a detailed discussion of accidental oil spills in ice and ice-free conditions.

Conclusion. Impacting factors for EFH include both OCS and non-OCS activities. Non-OCS activities with a potential to impact EFH in the Beaufort and Chukchi Sea Planning Areas include oil and gas production in State waters, sediment dredging and disposal, and vessel traffic. Impacts from OCS activities would be limited by specific lease stipulations. Cumulative impacts to EFH as a result of OCS and non-OCS program activities would be minor to moderate, proportional to the EFH area affected. The incremental contribution of routine Program activities to these impacts would be small (see Section 4.4.6.3.3).

Accidental releases of oil and gas from OCS and non-OCS facilities could also have effects on EFH. The cumulative impacts of past, present, and future oil spills on EFH would be minor to moderate. The incremental impacts of accidental spills associated with the proposed action on EFH would be small to large, depending on the location, timing, duration, and size of spills; the proximity of spills to particular fish habitats; and the timing and nature of spill containment and cleanup activities (see Section 4.4.6.3.3). While most accidents related to OCS activities assumed under the cumulative spill scenario would be small and would have relatively small incremental impacts on EFH, oil that reaches coastal wetlands could have more persistent impacts and could require remediation. Spills in deeper water, whether from OCS or non-OCS sources, are unlikely to have overall population-level effects on fish resources because of the relatively small proportion of similar available fish habitats that would come in contact with released oil at concentrations great enough to elicit toxic effects. Oil spills that have the greatest potential to impact EFH and managed species are those that occur in shallower subtidal and intertidal areas and spills that reach areas at the same time substantial numbers of eggs or larvae of managed species are present.

4.6.4 Marine and Coastal Fauna

Previous BOEM/MMS NEPA documents for OCS lease sales have addressed cumulative impacts on marine and coastal fauna. Unless referenced otherwise, the following cumulative impacts discussion includes information provided in those NEPA documents prepared for the GOM (see http://www.gomr.boemre.gov/homepg/regulate/environ/nepa/nepaprocess.html) and for Alaska (see http://alaska.boemre.gov/ref/eis_ea.htm).

4.6.4.1 Gulf of Mexico Region

4.6.4.1.1 Mammals.

Marine Mammals. The cumulative analysis considers past, ongoing, and foreseeable future human and natural activities that may occur and adversely affect marine mammals in the same general area. These activities include effects of the OCS Program (proposed action and prior and future OCS sales), oil and gas activities in State waters, commercial shipping, commercial fishing, recreational fishing and boating activities, military operations, scientific research, and natural phenomena. Specific types of impact-producing factors considered include noise from numerous sources, pollution, ingestion and entanglement in marine debris, vessel strikes, habitat degradation, military activities, industrial development, community development, climate change, and natural catastrophes. Section 4.4.7.1.1 provides the major impact-producing factors related for the proposed action.

Routine Activities.

OCS Activities. Marine mammals and their habitats in the GOM could be affected by a variety of exploration, development, and production activities as a result of the proposed and future OCS leasing actions (see Section 4.4.7.1.1). These activities include seismic exploration, offshore and onshore infrastructure construction, discharge of operational wastes, vessel and aircraft traffic, and explosive removal of platforms. Impacts on marine mammals from these activities may include physical injury or death; behavioral disturbances; lethal or sublethal toxic effects; and loss of reproductive, nursery, feeding, and resting habitats.

Potential impacts (primarily behavioral disturbance) on marine mammals from OCS-related seismic activity would be short term and temporary, and not expected to result in population level impacts for any affected species with implementation of appropriate mitigation measures.

Impacts from OCS construction and operation activities could include the temporary disturbance and displacement of individuals or groups by construction equipment and long-term disturbance of some individuals from operational noise. No long-term, population-level effects are expected because individuals most affected by these impacts would be those in the immediate vicinity of the construction site or operational platform and disturbance of individuals during construction would be largely temporary.

Operational and waste discharges (e.g., produced water, drilling muds, and drill cuttings) would be disposed of through downhole injection into NPDES-permitted disposal wells, and would not be expected to result in any incremental impacts on marine mammals. Liquid wastes (such as bilge water) may also be generated by OCS support vessels and on production platforms. While these wastes may be discharged (if permitted) into surface waters, they would be rapidly diluted and dispersed, and are expected to result in minor incremental impacts on marine mammals. Drilling and production wastes may contain materials such as metals and hydrocarbons, which can bioaccumulate through the food chain into the tissues of marine mammals. Although the bioaccumulation of anthropogenic chemicals has been reported for a variety of marine mammals, adverse impacts or population-level effects resulting from such bioaccumulation have not been demonstrated (Norstrom and Muir 1994; Muir et al. 1999).

Marine mammals could be temporarily disturbed by OCS vessel traffic (all species) or incur injury or death from collisions with support vessels (primarily larger, slower moving cetaceans). The addition of up to 600 OCS vessel trips per week under the proposed actions could result in minor to moderate incremental impacts to marine mammals, be largely short term, and not result in population-level effects. Noise from helicopter overflights would be transient. Impacts on marine mammals would be behavioral in nature, primarily resulting in short-term disturbance in normal activities, and would not be expected to result in population-level effects. Appropriate mitigation measures could lessen the potential for incremental impacts from vessel and helicopter traffic.

There have been no documented losses of marine mammals resulting from explosive removals of offshore oil and gas structures, but there are sporadic incidents reported of marine mammals being killed by underwater detonations (Continental Shelf Associates 2004; MMS 2007, 2008). Harassment of marine mammals as a result of a non-injurious physiological response to the explosion-generated shock wave as well as to the acoustic signature of the detonation is also possible. However, explosive platform removals would comply with BOEM guidelines and would not be expected to adversely affect marine mammals in the GOM.

All of the marine mammals in the GOM are potentially exposed to OCS-industrial activities (particularly noise) due to the rapid advance into the GOM deep oceanic waters by the oil and gas industry in recent years; whereas, over two decades ago, the confinement of industry to shallower coastal and continental shelf waters generally only exposed the bottlenose dolphin, Atlantic spotted dolphin, and West Indian manatee to industry activities and their related sounds. Industry noise sources include seismic operations, fixed platforms and drilling rigs, drilling ships, helicopters, vessel traffic, and explosive operations (particularly for structure removal).

<u>Non-OCS Activities.</u> A number of non-OCS activities such as State oil and gas exploration and development, commercial and recreational fishing, vessel traffic, industrial and municipal discharges, climate change, and invasive species could also affect marine mammals in the GOM.

Oil and Gas Exploration and Development in State Waters. Exploration, construction, and operation activities associated with State leases would occur in nearshore and coastal areas, while OCS platforms and pipelines would be located away from coastal areas (with the exception of relatively few pipeline landfalls and onshore bases and processing facilities). Thus, State oil and gas leasing activities may be expected to have a greater potential for affecting marine mammals in coastal habitats than would the proposed OCS actions. The marine mammal species most likely affected by State leases are the bottlenose dolphin, Atlantic spotted dolphin, and the West Indian manatee.

Commercial Fisheries. Commercial fisheries are an impacting factor for marine mammals in the GOM. These fisheries employ a variety of methods, such as longlines, seines, trawls, and traps, which can result in the entanglement, injury, and death of mammal mammals. For more than a decade, few human-induced mortalities or serious injuries of marine mammals due to commercial fishery interactions have occurred in the GOM. The following interactions with commercial fisheries were reported by Waring et al. (2010):

- In 2008, one mortality and two serious injuries of Risso's dolphins in the GOM related to entanglement interactions with the pelagic longline fishery.

- In 2008, there was one killer whale released alive after an entanglement incident with the pelagic longline fishery.

- In 1999, there was one reported stranding of a false killer whale that was likely caused by fishery interactions or other human-related causes evidenced by its fins and flukes having been amputated.

- From 1998 through 2007, there were no reported fishing-related mortalities of short-finned pilot whales in the GOM. However, one animal was released alive after an entanglement interaction with the pelagic longline fishery.

- From 1998 through 2007, there were no reported fishing-related mortalities of beaked whales in the GOM. However, during 2007, one unidentified beaked whale was released alive after an entanglement interaction with the pelagic longline fishery.

- From 1998 through 2008, there were no reported fishing-related mortalities of sperm whales in the GOM. However, one animal was released alive with no serious injuries after an entanglement interaction with the pelagic longline fishery.

- Some bottlenose dolphins have suffered mortalities associated with the shark bottom longline fishery, pelagic longline fishery, shrimp trawl fishery, blue and stone crab trap/pot fisheries, menhaden purse seine fishery, and gillnet fishery. Strandings of bottlenose dolphins have also occurred throughout the northern GOM from both human-caused and natural events. Human-caused strandings result from gear entanglement, mutilation, gunshot wounds, vessel strikes, contaminants, and ingestion of foreign objects.

- Fishery interactions likely caused the stranding of two Atlantic spotted dolphins in 2004.

- A stranded spinner dolphin had monofilament line around its tail and abrasions around its flukes as though it had been towed. It also had possible propeller marks.

Vessel Traffic. There are a number of non-OCS activities that are occurring in the GOM that could result in collisions between marine mammals and ships. These activities include dredging and marine disposal, the domestic transportation of oil and gas, State oil and gas development, foreign crude oil imports, commercial shipping and recreational boating, commercial fisheries, and military training and testing activities. Vessel traffic associated with these activities may also disturb normal behaviors with unknown long-term consequences. With all of these activities, the GOM is one of the world's most concentrated shipping areas (USACE 2003a, b). The GOM also supports an extensive commercial fishery, as well as recreational boating. Because of the very large number of vessels typically present in the GOM, the potential for vessel-marine mammal collisions is high, and may be expected to increase for the foreseeable future. The amount of OCS-related vessel traffic anticipated as a result of the Program is provided in Table 4.4.1-1.

Contaminants. There are a number of non-OCS facilities or activities that discharge wastes to GOM waters, and thus may expose marine mammals to potentially toxic materials or solid debris that could become entangled or ingested. These facilities or activities include sewage treatment plants, industrial manufacturing or processing facilities, electric generating plants, cargo and tanker shipping, cruise ships, commercial fishing, and recreational pleasure craft. In addition, the Mississippi River (and to a lesser extent, other rivers and streams that discharge to the northern GOM) discharges waters containing suspended sediments, fertilizers, herbicides, and urban runoff (Rabalais et al. 2001, 2002). While marine mammals are exposed to a variety of contaminants from these discharges, little is known about the levels of contaminants at which lethal or sublethal effects may be incurred. These discharges may also affect habitat quality in the vicinity of the discharges.

The role of exposure to toxins to marine mammal mortality is unknown. Elevated levels of chemicals such as polychlorinated biphenyls (PCBs) and pesticides have been measured in individuals sampled from waters that receive municipal, industrial, and agricultural inputs and have high concentrations of contaminants (such as in the immediate vicinity of Tampa Bay) (NOAA 2004b). There is little information, however, regarding the level at which tissue concentrations of contaminants may result in lethal or sublethal effects.

Climate Change. Marine mammal populations throughout the GOM may be adversely affected by climate change and, to a lesser extent, by hurricane events. There is growing evidence that climate change is occurring, and potential effects in the GOM may include a change (i.e., rise) in sea level or a change in water temperatures. Such changes could affect the distribution, availability, and quality of feeding habitats and the abundance of food resources. It is not possible at this time to identify the likelihood, direction, or magnitude of any changes in the environment of the GOM due to changes in the climate, so it is too speculative to further discuss climate change impacts on marine mammals.

Natural Catastrophes. Severe storm events such as hurricanes may result in direct or indirect mortality of manatees and have the potential to impact their nearshore habitats (Langtimm and Beck 2003). Heightened wave action and intensity could alter nearshore channels affecting the abundance and distribution of shallow-water habitats such as lagoons and bays, while sediments deposited into foraging habitats by storm waves may alter the thermal environment and affect aquatic vegetation in feeding habitats. Because hurricanes are annual events that are an inherent component of the overall GOM ecosystem, it may be assumed that marine mammals of the GOM have experienced hurricane impacts in the past and may be expected to continue to experience future hurricane events.

Other Impacting Factors. Marine mammals may also be impacted by other factors such as unusual mortality events (UMEs) and invasive species. A UME is an unexpected stranding that involves a significant die-off of any marine mammal population, and demands immediate response (NMFS 2011b). Since establishment of the UM program in 1991, there have been 53 formally recognized UMEs in the U.S., with 33% of them occurring in the GOM (NMFS 2011b). Species in the GOM most commonly involved in UMEs are bottlenose dolphins and manatees. Causes of UMEs have been determined for 25 of the UMEs, and include infections, biotoxins (particularly domoic acid and brevetoxin), human interactions, and malnutrition. Red tides in the GOM, caused by annual blooms of the dinoflagellate Karenia brevis, are the source of UMEs caused by biotoxins in the GOM (NMFS 2011b). Invasive species could affect some marine mammals by disrupting local ecosystems and fisheries of the GOM. As examples, the Australian jellyfish (*Phylloriza punctata*) introduced to the northern GOM may feed heavily on juvenile fish and fish eggs (Ray 2005), while exotic shrimp viruses may affect shrimp and other crustaceans such as copepods and crabs (Batelle 2001). These could affect the prey base for some marine mammals.

Accidents. Marine mammals could be exposed to oil accidentally released from platforms, pipelines, and vessels (Table 4.4.2-1). Potential non-OCS sources of oil spills in the planning area include the domestic transportation of oil, State oil and gas development, and natural sources such as oil seeps. Accidental oil releases from OCS activities and other sources could expose marine mammals to oil by direct contact or through the inhalation or ingestion of oil or tar deposits. The magnitude and duration of exposure will be a function of the location, timing, duration, and size of the spill; the proximity of the spill to feeding and other important habitats; the timing and nature of spill containment; and the status of the affected animals. Depending on their location, as well as the location of non-OCS oil sources, accidental spills associated with the proposed action could contribute to the overall exposure of marine mammals in the northern GOM. Most of the small to medium spills would have limited effects on marine mammals due to the relatively small areas likely to incur high concentrations of hydrocarbons and the short period of time during which potentially toxic concentrations would be present. The magnitude of impact would be expected to increase should a spill occur in habitats important to marine mammals or affect a number of individuals from a population listed under the ESA. However, some spills from OCS activity may locally represent the principal source of oil exposure for some species, especially for spills contacting important coastal and island habitats.

Conclusion. Cumulative impacts on marine mammals in the GOM as a result of ongoing and future OCS and non-OCS activities and natural phenomena could be minor to moderate over the next 40 to 50 yr. Non-OCS activities or phenomena include climate change, natural catastrophes, contaminant releases, vessel traffic, commercial fishing, and invasive species. The incremental contribution of routine Program activities to these impacts would be small (see Section 4.4.7.1.1).

Marine mammals may also be adversely affected by exposure to oil that is accidentally released from OCS and non-OCS activities as well as naturally occurring seeps. The cumulative impacts of past, present, and future oil spills on marine mammals would be minor to moderate. The incremental impacts of accidental spills associated with the proposed action on marine mammals would be small to large, depending on the location, timing, duration, and size of the spill; the proximity of the spill to feeding and other important habitats; the timing and nature of spill containment; and the status of the affected animals (see Section 4.4.7.1.1).

Terrestrial Mammals. Under the proposed action, terrestrial mammals in the GOM are not expected to be affected by normal OCS-related activities (Section 4.4.7.1.1). The terrestrial mammals considered in the impact analysis for the proposed action are four federally endangered GOM coast beach mouse subspecies and the federally endangered Florida salt marsh vole. Because of the listing of these species under the ESA, as well as their occurrence in protected areas, the siting and construction of any onshore facilities associated with the proposed action would be required to take into account these species and their habitats, and construction activities would not be allowed in the habitats of these species.

Present beach mice habitat is no longer of optimal quality because of historical beach erosion, construction, and tropical storm damage. Dredge-and-fill activities occur throughout the nearshore areas of the U.S. and disrupt beach and transport, which could affect coastal systems of dunes where beach mice live. Coastal construction and traffic can be expected to threaten beach mice populations on a continual basis. Natural catastrophes including storms, floods, droughts, and hurricanes can substantially reduce or eliminate beach mice. Storms can wash large amounts of debris into dune and marsh habitats. Trash and debris may be mistakenly consumed by beach mice or may entangle them. Cleanup efforts to remove debris could result in adverse habitat impacts. Other activities that threaten beach mice and the Florida salt marsh vole include predation and competition, artificial lighting, and coastal spills. Predation from feral and free-ranging cats and dogs, feral hogs, coyotes, and red foxes, and competition with common house mice could reduce beach mice and Florida salt marsh vole populations. Isolation of small populations of beach mice due to habitat fragmentation can preclude gene flow between populations and cause a loss of genetic diversity. Separation of frontal dune habitat from scrub habitat by a highway can make a beach mouse especially vulnerable to hurricane impacts. Global climate change and sea level rise could also impact the species (Bird et al. 2009; Hatley 2003; USFWS 2007, 2008, 2009, 2010; Wooten 2008).

Activities in the GOM that could result in the accidental release of oil and may affect terrestrial mammals and their habitats include oil production from prior, proposed, and future OCS sales; domestic transportation of oil; State oil development; foreign crude oil imports; and military training activities involving open-water ship refueling. If spills from these activities occur in the vicinity of, or are transported by GOM currents to, the habitats of the beach mice or the Florida salt marsh vole, potential impacts would be similar in nature to those identified for the proposed action. Impacts associated with an oil spill may include loss of thermoregulatory ability from oiling of fur, lethal and sublethal toxic effects from inhalation or ingestion of oil or oil-contaminated foods, a decrease in food supply due to oiled vegetation, a decrease in habitat quantity and quality due to oiling of beach sands, and the fouling of burrows and nests. In addition, spill response activities could further impact habitats due to beach cleanup activities and vehicle and pedestrian traffic.

Given the relatively small number of spills that are expected under the proposed action and during the life of the Program (Table 4.4.2-1), the requirement under the Oil Pollution Act of 1990 to prevent contact of protected or sensitive habitats (such as the habitats of the beach mice and the salt marsh vole) with spilled oil, and the need of a spill to be associated with environmental conditions (such as a storm surge sufficient to transport the spilled oil over foredunes) that could favor exposure of the species and their habitats, relatively few cumulative impacts may be expected from accidental oil spills from all potential sources, and the contribution of spills associated with the proposed action is expected to be limited.

Conclusion. Cumulative impacts on terrestrial mammals in the GOM as a result of ongoing and future OCS and non-OCS program activities could be minor to moderate over the next 40 to 50 yr. Non-OCS activities or phenomena that may affect populations of terrestrial mammals include climate change, natural catastrophes, contaminant releases, vehicle traffic, and invasive and feral species. The incremental contribution of routine Program activities to these impacts would be small (see Section 4.4.7.1).

Terrestrial mammals may also be adversely affected by exposure to oil that is accidentally released from OCS and non-OCS operations. The cumulative impacts of past, present, and future oil spills on terrestrial mammals would be minor to moderate. The incremental impacts of accidental spills associated with the proposed action on terrestrial mammals would be small to large, depending on the location, timing, duration, and size of the spill; the proximity of the spill to feeding and other important habitats; the timing and nature of spill containment; and the status of the affected animals (see Section 4.4.7.1).

4.6.4.1.2 Marine and Coastal Birds. Section 4.4.7.2.1 discusses impacts on marine and coastal birds in the GOM resulting from the proposed action (OCS program activities from 2012 to 2017). Cumulative impacts on marine and coastal birds result from the incremental impacts of the proposed action when added to impacts from existing and reasonably foreseeable future OCS program activities (that are not part of the proposed action) and other non-OCS program activities. Table 4.6.1-1 presents the exploration and development scenario for the GOM cumulative case (encompassing the proposed action and other OCS program activities) over the next 40 to 50 yr. A number of OCS program activities could affect GOM marine or terrestrial birds or their habitats; these include offshore structure placement and pipeline trenching, offshore structure removal, operational discharges and wastes, service vessel and aircraft traffic, construction and operation of onshore infrastructure (including new pipeline landfalls), and noise. Potential impacts on marine and coastal birds from service program activities include injury or mortality of birds from collisions with platforms, vessels, and aircraft; exposure to operational discharges and ingestion of trash or debris; loss or degradation of habitat due to construction activities; and behavioral disturbance due to the presence of, and noise generated by, equipment and human activity.

Non-OCS program activities affecting marine and coastal birds include dredging and marine disposal; coastal and community development; onshore and offshore construction and operations of facilities associated with State oil and gas development and with the extraction of nonenergy minerals; commercial and recreational boating; and small aircraft traffic. Potential impacts on marine and coastal birds from these activities are similar to those under the OCS program and include injury or mortality of birds from collisions with platforms associated with State oil and gas development and other onshore and offshore structures (e.g., radio, television, cell phone towers or wind towers); non-energy mineral mines (e.g., sand and gravel and other hard minerals mined in the northern part of the GOM; onshore industrial, commercial, and residential development; exposure to discharges from permitted point sources such as sewage treatment discharges and nonpoint sources such as irrigation runoff, or accidental releases (e.g., oil spills), as described in Section 4.6.2.1.1 and Table 4.6.2-1; exposure to emissions from various onshore and offshore sources (e.g., power generating stations, refineries, and marine vessels), as described in Section 4.6.2.1.2; ingestion of trash or debris; loss or degradation of habitat due to construction and operations activities; and behavioral disturbance due to the presence of noise generated by equipment and human activity. Other trends such as sea level rise and increasing seawater temperature brought on by global climate change, as well as extreme wind conditions from storm events, are also expected to adversely affect marine and coastal birds over the next 40 to 50 yr.

Injury or Mortality from Collisions. Annual bird collision mortalities under the proposed action (estimated at about 10,000 to 22,500) represent less than 0.01% of the hundreds of millions of birds that annually migrate across the GOM (Russell 2005). Under the cumulative scenario, annual collision mortality (estimated at 200,000 birds under current OCS activities in the GOM) could increase by about 8%. During the life of the proposed action from 2012 to 2017, older platforms would be decommissioned and removed as new platforms are installed, so it is likely that the estimated 200,000 collision-related deaths per year would persist throughout the life of the program. The proposed action would likely result in a small incremental increase of the total annual bird collision mortality in the GOM that occurs from collisions with other OCS and non-OCS structures (Klem 1990; Kerlinger 2000).

Exposure to Wastewater Discharges and Air Emissions. The discharge of operational wastes and air emissions from current OCS- and non-OCS-related vessel traffic and platform operations is strongly regulated and would continue to be regulated over the next 40 to 50 yr. However, such wastes and emissions would still expose marine and coastal birds to potentially toxic materials or to solid debris that could be ingested or result in entanglement. In addition, the Mississippi River, and, to a lesser extent, other rivers and streams annually discharge waters containing suspended sediments, agricultural fertilizers and herbicides, and urban runoff to the northern GOM (Rabalais et al. 2001, 2002). Birds and their habitats in the vicinity of these discharges may be exposed to lethal and sublethal levels of contaminants. Operational wastewater discharges and air emissions associated with the proposed action would contribute to the overall cumulative risk of toxic exposure and debris ingestion or entanglement of existing OCS and non-OCS wastewater discharges and air emissions in the GOM, but the incremental increase in impact is expected to be small relative to these other activities.

Under the proposed action, marine and coastal birds could be exposed to oil accidentally released from platforms, pipelines, and marine vessels, and would be most susceptible to adverse impacts from spills occurring in coastal areas and affecting feeding and nesting areas. Accidental oil releases occur in the GOM from a variety of non-OCS related activities, such as the domestic transportation of oil, import of foreign crude oil, and State development of oil.

Crude oil may also enter the environment of the northern GOM from naturally occurring seeps (MacDonald et al. 1996; MacDonald 1998b; Mitchell et al. 1999; NRC 2003). Oil releases from all sources may expose marine and coastal birds via direct contact or through the inhalation or ingestion of oil or tar deposits (see Section 4.4.7.2.1).

The spills that could occur in the cumulative scenario are shown in Table 4.6.1-3. Spills from non-OCS sources could occur from import tankers, State oil and gas operations, and coastal transportation of crude and refined petroleum products. Releases from natural seeps in the northern part of the GOM have been estimated at about 73,000 tons (526,000 bbl) per year (Kvenvolden and Cooper 2003). Most spills associated with the proposed action would be relatively small (less than 50 bbl) (Table 4.4.2-1). Depending on their location, accidental spills associated with the proposed action could represent a major component of the overall exposure of marine and coastal birds in the GOM OCS Planning Areas.

The magnitude and duration of exposure, and any subsequent adverse effects, would be a function of the location, timing, duration, and size of the spill; the proximity of the spill to feeding habitats; and the timing and nature of spill containment. Spills in nearshore coastal areas have the greatest potential for impacting high concentrations of bird populations. Most activities associated with the Program would take place in deep or ultradeep waters. Some seabirds spend a significant amount of time offshore and could be exposed to accidental oil spills that occur in these deep waters, but even marine birds that remain in coastal waters could be exposed to accidental oil spills if they were to occur closer to shore.

Loss and Degradation of Habitat. Marine and coastal birds could be affected by platform construction and removal activities, and pipeline trenching, which could disrupt behaviors of nearby birds. Platforms constructed under the proposed action would increase the number of offshore platforms present in open-water areas of the northern GOM; and these structures may be used by birds to rest or avoid bad weather conditions during spring and fall migrations across the GOM (see Section 4.4.7.2). The proposed action would increase the number of platforms to be removed by only 9% of current OCS numbers, and up to 75% of the construction of new platforms would occur in deep water (i.e., 300 m [1,000 ft] or greater), well away from coastal areas. Under the proposed action, there would also be construction associated with no more than 12 new pipeline landfalls and offshore pipeline placement (Table 4.4.1-1). These platform and pipeline construction activities could add to the overall disturbance level of birds and their habitats from all construction sources in the GOM.

Platform construction and removal under the proposed action would be localized (primarily in deep water areas) and short in duration, and would result in only a small increase in the overall level of disturbance incurred by birds and their habitats from all construction activities in the GOM OCS Planning Areas. Pipeline trenching and landfall construction that would occur under the proposed action would similarly be of short duration and limited in extent (associated with no more than 12 new landfalls), and would be expected to contribute little to overall levels of bird disturbance that occur in coastal areas of the GOM on a much more regular basis from existing OCS and non-OCS construction activities, such as channel construction and maintenance, creation of harbor and docking areas and facilities, State oil and gas development (including platform construction and removal), non-energy minerals extraction, and pipeline emplacement.

Vessel traffic potentially disturbs, feeding and nesting birds with unknown long-term consequences. The GOM is one of the world's most concentrated commercial shipping areas (COE 2003a,b), and it supports extensive commercial fishing and recreational boating. As a result, OCS and non-OCS program-related vessel traffic disturbs birds on a daily basis. This trend is expected to increase as marine traffic in the GOM increases over the next 40 to 50 yr (see Table 4.6.2-1). OCS program-related marine vessel traffic in the GOM could be as high as 1,900 trips per week over the next 40 to 50 yr; vessel traffic associated with the proposed action represents about 27% of this traffic (Section 4.6.2.1). Non-OCS program traffic includes that related to crude oil and natural gas imports, commercial container vessels, military and USCG vessels, cruise ships, commercial fishing, and small watercraft. In 2010, the Port of New Orleans alone handled about 7,500 vessel calls (mainly tanker and dry bulk carrier), about 140 vessel calls per week (USDOT 2011b). Impacts on water quality from marine traffic arise from regular discharges of bilge water and waste, leaching of antifouling paints, and incidental spills (MMS 2001d), although operational discharges and spillage from marine vessels have declined substantially in the past few decades (NRC 2003b). Vessel traffic associated with the proposed action would result in a small increase in the overall disturbance of birds in the GOM region.

Disturbance Due to Noise. Noise generated during construction activities and normal operations (e.g., helicopter overflights) may disturb marine and coastal birds, causing a short-term change in normal behavior and potentially disrupting feeding and nesting activities. Non-OCS activities that currently generate noise in the GOM include construction and/or operation of offshore structures for State oil and gas development; offshore LNG facilities and tankers; hard mineral extraction; dredging and marine disposal; commercial and recreational vessel traffic; small aircraft flight; and military training and testing activities. These activities are expected to continue or increase in the foreseeable future. Although noise generated as a result of the proposed action would likely add only a small increment to the overall (cumulative) noise levels in the GOM, locally it could represent the dominant noise in the environment, resulting in more moderate impacts on marine and coastal birds.

Climate Change and Storm Events. Populations of marine and coastal birds throughout the GOM may be adversely affected by climate change and, to a lesser extent, by storm events (including hurricanes). As discussed in Section 3.3, there is growing evidence that climate change is occurring, and potential effects in the GOM may include sea level rise and increases in water temperatures in the GOM. Over time these changes will result in a loss of wetlands in the GOM, important water bird habitat. Climate change could also affect the distribution, availability, and quality of feeding habitats and the abundance of food resources. It is not possible at this time to identify the likelihood, direction, or magnitude of any changes in the environment of the GOM due to changes in climate, so it is too speculative to identify the extent of effects on GOM populations of marine and coastal birds. It should be noted that such information is not essential to a reasoned choice among OCS program alternatives, even in a cumulative analysis, because the information missing here is missing across the board for all action alternatives.

Severe storm events such as hurricanes may result in direct or indirect mortality of marine and coastal birds and may impact important coastal habitats. Heightened wave action and intensity could alter nearshore channels, affecting the abundance and distribution of shallow-water habitats such as lagoons and bays, while sediments deposited into foraging habitats by storm waves may alter the thermal environment and affect aquatic vegetation in feeding habitats. Extreme wind conditions could damage or destroy historic rookery sites or disrupt nesting birds. Because storms (including hurricanes) are annual events that are an inherent component of the overall GOM ecosystem, it could be assumed that marine and coastal birds have experienced and largely tolerated extreme weather conditions in the past and may be expected to continue to do so in the foreseeable future. The occurrences and aftermaths of Hurricanes Katrina and Rita in 2004, however, have impacted avian habitats on a large scale throughout the GOM. Large areas of coastal wetlands have been converted to open-water habitat, potentially affecting avian species that utilized the wetlands for foraging, nesting, and as stopover points during migration (Congressional Research Service 2005). Impacts on these habitats have the potential to result in population-level impacts affecting both abundance and distribution of some species. For example, the coastal habitats that were significantly impacted in southeastern Louisiana and the Galveston Bay area of Texas support nesting by up to 15% of the world's brown pelicans and 30% of the world's sandwich terns (FWS 2006). Impacts on these habitats could reduce future nesting success and affect overall population levels of these species.

Hurricane impacts on bottomland forest habitat along the Louisiana and Mississippi coasts represent further loss of avian habitat affecting many different species; up to 70% of the cavity trees used by the endangered red-cockaded woodpecker at Big Branch Marsh National Wildlife Refuge were destroyed by Hurricane Katrina (FWS 2006). The long-term effects of avian habitat loss due to these hurricanes is not known, and agencies such as the USFWS and USGS are implementing numerous studies and monitoring programs to determine the extent and magnitude of impacts on affected avian populations. The occurrence of similar magnitude storms during the life of the 5-year OCS program could result in population-level impacts on some bird species.

Conclusion. Marine and coastal birds in the GOM could be adversely affected by activities associated with the proposed action as well as those associated with other OCS program and non-OCS program activities. Potential impacts include injury or mortality of birds from collisions with platforms associated with OCS and State oil and gas development and other onshore and offshore structures (e.g., radio, television, cell phone, or wind towers), non-energy mineral mines; onshore industrial, commercial, and residential development; exposure to discharges from permitted point sources or accidental releases; exposure to emissions from various onshore and offshore sources; ingestion of trash or debris; loss or degradation of habitat due to construction and operations activities; and behavioral disturbance due to the presence of, and noise generated by, equipment and human activity. Other trends such as sea level rise and increasing seawater temperature brought on by global climate change, as well as extreme wind conditions from storm events, are also expected to adversely affect marine and coastal birds over the next 40 to 50 yr. While the cumulative impact of all OCS and non-OCS activities in the GOM is expected to be moderate, the incremental impact due to the proposed action would be small (see Section 4.4.7.2.1).

Marine and coastal birds may also be adversely affected by exposure to oil (via direct contact or through the inhalation or ingestion of oil or tar deposits) that is accidentally released from OCS and non-OCS activities, especially near coastal areas and affecting feeding and nesting areas. The incremental impacts of accidental spills associated with the proposed action on marine and coastal birds would be small to large, depending on the location, timing, duration, and size of the spill; the proximity of the spill to feeding and nesting areas; the timing and nature of spill containment; and the status of the affected birds (see Section 4.4.7.2.1).

4.6.4.1.3 Fish. There are numerous fish species that inhabit different niches throughout the surface waters, water column, and benthic environments of the GOM. Routine activities will cumulatively have varied effects on these fish populations depending on their habitat and life history. Impacts on fish resulting from ongoing and future routine OCS program activities, including those of the proposed action, could result primarily from noise (vessel, seismic surveys, and construction), well drilling, pipeline placement (trenching, landfalls, and construction), platform placement (anchoring, mooring, and removal, except in deep waters) and routine discharges (drilling, production, platform, and vessel). Accidental oil spills are also counted among OCS program-related activities. Cumulative impacts could result from the combination of the proposed action and past present and reasonably foreseeable future OCS and non-OCS activities.

Routine OCS activities that temporarily disturb sediments and increase turbidity include installation of new pipelines and platforms and discharges of drill cuttings and associated fluids. This could cause soft-bottom fish such as Atlantic croaker, sand sea trout, Atlantic bumper, sea robins, and sand perch to temporarily move from or be attracted to the disturbed area. Fish species that are normally associated with reefs, such as snappers, groupers, grunts, and squirrelfishes, may also move from areas of increased turbidity. Sedimentation could smother eggs, larvae, and juvenile fishes as well as the benthic prey of some of these fish species. See Table 4.6.2-1 for a quantification of bottom disturbance and drilling and operational discharges expected during the life of the Program. The impacts of routine activities (exploration and site development, production and decommissioning) on fish communities are discussed in detail in Section 4.4.7.3.1. Overall, routine activities represent up to a minor disturbance, primarily affecting demersal fishes, with the severity of the impacts generally decreasing dramatically with distance from bottom-disturbing activities.

Up to 2,100 additional platforms would be constructed under ongoing and future OCS activities, including up to 450 from the proposed action. The addition of new platforms may act as fish attracting devices (FADs). Many reef species, as well as highly migratory species, use platforms as habitat. There has been some speculation that an increase in FADs could impact the migration patterns of highly migratory species. While many platforms may be allowed to remain as artificial reefs, removal of platforms will reduce available substrate and structures for these fish and some of their prey species. Some fish will be killed in the process of these platform removals, especially when explosives are used to accomplish the removals. A total of up to 1,250 platforms would be subject to explosive removal over the life of the Program, including up to 275 platforms under the proposed action. A detailed discussion of oil platforms as FADs can be found in Section 4.4.7.3.1.

Non-OCS actions may also negatively influence fish resources in various life stages and habitats. Non-OCS oil and gas exploration and production activities in GOM State waters occur primarily off Louisiana and Texas, and off Alabama in the vicinity of Mobile Bay. The States of Florida and Mississippi have had limited activities in State waters, with a moratorium on drilling activity now in effect in Florida waters. The increasing presence of offshore LNG facilities could lead to impacts associated with entrainment and impingement of eggs, larvae, and juvenile lifestages and discharges of water used in the vaporization process. In addition to the thermal discharge, biocides are also discharged from the facilities. Other non-OCS activities that could impact fish communities include non-OCS activities with a potential to impact marine benthic and pelagic habitats, such as sand mining, sediment dredging and disposal, anchoring, offshore marine transportation, and pollutant inputs from point and non-point sources. Many of these activities would affect bottom-dwelling fishes at various life stages as well as their food sources in a manner similar to OCS bottom-disturbing activities (Section 4.4.7.3.1).

Commercial fishing practices that are indiscriminate, such as some types of trawling and pots, are responsible for significant amounts of bycatch that can injure or kill juveniles of many fish species. These types of fishing practices could damage future year classes, reduce available prey species, and damage benthic habitat for many GOM fish resources. Sportfishing may also contribute significantly to cumulative effects on some fishery resources. As a consequence of the pressure fishing places on fishery resources, appropriate management is required to reduce the potential for depletion of stocks due to overharvesting. Even with management, the possibility of overfishing still exists.

The eutrophication that has contributed to the hypoxic zone in the GOM will continue to act as a source of lethal and sublethal stress to fish communities. In addition, natural events, including hurricanes and turbidity plumes, could also cause localized damage to important habitat areas and could affect individuals or populations. However, the GOM fish community as a whole should be adapted to such natural events.

Climate change could affect fish communities through direct physiological action, habitat loss, and by altering large-scale oceanographic and ecosystem processes (Section 3.8.4.1). At the level of individual behavior and physiology, increasing water temperature could increase the spread and virulence of new and existing pathogens, and alter reproductive rates by speeding growth and altering the timing of migrations (including reproductive movements). Fish in river-influenced systems such as the GOM would be particularly susceptible to changes in salinity, turbidity, and temperature linked to changes in the hydrology of the Mississippi River and Atchafalaya River. At larger scales, climate change could promote the range expansion of new species into the GOM, reduce or eliminate critical fish habitats including estuarine waters and coral reef due to sea level rise, and increase the size of the GOM "dead zone," reducing the amount of benthic habitat available to demersal fishes (Rabalais et al. 2010).

Oil spills resulting from both OCS and non-OCS activities could impact fish communities in the GOM. See Table 4.6.1-3 for anticipated oil spills over the life of the Program. Catastrophic spill assumptions are provided in Table 4.4.2-2. Crude oil may also enter the environment from naturally occurring seeps. Large spills may also occur from tankers carrying imported oil in the GOM. The potential effects of spills from non-OCS activities would be similar to those described for OCS activities (Section 4.4.7.3.1). Most adult fish in marine environments are highly mobile and are capable of avoiding high concentrations of hydrocarbons, although they may be subject to sublethal exposures. However, eggs and larvae do not have the ability to avoid spills and may therefore suffer lethal or sublethal effects. Any oil spills reaching shallow seagrass, estuarine, or coastal marine habitats could affect fish species that use the affected areas as spawning or juvenile nursery habitat. Coastal pelagic fish and highly migratory species throughout the GOM could come into contact with surface oil, but would most likely move away from affected areas. Because of the wide dispersal of early life history stages of fishes in the GOM surface waters, it is anticipated that only a relatively small proportion of early life stages present at a given time would be impacted by a particular oil spill, which would limit the potential for population-level effects. However, the impact magnitude would also depend on the temporal and spatial scope of the oil spill. Since some species of fish spawn in a limited geographic area(s) during a small temporal window, a spill could have population-level impacts if the spill coincided in time and space with spawning activity. In addition, fish species such as tuna, swordfish, and billfish that currently have depressed populations and important spawning grounds in the GOM could experience population-level impacts if high numbers of early life stages were killed by a spill. The potential impacts of oil spills on fish communities are discussed in detail in Section 4.4.7.3.1.

Threatened or Endangered Species. Routine activities such as placement and removal of structures, discharges of operational wastes, and accidental spills of oil have the potential to physically harm or disturb individual Gulf sturgeon, smalltooth sawfish, or their respective habitats; cause sedimentation of areas that provide food; or elicit lethal or sublethal toxic effects. As described in Section 3.8.4.1.4, most routine activities would not take place in shallow nearshore habitat preferred by Gulf sturgeon. Gulf sturgeon are also not likely to be directly affected by routine operations that impact estuarine areas because the more vulnerable egg and larval stages are not present in estuarine areas and juveniles and adults will be able to avoid most disturbances. Consequently, it is anticipated that effects on Gulf sturgeon from routine OCS activities would be limited. Smalltooth sawfish are primarily found in peninsular Florida away from the Central and Western Planning Areas. Vulnerable early life stages of smalltooth sawfish exist only in shallow estuarine areas far removed from most routine OCS activities. Adults and larger juveniles do occupy coastal waters where OCS activities would occur. However, it is expected that, given their size, they will be able to avoid direct impacts from routine operations, although their habitat would be disturbed.

In addition to potential effects from OCS oil and gas activities identified above, Gulf sturgeon and smalltooth sawfish could be affected by non-OCS activities such as commercial fishing, water quality degradation, coastal and upland development, dredge and fill activities, and damming of major spawning rivers (Section 3.8.4.1.4). Even though it is illegal to fish for Gulf sturgeon or smallthooth sawfish, some individuals, particularly smalltooth sawfish, may be harmed or killed when captured as bycatch during trawling activities. Dredging and fill activities in estuaries may disturb smalltooth sawfish and Gulf sturgeon habitat. Increased barriers (e.g., locks or dams) to major spawning sites may result in Gulf sturgeon reproducing in less desirable locations. The eggs and fry of Gulf sturgeon are also susceptible to other fish and invertebrate predators as well as anthropogenic effects, such as artificially increased water temperatures due to the release of cooling water from power plants and exposure to pesticides and heavy metals.

Other events, including hurricanes, turbidity plumes, and hypoxia, could also affect Gulf sturgeon, smalltooth sawfish, or their habitat. Regardless, a severe event could cause localized damage to important habitat areas and could result in the introduction of contaminants via surfacewater runoff. Therefore, such events could affect individual Gulf sturgeon or population levels for some period of time.

Oil is released in GOM waters by accidental oil spills (OCS and non-OCS) and natural seepage, primarily in deep water. Non-OCS oil and gas exploration and production activities in GOM State waters occur primarily off Louisiana and Texas, and off Alabama in the vicinity of Mobile Bay. The States of Florida and Mississippi have had limited activities in State waters, with a moratorium on drilling activity now in effect in Florida waters. Non-OCS spills in the GOM could have impacts similar to those for OCS spills. Smalltooth sawfish are primarily found in peninsular Florida and are uncommon in most of the Central and Western GOM Planning Areas. Therefore, oil spills in the GOM have the greatest potential to impact Gulf sturgeon populations. Most spills would be minor and are unlikely to reach estuarine and shelf habitat of adult sturgeon. Spills in shallow areas have the greatest potential to affect Gulf sturgeon. As identified in Section 3.8.4.1, eggs and larvae of Gulf sturgeon are typically located in freshwater areas, and oil from OCS-related spills are unlikely to come into contact with these life stages. Because adult sturgeons are benthic feeders, they are relatively unlikely to come into contact with surface oil in deeper waters.

Conclusion. Cumulative impacts on fish communities in the GOM Planning Areas could result from OCS and non-OCS activities. Overall, routine activities represent up to a minor disturbance, primarily affecting demersal fishes, with the severity of the impacts generally decreasing dramatically with distance from bottom-disturbing activities. In addition to routine OCS activities, non-OCS actions including oil and gas development in State waters, sand mining, sediment dredging and disposal, LGN facilities, hypoxia, anchoring, fishing/trawling, commercial shipping, and pollutant inputs from point and non-point sources could also adversely affect invertebrate populations. Many of these activities would affect bottom-dwelling fish at various life stages as well as their food sources in a manner similar to OCS bottom-disturbing activities. Fish could also be affected by the environmental changes predicted to result from climate change. The proposed action is expected to contribute only a small increment (impacts ranging from negligible to minor) to the potential for overall cumulative effects on fish resources because of existing regulations, the limited time frame over which most individual activities would occur, and the small proportion of available habitats that would be affected during a given period (see Section 4.4.7.3.1). Therefore, it is anticipated that the cumulative effects of OCS and non-OCS activities on fish species in the GOM Planning Areas would be similar to the effects of non-OCS activities alone.

The magnitude and severity of potential effects to fish resources from oil spills would be a function of the location, timing, duration, and size of spills; the proximity of spills to particular fish habitats; and the timing and nature of spill containment and cleanup activities. Small spills, whether from OCS or non-OCS sources, are unlikely to have overall population-level effects on fish resources. However, oil from catastrophic spills that contacted shallow nearshore areas of these planning areas has the potential to be of greatest significance to fish communities. Such spills could result in long-term, population-level impacts on fish communities.

Although Gulf sturgeon may be affected by a variety of OCS and non-OCS activities, most OCS activities occur in deeper areas that are outside of the normal habitat areas used by Gulf sturgeon. Similarly, smalltooth sawfish are primarily found in peninsular Florida away from the Central and Western Planning Areas. Consequently, it is anticipated that the cumulative effects of OCS and non-OCS activities on Gulf sturgeon and smalltooth sawfish would be similar to the effects of non-OCS activities alone, and the proposed action is expected to contribute little to any overall incremental impacts on these species.

4.6.4.1.4 Reptiles. Section 4.4.7.4 discusses impacts on reptiles in the GOM coastal environment resulting from the proposed action. Cumulative impacts result from the incremental impacts of the proposed action when added to impacts from existing and reasonably foreseeable future OCS program activities (that are not part of the proposed action) and other non-OCS program activities. Table 4.6.1-1 presents the exploration and development scenario for the GOM cumulative case (encompassing the proposed action and other OCS program activities). Non-OCS program activities contributing to adverse cumulative impacts on reptiles include activities associated with offshore construction (e.g., seismic surveys, dredging and marine disposal, extraction of nonenergy minerals, State oil and gas development, domestic transportation of oil and gas, and foreign crude oil imports), onshore construction (e.g., coastal and community development), the discharge of municipal and other waste effluents, and vessel traffic (e.g., commercial shipping, recreational boating, and military training and testing activities).

Ongoing and future routine OCS program activities include seismic surveys, onshore and offshore construction (including pipeline trenching and removal of offshore structures), the discharge of operational wastes (such as produced water and ship wastes), and vessel traffic. All these activities have the potential to adversely affect reptiles in the GOM via physical injury or death, lethal or sublethal toxic effects, or loss of reproductive, nursery, and feeding habitats (Section 4.4.7.4). Accidental oil spills are also counted among OCS program-related activities; assumptions for oil spills under the cumulative case scenario are provided in Table 4.6.1-3.

Anthropogenic mortality in sea turtles has been attributed to a number of sources (NRC 1990; NOAA 2003). Human activities responsible for mortality of sea turtle eggs and hatchlings include (in descending order of relative importance) beach development, beach lighting, beach use, entanglement in trash and debris, and beach replenishment. Each of these activities is associated, either exclusively or to a large degree, with coastal development. In addition, the contributions of exposure of eggs and hatchlings to toxins and of the ingestion of plastics and debris by hatchlings are unknown (NRC 1990; NOAA 2003). Human activities responsible for mortality of juvenile and adult turtles include shrimp trawling and other fisheries, beach lighting, beach use, vessel collisions, dredging, entanglement, power plant entrainment, and oil platform removal (NRC 1999; NOAA 2003). The role of exposure to toxins in overall sea turtle mortality is unknown. However, this information is not necessary to make a reasoned choice among the alternatives.

Non-OCS offshore (deepwater and nearshore) construction activities in the GOM that could affect sea turtles include channel construction and maintenance activities (e.g., dredging) conducted by Federal, State, and local governments and the public; the offshore extraction of nonenergy minerals; State oil and gas development; and the transport of domestic and foreign oil and gas (requiring loading and offloading facilities). Potential impacts on sea turtles from these activities may include physical injury or death of individuals present in the immediate construction area. In addition, construction or removal of offshore OCS facilities may result in a relatively small incremental increase in the potential for adverse impacts on sea turtles within the GOM planning areas. However, the mitigation measures established by BOEMRE for construction and platform removal activities may be expected to reduce the contribution of these proposed activities to cumulative impacts to sea turtles from all offshore construction activities throughout the GOM planning areas (MMS 2003, 2004, 2005).

Onshore construction in coastal areas can impact sea turtle nesting habitat. Coastal development is an ongoing activity throughout the GOM and may be expected to continue or increase for the foreseeable future. Residential (i.e., housing developments) and commercial (i.e., casinos) development near nesting beaches may disrupt nesting adults and disorient emerging hatchlings, while increasing the potential for recreational human activities on nesting beaches. Compliance with regulatory requirements and the implementation of appropriate mitigation measures may be expected to reduce the potential for the siting, construction, and operation of onshore facilities.

There are a number of types of facilities or activities that discharge wastes to GOM waters and thus expose sea turtles to potentially toxic materials or solid debris that could entangle or be ingested by sea turtles. These facilities or activities include sewage treatment plants, industrial manufacturing or processing facilities, electric generating plants, cargo and tanker shipping, cruise ships, commercial fishing, pleasure craft, and vessel traffic associated with the Program. In addition, the Mississippi River (and to a lesser extent other rivers and streams that discharge to the northern GOM) annually discharges waters containing suspended sediments, agricultural fertilizers and herbicides, and urban runoff (Rabalais et al. 2001, 2002). The exposure of sea turtles to these discharges may result in physical injury or death, or a variety of lethal or sublethal toxic effects on adults, juveniles, and hatchlings. These discharges may also affect habitat quality in the vicinity of the discharges.

Operational discharges and wastes associated with OCS activities could adversely affect sea turtles, especially those in the immediate vicinity of discharging platforms and vessels (Section 4.4.7.4). However, discharges from OCS program-related vessels and platforms would be strongly regulated under the proposed action (as they are for current OCS program-related discharges). Thus, the potential for sea turtles to be exposed to discharges under the proposed action may be expected to be much less than the potential of exposure to many of the nonpoint and non-OCS related discharge sources. Similarly, because of existing USCG and USEPA regulations, the nature of the OCS discharges that could occur are expected to be less toxic or less likely to cause entanglement than discharges from non-OCS program sources.

The GOM is one of the world's most concentrated shipping areas, with extensive commercial traffic transporting a variety of materials ranging from agricultural products to domestic and foreign oil (USACE 2003a). For example, in 2003, the Port of New Orleans handled over 255,000 domestic and foreign container vessels, while the port at Gulfport, Mississippi, handled more than 161,000 foreign container vessels (USACE 2003b). The GOM also supports extensive commercial fisheries as well as recreational boating. For example, there were 2 million recreational watercraft between 4 and 20 m (12 and 64 ft) in length registered in the GOM States, many of which are used in GOM waters (USCG undated). The GOM also supports training by U.S. Navy vessels as well as routine USCG activities. Because of the very large number of vessels typically present in the GOM, the potential for sea turtles colliding with watercraft is high, and may be expected to continue and increase into the foreseeable future. In comparison with the overall level of vessel traffic in the GOM, the additional numbers of vessel trips that would occur to support OCS program activities is expected to result in a minor incremental increase to the overall potential for sea turtle–vessel collisions in the GOM planning areas.

The information on the extent to which sea turtles may be affected by noise is very limited (Section 4.4.7.4). However, this information is not necessary to make a reasoned choice among the alternatives Current noise generating activities in the GOM unrelated to OCS activities or the proposed action include the construction of offshore structures (such as those supporting State oil and gas development or nonenergy minerals extraction), dredging, commercial and recreational vessel traffic, and military training and testing activities. These may be expected to continue or increase in the foreseeable future.

Sea turtles could be exposed to OCS oil spills that could occur from platform, pipeline, and/or vessel accidents (see Section 4.4.7.4). Most spills associated with the proposed action would be relatively small (less than 50 bbl), and most would be expected to occur in water depths of 300 m (984 ft) or more (BOEMRE 2011).

Storms, operator error, and mechanical failures may result in accidental oil releases from a variety of non-OCS related activities, such as the domestic transportation of oil, the import of foreign crude oil, and State development of oil. Crude oil may also enter the environment of the northern GOM from naturally occurring seeps. At least 63 seeps have been identified in the northern GOM (mostly off the coast of Louisiana) (MacDonald et al. 1996), and more than 350 naturally occurring and constant oil seeps that produce perennial slicks of oil at consistent locations may be present in the GOM (MacDonald and Leifer [2002], as cited in Kvenvolden and Cooper [2003]). Seeps in the northern GOM have been estimated to discharge more than 1.2 million gal of crude oil annually to overlying GOM waters (MacDonald 1998). Using remotely sensed satellite data, Mitchell et al. (1999) identified approximately 1,000 km^2 (390 mi^2) of floating oil in the northern GOM, presumably from natural seeps.

Accidental oil releases from these activities and from naturally occurring seeps could impact reptiles by oiling (fouling) nesting beaches and nest sites and hatchlings, and through the inhalation or ingestion of oil or tar deposits. The magnitude and severity of potential effects on reptiles from such exposure will be a function of the location, timing, duration, and size of the spill; the proximity of the spill to nesting beaches and feeding habitats; and the timing and nature of spill containment and cleanup activities. Depending on their location, as well as the location of spills from other sources and releases from natural seeps, accidental spills associated with the proposed action could contribute to the overall exposure of nest beaches, eggs, and hatchlings to oil, and subsequent lethal and sublethal effects, in the GOM planning areas. For example, American crocodiles in southern Florida might only be affected by natural seepage and accidental releases of oil in the Eastern Planning Area or from catastrophic spills in the Central and Western Planning Areas.

Reptile populations throughout the GOM may be adversely affected by climate change or hurricane events. As previously discussed (Section 4.4.7.4), there is growing evidence that climate change is occurring, and potential effects in the GOM may include a change (i.e., rise) in sea level or a change in water temperatures. Climate change could affect the availability or quality of nesting beaches, the location and duration of current convergence areas utilized by hatchlings in the open waters of the GOM, and the distribution, availability, and quality of feeding habitats. For reptiles that rely on temperature to determine the gender of offspring in incubating eggs (referred to as temperature-dependent sex determination), including sea turtles and crocodilians, subtle increases in atmospheric temperatures could skew sex ratios of hatchlings, which could have future population implications (Walther et al. 2002).

Severe storm events such as hurricanes have the potential to impact nesting beaches if they result in a change in beach topography or in the composition of beach materials. Heightened wave action and intensity could erode nesting beach sites, storm surges could flood beaches and drown eggs and hatchlings, and sediments deposited onto beach surfaces by storm waves may alter the thermal and structural environment of nest sites, potentially decreasing the availability and/or quality of the nesting areas (Milton et al. 1994; Hays et al. 2001; Holloman and Godfrey 2005). Hurricanes Katrina and Rita adversely affected sea turtle habitats in 2005. Approximately 50 Kemp's ridley sea turtle nesting sites were destroyed along the Alabama coast (Congressional Research Service 2005; FWS 2006). The loss of beaches through the affected coastal areas has probably affected other existing nests and nesting habitats of this species, as well as the loggerhead turtle. Similarly, impacts on seagrass beds may affect the local distribution and abundance of species that use these habitats, such as the green sea turtle and Kemp's ridley sea turtle. Although hurricanes are annual events that are an inherent component of the overall GOM ecosystem, including sea turtle nesting beaches, if hurricanes similar in magnitude to Katrina and Rita occur during the life of the Program, population-level impacts on reptiles could occur, particularly since the availability of nesting habitat (e.g. beaches) has become limited because of coastal residential and commercial development.

Conclusion. Impacts on reptiles may occur in the future as a result of normal activities related to the proposed action, as a result of activities related to ongoing and expected OCS leasing, and as a result of non-OCS program activities. The potential impacts associated with normal OCS operations represent a relatively small incremental increase in the impacts incurred by reptiles from non-OCS program activities in the GOM (see Section 4.4.7.4). Accidental oil spills under the proposed action would result in a comparatively small incremental increase in the overall impact of exposure to oil from other anthropogenic activities (such as spills from foreign tankers). Additional impacts on reptiles may occur as a result of habitat loss or alteration due to climate change and hurricanes, and from exposure to oil from naturally occurring seeps.

4.6.4.1.5 Invertebrates and Lower Trophic Levels. Cumulative impacts could result from the combination of the proposed action and past present and reasonably foreseeable future OCS and non-OCS activities. Routine activities will cumulatively have varied effects on invertebrate populations in the sediment and water column depending on their habitat and life history. Impacts resulting from ongoing and future routine OCS program activities, including those of the proposed action, could result primarily from noise (vessel, seismic surveys, and construction), well drilling, pipeline placement (trenching, landfalls, and construction), platform placement (anchoring, mooring, and removal, except in deep waters) and routine discharges (drilling, production, platform, and vessel). Accidental oil spills are also counted among OCS program-related activities.

Routine activities that temporarily disturb sediments and increase turbidity include installation of new pipelines and platforms and discharges of drill cuttings and associated fluids. Under the cumulative scenario, as much as 55,450 ha (137,020 ac) of sea bottom would be disturbed by construction of platforms and pipelines over the period of the Program (Table 4.6.1-1). Bottom-disturbing impacts would most directly affect benthic and near bottom invertebrates. The impacts of routine activities (exploration and site development, production and decommissioning) on invertebrate communities are discussed in detail in Section 4.4.7.5.1. Overall, routine activities represent up to a moderate disturbance, with the severity of the impacts generally decreasing dramatically with distance from bottom-disturbing activities.

The addition of up to 2,100 new platforms over the life of the Program (up to 450 new platforms under the proposed action) would allow the colonization of invertebrates requiring hard substrate. While many platforms may be allowed to remain as artificial reefs, removal of platforms will reduce available substrate and structures for invertebrates and injure or kill them during removal.

Non-OCS actions may negatively influence invertebrate resources in various life stages and habitats. Non-OCS oil and gas exploration and production activities in GOM State waters occur primarily off Louisiana and Texas, and off Alabama in the vicinity of Mobile Bay. The States of Florida and Mississippi have had limited activities in State waters, with a moratorium on drilling activity now in effect in Florida waters. The increasing presence of offshore LNG facilities could lead to impacts associated with discharges of water used in the vaporization process. In addition to the thermal discharge, biocides are also discharged from the facilities. Other non-OCS activities that could impact invertebrate communities include non-OCS activities with a potential to impact marine benthic and pelagic habitats, such as sand mining, sediment dredging and disposal, anchoring, fishing/trawling, offshore marine transportation, and pollutant inputs from point and non-point sources. Many of these activities would affect bottom-dwelling invertebrates at various life stages as well as their food sources in a manner similar to OCS bottom-disturbing activities (Section 4.4.7.5.1).

The eutrophication that has contributed to the hypoxic zone in the GOM will continue to act as a source of lethal and sublethal stress to invertebrate communities. Natural events, including hurricanes and turbidity plumes, could also cause localized damage to important habitat areas and could affect individuals or populations, although the invertebrate community as a whole should be adapted to such natural events.

Commercial fishing practices that are indiscriminate, such as some types of trawling and pots, are responsible for significant amounts of bycatch that can injure or kill large numbers of invertebrates. Bottom trawling also degrades benthic habitats and temporarily increases the turbidity of the water, both of which represent chronic disturbances to invertebrates. Bottom trawling is particularly common in the GOM because of the importance of the shrimp fishery.

Several major classes of invertebrates could be affected by the environmental changes predicted to result from climate change. Climate change could affect invertebrate communities through direct physiological action, habitat loss, and by altering large-scale oceanographic and ecosystem processes (Section 3.8.5.1). A significant loss of habitat-forming invertebrates like corals could result from increased water temperature and ocean acidification. The impacts of climate change on habitat-forming invertebrates are discussed in detail in Section 3.7.2.1. Potential impacts on benthic and water column invertebrates resulting from climate change include:

- An increase in the range and temporal variability of a water column’s oxygen, salinity, and temperature, which could significantly alter the existing invertebrate community structure, particularly in nearshore areas;

- A reduction in important estuarine habitats from sea level rise;

- A range expansion of new invertebrate species into the GOM;

- An increase in the extent and duration of the GOM hypoxic zone that could kill or displace existing invertebrate communities and reduce the amount of suitable habitat available; and

- Reduced oceanic pH, which could reduce the fitness of calcifying marine organisms like corals, echinoderms, foraminiferans, and mollusks.

Oil spills resulting from both OCS and non-OCS activities could impact invertebrate communities in the GOM. See Table 4.6.1-3 for anticipated oil spills over the life of the Program. Crude oil also enters the environment from naturally occurring seeps. Spills could occur from tankers carrying imported oil in the GOM. The potential effects of spills from non-OCS activities would be similar to those described for OCS activities (Section 4.4.7.5.1). In general, larger benthic and water column invertebrates that come into contact with oil would most likely move away from affected areas, while zooplankton and sessile or small infauna would not be able to avoid spills. Oil contacting invertebrates could have lethal or sublethal impacts. Any oil spills reaching shallow seagrass, estuarine, or coastal marine habitats could affect commercially important species such as shrimp, oysters, and blue crab that use these areas as spawning or juvenile nursery habitat. If they were to occur, deepwater surface spills could also affect invertebrate eggs and larvae, neuston communities such as jellyfish species, and *Sargassum*, together with any associated vertebrate and its invertebrate organisms. Because of the wide dispersal of invertebrates in the GOM surface waters, it is anticipated that only a relatively small proportion of early life stages present at a given time would be impacted by a particular oil spill event, which would limit the potential for population-level effects. The potential impacts of oil spills on invertebrate communities are discussed in Section 4.4.7.5.1.

Conclusion. Cumulative impacts on invertebrate communities in the GOM Planning Areas could result from OCS and non-OCS activities. Overall, routine activities represent up to a moderate disturbance, with the severity of the impacts generally decreasing dramatically with distance from bottom-disturbing activities. In addition to routine OCS activities, non-OCS actions including offshore LNG facilities, sand mining, sediment dredging and disposal, hypoxia, anchoring, fishing/trawling, offshore marine transportation, and pollutant inputs from point and non-point sources could also adversely affect invertebrate populations. Many of these activities would affect bottom-dwelling invertebrates at various life stages as well as their food sources in a manner similar to OCS bottom-disturbing activities. Several major classes of invertebrates could also be affected by the environmental changes predicted to result from climate change. It is anticipated that the cumulative effects of OCS and non-OCS activities on invertebrates would be similar to the effects of non-OCS activities alone, and routine Program activities, with impacts ranging from negligible to minor, are expected to contribute only a small increment to the potential for overall cumulative effects on invertebrate resources.

The magnitude and severity of potential effects to invertebrate resources from oil spills would be a function of the location, timing, duration, and size of spills; the proximity of spills to particular habitats; and the timing and nature of spill containment and cleanup activities. Spills in deeper water, whether from OCS or non-OCS sources, are unlikely to have overall population-level effects on invertebrate resources because of the relatively small proportion of similar available habitats that would come in contact with released oil at concentrations great enough to elicit toxic effects. Oil from catastrophic spills that reaches shallower, nearshore areas of these planning areas has the potential to be of greatest significance to invertebrate communities. Impacts from such spills could result in long-term, population level impacts on invertebrate communities.

4.6.4.1.6 Areas of Special Concern. Section 4.4.8.1 identified potential effects of the proposed action on areas of special concern in the GOM. This section identifies activities that could affect such areas in the GOM, including non-OCS activities and current and planned OCS activities that would occur during the life of the Program, and the potential incremental effects of implementing the proposed action.

National Marine Sanctuaries. The FGBNMS is the only National Marine Sanctuary located in the Western and Central GOM Planning Areas. The Flower Gardens Bank sanctuary is protected from direct mechanical damage due to oil and gas exploration and development by an MMS Topographic Features Stipulation, which includes a No Activity Zone (Section 4.4.6.2). Additional OCS activities that could affect the marine sanctuaries include discharges of drilling cuttings, drilling muds, and produced waters. However, as identified in Section 4.4.6.2, the Topographic Features Stipulation does not allow discharges from OCS activities to be released within the vicinity of the FGBNMS. Consequently, it is anticipated that the sanctuary would not be affected by discharges from OCS activities.

Non-OCS activities that could affect the marine sanctuaries include fishing, diving, offshore marine transportation, and tankering. Natural events such as hurricanes could also impact the sanctuaries. Fishing and diving impacts are controlled by sanctuary guidelines regulating these activities. The distance of the Flower Garden Banks from shore (over 160 km [99 mi]) serves to reduce the number of visitors to the sanctuary, further reducing the potential for impacts from fishing and diving activities. Sanctuary regulations also prohibit collecting activities and ban anchoring within the sanctuary in order to minimize structural damage to the reef system from commercial and recreational vessels.

Climate change has the potential to profoundly affect coral communities on topographic features in several ways, including:

- Increased frequency of bleaching as a stress response to warming water temperatures (Hoegh-Guldberg et al. 2007);

- Excessive algal growth on reefs and an increase in bacterial, fungal, and viral agents (Boesch et al. 2000; Twilley et al. 2001);

- Greater frequency of mechanical damage to corals from greater severity of tropical storms and hurricanes (Janetos et al. 2008);

- Decreases in the oceanic pH and carbonate concentration are expected to reduce the reef formation rate, weaken the existing reef structure, and alter the composition of coral communities (Janetos et al. 2008); and

- Invasive species may expand their range into the GOM due to climate change.

Impacts on the marine sanctuaries could occur due to surface hydrocarbon discharges from platform spills, OCS and non-OCS tankers, or other marine traffic passing in the vicinity of the sanctuary. Discharges in the vicinity of the FGBNMS should be greatly diluted before they could reach reef features because water depths within the sanctuary are greater than 20 m (66 ft). Consequently, it is anticipated that concentrations of contaminants within such discharges would be diluted to levels unlikely to have toxic effects on reef organisms. Oil spills could also impact the Flower Garden Banks communities. The No Activity Zone mandated in the Topographic Features Stipulation and adopted as a regulation for the Flower Garden Banks precludes placement of platforms or pipelines immediately adjacent to the marine sanctuary and reduces the likelihood that oil from a pipeline leak would reach bank communities. If oil from a series of subsurface spills were to reach one of these banks, sensitive biota could be affected. Potential impacts have been discussed in Section 4.4.6.2. It is anticipated that impacts of a large oil spill reaching coral reef or hard-bottom habitat may be long term.

National Parks, Reserves, and Refuges. As identified in Section 4.4.8.1, routine OCS activities potentially affecting parks, reserves, and refuges include placement of structures, pipeline landfalls, operational discharges and wastes, and vessel and aircraft traffic. It is assumed that pipeline landfalls, shore bases, and waste facilities would not be located in national parks, NWRs, or national estuarine research reserves because of the special status and protections afforded these areas. Consequently, there would be no direct impacts from these activities on any GOM national parks, reserves, or refuges.

It is possible that future pipeline landfalls, shore bases, and waste facilities could be located in one or more estuaries in the Western or Central GOM Planning Areas that are included in the National Estuary Program. This includes Corpus Christi Bay (Coastal Bend Bays and Estuaries), Galveston Bay, Barataria-Terrebonne Estuarine Complex, and Mobile Bay. Under the cumulative scenario, it is anticipated that less than 40 new pipeline landfalls could occur in the GOM, with less than 12 of these resulting from the proposed action (Table 4.4.1-1). In addition, gas-processing facilities could be built in the GOM area under the cumulative scenario. It is assumed that new onshore facilities and structures would be subject to additional evaluations under the NEPA and that they would be sited to avoid national parks, reserves, and refuges and to limit impacts on estuarine and coastal habitats.

Trash and debris are a recognized problem affecting enjoyment and maintenance of recreational beaches along the GOM coast. From extensive aerial surveys conducted by NMFS over large areas of the GOM, floating offshore trash and debris was characterized by Lecke-Mitchell and Mullin (1997) as a ubiquitous, Gulfwide problem. Not surprisingly, such trash and debris frequently washes up on beaches, including those associated with areas of special concern such as the Padre Island National Seashore. Trash and debris can detract from the aesthetic quality of beaches, can be hazardous to beach users and wildlife, and can increase the cost of maintenance programs.

Trash and debris in the GOM originates from various sources, including OCS operations, offshore and onshore oil and gas operations in State waters, naval operations; merchant vessels, commercial and recreational fishing activities, and onshore residences and businesses (Miller and Echols 1996). The discharge or disposal of solid debris from OCS structures and vessels is prohibited by the MMS (30 CFR 250.40) and by the USCG (MARPOL, Annex V, Public Law 100-220 [101 Statute 1458]). Assuming that operators of OCS facilities comply with regulations, most potential impacts would be avoided, although some accidental loss of materials is inevitable. Natural phenomena (such as storms, hurricanes, and river outflows) contribute to movement of trash and debris onto the beaches in the GOM.

Vessel wakes from a large number of vessel trips can, over time, erode shorelines along inlets, channels, and harbors. The GOM is one of the world's most concentrated shipping areas, and the Port of New Orleans supports extensive commercial shipping traffic. The GOM also supports extensive commercial fisheries as well as recreational boating. The GOM also supports training by U.S. Navy vessels as well as routine USCG activities (Section 4.3). The additional vessel activity that would occur under the proposed action will result in an increase in the overall potential for wakes to affect sensitive shorelines in the GOM OCS Planning Areas.

Overall, it is assumed that there could be 1,400–1,900 OCS-related vessel trips per week in the GOM under the cumulative scenario; 300 to 600 of these would occur as a result of OCS activities attributable to the proposed action (Table 4.4.1.1-1). The majority of such vessel trips would occur in offshore waters, thereby precluding effects on shorelines associated with national parks, reserves, and refuges. Existing regulations typically limit vessel speeds in the sensitive inland waterways of areas of special concern. With these measures in place, most impacts due to vessel traffic in such areas would be avoided.

Under the proposed action, national parks, NWRs, national estuarine research reserves, or national estuary program sites could be exposed to oil accidentally released from platforms, pipelines, and vessels (see Section 4.4.8.1). In addition to the potential for spills from OCS sources, storms, operator error, and mechanical failures could also result in accidental oil releases from a variety of non-OCS-related activities including domestic transportation of oil, importing foreign crude oil, and development of oil production under State programs. The potential exists for impacts to National Parks, Reserves, and Refuges that could result from both oiling of the shoreline and mechanical damage during the cleanup process. Most spills associated with the proposed action would be relatively small (less than 50 bbl), and most would be expected to occur in waters depths of 200 m (656 ft) or more (Table 4.4.2-1) where they are not likely to affect coastal areas. Because of the expected distribution of leasing activities, it is assumed that such spills would occur in either the Western or Central GOM Planning Areas.

Based on the expected distribution of activities and facilities associated with current or proposed activities under OCS leasing programs, it is assumed that any accidental oil spills from OCS-activities would occur in either the Western or Central GOM Planning Area. In contrast, non-OCS spills could occur anywhere in the GOM. Thus, while it is considered likely that only national seashores, NWRs, national estuarine research reserves, and National Estuary Program sites in the Western or Central GOM are at risk from spills due to ongoing or proposed OCS activities, any of these types of properties located along the GOM coast has a potential to be affected by non-OCS accidental spills. Regardless of the source, oil from a large or catastrophic spill that reached the shoreline of any of these sites could have adverse effects on resources or resource values.

Hurricanes and tropical storms occur regularly in the GOM area. The natural environments that parks and refuges preserve and maintain have developed in a setting of regular occurrences of severe storms. In 2004 and 2005, however, Hurricanes Katrina, Rita, and Ivan severely impacted numerous national parks, NWRs, and national estuaries. In 2004, Hurricane Ivan damaged 10 NWRs between the Florida panhandle and Louisiana. In 2005, Hurricane Katrina affected 16 refuges in the same area, temporarily closing all of them. Impacts included damage to beaches, dunes, vegetation and infrastructure. Breton NWR in Louisiana was reduced to about one-half its pre-Katrina size. Many impacted refuges remain impacted by huge quantities of debris and hazardous gases and liquids spread over large areas of wetlands within the sanctuaries. Should storms of similar strength and size occur during the life of the Program, long-term impacts on areas of special concern in the GOM could occur.

Conclusion. In addition to OCS activities, non-OCS activities that could affect National Sanctuaries, Parks, Reserves and Refuges include fishing, diving trash and debris, vessel wakes, vessel traffic, tinkering, and oil and gas activities in State waters. Hurricanes and tropical storms also occur regularly in the GOM area potentially causing damage. Due to existing protections, it is anticipated that the FGBNMS would not be affected by OCS activities. Development of OCS onshore facilities within National Park lands is considered unlikely, making impacts from cumulative routine OCS operations unlikely in these areas. Offshore construction of pipelines and platforms could contribute to cumulative effects on wildlife and on scenic values for park visitors. Impacts could also include increases to the amount of trash or debris that currently washes up on shorelines, and increases in shoreline erosion due to increased vessel traffic in inshore waters. Overall, routine Program activities could result in minor incremental increases in effects on areas of special concern compared to existing non-OCS activities within the Gulf of Mexico (see Section 4.4.8.1).

The proposed action would be expected to result in a small incremental increase in the risk of impacts from oil spills to areas of special concern. The cumulative level of impacts from spills would depend on spill frequency, location, and size; the type of product spilled; weather conditions; effectiveness of cleanup operations; and other environmental conditions at the time of the spill. Large and catastrophic oil spills in areas adjacent to the National Parks, NWRs, or National Forests, whether from OCS or non-OCS sources, could negatively impact the FGBNMS and coastal habitats and fauna and could also affect subsistence uses, commercial or recreational fisheries, and tourism.

4.6.4.2 Alaska Region – Cook Inlet

4.6.4.2.1 Marine Mammals.

Marine Mammals. The cumulative analysis considers past, ongoing, and foreseeable future human and natural activities that may occur and adversely affect marine mammals in the same general area. These activities include effects of the OCS Program (proposed action and prior and future OCS sales), oil and gas activities in State waters, commercial and subsistence shipping, commercial fishing, recreational fishing and boating activities, military operations, scientific research, and natural phenomena. Specific types of impact-producing factors considered include noise from numerous sources, pollution, ingestion and entanglement in marine debris, vessel strikes, habitat degradation, subsistence harvests, military activities, industrial development, community development, climate change, and natural catastrophes. Section 4.4.7.1.2 provides the major impact-producing factors for the proposed action in Cook Inlet.

Routine Activities.

OCS Activities. Marine mammals and their habitats in the Cook Inlet Planning Area could be affected by a variety of exploration, development, and production activities as a result of the proposed and future OCS leasing actions (see Section 4.4.7.1.2). These activities include seismic exploration, offshore and onshore infrastructure construction, the discharge of operational wastes, and vessel and aircraft traffic. Impacts on marine mammals from these activities may include physical injury or death; behavioral disturbances; lethal or sublethal toxic effects; and loss of reproductive, nursery, feeding, and resting habitats. The degree of impact at the population level depends greatly on the status of the population (reflected in its listing under the ESA) and the degree of disturbance or harm from OCS-related activities in areas important to species survival (i.e., feeding, breeding, molting, rookery, or haulout areas).

Potential impacts (primarily behavioral disturbance) on marine mammals from OCS-related seismic activity would be short term and temporary, and not expected to result in minor impacts on any affected species.

Impacts from OCS construction and operation activities could include the temporary disturbance and displacement of individuals or groups by construction equipment and long-term disturbance of some individuals from operational noise. No long-term, population-level effects would be expected because individuals most affected by these impacts would be those in the immediate vicinity of the construction site or operational platform and disturbance of individuals during construction would be largely temporary. In addition, appropriate mitigation measures could lessen the potential for impacts.

Operational and waste discharges (e.g., produced water, drilling muds, and drill cuttings) would be disposed of through downhole injection into NPDES-permitted disposal wells, and thus would not be expected to result in any incremental impacts on marine mammals. Liquid wastes (such as bilge water) may also be generated by OCS support vessels and on production platforms. While these wastes may be discharged (if permitted) into surface waters, they would be rapidly diluted and dispersed and would result in minor incremental impacts on marine mammals. Drilling and production wastes may contain materials such as metals and hydrocarbons, which can bioaccumulate through the food chain into the tissues of marine mammals. Although the bioaccumulation of anthropogenic chemicals has been reported for a variety of marine mammals, adverse impacts or population-level effects resulting from such bioaccumulation have not been demonstrated (Norstrom and Muir 1994; Muir et al. 1999).

Marine mammals could be temporarily disturbed by OCS vessel traffic (all species) or incur injury or death from collisions with support vessels (primarily larger, slower moving cetaceans). The low level of expected OCS vessel trips in the Cook Inlet Planning Area under the proposed action (one to three trips per week) would be a minor contribution to all vessel traffic occurring in the Cook Inlet. Noise from the one to three helicopter overflights expected each week would be transient in nature and be a minor component of all aircraft flights that occur within Cook Inlet. Overflights disturbing active rookery sites could result in decreased pup survival and in population-level impacts on some species, although overflight restrictions and flightline selection to avoid rookeries would greatly limit the potential for adversely affecting animals at these locations.

No platforms would be removed under the proposed action for the Cook Inlet Planning Area. It is possible that platforms would be removed from future lease sales or from platforms associated with oil and gas activities in State waters. There have been no documented losses of marine mammals resulting from explosive removals of offshore oil and gas structures, but there are sporadic incidents reported of marine mammals being killed by underwater detonations

(Continental Shelf Associates 2004; MMS 2007, 2008). Harassment of marine mammals as a result of a non-injurious physiological response to the explosion-generated shock wave, as well as to the acoustic signature of the detonation, is also possible. However, explosive platform removals would comply with appropriate BOEM or State guidelines and would not be expected to adversely affect marine mammals in Cook Inlet.

Non-OCS Activities. A number of non-OCS activities such as oil and gas exploration and development in State waters: commercial, subsistence, and recreational fishing; vessel traffic; and climate change could also affect marine mammals in the Cook Inlet Planning Area (or portions of the Gulf of Alaska that could be affected by activities in Cook Inlet). Many of the effects of these activities on marine mammals would be similar in nature to those resulting from OCS-related activities, namely, behavioral disturbance, habitat disturbance, injury or mortality, and exposure to toxic substances. Marine mammals may also be adversely affected by climate change.

Oil and Gas Exploration and Development in State Waters. The State of Alaska has made nearshore State lands available for leasing along the northern portion of Cook Inlet (above Homer). Exploration, construction, and operation activities associated with State leases would occur in nearshore and coastal areas, while OCS platforms and pipelines would be located away from coastal areas. Thus, State oil and gas leasing activities may be expected to have a greater potential for affecting marine mammals in coastal habitats than would the proposed OCS actions.

Commercial and Subsistence Fishing and Harvesting. Commercial and subsistence fishing has been identified as impacting many of the marine mammals in Alaskan waters (Allen and Angliss 2011). These fisheries employ a variety of methods, such as longlines, seines, trawls, and traps, and can result in the entanglement, injury, and death of individuals of marine mammal species. Fisheries also remove a portion of the prey base for some marine mammals. Subsistence harvest has targeted and continues to target some marine mammal species, especially some of the whale species.

The following are minimum reported estimated annual mortality rates incidental to commercial fisheries and subsistence harvests for marine mammals that occur in Cook Inlet and/or in the Gulf of Alaska that could be affected by the proposed action in Cook Inlet (Allen and Angliss 2011):

- The estimated minimum mortality rate for Western U.S. Stock of the Steller sea lion incidental to Alaska commercial fisheries is 26.2 animals per year. The best estimate of annual subsistence harvest of the Steller sea lion is 197 animals.

- The estimated minimum mortality rate for Eastern Pacific Stock of the northern fur sea lion incidental to Alaska commercial fisheries is 1.9 animals per year. The best estimate of annual subsistence harvest of the northern fur seal is 562 animals.

- The estimated minimum mortality rate for Gulf of Alaska Stock of the harbor seal incidental to Alaska commercial fisheries is 24 animals per year. The best estimate of annual subsistence harvest of the harbor seal is 807 animals.

- There are no reports of mortality incidental to commercial fisheries for the Cook Inlet Stock of the beluga whale. Annual subsistence harvest of Cook Inlet beluga whales ranged from 30 to over 100 between 1993 and 1999. Since 2000, subsistence harvests totaled only 11 whales, with no subsistence harvests allowed between 2008 and 2012 (Allen and Angliss 2011; NMFS 2008b).

- The estimated minimum mortality rate for the Alaska Resident Stock of the killer whale incidental to Alaska commercial fisheries is 1.2 animals per year. There are no reports of subsistence harvests of killer whales in Alaska.

- The estimated minimum mortality rate for the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient Stock of the killer whale incidental to Alaska commercial fisheries is 0.4 animal per year. There are no reports of subsistence harvests of killer whales in Alaska.

- There are no reports of mortality incidental to commercial fisheries or subsidence harvest for the ATI Transient Stock of the killer whale.

- There were no serious injuries or mortalities observed or reported incidental to commercial fisheries between 2002 and 2006 for the North Pacific Stock of the Pacific white-sided dolphin. However, between 1978 and 1991, thousands of individuals died annually incidental to high seas fisheries (these fisheries have not operated in the central North Pacific since 1991). There are no reports of subsistence harvests of Pacific white-sided dolphins.

- The estimated minimum mortality rate for the Gulf of Alaska Stock of the harbor porpoise incidental to commercial fisheries is 71.4 animals per year. There are no reports of subsistence harvests of the harbor porpoise. Two harbor porpoises were taken incidentally in subsistence gillnets in 1995.

- The estimated minimum mortality rate for the Alaska Stock of the Dall's porpoise incidental to commercial fisheries is 29.6 animals per year. There are no reports of subsistence harvests of the Dall's porpoise.

- The estimated minimum mortality rate for the North Pacific Stock of the sperm whale incidental to commercial fisheries in the Gulf of Alaska is 2.01 animals per year. There are no reports of subsistence harvests of the sperm whale. The sperm whale was the dominant species killed by the commercial whaling industry in the North pacific in the years following the Second World War.

- The estimated annual mortality rate for the Alaska Stock of Cuvier's beaked whale incidental to commercial fisheries is zero. There are no reports of subsistence harvests of the Cuvier's beaked whale.

- Serious injuries to or mortalities of Eastern North Pacific Stock of the gray whale occur throughout their range incidental to commercial fisheries and from strandings due to various causes. The annual mortality rate incidental to U.S. commercial fisheries is 3.3 whales. Annual subsistence take averaged 121 whales between 2003 to 2007. Russian Chukotka people take most of the gray whales. The U.S. Makah Indian Tribe has a yearly average quota of only 4 whales. In 2005, an unlawful subsistence hunt and kill of a gray whale occurred in Alaska.

- The Western North Pacific Stock of the humpback whale's feeding area includes the Gulf of Alaska. The estimated annual mortality incidental to U.S. commercial fisheries is 0.2 humpback whales per year based on one mortality observed in the Bering Sea sablefish pot fishery from 2002 through 2006. Bycatch in Japan and Korea average 1.1 to 2.4 humpback whales per year. The annual mortality rate for subsistence takes for the 2003 to 2007 period was 0.2 whales. The species received full protection in 1965; however, the Union of Soviet Socialist Republics (USSR) continued illegal catches until 1972. From 1961 through 1971, 6,793 humpback whales were illegally killed. Many of these were taken from the Gulf of Alaska and the Bering Sea.

- The Central North Pacific Stock of the humpback whale feeding area includes the Gulf of Alaska area that encompasses Cook Inlet. Based on observations from 2003 through 2007, the estimated annual mortality in Alaska is 3.4 animals per year from commercial fishery, 0.2 animals per year from recreational fishery, and 1.6 animals per year from vessel collisions. Subsistence harvesting is not allowed for humpback whales from the Central North Pacific Stock.

- There was one observed incidental mortality of a fin whale from the Northeast Pacific Stock in the Bering Sea/Aleutian Island pollock trawl fishery. No current or historical subsistence takes of this stock are reported from Alaska or Russia. Between 1925 and 1975, commercial whaling throughout the North Pacific killed 47,645 fin whales.

- For the Alaska Stock of the minke whale, the total estimated mortality and serious injury incidental to U.S. commercial fisheries for 2002 through 2006 was zero. Prior to that time, whale mortalities were very rare. Subsistence take by Alaska Natives is rare (e.g., only nine between 1930 and 1995).

- There are no records of North Pacific right whale mortalities incidental to U.S. commercial fisheries. There are no reported subsistence takes of the species in Alaska or Russia. Up to 37,000 North Pacific right whales were killed by whaling from 1839 to 1909; while 742 were killed by whaling from 1900 to 1999, in addition to 372 killed illegally, taken by the U.S.S.R., from 1963 through 1967, primarily in the Gulf of Alaska and Bering Sea, that left the population at an estimated 50 individuals (Allen and Angiss 2011; Encyclopedia of Life 2011).

- Based on commercial fisheries observer program results, fishing mortality and serious injury for the south central Alaska Stock of the northern sea otter is insignificant (i.e., approaches zero mortalities and serious injuries). The mean annual report of subsistence take for the stock from 2002 through 2006 was 346 animals.

- The total fishery mortality and serious injury rate for the Southwest Alaska stock of the northern sea otter is less than 10 animals per year. The mean annual report of subsistence take for the stock from 2002 through 2006 was 91 animals.

In addition to the above, no serious injuries or mortalities due to fisheries or subsistence have been reported for blue whales in Alaska (Carretta et al. 2011).

Climate Change. A concern regarding marine mammals in polar regions is the potential for climate change and associated changes in the extent of sea ice in some arctic and subarctic waters. It is not possible at this time to identify the likelihood, direction, or magnitude of any changes in the environment of Cook Inlet waters due to changes in the climate, or how climate change could impact marine mammals in these waters. The current state of climate change and its impacts on marine mammals would also be further considered in any subsequent environmental reviews for lease sales or other OCS-related activities; therefore, this information is not essential to a reasoned choice among the alternatives presented in this PEIS.

Other Impacting Factors. Marine mammals in the Cook Inlet area may also be impacted by other factors such as UMEs and invasive species. A UME is an unexpected stranding that involves a significant die-off of any marine mammal population, and demands immediate response (NMFS 2011b). Since establishment of the UM program in 1991, there have been 53 formally recognized UMEs in the U.S.; only one UME occurred in Alaska and involved sea otters (NMFS 2011b). Causes have been determined for 25 of the UMEs, and include infections, biotoxins (particularly domoic acid and brevetoxin), human interactions, and malnutrition. The cause of the UME in Alaska is undetermined (NMFS 2011b). Invasive species could affect some marine mammals by disrupting local ecosystems and fisheries of the area of Cook Inlet. For example, introduced northern pike (*Esox lucius*) consume salmon, trout, and whitefish, affecting total populations of these prey species where pike become established. The potential introductions of other invasive species of concern, such as the Chinese mitten crab (*Eriocheir sinensis*), which could eat and/or out compete native invertebrate species, could adversely affect natural communities (McClory and Gotthardt 2008). These and other invasive species could affect the prey base for some marine mammals. As climate change continues to warm Alaskan waters, Alaska may become more susceptible to invasive species (McClory and Gotthardt 2008).

Accidents. Marine mammals could be exposed to oil accidentally released from platforms, pipelines, and vessels in each of the areas offshore Alaska included in the proposed Program (Table 4.4.2-1). Non-OCS sources of oil in Cook Inlet may include the domestic transportation of oil, State oil and gas development, and natural sources such as seeps. Accidental oil releases from OCS activities and other sources could expose marine mammals to oil by body contact or through the inhalation or ingestion of oil or tar deposits. Indirect effects may occur as a result of loss or displacement of prey resources or habitat loss resulting from oil. The magnitude and duration of exposure will be a function of the location, timing, duration, and size of the spill; the proximity of the spill to feeding and other important habitats; the timing and nature of spill containment; and the status of the affected animals.

It is anticipated that most of the small to medium spills would have limited effects on marine mammals due to the relatively small areas likely to incur high concentrations of hydrocarbons and the short period of time during which potentially toxic concentrations would be present. The magnitude of impact would be expected to increase should a spill occur in habitats important to marine mammals or affect a number of individuals from a population listed under the ESA, and, as such, a significant spill would have a high probability of producing significant, population-level cumulative impacts on Cook Inlet beluga whales.

Conclusion. Cumulative impacts on marine mammals in the Cook Inlet Planning Area as a result of future OCS program and ongoing and future non-OCS program activities could be minor to moderate over the next 40 to 50 yr. Non-OCS program activities or phenomena include climate change, natural catastrophes, contaminant releases, vessel traffic, commercial fishing, subsistence harvests, and invasive species. The incremental contribution of routine Program activities to these impacts would be small (see Section 4.4.7.1.2).

Marine mammals may also be adversely affected by exposure to oil that is accidentally released from OCS and non-OCS activities as well as naturally occurring seeps. The cumulative impacts of past, present, and future oil spills on marine mammals would be minor to moderate. The incremental impacts of accidental spills associated with the proposed action on marine mammals would be small to large, depending on the location, timing, duration, and size of the spill; the proximity of the spill to feeding and other important habitats; the timing and nature of spill containment; and the status of the affected animals (see Section 4.4.7.1.2).

Terrestrial Mammals. Terrestrial mammals and their habitats could be affected by a variety of activities associated with the proposed OCS actions (Section 4.4.7.1.2). These activities include the construction and operation of onshore pipelines and aircraft traffic. Impacts on terrestrial mammals may include physical injury or death; behavioral disturbances; lethal or sublethal toxic effects; and loss of reproductive, nursery, feeding, and resting habitats. There are currently no ongoing OCS activities in the Cook Inlet; thus all OCS development and any associated impacts on terrestrial wildlife in the Cook Inlet Planning Area would result from the proposed action and future actions.

Impacts from OCS pipeline construction and operation could include the injury or death of smaller mammals (such as mice and voles) and the disturbance and displacement of individuals or groups of larger species (such as deer and bear). Individuals most affected by these impacts would be those in the immediate vicinity of the pipeline. Because of the limited areal extent of new facilities under the proposed action, disturbance (primarily behavioral in nature) of most of these species during construction would be largely temporary, and no long-term population-level effects would be expected. However, careful siting of pipelines to avoid important habitats could minimize the potential impacts.

Under the proposed action, vehicle traffic associated with normal construction, operation, and maintenance of the onshore pipelines could disturb wildlife. Vehicle traffic could disturb wildlife foraging along pipelines or access roads, causing affected wildlife to temporarily stop normal activities (e.g., foraging, resting) or leave the area, while collision with vehicles could injure or kill some individuals. Because vehicle traffic would be infrequent, vehicle-related impacts associated with the proposed action would be minimal. In the Cook Inlet, vehicle traffic along any new access roads would be very light and infrequent and, thus, not expected to affect more than a few individuals or result in population-level impacts on wildlife.

In the Cook Inlet area, terrestrial mammals are mostly habituated to aircraft due to year-round military and civilian aircraft operations. Only up to three weekly helicopter trips are projected in the Cook Inlet Planning Area under the proposed action. Impacts on terrestrial mammals from helicopter overflights would be behavioral in nature, primarily resulting in short-term disturbance in normal activities, and would not result in population-level effects.

Terrestrial mammals could also be affected by a number of non-OCS activities, including oil and gas exploration and development in State waters, and coastal and community development. Many of the effects of these activities on terrestrial mammals would be similar in nature to those resulting from OCS-related activities, namely behavioral disturbance, habitat disturbance, and injury or mortality. The State of Alaska has made leases of State waters available along the northern portion of Cook Inlet (above Homer) since the 1950s. Impacts on terrestrial mammals that could result with oil and gas lease sales in State waters may exceed potential impacts that could occur under the OCS proposed action because of the greater extent of offshore and onshore development. In addition, much of the infrastructure is over 40 yr old, and many of the pipes are aging and corroded (NMFS 2008c). Terrestrial mammals may be affected as a result of coastal and community development. Such development may result in the loss of habitat and the permanent displacement of some species from the developing areas. Implementation of the proposed action could increase coastal and community development, indirectly adding to impacts on terrestrial mammals and their habitats.

Terrestrial wildlife could be adversely affected by the accidental release of oil from an onshore pipeline, or by offshore spills contacting beaches and shorelines utilized by terrestrial mammals (such as Sitka black-tailed deer or brown bear). Impacts on terrestrial mammals from an oil spill would depend on such factors as the time of year, volume of the spill, type and extent of habitat affected, food resources used by the species, and home range or density of the wildlife species. Spills contacting high-use areas could locally affect a relatively large number of animals. It is anticipated that most of the spills would have limited effects on terrestrial mammals, due to the relatively small, mostly offshore, areas likely to be directly exposed to the spills and due to the small number and size of spills projected for the proposed action and for any future OCS oil and gas developments.

State oil and gas development poses a major potential for accidental oil releases in the Cook Inlet Planning Area. Because of the much greater level of oil and gas development in State waters and the aging infrastructure associated with many of these developments, accidental spills associated with the proposed OCS action could contribute relatively little to the overall potential exposure of terrestrial mammals to accidental oil releases in Cook Inlet.

Conclusion. Cumulative impacts on terrestrial mammals in the Cook Inlet Planning Area as a result of future OCS program and ongoing and future non-OCS activities could be minor to moderate over the next 40 to 50 yr. Non-OCS activities or phenomena that may affect populations of terrestrial mammals include climate change, natural catastrophes, contaminant releases, and vehicle traffic. The incremental contribution of routine Program activities to these impacts would be small (see Section 4.4.7.1.2).

Terrestrial mammals may also be adversely affected by exposure to oil that is accidentally released from OCS and non-OCS operations. The cumulative impacts of past, present, and future oil spills on terrestrial mammals would be minor to moderate. The incremental impacts of accidental spills associated with the proposed action on terrestrial mammals would be small to large, depending on the location, timing, duration, and size of the spill; the proximity of the spill to feeding and other important habitats; the timing and nature of spill containment; and the status of the affected animals (see Section 4.4.7.1.2).

4.6.4.2.2 Marine and Coastal Birds. Section 4.4.7.2.2 discusses impacts on marine and coastal birds in Cook Inlet resulting from the proposed action (OCS program activities from 2012 to 2017). Cumulative impacts on marine and coastal birds result from the incremental impacts of the proposed action when added to impacts from existing and reasonably foreseeable future OCS program activities (that are not part of the proposed action) and other non-OCS program activities. Table 4.6.1-2 presents the exploration and development scenario for the Cook Inlet cumulative case (encompassing the proposed action and other OCS program activities) over the next 40 yr. A number of OCS program activities could affect Cook Inlet marine or terrestrial birds or their habitats; these include offshore exploration, construction of offshore platforms and pipelines, construction of onshore pipeline landfalls and pipelines, operations of offshore and onshore facilities, and OCS-related marine vessel and aircraft traffic. Potential impacts on marine and coastal birds from OCS program activities include injury or mortality from collisions with platforms, vessels, and aircraft; lethal and sublethal exposure to operational discharges; injury or mortality from the ingestion of trash or debris from OCS vessels and platforms; loss or degradation of habitat due to construction; and behavioral disturbance due to the presence of, and noise generated by, equipment and human activity.

Non-OCS program activities affecting marine and coastal birds in Cook Inlet (both inside and outside of the Planning Area proper) include dredging and marine disposal; coastal and community development; onshore and offshore construction and operations of facilities associated with State oil and gas development and other industrial complexes (e.g., at Nikiski); commercial and recreational boating; and small aircraft traffic. Potential impacts on marine and coastal birds from these activities are similar to those under the OCS program and include injury or mortality of birds from collisions with platforms associated with State oil and gas development and other onshore and offshore structures (e.g., radio, television, or cell phone towers), onshore industrial, commercial, and residential development; exposure to discharges from permitted point sources such as sewage treatment discharges and nonpoint sources such as urban runoff, or accidental releases (e.g., oil spills), as described in Section 4.6.2.1.2 and Table 4.6.2-3; exposure to emissions from various onshore and offshore sources (e.g., power generating stations, refineries, and marine vessels), as described in Section 4.6.2.1.2; ingestion of trash or debris; loss or degradation of habitat due to construction and operations activities; and behavioral disturbance due to the presence of, and noise generated by, equipment and human activity. Other trends such as extensive melting of glaciers (and increasing river discharges) and increased precipitation brought on by global climate change are also expected to adversely affect marine and coastal birds over the next 40 yr.

Injury or Mortality from Collisions. Under the cumulative scenario, annual collision injury or mortality in Cook Inlet could increase in the near term as platforms are built under the proposed action. Such impacts would be minor relative to those that currently involve non-OCS structures. Over time, the injury or mortality impacts from collisions could decrease as oil and gas production in the inlet declines.

Exposure to Wastewater Discharges and Air Emissions. The discharge of operational wastes and air emissions from current non-OCS related vessel traffic and platform operations in Cook Inlet is strongly regulated and would continue to be so regulated over the next 40 yr. However, such wastes and emissions would still expose marine and coastal birds to potentially toxic materials or to solid debris that could be ingested or result in entanglement. These facilities and activities include sewage treatment plants, industrial manufacturing or processing facilities, electric generating plants, dredging and marine disposal, and vessel traffic (e.g., cargo and tanker ships, cruise ships, commercial fishing vessels, and recreational vessels). Operational wastewater discharges and air emissions associated with the proposed action would contribute to the overall cumulative risk of toxic exposure and debris ingestion or entanglement of existing non-OCS wastewater discharges and air emissions in the inlet, but the incremental increase in impact is expected to be small relative to these other activities.

Under the proposed action, marine and coastal birds could be exposed to oil accidentally released from platforms, pipelines, and vessels, and would be most susceptible to adverse impacts from spills occurring in coastal areas and affecting feeding and nesting areas. Most of the oil released to Cook Inlet is from commercial and recreational vessels (Section 4.6.2.2.1). Oil releases from all sources may expose marine and coastal birds via direct contact or through the inhalation or ingestion of oil or tar deposits (see Section 4.4.7.2.1).

Marine and coastal birds may become entangled in, or ingest, floating, submerged, and beached debris (Heneman and the Center for Environmental Education 1988; Ryan 1987, 1990). Entanglement may result in strangulation, injury or loss of limbs, entrapment, or the prevention or hindrance of the ability to fly or swim; all of these effects may be considered lethal. Ingestion of debris may irritate, block, or perforate the digestive tract, suppress appetite, impair digestion of food, reduce growth, or release toxic chemicals (Fry et al. 1985; Dickerman and Goelet 1987; Ryan 1988; Derraik 2002). Because the discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by BOEM (30 CFR 250.40) and the USCG

(MARPOL, Annex V, Public Law 100 220 [101 Statute 1458]), entanglement in or ingestion of OCS-related trash and debris by marine and coastal birds would not be expected under normal operations.

Oil Spills and Cleanup Activities. Oil spills under the cumulative scenario are shown in Table 4.6.1-3. No more than one large spill (between 1,000 and 5,300 bbl from either a platform or a pipeline) and 18 small spills (less than 1,000 bbl) would be expected as a result of the Cook Inlet Planning Area OCS program over the next 40 yr. Previous modeling of similar-sized oil spills in Cook Inlet indicates that land segments with the highest chance of contact with an offshore platform or pipeline spill are generally along the western shore of lower Cook Inlet in Kamishak Bay and Shelikof Strait (MMS 2002b). A large number of seabird colonies occur in these areas (USGS undated) and could be affected by oil spills reaching these areas.

Nesting and brood-rearing seabirds, waterfowl, and a few shorebirds, as well as the many species of waterfowl/loons, seabirds, and shorebirds that molt, stage, migrate through, or overwinter in large numbers in south central Alaska would be vulnerable to the potential disturbance resulting from elevated vessel and aircraft activity associated with cleanup of an oil spill. For all species, the degree of impact depends heavily on the location of the spill and cleanup response and its timing with critical natural behaviors (e.g., breeding, molting, feeding). Survival and fitness of individuals may be affected, but this infrequent disturbance is not expected to result in significant population losses.

As a result of response to the *EVOS* of 1989, and subsequent study of its effect on regional bird populations, there exists an extensive literature concerning the effects of a large oil spill in the South Alaska region (e.g., Agler and Kendall 1997; Boersma et al. 1995; Day et al. 1997a,b; *EVOS* Trustee Council 2004; Irons et al. 2000; Klowsiewski and Laing 1994; Lanctot et al. 1999; Murphy et al. 1997; Piatt and Ford 1996; Piatt et al. 1990; Rosenberg and Petrula 1998; van Vliet and McAllister 1994; Wiens et al. 2001). An estimated 100,000 to 300,000 marine birds died as a result of this spill (Piatt and Ford 1996), which occurred in March, when substantial numbers of overwintering birds were present in Prince William Sound and downstream to the west, and large numbers of seabirds were aggregating near colonies from Prince William Sound to the western Gulf of Alaska, prior to the breeding season. Although surveys and other studies carried out every year since the spill occurred indicate that populations of some marine bird species have recovered from their initial losses (e.g., common murre, black oystercatcher [*EVOS* Trustee Council 2004]), or are recovering (e.g., marbled murrelet), several species have shown little or no recovery (e.g., common loon, three cormorant species, harlequin duck, pigeon guillemot) or the recovery status is unknown (Kittlitz's murrelet). Although the effect on a bird population that is observed immediately following a spill to have suffered a large mortality is quite obvious, without frequent monitoring of each species following a spill it usually is difficult to be certain whether changes in measured population parameters are the result of lingering spill effects or natural variations that generally occur in all populations over time (Wiens and Parker 1995; Wiens 1996; Wiens et al. 2001). For example, forage fish populations utilized by many marine bird species may have experienced lingering spill effects of severe mortality or interruption of the annual cycle, in turn affecting food availability following the spill and thus influencing the effect of the spill on these bird populations or their recovery from it.

In addition to the birds occupying the open water of bays and inlets, shorebirds numbering in the tens to hundreds of thousands are at risk of oiling where they occupy various shore habitats during their spring passage to northern breeding areas (Gill and Tibbitts 1999). Particularly large numbers would be at risk on the southern Redoubt Bay, Fox River Delta, northern Montague Island, Kachemak Bay, and Copper River Delta, but substantial numbers may be at risk along most shorelines of the region during this season (Gill et al. 1994; Gill and Senner 1996; Gill and Tibbitts 1999; Alaska Shorebird Working Group 2000). Based on the experience of the *Exxon Valdez* oil spill, where studies extending 15 yr after the event continue to find oil or effects on organisms from exposure to oil, it is highly probable that not all oil spilled would be removed from the environment. Because substantial numbers of birds are present year round in the marine environment of south central Alaska, major effects are expected to result from a spill at any time of year.

Loss or Degradation of Habitat. Marine and coastal birds could be affected by platform construction and removal activities, and pipeline trenching, which could disrupt behaviors of nearby birds. Platforms constructed under the proposed action would increase the number of offshore platforms present in the inlet by three, and up to 241 km (150 mi) of new offshore pipeline could be constructed. Platform emplacement could disturb birds temporarily; pipeline trenching may also affect birds in nearshore coastal habitats if it occurs in or near foraging, overwintering, or staging areas, or near seabird colonies. About 169 km (105 mi) of new pipeline and one pipeline landfall may be constructed under the proposed action. The pipelines would likely result in the short- and/or long-term disturbance of a small amount of habitat along the pipeline routes.

While habitat impacts from the construction and operations of onshore facilities could be long term in nature, the areas disturbed would be largely limited to the immediate vicinity of the pipelines and represent a very small portion of habitat available in the Cook Inlet Planning Area. Siting new pipelines and facilities away from coastal areas would reduce the amount of marine or coastal bird habitat that could be affected. Potential habitat impacts could be further reduced by locating the new pipelines within existing utility or transportation rights-of-way, and by locating the new pipeline landfalls away from active colony sites or coastal staging areas of migratory birds. Because there are relatively few nesting colonies in Cook Inlet of Anchor Point (USGS undated), only a few seabird colonies could be affected by onshore construction activities in this area. The disturbance of birds in these colonies could be reduced or avoided by siting new pipelines and facilities away from colony sites, and by scheduling construction activities to avoid nesting periods. Overall, onshore construction activities are expected to affect only a relatively small number of birds and not result in population-level effects.

Only small numbers of nesting birds are likely to be displaced away from the vicinity of onshore pipeline corridors (a few hundred meters) by construction activity and support vessel traffic in the Cook Inlet Planning Area. Onshore habitat alteration is likely to be relatively minor in most of the development support centers. Offshore, disturbance of bottom habitats by platform placement may disrupt small areas of potential diving duck and seabird foraging habitat, but these small removals would be inconsequential.

Construction of landfalls, onshore pads, and roads is not expected to affect the relatively low numbers of loons, waterfowl, and shorebirds nesting in south central Alaska adjacent to likely oil development areas, particularly because construction may take place mainly during the winter season. Like loons and waterfowl that do not migrate out of State, seabirds disperse into nearshore or offshore waters in winter, away from likely development activity.

Disturbance Due to Noise. Noise and human activities (such as normal maintenance) could disturb birds arriving in the area during spring migration and later in the year during nesting, fall molting, and staging periods, causing them to avoid the area and nearby habitats. Because of the small number of new platforms (no more than three), the disturbance of birds in offshore waters by operational noise and human activity would likely be limited to the individuals that might be present around a platform. Potential impacts on colonies could be avoided or mitigated by siting platforms and onshore facilities away from colony sites. Noise from air guns and disturbance from survey vessel traffic could displace foraging seabirds in offshore waters, especially if exploration occurs in high seabird density areas such as the open waters adjacent to the Stevenson and Kennedy Entrances to Cook Inlet and off of the northwestern coast of Kodiak Island (MMS 2003b).

Nesting, staging, migrant, or overwintering loons, waterfowl, and seabirds occurring in areas closer to primary Cook Inlet support facilities on the Kenai Peninsula and vicinity, for example, are more likely to be overflown by aircraft than those in more distant lease areas. This is due to the convergence of routes from offshore sites to the support area, and is expected to be the case in the Gulf of Alaska, Kodiak Island, and Alaska Peninsula areas, where there are few communities capable of adequate support activity. Effects from noise disturbance would be greater in areas where higher concentrations of birds occurred and less where birds were more dispersed and in fewer numbers. The degree of effect is also dependent on whether birds are engaged in critical aspects of their seasonal activity, as well as the intensity and type of disturbance (aircraft overflights, seismic surveys, vessel traffic). In addition, several open-water areas in the vicinity of Kachemak and Kamishak Bays represent important wintering areas (December–April) for the threatened Steller eider (USFWS unpublished data), and disturbance during the winter in these areas has a greater potential to affect this listed species.

Effects on ESA-Listed Species in South Central Alaska. The cumulative effects of OCS and non-OCS program activities on the endangered short-tailed albatross, threatened Steller's eider, formerly threatened Aleutian Canada goose, and proposed Kittlitz's murrelet are expected to be similar to those noted for nonlisted species over the next 40 yr. Continued compliance with ESA regulations and coordination with the USFWS would ensure that lease-specific OCS operations would be conducted in a manner likely to avoid or greatly minimize the potential for affecting these species.

Short-tailed albatrosses occur in waters of south central Alaska, and particularly in continental shelf waters, which places them at considerable oil-spill risk. Although their small population is spread throughout the North Pacific Ocean and few would be expected to be present during any given oil-spill event, the species has a high oil vulnerability index (King and Sanger 1979), and the loss of a few individuals could be detrimental to their small population size (MM 2003b). Because Aleutian Canada geese are not known to occupy marine waters during migration to any great extent, their risk of oil-spill contact in that habitat is considered low. It is unlikely that infrastructure development would occur near the two nesting areas, thus avoiding disturbance and onshore spills that could contact the species.

Factors such as disturbance due to increased boat traffic related to wildlife cruises and offshore oil and gas development, impacts related to oil spills, and a high oil vulnerability index (King and Sanger 1979) make the Kittlitz's murrelet particularly vulnerable to population declines. Although impacts of oil spills have been documented (van Vliet and McAllister 1994; Carter and Kuletz 1995), little is known about potential impacts of disturbance on courtship behavior, foraging ecology and feeding, or energetics (Day et al. 1999). The relatively small population size, limited distribution, apparent periodic breeding failures and low reproductive potential (Beissinger 1995), in conjunction with the above factors, has led to Kittlitz's status as a candidate species (priority 5; 50 CFR 17) under the ESA.

Steller's eiders occupying nearshore areas of the eastern Aleutian Islands to Cook Inlet from late fall to early spring could be exposed to the disturbance of air and vessel traffic, seismic surveys, oil-spill cleanup, and pipeline construction. Such activities would be scattered in occurrence, as are the flocks of eiders, or confined to specific corridors in the case of aircraft and vessels, which the flocks are likely to avoid. In general, interactions are expected to result in short-term and localized displacement. Pipeline construction is expected to result in the loss of a small amount of eider nearshore bottom-feeding habitat. Steller's eiders could be killed or injured as a result of collisions with platforms. This is most likely during migration; when visual conditions are reduced, such as in foggy weather; and during movement among habitats on wintering grounds. Because they typically are present throughout the winter, they are at risk of oil-spill contact, particularly in the northern portion of the region including Cook Inlet, where development may first occur, and potentially in the Kodiak Archipelago. However, mortality from a spill is difficult to estimate because of the substantial variation in between-year, seasonal, or even weekly presence and distribution of eiders and uncertainties of where an oil spill might occur. Based on USFWS assumptions, there is greater potential for the majority of individuals affected by factors discussed above to be from the Russian breeding population rather than the ESA-listed Alaska breeding population.

Kittlitz's murrelets typically show a very patchy distribution and are generally found in the vicinity of glaciated fjords of Cook Inlet, Prince William Sound, and southeast Alaska (Kendall and Agler 1998; Dat et al. 1999; Kuletz et al. 2003a). Exploration and development activities are expected to be separated in time, so exposure to disturbing factors such as aircraft and vessel traffic, seismic surveys, and pipeline construction could be infrequent and localized in areas where this species concentrates. There is a greater potential for effects if disturbance occurs in areas where murrelets concentrate and displacement becomes a possibility. In addition, the potential impacts from oil spills vary depending on the timing and location of the spill. For example, oil spills in College or Harrison Fjords during peak breeding or post-breeding would have larger impacts and could cause population-level effects, especially if birds come in contact with spilled oil or larger numbers of breeding age females are impacted. A large spill is likely to spread over a sufficiently large area to contact one or more bays where they may be concentrated during the summer breeding season, or offshore areas where they may be wintering in the Gulf of Alaska. For example, the *EVOS* spill resulted in the loss of an estimated 500 to

1,000 individuals, probably a substantial proportion of the world population, and certainly a major effect on this species.

Conclusion. Marine and coastal birds in Cook Inlet, including those that are ESA-listed, could be adversely affected by activities associated with the proposed action, as well as those associated with future OCS and non-OCS program activities. Potential impacts include injury or mortality of birds from collisions with platforms associated with OCS and State oil and gas development and other onshore and offshore structures (e.g., radio, television, or cell phone towers), onshore industrial, commercial, and residential development; exposure to discharges from permitted point sources such as sewage treatment discharges and nonpoint sources such as urban runoff, or accidental releases (e.g., oil spills); exposure to emissions from various onshore and offshore sources; ingestion of trash or debris; loss or degradation of habitat due to construction and operations activities; and behavioral disturbance due to the presence of, and noise generated by, equipment and human activity. Other trends such as extensive melting of glaciers (and increasing river discharges) and increased precipitation brought on by global climate change are also expected to adversely affect marine and coastal birds over the next 40 to 50 yr. While the cumulative impact of all OCS and non-OCS activities in Cook Inlet could be minor to moderate, the incremental impact due to routine Program activities would be small (see Section 4.4.7.2.2). Compliance with ESA regulations and coordination with the USFWS would ensure that lease-specific OCS operations would be conducted in a manner that is likely to avoid or to greatly minimize the potential for affecting these species.

Marine and coastal birds may also be adversely affected by exposure to oil (via direct contact or through the inhalation or ingestion of oil or tar deposits) that is accidentally released from OCS and non-OCS activities, especially near coastal areas and affecting feeding and nesting areas. The incremental impacts of accidental spills associated with the proposed action on marine and coastal birds would be small to large, depending on the location, timing, duration, and size of the spill; the proximity of the spill to feeding and nesting areas; the timing and nature of spill containment; and the status of the affected birds (see Section 4.4.7.2.2).

Whether net cumulative impacts are minor or moderate depends on the nature and duration of activities that reduce bird survival and productivity. Losses would be limited in areas occupied by scattered flocks during relatively brief staging and migration periods or scattered nest sites during the brief nesting season; however, in cases for which exposure to localized disturbance is greater, impacts have the potential to rise to the population level.

4.6.4.2.3 Fish. This section evaluates the cumulative effects of the proposed action, future OCS activities, and non-OCS activities on populations of fishes in Cook Inlet that could occur during the life of the Program. The primary routine OCS activities in the Cook Inlet Planning Area that could result in impacts on fish include seismic surveys, drilling, platform and pipeline placement; releases of permitted discharges from wells; and removal of existing structures. Potential environmental impacts associated with the building and operation of OCS facilities such as platforms and pipelines would increase in conjunction with the increased number of wells. The impacts of routine activities (exploration and site development, production, and decommissioning) on fish communities are discussed in detail in

Section 4.4.7.3.2. Overall, routine activities represent up to a minor disturbance, primarily affecting demersal fishes, with the severity of the impacts generally decreasing dramatically with distance from bottom-disturbing activities.

In the Cook Inlet Planning Area, up to three platforms would be constructed, all of which would result from the proposed action. The addition of new platforms may act as FADs that would attract rockfish and cod-like fishes in Cook Inlet. While some platforms may be allowed to remain as artificial reefs, removal of platforms would reduce available substrate and structures for these fish and some of their prey species. Some fish would be killed in the process of these platform removals although the chance of mortality would be greatly reduced by the fact that explosives would not be used in removal.

Oil and gas exploration and development in State waters could also contribute to cumulative effects on fishery resources in the Cook Inlet. Drilling of wells in State waters could also require construction of platforms and pipelines in waters of Alaska. The effects on fish would be similar to those described above for OCS oil and gas programs (Section 4.4.7.3.2). Other non-OCS activities that could impact fish communities include land use practices, point and non-point source pollution, logging, dredging and disposal of dredging spoils in OCS waters, anchoring, and commercial or sportfishing activities, and commercial shipping (including imported oil). Many of these activities would result in bottom disturbance that would affect bottom-dwelling fishes as well as their food sources in a manner similar to those described for OCS activities (Section 4.4.7.3.2).

Logging could also degrade riverine habitats that are important reproductive and juvenile habitat for migratory fish species. Erosion from areas undergoing commercial logging could increase the silt load in streams and rivers, which could reduce levels of invertebrate prey species and adversely affect spawning success and egg survival. The introduction of fine sediments into spawning gravels may render these habitats unsuitable for salmon spawning. Logging could also remove riparian canopies along some streams, which could increase solar heating of freshwater habitats. Downed timber could physically block salmon migrations. Because of past damage inflicted by commercial logging, improved forestry practices have been initiated, and timber harvests have been curtailed. Continued implementation of effective forest management techniques should help mitigate the adverse effects of logging in the future. Cumulative impacts on migratory species could also occur as a result of activities that obstruct fish movement in marine environments during migration periods.

Commercial fishing practices that are indiscriminate, such as trawling and pots, are responsible for significant amounts of bycatch that can injure or kill juveniles of many fish species (Cooke and Cowx 2006). These types of fishing practices could damage future year classes, reduce available prey species, and damage benthic habitat for many Cook Inlet fish resources. A wide variety of methods are used to target numerous species of fishes and shellfishes, including longlines, seines, setnets, trawls, and traps. Some fisheries target particular fish species returning to their natal stream or river, while other fisheries take place in pelagic waters and target mixed stocks of fishes or shellfishes.

Commercial fishing practices that are indiscriminate, such as trawling and pots, are responsible for significant amounts of bycatch that can injure or kill juveniles of many fish species. These types of fishing practices could damage future year classes, reduce available prey species, and damage benthic habitat for many Cook Inlet fish resources. A wide variety of methods are used to target numerous species of fishes and shellfishes, including long lines, seines, setnets, trawls, and traps. Some fisheries target particular fish species returning to their natal stream or river, while other fisheries take place in pelagic waters and target mixed stocks of fishes or shellfishes.

As a consequence of the pressure commercial fishing places on fishery resources, appropriate management is required to reduce the potential for depletion of stocks due to overharvesting. Fisheries in the Cook Inlet Planning Area are managed by State (Alaska Department of Fish and Game) and Federal (North Pacific Fishery Management Council of the National Marine Fisheries Service) agencies. Even with management, the possibility of overfishing still exists. Occasionally fisheries are closed when stocks are considered insufficient to support harvesting, and will sometimes remain closed for multiple seasons before stocks are deemed sufficient.

Although the magnitude of harvests is considerably smaller than for commercial fisheries (Fall et al. 2009), sportfishing also contributes to cumulative effects on the abundance of some fishery resources. Recreational fisheries have a potential to result in overharvest of managed species over the life of the Program. Recreational fishing is subject to harvest limits that reduce the potential for overfishing and recreational fishing methods are less destructive of EFH compared to commercial fisheries.

Subsistence fishing may also contribute to the cumulative effects on the abundance of some fishery resources. Alaska State law defines subsistence as the “noncommercial customary and traditional uses” of fish and wildlife. Subsistence fishing is subject to harvest limits that reduce the potential for overfishing. Also, much of Cook Inlet is defined as a nonsubsistence area and subsistence fishing is therefore not authorized. Consequently, subsistence fishing makes a relatively minor contribution to the reduction in fish stocks compared to commercial fishing (Fall et al. 2009).

Another source of cumulative impacts to fishery resources is the “personal use” fishery which is a legally defined as “the taking, fishing for, or possession of finfish, shellfish, or other fishery resources, by Alaska residents for personal use and not for sale or barter, with gill or dip net, seine, fish wheel, long line, or other means defined by the Board of Fisheries.” In the Cook Inlet Planning Area, there are personal use fisheries for salmon, herring, and eulachon. Personal use fisheries are subject to harvest limits that reduce the potential for overfishing. Like subsistence fishing, the personal use fishery is a relatively minor contributor to the reduction in fish stocks compared to commercial fishing.

Climate change may affect fish communities in the Cook Inlet Planning Area. Climate would only be one of several factors that regulate fish abundance and distribution. Many fish populations are already subject to stresses, and global climate change may aggravate the impacts of ongoing and future commercial fishing and human use of the coastal zone. Fish respond directly to climate fluctuations, as well as to changes in their biological environment including predators, prey, species interactions, disease, and fishing pressure. Projected changes in hydrology and water temperatures, salinity, and currents could affect the growth, survival, reproduction, and spatial distribution of marine fish species and of the prey, competitors, and predators that influence the dynamics of these species (Watson et al. 1998). Changes in primary production levels in the ocean because of climate change may affect fish stock productivity.

Climate change could potentially affect large-scale ecological processes. Important coastal habitats could be reduced or eliminated by rising sea levels and increased storm damage. For species spawning in low-lying areas or the intertidal zone, or species using coastal estuaries as nursery grounds, rising sea levels could eliminate spawning or juvenile habitat. Anadromous fish and species using nearshore marshes are likely to be most affected. In addition, the current trend of steadily increasing sea surface temperature may favor higher trophic-level fish by increasing their local productivity or by promoting the expansion of large temperate predators into Alaskan waters (Litzow 2006). The establishment of temperate species and non-native fish introduced by human activities could come at the expense of native species, particularly forage fish like herring and capelin. However, given the complexity and compensatory mechanisms of the ecosystem, predictions about the indirect effects of climate change on specific fish species are subject to great uncertainty.

Oil spills could result from OCS and non-OCS activities. The total number of oil spills and the extent of affected areas would likely increase under the proposed action in conjunction with increased levels of petroleum exploration and production (Table 4.6.2-3). Non-OCS activities, such as oil and gas development in State waters, domestic transportation of oil or refined petroleum products, and commercial shipping, may also result in accidental spills that could potentially impact fish resources within the Cook Inlet Planning Area. While effects on fishery resources would depend on the timing, location, and magnitude of specific oil spills, it is anticipated that most small to medium spills that occur in OCS waters would have limited effects on fishery resources due to the relatively small areas likely to be exposed to high concentrations of hydrocarbons and the short period of time during which potentially toxic concentrations would be present. Most adult fish in marine environments are highly mobile and may avoid high concentrations of hydrocarbons, although they may be subject to sublethal exposures. However, eggs and larvae as well as small obligate benthic species do not have the ability to avoid spills and may therefore suffer lethal or sublethal effects. Oil from a catastrophic spill that reaches shallower, nearshore areas of these planning areas has the potential to be of greatest significance to fish communities. Impacts from such spills could result in long-term, population level impacts on fish communities. The potential impacts of OCS oil spills on fish communities in Cook Inlet are discussed in detail in Section 4.4.7.3.2.

Oil reaching salmon spawning areas, nursery areas, or migration routes has the greatest potential to reduce salmon stocks. However, because of the limited area affected by oil spills relative to the wide pelagic distribution and highly mobile migratory patterns of salmonids, it is anticipated that most impacts would be limited to small fractions of exposed salmon populations. Oil spills occurring at constrictions in migration routes would have an increased potential for adversely affecting salmon. However, the weathering and dispersal of the spilled oil would limit the length of time that an area would be affected. Pacific salmon are also able to detect and avoid oil spills in marine waters (Weber et al. 1981), which would help to reduce the potential for contact. Aggregations of salmon in marine waters typically consist of mixed stocks, so even in the unlikely event of contact with an oil spill, it is anticipated that only a small fraction of any unique spawning population would be adversely affected.

Adverse effects of oil spills on groundfishes of southern Alaska would also be a function of spill magnitude, location, and timing. Adult groundfishes are primarily demersal and would generally be subjected only to the insoluble oil and water-soluble fractions of oil that reach deeper strata. Insoluble oil fractions would sink to the bottom and be distributed diffusely as tar balls over a wide area, and would be unlikely to produce noticeable reductions in the overall numbers of adult fishes. Egg and larval stages would be at a greater risk of exposure to oil spills because spawning aggregations of many groundfish species (e.g., walleye pollock) produce pelagic eggs that could come into contact with surface oil slicks. Herring are also potentially susceptible to oil spills because they spawn in nearshore waters for protracted periods of time.

Conclusion. Cumulative impacts on fish communities in the Cook Inlet Planning Area could result from OCS and non-OCS activities. Overall, routine OCS activities represent up to a minor disturbance, with the severity of the impacts generally decreasing dramatically with distance from bottom-disturbing activities. In addition to routine OCS activities, non-OCS actions including oil and gas development in State waters, sediment dredging and disposal, logging, anchoring, fishing/trawling, commercial shipping, and pollutant inputs from point and non-point sources could also adversely affect fish populations. Many of these activities would affect fish at various life stages as well as their food sources in a manner similar to OCS activities. Fish could also be affected by the environmental changes predicted to result from climate change. The proposed action is expected to contribute only a small increment to the potential for overall cumulative effects on fish resources because of existing regulations, the limited timeframe over which most individual activities would occur, and the small proportion of available habitats that would be affected during a given period (see Section 4.4.7.3.2). Therefore, it is anticipated that the cumulative effects of OCS and non-OCS activities on fish species in the Cook Inlet Planning Areas would be similar to the effects of non-OCS activities alone.

The magnitude and severity of potential effects to fish resources from oil spills would be a function of the location, timing, duration, and size of spills; the proximity of spills to particular fish habitats; and the timing and nature of spill containment and cleanup activities. Small spills, whether from OCS or non-OCS sources, are unlikely to have overall population-level effects on fish resources. However, oil from catastrophic spills that contacted shallow nearshore areas of these planning areas has the potential to be of greatest significance to fish communities. Such spills could result in long-term, population-level impacts on fish communities (see Section 4.4.7.3.2).

4.6.4.2.4 Invertebrates and Lower Trophic Levels. This section evaluates the cumulative effects of the proposed action, and any past, present, and reasonably foreseeable future actions from OCS activities, and non-OCS activities on invertebrates in the Cook Inlet Planning Area that could occur during the life of the Program. The primary routine OCS activities that could result in impacts on invertebrates include seismic surveys, drilling, platform and pipeline placement; releases of permitted discharges from wells; and removal of existing structures. Potential environmental impacts associated with the building and operation of OCS facilities such as platforms and pipelines would increase in conjunction with the increased number of wells. The impacts of routine activities (exploration and site development, production and decommissioning) on invertebrate communities are discussed in detail in Section 4.4.7.5.2. Overall, routine activities represent up to a moderate disturbance, primarily affecting benthic infaunal invertebrates, with the severity of the impacts generally decreasing dramatically with distance from bottom-disturbing activities.

Up to three platforms could be constructed over the life of the Program, all of which would result from the proposed action, would allow the colonization of invertebrates requiring hard substrate. While some platforms may be allowed to remain as artificial reefs, removal of platforms will reduce available substrate and structures for invertebrates and injure or kill them during removal.

Oil and gas exploration and development in State waters could also contribute to cumulative effects on invertebrates in the Cook Inlet Planning Area. Drilling of wells in State waters could also require construction of platforms and pipelines in waters of Alaska. The effects on invertebrates would be similar to those described above for OCS oil and gas programs (Section 4.4.7.5.2). Other non-OCS activities that could impact invertebrate communities include land use practices, point and non-point source pollution, logging, dredging and disposal of dredging spoils in OCS waters, anchoring, commercial or sportfishing activities, and commercial shipping (including shipping of imported oil). Many of these activities would affect bottom-dwelling invertebrates at various life stages as well as their food sources in a manner similar to OCS bottom-disturbing activities (Section 4.4.7.5.2). Other non-OCS activities generating pollution and noise may contribute to general habitat degradation (Section 4.6.3.2.2).

Commercial fishing practices that are indiscriminate, such as trawling and pots, are responsible for significant amounts of bycatch that can injure or kill juveniles of many invertebrate species. These types of fishing practices could also damage benthic habitat for many Cook Inlet invertebrate resources.

Physical and chemical changes to invertebrate habitat resulting from climate change could alter the existing distribution, composition, and abundance of invertebrates in Cook Inlet, since physical and chemical parameters are the primary influence on invertebrate communities. For example, the increase in seawater temperature may facilitate a northward expansion of subarctic and temperate invertebrate species. Rising seawater temperatures are also expected to decrease winter ice extent and duration. Currently, ice formation primarily occurs on the western side of Cook Inlet, and changes in benthic invertebrate community structure could result from the reduction in ice scour. In addition, in heavily river influenced systems like Cook Inlet, the predicted hydrologic alterations associated with climate change can rapidly alter existing invertebrate communities in the water column and benthos if the new chemical conditions are not within the physiological tolerance of the existing communities. Another significant source of physiological stress is the expected increase in ocean acidification. Crustaceans, echinoderms, foraminiferans, and mollusks could have greater difficulty in forming shells, which could result in a reduction in their fitness, abundance, and distribution (Fabry et al. 2008).

Oil spills could result from OCS and non-OCS activities. The total number of oil spills and the extent of affected areas would likely increase under the proposed action in conjunction with increased levels of petroleum exploration and production (Table 4.6.1-3). Non-OCS activities, such as oil and gas development in State waters, domestic transportation of oil or refined petroleum products, and commercial shipping, may also result in accidental spills that could potentially impact invertebrate resources within the Cook Inlet Planning Area. While effects on invertebrate resources would depend on the timing, location, and magnitude of specific oil spills, it is anticipated that most small to medium spills that occur in OCS waters would have limited effects due to the relatively small areas likely to be exposed to high concentrations of hydrocarbons and the short period of time during which potentially toxic concentrations would be present. Large water column and benthic invertebrates are mobile and therefore have the potential to avoid high concentrations of hydrocarbons although they may be subject to sublethal exposures. However, zooplankton and infauna do not typically have the ability to avoid spills and may therefore suffer lethal or sublethal effects. Oil from catastrophic spills that reaches shallower, nearshore areas of the Cook Inlet Planning Area has the potential to be of greatest significance to invertebrate communities. Impacts from such spills could result in long-term, population-level impacts on intertidal invertebrate communities. The potential impacts of OCS oil spills on invertebrate communities in Cook Inlet are discussed in detail in Section 4.4.7.5.2.

Commercial shellfish stocks (such as tanner, snow, and red king crab) are unlikely to be exposed to surface oil. Although soluble and insoluble hydrocarbon fractions could reach deeper strata, these fractions would be distributed diffusely over wide areas and would likely not constitute a threat to shellfish stocks. Pelagic crab larvae could be affected if a large surface oil spill occurred during the spring spawning season. However, because the area affected by most spills would be expected to be small relative to overall distributions of crab larvae, overall population levels are unlikely to be noticeably affected.

Conclusion. Cumulative impacts on invertebrate communities in the Cook Inlet Planning Area could result from OCS and non-OCS activities. Overall, routine activities represent up to a moderate disturbance, primarily to benthic and near bottom invertebrates, with the severity of the impacts generally decreasing dramatically with distance from bottom-disturbing activities. Non-OCS actions including oil and gas development in State waters, sediment dredging and disposal, logging, anchoring, fishing/trawling, commercial shipping, and pollutant inputs from point and non-point sources could also adversely affect invertebrate populations. Several major classes of invertebrates could also be affected by the environmental changes predicted to result from climate change. The proposed action is expected to contribute only a small increment to the potential for overall cumulative effects on invertebrate resources because of existing regulations, the limited timeframe over which most individual activities would occur, and the small proportion of available habitats that would be affected during a given period (see Section 4.4.7.5.2). Therefore, it is anticipated that the cumulative effects of OCS and non-OCS activities on invertebrates in the Cook Inlet Planning Areas would be similar to the effects of non-OCS activities alone.

4.6.4.2.5 Areas of Special Concern. Section 4.4.8.2 identifies potential impacts that could result from routine activities or accidents related to the proposed leasing program on areas of special concern adjacent to and in the Cook Inlet Planning Area. In considering the potential cumulative effects of OCS activities on these areas, the level of routine activities and the potential for accidental spills under the proposed action must be considered with other past, present, and reasonably foreseeable future actions that would occur during the 40-yr life of the proposed program. Overall cumulative impacts on these areas of special concern in Cook Inlet consider impacts from both OCS and non-OCS activities.

National Park Service Lands. As identified in Section 4.4.8.2, NPS lands are potentially susceptible to cumulative impacts from activities related to OCS oil and gas development as a consequence of the proposed 5-yr leasing program in Cook Inlet. The potentially affected lands include the Lake Clark National Park and Preserve and the Katmai National Park and Preserve and Aniachak National Monument. Kenai Fjords National Park is east of Cook Inlet on the GOA, but it could be affected by an oil spill associated with OCS activities in Cook Inlet.

Impacts from routine OCS operations could come from facilities developed to support oil drilling and production, and could include effects from pipeline landfalls, dredging, air pollution, and the construction of roads and new facilities. Onshore oil facilities are permissible only on private acreage within each national park. All of these national parks, monuments, and preserves contain privately held acreage, and development of onshore oil support facilities is possible in these areas. Because of the more confined nature of Cook Inlet, OCS construction of facilities within the Cook Inlet Planning Area could have some negative effects on scenic values for some users if the facilities were visible from shore or air during flightseeing. It is assumed that pipeline landfalls, shore bases, and waste facilities would not be located in national parks, because of the special status and protections afforded these areas.

Increased traffic (i.e., land, sea, and air) and development within the vicinity of NPS lands could also contribute to cumulative impacts on these areas. Because the amount of traffic is restricted and activities within the parks regulated, traffic would likely create a minor addition to cumulative impacts on the NPS lands. It is anticipated that noise generated by OCS offshore construction activities would be at low levels and intermittent, and would not persist for more than a few months at any one time. It is considered unlikely that these additional activities would noticeably affect wildlife or park user values compared to current (non-OCS) activities within the considered planning areas. Increased traffic may also affect air quality (see Section 4.4.4.2 and Section 4.6.2.1.2). Air quality in Alaska is expected to remain good, with pollutant concentrations associated with offshore and onshore emission sources well within applicable State and Federal standards. The contribution of OCS program activities to cumulative air quality impacts would be small. Air quality impacts from oil spills and fires would be localized and short in duration.

Impacts on these areas could occur due to accidental releases of oil spilled from onshore facilities and offshore drilling rigs (Table 4.6.1-3). Non-OCS activities, such as oil and gas development in State waters, the domestic transportation of oil or refined petroleum products including LNG from Cook Inlet and the Alaska Peninsula, the production and storage of petroleum products and LNG, and commercial shipping, could also result in accidental spills that could affect park lands. In addition to affecting the National Parks mentioned above, oil spills from tankering to and from Valdez could also affect Kenai Fjords NP and Wrangell St Elias NPP. Naturally occurring seeps may also be a source of crude oil introduced into nearshore waters (Kvenvolden and Cooper 2003). An oil spill would have the greatest effect if it came into contact with shoreline habitats. Impacts would depend primarily on the spill location, size, and time of year. In general, directly affected coastal fauna could include invertebrates; marine mammals; fishes that reproduce in, inhabit, or migrate through coastal areas; terrestrial mammals that feed on these fishes; and marsh birds and seabirds. Spilled oil could also affect subsistence harvests in those parks in which subsistence hunting and fishing are allowed (see Section 4.6.5.2) and could affect the number of park visitors.

National Wildlife Refuges. NWRs in the vicinity of Cook Inlet are identified in Section 3.9.2.2. NWRs potentially affected by OCS activities in the Cook Inlet Planning Areas include the Alaska Peninsula NWR, Becharof NWR, Kodiak NWR, Kenai NWR, and Izembek NWR. These refuges could be contaminated by oil spilled from offshore projects or could be subject to negative effects from routine operations associated with the development of onshore oil and gas support facilities. They could also be affected by non-OCS activities within or adjacent to refuges, including oil and gas development in State waters, the domestic transportation of oil or refined petroleum products including LNG from Cook Inlet and the Alaska Peninsula, the production and storage of petroleum products and LNG, and commercial shipping. Numerous refuge lands have been conveyed to private owners and Native corporations. Section 22(g) of ANCSA requires that new development on these lands must be in accordance with the purpose for which the refuge was formed. Thus, while development of onshore oil and gas support facilities is technically possible, such development would be subject to intensive review (as would any other development).

The potential cumulative effects of routine operations and accidental events on these NWRs are essentially the same as those discussed above for the NPS lands. In addition, subsistence hunting and fishing are permitted on all refuges in Alaska and could, therefore, be affected by accidents and routine operations in the immediate vicinity of refuge properties.

National Forests. The only national forest within the vicinity of the Cook Inlet Planning Area is the Chugach National Forest, which is located mainly on the eastern side of the Kenai Peninsula (Figure 3.9.2-1). Because there would be no OCS-related development, such as pipelines or other onshore facilities, within the Chugach National Forest, it would not be affected by routine OCS activities associated with lease sales in the Cook Inlet Planning Area. Because of the forest location, oil spills from OCS platforms or pipelines within the Cook Inlet Planning Area would not be expected to affect shoreline areas or other resources within Chugach National Forest.

The Chugach National Forest is adjacent to the Gulf of Alaska. It also borders Prince William Sound and is close to Valdez. The Chugach National Forest is, therefore, potentially susceptible to cumulative effects of routine oil-related operations from transport and tanker loading of oil produced (OCS and non-OCS) in other regions (e.g., the Beaufort Sea Planning

Area) and transported by pipeline to the Port of Valdez. Potential effects include increased noise and air pollution from tanker traffic.

Additional, non-OCS-related cumulative impacts in the national forest could result from mining operations (e.g., for gold or gravel/stone), hunting, flightseeing, ski resorts, trains, and tourism. However, the impacts of these activities are regulated through a permitting process following an approved resource use plan.

The Chugach National Forest would be potentially susceptible to oil (mostly non-OCS) spilled from tankers that utilize the loading facilities at the Port of Valdez. Oil spills that reached the coastline could affect coastal fauna; subsistence, recreational, and commercial fishing; and tourism. Impacts would depend on the size and timing of a spill and would be expected to be minor to moderate.

Other Areas of Special Concern. There are multiple State parks and State recreation areas near the Cook Inlet Planning Area, many of which border Cook Inlet or are located in areas that could be contacted by accidental oil spills. Such areas include Captain Cook State Recreation Area, Clam Gulch State Recreation Area, Chugach State Park, Kachemak Bay State Park and State Wilderness Park, and Ninilchik State Recreation Area. In addition, the Kachemak Bay National Estuarine Research Reserve is located in Cook Inlet on the southern end of the Kenai Peninsula. Cumulative impacts from offshore activities would be similar to those described above for National Parks and Refuges. Existing protections and restrictions on uses should limit the direct terrestrial cumulative impacts from OCS and non OCS activities on these areas. There is existing oil and gas infrastructure in State waters of Cook Inlet and the addition of OCS infrastructure and activities could have negative effects on scenic values for some users if the facilities were visible from shore or the air during flightseeing. It is assumed that pipeline landfalls, shore bases, and waste facilities would not be located in the State parks and recreation areas. Increased traffic (i.e., land, sea, and air) and development within the vicinity of State parks lands could also contribute to cumulative impacts on these areas. It is anticipated that noise generated by OCS offshore construction activities would be at low levels, intermittent, and would not persist for more than a few months at any one time. It is considered unlikely that these additional activities would noticeably affect wildlife or park user values compared to current (non-OCS) activities within the considered planning areas.

As described above, impacts on State parks and recreational areas could occur due to accidental releases of oil spilled from onshore facilities and offshore drilling rigs. An oil spill contacting shoreline habitats could affect subsistence harvests in those parks in which recreation and subsistence hunting and fishing are allowed and could affect the number of park visitors. Impacts would depend primarily on the spill location, size, and time of year.

Conclusion. Overall, routine OCS operations could result in minor incremental increases in effects on national sanctuaries, parks, refuges, and estuarine research reserves compared to existing non-OCS activities (see Section 4.4.8.2). Development of onshore facilities within national park lands in the vicinity of the areas included in the Program is considered unlikely, thereby making impacts from cumulative routine OCS operations unlikely in these areas. Offshore construction of pipelines and platforms could contribute to cumulative effects on wildlife and on scenic values for park visitors due to noise and activity levels, particularly in the vicinity of Cook Inlet. However, such effects would be localized, intermittent, and temporary.

Compared to the existing potential for oil spills to affect such areas, the activities under the proposed action would be expected to result in a small incremental increase in the risk of impacts from oil spills to areas of special concern. The cumulative level of impacts from spills would depend on spill frequency, location, and size; the type of product spilled; weather conditions; effectiveness of cleanup operations; and other environmental conditions at the time of the spill. Large and catastrophic oil spills in areas adjacent to the national parks, NWRs, or national forests, whether from OCS or non-OCS sources, could negatively impact coastal habitats and fauna and could also affect subsistence uses, commercial or recreational fisheries, and tourism.

4.6.4.3 Alaska Region – Arctic

4.6.4.3.1 Marine Mammals.

Marine Mammals. The cumulative analysis considers past, ongoing, and foreseeable future human and natural activities that may occur and adversely affect marine mammals in the Arctic Planning Areas. These activities include effects of the OCS Program (proposed actions and prior and future OCS sales), oil and gas activities in State waters, vessels, subsistence harvests, recreational fishing and boating activities, military operations, scientific research, and natural phenomena. Specific types of impact-producing factors considered include noise from numerous sources, pollution, ingestion and entanglement in marine debris, vessel strikes, habitat degradation, subsistence harvests, military activities, industrial development, community development, climate change, and natural catastrophes. Section 4.4.7.1.3 provides the major impact-producing factors related to the proposed action in Cook Inlet.

Routine Activities.

<u>OCS Activities.</u> Marine mammals and their habitats in the Arctic Planning Areas could be affected by a variety of exploration, development and production activities as a result of the proposed and future OCS leasing actions (see Section 4.4.7.1.3). These activities include seismic exploration, offshore and onshore infrastructure construction, the discharge of operational wastes, and vessel and aircraft traffic. Impacts to marine mammals from these activities may include physical injury or death; behavioral disturbances; lethal or sublethal toxic effects; and loss of reproductive, nursery, feeding, and resting habitats. The degree of impact at the population level depends greatly on the status of the population (reflected in its listing under the ESA) and the degree of disturbance or harm from OCS-related activities in areas important to species survival (i.e., feeding, breeding, molting, rookery or haulout areas).

Potential impacts (primarily behavioral disturbance) to marine mammals from OCS-related seismic activity would be short-term and temporary, and not expected to result in population level impacts for any affected species if appropriate mitigation measures are implemented.

Impacts from OCS construction and operation activities could include the temporary disturbance and displacement of individuals or groups by construction equipment and long-term disturbance of some individuals from operational noise. No long-term, population-level effects would be expected because individuals most affected by these impacts would be only those in the immediate vicinity of the construction site or operational platform and disturbance of individuals during construction would be largely temporary. In addition, appropriate mitigation measures could lessen the potential for impacts.

Operational and waste discharges (e.g., produced water, drilling muds, and drill cuttings) would be disposed of through downhole injection into NPDES-permitted disposal wells, and thus would not be expected to result in any incremental impacts to marine mammals. Liquid wastes (such as bilge water) may also be generated by OCS support vessels and on production platforms. While these wastes may be discharged (if permitted) into surface waters, they would be rapidly diluted and dispersed, and would not be expected to result in any incremental impacts to marine mammals from exposure to these wastes. Drilling and production wastes may contain materials such as metals and hydrocarbons, which can bioaccumulate through the food chain into the tissues of marine mammals. Although the bioaccumulation of anthropogenic chemicals has been reported for a variety of marine mammals, adverse impacts or population-level effects resulting from such bioaccumulation have not been demonstrated (Norstrom and Muir 1994; Muir et al. 1999).

Marine mammals could be temporarily disturbed by OCS vessel traffic (all species) or incur injury or death from collisions with support vessels (primarily larger, slower moving cetaceans). The low level of OCS vessel trips in the Arctic Planning Areas under the proposed actions would likely limit potential cumulative impacts to a few individuals, be largely short-term in nature, and not result in population-level effects. Noise from helicopter overflights would be transient in nature. Impacts to marine mammals would be behavioral in nature, primarily resulting in short-term disturbance in normal activities, and would not be expected to result in population-level effects. Overflights and vessels could disturb pinnipeds on rookeries and haul-outs. In particular, disturbance of walruses can cause stampedes, where younger animals and calves can be killed, possibly causing population-level impacts to some species. Appropriate mitigation measures such as overflight restrictions and flightline selection to avoid rookeries and haul-outs would limit the potential for adversely affecting animals at these locations.

No platforms would be removed under the proposed action for the Arctic Planning Areas.

<u>Non-OCS Activities.</u> A number of non-OCS activities such as oil and gas exploration and development in State waters, subsistence harvests, vessel traffic, and climate change could also affect marine mammals in the Arctic Planning Areas. Many of the effects of these activities on marine mammals would be similar in nature to those resulting from OCS-related activities, namely, behavioral disturbance, habitat disturbance, injury, or mortality, and exposure to toxic substances. Marine mammals may also be adversely affected by climate change.

Oil and Gas Exploration and Development in State Waters. The State of Alaska has made nearshore State lands available for leasing along the Beaufort Sea coast. The exploration activities (and associated impacts to marine mammals) that could result with State oil and gas lease sales may greatly outnumber exploration activities (and potential impacts to marine mammals) that could occur under the OCS proposed action.

Exploration, construction, and operation activities associated with State leases would occur in nearshore and coastal areas, while OCS platforms and pipelines would be located away from coastal areas (with the exception of relatively few pipeline landfalls and onshore bases and processing facilities). Thus, State oil and gas leasing activities may be expected to have a greater potential for affecting marine mammals in coastal habitats than would the proposed OCS actions.

Subsistence Harvesting. Subsistence harvesting has been identified as impacting marine mammals in Alaskan waters (Allen and Angliss 2011). However, annual mortality from subsistence harvests is considered to have little adverse effect on most marine mammal populations or stocks. The following are the reported estimated annual Alaska-wide subsistence harvests for marine mammals that occur in the Beaufort and/or Chukchi Seas (Allen and Angliss 2011):

- The best estimate of annual subsistence harvest of spotted seals is 5,265 animals.

- The best estimate of annual subsistence harvest of bearded seals is 6,788 animals.

- The best estimate of annual subsistence harvest of ringed seals is 9,567 animals.

- The best estimate of annual subsistence harvest of ribbon seals is 193 animals.

- The best estimate of annual subsistence harvest for the Beaufort Sea whale stock is 139 animals, which includes 25 individuals in Alaska and 114 individuals in Canada.

- The best estimate of annual subsistence harvest for the Eastern Chukchi Sea beluga whale stock is 59 animals.

- There are known subsistence harvests of narwhals by Alaska Natives.

- There are no known subsistence harvests of the Bering Sea stock of harbor porpoises by Alaska Natives. However, Suydam and George (1992) noted that individuals from this stock have been entangled in subsistence nets.

- Annual subsistence take of grey whales averaged 121 individuals between 2003 to 2007. Russian Chukotka people take most of the gray whales. The

U.S. Makah Indian Tribe has a yearly average quota of 4 whales. In 2005, an unlawful subsistence hunt and kill of a gray whale occurred in Alaska.

- No subsistence takes of the Northeast Pacific stock of fin whales are reported from Alaska or Russia.

- Subsistence take of minke whales by Alaska Natives is rare (e.g., only nine between 1930 and 1995).

- Alaska Native subsistence hunters take 14 to 72 bowhead whales per year (0.1 to 0.5% of the population). Russian and Canadian subsistence hunters also take a few bowhead whales. The annual subsistence take from 2004 to 2008 for Alaska, Russian, and Canadian Natives averaged 41.2 bowhead whales. Several cases of fishing rope or net entanglement have been reported from whales taken in subsistence hunts.

- The 1925 to 1953 estimated annual Alaska harvests of polar bears for subsistence, handicrafts, and recreation was 120 animals. Recreational harvests by non-Native sports hunters using aircraft averaged 150 annually from 1951 to 1960 and 260 annually from 1960 to 1972. A prohibition on non-Native hunting became effective in 1973. The annual subsistence harvests for the Chukchi/Bering Seas stock was 92/year in the 1980s, 49/year in the 1990s, and 43/year in the 2000s.

- The annual harvests for the Southern Beaufort Sea polar bear stock was 39/year in the 1980s, 33/year in the 1990s, and 32/year in the 2000s.

- The estimated annual subsistence harvests for the Pacific walrus from 2003 to 2007 were at 4,960 to 5,457 animals/year and included those harvested in the U.S. and Russia.

Climate Change. A concern regarding marine mammals in polar regions is the potential for climate change and associated loss in the extent of sea ice in some Arctic and subarctic waters. Some species, such as the bearded seal and polar bear, are dependent on sea ice for at least part of their life history, and may be more sensitive to changes in arctic weather, sea-surface temperatures, or extent of ice cover (Allen and Angliss 2011). Ice edges are biologically productive systems where ice algae form the base of the food chain. The ice algae are crucial to arctic cod, which is a pivotal species in the arctic food web. As ice melts, there is concern that there will be loss of prey species of marine mammals, such as arctic cod and amphipods, that are associated with ice edges (MMS 2004a). Changes in the extent, concentration, and thickness of the sea ice in the Arctic may alter the distribution, geographic ranges, migration patterns, nutritional status, reproductive success, and, ultimately, the abundance of ringed seals and other ice-dependent pinnipeds that rely on the ice platform for pupping, resting, and molting (MMS 2004a). Reductions in sea ice coverage would adversely affect the availability of pinnipeds as prey for polar bears. More polar bears may stay onshore during the summer (MMS 2004a). If the arctic climate continues to warm and early spring rains become more widespread, ringed seal lairs might collapse prematurely, exposing ringed seal pups to increased predation by polar bears and Arctic foxes, negatively impacting the ringed seal population and, therefore, eventually the polar bear population (MMS 2004a).

The loss of sea ice could have several potential effects on bowhead whales. These would include increased noise and disturbance related to increased shipping, increased interactions with commercial fisheries, including noise and disturbance, incidental intake, and gear entanglement; changes in prey species concentrations and distribution; changes in subsistence-hunting practices; increased predation from expanding killer whale range; and competition from expanding fin, humpback, and other baleen whale ranges. Bowhead whale seasonal distribution may change with changes in seasonal ice distribution as well.

Other Impacting Factors. Marine mammals may also be impacted by other factors such as UMEs and invasive species. A UME is an unexpected stranding that involves a significant die-off of any marine mammal population, and demands immediate response (NMFS 2011b). Causes of UMEs include infections, biotoxins, human interactions, and malnutrition (NMFS 2011b). Since establishment of the UM program in 1991, there have been 53 formally recognized UMEs in the U.S., none of which occurred Arctic Planning Areas (NMFS 2011b). Invasive species could affect some marine mammals by disrupting local species and ecosystems, affecting the prey base for some marine mammals. Currently, invasive species are not a major factor in the Arctic Planning Areas. However, as climate change continues to warm Alaskan waters, the Arctic Planning Areas may become more susceptible to invasive species (e.g., from ballast discharges associated with increased vessel traffic).

Accidents. Marine mammals could be exposed to oil accidentally released from platforms, pipelines, and vessels from the Program (Table 4.4.2-1). Potential non-OCS sources of oil spills include the domestic transportation of oil, oil and gas development in State waters, and natural sources such as seeps. Accidental oil releases could expose marine mammals to oil by direct contact or through the inhalation or ingestion of oil or tar deposits. The magnitude and duration of exposure will be a function of the location, timing, duration, and size of the spill; the proximity of the spill to feeding and other important habitats; the timing and nature of spill containment; and the status of the affected animals. It is anticipated that most of the small to medium spills would have limited effects on marine mammals due to the relatively small areas likely to incur high concentrations of hydrocarbons and the short period of time during which potentially toxic concentrations would be present. The magnitude of impact would be expected to increase should a spill occur in habitats important to marine mammals or affect a number of individuals from a population listed under the ESA. Some spills from OCS activity may locally represent the principal source of oil exposure for some species, especially for spills contacting important coastal and island habitats or collecting along ice leads.

Conclusion. Cumulative impacts on marine mammals in the Beaufort and Chukchi Sea Planning Areas as a result of future OCS program and ongoing and future non-OCS program activities could be minor to moderate over the next 40 to 50 yr. Non-OCS program activities or phenomena that may affect populations of marine mammals include climate change, contaminant releases, vessel traffic, subsistence harvests, and invasive species. The incremental contribution of routine Program activities to these impacts would be small (see Section 4.4.7.1.3).

Marine mammals may also be adversely affected by exposure to oil that is accidentally released from OCS and non-OCS activities. The cumulative impacts of past, present, and future oil spills on marine mammals would be minor to moderate. The incremental impacts of accidental spills associated with the proposed action on marine mammals would be small to large, depending on the location, timing, duration, and size of the spill; the proximity of the spill to feeding and other important habitats; the timing and nature of spill containment; and the status of the affected animals (see Section 4.4.7.1.3).

Terrestrial Mammals. Terrestrial mammals and their habitats could be affected by a variety of activities associated with the proposed OCS actions (Section 4.4.7.1.3). These activities include construction and operation of onshore pipelines and vehicle and aircraft traffic. Impacts to terrestrial mammals from these activities may include physical injury or death; behavioral disturbances; lethal or sublethal toxic effects; and loss of reproductive, nursery, feeding, and resting habitats. In the Arctic Planning Areas, these impacts would be in addition to similar (in nature) impacts resulting from ongoing and planned OCS lease sales under the Program.

Impacts from OCS construction and operation activities could include the injury or death of smaller mammals (such as mice and voles) and the disturbance and displacement of individuals or groups of larger species (such as caribou, muskoxen, and brown bear). Because of the limited areal extent of new pipeline under the proposed action, disturbance (primarily behavioral in nature) of most of these species during construction would be largely temporary, and no long-term population level effects would be expected. However, construction activities in the Arctic could disturb caribou in calving, foraging, or insect avoidance habitats, which could affect adult and calf survival. However, the potential for such impacts could be minimized by careful siting of new pipelines to avoid important habitats.

Species such as the Arctic fox that habituate to human activity and facilities could experience local increases in density, while bears may experience increases in mortality associated with defense of life and property killings. In the Arctic, pipelines and roads associated with the proposed action have the potential to incrementally affect local and seasonal movements of caribou.

Under the proposed action, vehicle traffic associated with normal operations and maintenance of onshore pipelines could disturb wildlife. Vehicle traffic could disturb wildlife foraging along pipelines or access roads, causing affected wildlife to temporarily stop normal activities (e.g., foraging, resting) or leave the area, while collision with vehicles could injure or kill some individuals. Because vehicle traffic would be infrequent, vehicle-related impacts associated with the proposed action would result in little incremental increase in vehicle-related impacts from current or ongoing OCS activities in the Arctic.

Up to 27 weekly helicopter trips would occur to platforms in the Arctic Planning Areas. Impacts to terrestrial mammals from helicopter overflights would be behavioral in nature, primarily resulting in short-term disturbance in normal activities, and would not be expected to result in population-level effects. Overflights disturbing active calving and overwintering sites could result in decreased survival of young or adults, and potentially result in population level impacts to some species. Selection of flight lines to avoid overflights of important habitats would greatly limit the potential for adversely affecting calving or overwintering animals.

Terrestrial mammals in the Arctic Planning Area could also be affected by a number of non-OCS activities, including oil and gas exploration and development in State waters, and coastal and community development, and climate change. Many of the effects of these activities on terrestrial mammals would be similar in nature to those resulting from OCS-related activities, namely behavioral disturbance, habitat disturbance, and injury or mortality. The State of Alaska has made leases of State waters available along much of the Beaufort Sea coast. Because these leases are closer to shore than those for the proposed action, impacts on terrestrial mammals may exceed the potential impacts that could occur under the OCS proposed action. Implementation of the proposed action could increase coastal and community development, indirectly adding to impacts to terrestrial mammals and their habitats. Terrestrial mammals could be adversely affected by the accidental release of oil from an onshore pipeline, or by offshore spills contacting beaches and shorelines utilized by terrestrial mammals (such as caribou or brown bears). Impacts to terrestrial mammals from an oil spill would depend on such factors as the time of year and volume of the spill, type and extent of habitat affected, and home range or density of the species. Spills contacting high-use areas (such as caribou calving areas) could locally affect a relatively large number of animals. It is anticipated that most of the spills would have limited effects on terrestrial mammals, due to the relatively small areas likely to be directly exposed to the spills, and the small number and size of spills projected for the proposed action and for current and planned OCS oil and gas developments. However, some spills may locally represent the principal source of oil exposure for some species, especially for spills contacting important calving or overwintering habitats.

Conclusion. Cumulative impacts on terrestrial mammals in the Beaufort and Chukchi Sea Planning Areas as a result of future OCS program and ongoing and future non-OCS activities could be minor to moderate over the next 40 to 50 yr. Non-OCS activities or phenomena that may affect populations of terrestrial mammals include climate change, natural catastrophes, contaminant releases, and vehicle traffic. The incremental contribution of routine Program activities to these impacts would be small (see Section 4.4.7.1.3).

Terrestrial mammals may also be adversely affected by exposure to oil that is accidentally released from onshore (e.g., Prudhoe Bay) and State offshore oil and gas activities. The cumulative impacts of past, present, and future oil spills on terrestrial mammals would be minor to moderate. The incremental impacts of accidental spills associated with the proposed action on terrestrial mammals would be small to large, depending on the location, timing, duration, and size of the spill; the proximity of the spill to feeding and other important habitats; the timing and nature of spill containment; and the status of the affected animals (see Section 4.4.7.1.3).

4.6.4.3.2 Marine and Coastal Birds. Section 4.4.7.2.3 discusses impacts to marine and coastal birds in the Arctic region resulting from the proposed action (OCS program activities from 2012 to 2017). Cumulative impacts on marine and coastal birds result from the incremental impacts of the proposed action when added to impacts from existing and reasonably foreseeable future OCS program activities (that are not part of the proposed action) and other non-OCS program activities. Table 4.6.1-2 presents the exploration and development scenario for the Beaufort and Chukchi Seas cumulative cases (encompassing the proposed action and other OCS program activities) over the next 50 yr. A number of OCS program activities could affect Arctic marine or terrestrial birds or their habitats; these include offshore exploration, construction of offshore platforms and pipelines, construction of onshore pipelines, operations of offshore platforms, operational discharges and wastes, and OCS-related marine vessel and aircraft traffic. Potential impacts on marine and coastal birds from OCS program activities include injury or mortality of birds from collisions with platforms, vessels, and aircraft; exposure to operational discharges; ingestion of trash or debris; loss or degradation of habitat due to construction; and behavioral disturbance due to the presence of, and noise generated by, equipment and human activity.

Non-OCS program activities affecting marine and coastal birds in the Beaufort Sea and Chukchi Sea Planning Areas include dredging and marine disposal; coastal and community development; onshore and offshore construction and operations of facilities associated with State oil and gas development (mainly Prudhoe Bay); commercial and recreational boating; and small aircraft traffic. Potential impacts on marine and coastal birds from these activities are similar to those under the OCS program and include injury or mortality of birds from collisions with platforms associated with State oil and gas development and other onshore and offshore structures (e.g., radio, television, or cell phone towers); onshore industrial, commercial, and residential development; exposure to discharges from permitted point sources such as sewage treatment discharges and nonpoint sources such as snowmelt and stormwater runoff; or accidental releases (e.g., oil spills), as described in Section 4.6.2.1.3 and Table 4.6.2-4; exposure to emissions from various onshore and offshore sources (e.g., power generating stations and marine vessels), as described in Section 4.6.2.1.3; ingestion of trash or debris; loss or degradation of habitat due to construction and operations activities; and behavioral disturbance due to the presence of, and noise generated by, equipment and human activity. Other trends such as extensive melting of glaciers (and increasing river discharges), thawing of permafrost, and increased precipitation brought on by global climate change are also expected to adversely affect marine and coastal birds over the next 50 yr.

Injury or Mortality from Collisions. Under the cumulative scenario, annual collision injury or mortality in the Beaufort and Chukchi Sea Planning Areas could increase in the near term as platforms are built under the proposed action. Such impacts would be minor relative to those that currently involve non-OCS structures. Over time, the injury or mortality impacts from collisions could decrease as oil and gas production in the inlet declines.

Exposure to Wastewater Discharges and Air Emissions. The discharge of operational wastes and air emissions from current non-OCS related vessel traffic and platform operations in the Beaufort and Chukchi Seas is strongly regulated and would continue to be so regulated over the next 50 yr. Many wastes (such as produced water, drilling muds, and drill cuttings) would be disposed of through onsite injection into NPDES-permitted disposal wells. However, such wastes and emissions would still expose marine and coastal birds to potentially toxic materials or to solid debris that could be ingested or result in entanglement. These facilities and activities include sewage treatment plants, industrial manufacturing or processing facilities, electric generating plants, dredging and marine disposal, and vessel traffic (e.g., cargo and tanker ships and military and research vessels). Operational wastewater discharges and air emissions associated with the proposed action would contribute to the overall cumulative risk of toxic exposure and debris ingestion or entanglement of existing non-OCS wastewater discharges and air emissions in the inlet, but the incremental increase in impact is expected to be small relative to these other activities.

Under the proposed action, marine and coastal birds could be exposed to oil accidentally released from platforms, pipelines, and vessels, and would be most susceptible to adverse impacts from spills occurring in coastal areas and affecting feeding and nesting areas. Most of the oil released to arctic waters is from leaks related to the oil industry (Section 4.6.2.3.1). Oil releases from all sources may expose marine and coastal birds via direct contact or through the inhalation or ingestion of oil or tar deposits (see Section 4.4.7.3.1).

Marine and coastal birds may become entangled in, or ingest, floating, submerged, and beached debris (Heneman and the Center for Environmental Education 1988; Ryan 1987, 1990). Entanglement may result in strangulation, injury or loss of limbs, entrapment, or the prevention or hindrance of the ability to fly or swim; all of these effects may be considered lethal. Ingestion of debris may irritate, block, or perforate the digestive tract, suppress appetite, impair digestion of food, reduce growth, or release toxic chemicals (Fry et al. 1985; Dickerman and Goelet 1987; Ryan 1988; Derraik 2002). Because the discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by BOEM (30 CFR 250.40) and the USCG (MARPOL, Annex V, Public Law 100 220 [101 Statute 1458]), entanglement in or ingestion of OCS-related trash and debris by marine and coastal birds would not be expected under normal operations.

Oil Spills and Cleanup Activities. Oil spills under the cumulative scenario are shown in Table 4.6.1-3. No more than six large spills (between 1,000 and 5,300 bbl from either a platform or a pipeline) and 530 small spills (less than 1,000 bbl) would be expected as a result of the Beaufort Sea and Chukchi Sea Planning Areas OCS program over the next 50 yr.

Loons, waterfowl, and shorebirds in onshore habitats are generally at low risk of contacting a spill while nesting, but risk of exposure increases as they leave the mainland nesting areas and concentrate in coastal or marine habitats for brood rearing, molting, or staging prior to southward migration. In addition, some species (e.g., red-throated loons) forage almost exclusively offshore and bring food back to their nestlings or young, so impacts of oil spills may be greater on these species (Eberl and Picman 1993). Likewise, species nesting on barrier islands, such as common eider, gulls, and terns, are at risk when post-nesting individuals join other species in lagoons and other nearshore habitats. Substantial numbers occupy Simpson and other Beaufort Sea lagoons, Harrison and Smith Bays, Kasegaluk Lagoon, and Peard and Ledyard Bays in the Chukchi Sea at this time. For example, tens of thousands of long-tailed ducks molting in Beaufort Sea lagoons, far outnumbering other species, are at risk in July and August, and in late August and early September, a large proportion of the Pacific flyway brant population could be exposed to a spill that enters Kasegaluk Lagoon. Substantial numbers of non-breeding, foraging, or staging birds that occupy offshore areas in both the Beaufort and Chukchi Seas, when open water beyond the barrier islands is available, could be exposed to an oil spill. Most brood rearing of loons, swans, and geese occurs on large lakes or coastal saltmarsh. Risk of oil spill contact is much greater for those using the latter habitat. The most important molting area for brant and several other species of geese (and to a lesser extent ducks) is the Teshekpuk Lake Special Area (Derksen et al. 1979, 1982). Beached oil along these coastlines could expose hundreds to low thousands or possibly greater numbers of shorebirds that pause along the coast during migration (Connors et al. 1979; Smith and Connors 1993; Andres 1994). In the southeastern Chukchi Sea, large numbers of murres and kittiwakes nesting in seabird colonies at Capes Lisburne and Thompson, together with nonbreeding individuals, form foraging flocks containing tens to hundreds of individuals that also could be exposed to an oil spill. Major effects on bird populations during the open water season are expected to follow a spill. A spill occurring in winter, when birds are virtually absent, still may have serious impacts if substantial quantities of oil are entrained in the ice and then released during the following breeding season.

Large flocks of long-tailed ducks molting in Beaufort Sea lagoons and common eiders occupying barrier islands or lagoons are particularly susceptible to oil spill impacts if they are nesting, brood rearing, or flightless. Likewise, brant staging in Kasegaluk Lagoon in the Chukchi Sea would be particularly vulnerable. For all species, the degree of impact depends heavily on the location of the spill and its timing with respect to critical natural behaviors (e.g., breeding, molting, feeding). Survival and fitness of individuals may be affected, but in many cases, this infrequent disturbance is not expected to result in significant population losses. However, effects may be greater if a spill and cleanup were to occur in the spring when large numbers of king and common eiders, long-tailed ducks, and other waterfowl, seabirds, and shorebirds are present following spring ice-lead systems. In addition, it is unlikely that all spilled oil would be removed from the environment, especially in winter; thus the remaining accumulations could move under the ice and into leads.

In addition to the potential impacts from spilled oil, the oil spill cleanup process may also affect marine and coastal birds in the Arctic region. The presence of large numbers of workers, boats, and additional aircraft during the breeding season following a spill is expected to displace waterfowl or other seabirds occupying affected offshore or nearshore waters, and shorebirds in coastal habitats for one to several seasons. Cleanup in coastal areas late in the breeding season may disturb brood-rearing, juvenile, or staging birds. Cleanup and the presence of oil can dramatically influence avian species composition and distribution (Piatt et al. 1990). It is extremely difficult to separate the effects of oiling and disturbance from cleanup activities, but either separately or together they have the potential to influence habitat use by birds (Wiens 1996). Survival and fitness of individuals may be affected to some extent, but this infrequent disturbance is not expected to result in significant population losses.

Loss or Degradation of Habitat. Marine and coastal birds could be affected by platform construction and removal activities, and pipeline trenching, which could disrupt behaviors of nearby birds. The proposed action would include the placement of up to 36 exploration and development wells and 9 offshore platforms; up to 652 km (405 mi) of new offshore pipeline and 129 km (80 mi) (0 in the Chukchi Sea) of onshore pipeline could be constructed (Table 4.4.1.1-4). Platform emplacement could disturb birds temporarily; pipeline trenching may also affect birds in nearshore coastal habitats if it occurs in or near foraging, overwintering, or staging areas, or near seabird colonies. No pipeline landfalls would be constructed under the proposed action. Depending on where they are sited, the pipelines would likely result in the permanent elimination of a small amount of habitat along pipeline routes.

Any construction activities that take place in summer (one season) (e.g., platform installation for field development) could displace birds from within about 1 km (0.62 mi) of the construction site. However, localized burial of potential prey and destruction of a few square kilometers of foraging habitat as a result of pipeline trenching or island construction are not expected to cause a significant decline in prey availability. It is likely that much construction, particularly of gravel islands, roads, pads, and pipelines, would take place during winter when most birds are absent. Several studies speculate that increased predator populations sustained by scavenging opportunities around human habitation may indirectly contribute to long-term declines of common eiders and long-tailed duck populations currently in evidence (Day 1998; S.R. Johnson 2000; Troy 2000). The effect of any habitat loss on the species' productivity would likely be localized to these areas but may persist over the life of any offshore field and beyond. The potential exists for long-term adverse effects to occur (e.g., fecundity reduced after location to suboptimal habitat due to disturbance).

Gravel placement (for artificial islands) results in nesting and foraging habitat loss for most shorebirds (Troy 2000). On the North Slope, gravel is generally extracted from the floodplains of large rivers (Pamplin 1979; BLM 2002). The effects of gravel extraction/placement would be reduced if areas where particular species seasonally concentrate are avoided.

Winter construction would also utilize ice roads to build and access gravel island construction sites. Ice roads may be constructed over both tundra habitats and frozen ocean habitats. Ice roads constructed in tundra habitats may delay ice-off and snow melt (NRC, 2003b), potentially reducing the availability of such areas for early nesting species. Ice roads could also flatten underlying vegetation, which may discourage use of the area by tundra-nesting birds (Walker et al., 1987a, b). Water removal from lakes and ponds for ice road construction may reduce the quality or quantity of aquatic habitats important for breeding and postmolting for some species. In each of these cases, the impacts to potential nesting habitat would be temporary and localized, and birds would likely respond by selecting other areas for nesting or postmolting.

Construction camps to support onshore construction activities would temporarily remove some areas from potential use by birds, and this loss may be short- or long-term depending on the nature and effectiveness of camp abandonment following completion of construction activities. Regardless of the duration of the effect, the amount of habitat that would be disturbed would be relatively small and not be expected to affect more than a few birds.

The construction and operation of up to 320 km (200 mi) of new overland pipelines would be expected to affect bird populations in a manner similar to that identified for the construction and operation of new onshore processing facilities and associated infrastructure (especially access roads). Potential nesting or post-molting habitat would be permanently lost within the footprint of the new pipelines, causing birds to select habitats in other locations.

Although pipeline trenching would also be carried out in winter when most seabird and waterfowl species are not present, seafloor trenching could locally disrupt benthic invertebrate communities that may serve as food sources for waterfowl during other seasons. The extent to which benthic food sources could be affected and the subsequent impact to waterfowl will depend on the type and amount of benthic habitat that would be permanently disturbed by trenching, the importance of the specific habitats in providing food resources to waterfowl, and the number of waterfowl that could be affected. Because no more than three new pipelines could be built under the proposed action within the entire Arctic region, relatively little benthic habitat could be disturbed (no more than 120 ha [297 ac] within the entire region). In addition, portions of the new pipelines would be in water depths down to 60 m (200 ft) and potentially unavailable for many marine birds and waterfowl. Thus, any impacts to food sources from pipeline trenching would be very localized and short-term, and not expected to result in population-level impacts to local waterfowl populations.

The construction of new facilities and pipelines would permanently eliminate potential bird habitat at the construction sites. While this habitat loss would be long-term, the areas disturbed would represent a small portion of the habitat present in the Arctic region. Careful siting of any new facilities to avoid important nesting or post-molting habitat would further reduce the magnitude of any potential effects on local bird populations.

Helicopter or fixed-wing aircraft overflights are generally conducted at low altitudes and could disturb birds in onshore and offshore locations (Ward and Stein 1989; Ward et al. 1994; Miller 1994; Miller et al. 1994). Helicopter and aircraft overflights during spring breakup of pack ice may disturb marine species feeding in open waters and waterfowl in coastal waters, causing birds to leave the area. Similarly, overflights in summer could displace waterfowl and seabirds from preferred foraging areas and waterfowl from coastal nesting or brood-rearing areas such as the lagoon systems of the Beaufort and Chukchi Seas. Molting and staging waterfowl may temporarily leave an area experiencing helicopter overflights (Derksen et al. 1992), while geese have been reported to exhibit alert behavior and flight in response to helicopter overflights (Ward and Stein 1989; Ward et al. 1994). The type of response elicited by the birds and the potential effect on the birds will depend in large part on the time of year for the overflights and the species disturbed. Birds experiencing frequent overflights may permanently relocate to less favorable habitats (MMS 2002b). In addition, the temporary absence of adult birds may increase the potential for predation of unguarded nests and young (NRC 2003b).

Marine vessel trips could disturb seabirds and waterfowl in preferred foraging, molting, and staging areas, causing them to leave the area and move to potentially less favorable habitats. Vessel traffic that displaces nesting seabirds or waterfowl may result in an increased predation rate on eggs and young, especially in areas near gull colonies (Day 1998; S.R. Johnson 2000; Noel et al. 2005). However, the amount of vessel and aircraft traffic that could occur under the proposed action would be relatively limited. Which birds could be affected, the nature of their response, and the potential consequences of the disturbance will be a function of a variety of factors, including the specific routes, the number of trips per day, the seasonal habitats along the routes, the species using the habitats and the level of their use, and the sensitivity of the birds to vessel traffic. Traffic over heavily used feeding or nesting habitats of sensitive species could result in population-level effects, while impacts from traffic over other areas with less sensitive species would largely be limited to a few individuals and not result in population-level effects.

Marine and coastal birds could be affected by accidental oil spills from offshore platforms and pipelines, as well as from onshore processing facilities and pipelines. In general, loons, waterfowl, seabirds, and shorebirds are not expected to survive moderate to heavy oil contact. Oiled feathers lose their insulative and water repellent characteristics, and birds die of hypothermia (Albers and Gay 1982). Swallowed oil is toxic and causes impaired physiological function and production of fewer young. Oiled eggs have significantly reduced hatching success (Albers 1980). Vulnerability of bird populations to an oil spill is highly variable because of their seasonally patchy distribution in areas where the probability of spill contact also is variable and depends on location, oceanography, weather patterns, and habitats typically occupied by and habits of, the particular species. Because they are unable to fly, molting birds probably are the most vulnerable. For all species, the degree of impact depends heavily on the location of the spill and its timing with respect to critical natural behaviors (e.g., breeding, molting, feeding).

If losses are substantial in a species with a low reproductive rate, including most marine species, recovery may take many years, or populations may not recover to their prespill size. Rate of recovery from oil spill mortality depends both on the numbers lost from a particular species population and its prevailing population trend, which in turn are determined by reproductive rate and survival rate. Oil contamination of food resources may influence recovery of a local population by affecting reproductive success and survival, with the degree of impact largely dependent on the patterns of prey distribution. Species dependent on widely dispersed prey would have more limited effects. However, seabirds, in particular, are attracted to patchy prey sources found on oceanic fronts (Piatt and Springer 2003) and would experience greater effects from prey reduction. In addition, nonbreeding individuals and those that have completed annual parental activities are better able to search for prey in uncontaminated areas. However, those individuals actively feeding young and dependent upon nearby food resources would be unable to seek uncontaminated prey elsewhere. If a leak in an onshore pipeline were to occur on a pad, the extent of the spill likely would be restricted by containment berms. If the spill occurred along the off-pad portion of the pipeline, the area covered may include several acres; if the spill were to enter streams or lakes, a larger area could be affected as the oil spreads over a water surface or is carried down a watercourse. From mid- to late summer, such an occurrence could contact broodrearing females and their young, as well as potentially large flocks of nonbreeding and postbreeding individuals undergoing wing molt.

Most bird species are absent from the Arctic region from late October to at least early April. During spring migration, substantial numbers of migrants moving north along the spring lead system in the Chukchi Sea are at risk if oil enters this habitat, since there are few alternatives until open water off river deltas is available as the ice breaks up in late spring. The most numerous species include king eider, common eider, long-tailed duck, brant, and murres. Likewise, a similar rather restricted open water situation exists in both the Beaufort and Chukchi Seas for migrants that pause awaiting further melting to the north or east, and for birds occupying delta waters and nearshore areas that have melted prior to general ice breakup and awaiting the availability of onshore habitats.

Disturbance Due to Noise. Noise and human activities (such as normal maintenance) could disturb birds. Operational facilities may provide additional nesting and feeding opportunities for some species. Unexpected noise can startle birds and potentially affect feeding, resting, or nesting behavior, and often causes flocks of birds to abandon the immediate area. Some species may react by avoiding nearby habitats, while other species may show little response or become habituated. Because of the small number of new onshore facilities (no more than four in the entire Arctic region), the disturbance of birds by operational noise and activity would likely be limited to relatively few individuals and would not be expected to result in population-level effects. Prolonged or repeated periods of maintenance activities could have a greater impact on nesting birds by increasing cooling periods of eggs, and on brood-rearing birds by increasing the time that young and adult birds are separated.

Effects on ESA-Listed Species in the Arctic Region. The cumulative effects of OCS and non-OCS program activities on ESA-listed species in the Arctic region, including the spectacled eiders and Steller's eider, are expected to be similar to those noted for nonlisted species over the next 50 yr. Continued compliance with ESA regulations and coordination with the USFWS would ensure that lease-specific OCS operations would be conducted in a manner likely to avoid or greatly minimize the potential for impacting these species.

The risk of oil contact to spectacled eiders using the spring lead system to move north into the Chukchi Sea during spring migration could be high if a spill entered the area of the leads. Since most spectacled eiders probably use overland routes from the Chukchi to complete their spring migration to nesting areas on the ACP, they are not likely to be contacted by an oil spill during migration. During the broodrearing period, when the young are led to watercourses and ultimately to nearshore marine environments for further development, staging, and fall migration, the risk of oil contact is much greater. Males could be exposed to an oil spill in any of the several bays and lagoons occupied for molting and staging in both the Beaufort and Chukchi Seas (Petersen et al. 1999). The period of highest exposure risk for a given individual migrating across the Beaufort is about 3–5 days. Females and young are at risk of contact primarily when they occupy Smith Bay in the Beaufort (Troy 2003) and Ledyard and Peard Bay (Laing and Platte 1994) in the Chukchi (this area is used by nonbreeding, failed breeding, and successful breeders, as well as both sexes) for the molt prior to fall migration (Petersen et al. 1999). Ledyard Bay has been defined as critical habitat for spectacled eiders. Since most, if not all, of the successfully breeding females (and their young) from the ACP could be concentrated in Ledyard Bay critical habitat area during the molt period, a spill affecting this group in this location could have a long-term population-level effect.

The small ACP population of Steller's eider is not likely to be exposed to an oil spill during nesting or postnesting periods, since most presumably move to the Russian side of the Chukchi prior to migrating south to molting areas. However, there is some evidence to suggest use of Peard Bay by postbreeding Steller's eiders (Martin unpubl. data; Dau and Larned 2004, 2005).

Climate Change. Climate change could have dramatic impacts on the Beaufort Sea and Chukchi Sea Planning Areas. The expected changes in air temperature would have the most immediate effect on the distribution and biology of arctic seabirds and the seabird species most dependent on the presence of ice and snow would be expected to be among the first affected. If temperature increases in the Arctic region are as high as predicted, the Beaufort Sea pack ice could retreat more than 100 km (62 mi) from mainland Alaska (Meehan et al. 1998). This sea ice retreat could have major adverse effects on seabirds that rely on prey associated with ice edges.

Conclusion. Marine and coastal birds in the Beaufort and Chukchi Sea Planning Areas, including those that are ESA-listed, could be adversely affected by activities associated with the proposed action as well as those associated with future OCS and non-OCS program activities. Potential impacts include injury or mortality of birds from collisions with platforms associated with OCS and State oil and gas development and other onshore and offshore structures (e.g., radio, television, or cell phone towers), onshore industrial, commercial, and residential development; exposure to discharges from permitted point sources such as sewage treatment discharges and nonpoint sources such as urban runoff, or accidental releases (e.g., oil spills); exposure to emissions from various onshore and offshore sources; ingestion of trash or debris; loss or degradation of habitat due to construction and operations activities; and behavioral disturbance due to the presence of, and noise generated by, equipment and human activity. Other trends such as extensive melting of glaciers (and increasing river discharges) and increased precipitation brought on by global climate change are also expected to adversely affect marine and coastal birds over the next 40 to 50 yr. While the cumulative impact of all OCS and non-OCS activities in the Beaufort and Chukchi Seas could be minor to moderate, the incremental impact due to the proposed action would be small (see Section 4.4.7.2.3). Compliance with ESA regulations and coordination with the USFWS would ensure that lease-specific OCS operations would be conducted in a manner that is likely to avoid or to greatly minimize the potential for impacting these species.

Marine and coastal birds may also be adversely affected by exposure to oil (via direct contact or through the inhalation or ingestion of oil or tar deposits) that is accidentally released from OCS and non-OCS activities, especially near coastal areas and affecting feeding and nesting areas. The incremental impacts of accidental spills associated with the proposed action on marine and coastal birds would be small to large, depending on the location, timing, duration, and size of the spill; the proximity of the spill to feeding and nesting areas; the timing and nature of spill containment; and the status of the affected birds (see Section 4.4.7.2.3).

Whether net cumulative impacts are minor or moderate depends on the nature and duration of activities that reduce bird survival and productivity. Losses would be limited in areas occupied by scattered flocks during relatively brief staging and migration periods or scattered nest sites during the brief nesting season; however, in cases where exposure to localized disturbance is greater, impacts have the potential to rise to the population level. Population-level effects could be incurred due to the tendency for large numbers of individuals of some bird species to concentrate in certain coastal arctic locations.

4.6.4.3.3 Fish. This section evaluates the cumulative effects of the proposed action, ongoing or planned OCS activities that would occur during the life of the Program, and non-OCS activities on populations of fishes in the Beaufort and Chukchi Sea Planning Areas. The primary routine OCS activities that could result in impacts on fish include seismic surveys; construction of artificial islands, ice roads, drilling, platforms and pipeline placement; releases of permitted discharges from wells; and removal of existing structures. Potential environmental impacts associated with the building and operation of OCS facilities such as subsea production wells, platforms, artificial islands, and pipelines would increase in conjunction with the increased number of wells. Although all of these activities would disturb bottom habitats to some degree, artificial islands result in a more complete loss of benthic habitat due to larger footprints (approximately 9 ha for artificial islands versus less than 1.5 ha for platforms) and due to complete burial of existing substrate during construction. The impacts of routine activities (exploration and site development, production and decommissioning) on fish communities are discussed in detail in Section 4.4.7.3.3. Overall, routine activities represent up to a minor disturbance, primarily affecting demersal fishes, with the severity of the impacts generally decreasing with distance from bottom-disturbing activities.

Oil and gas exploration and development in State waters could also contribute to cumulative effects on fishery resources in the Beaufort and Chukchi Planning Areas. Drilling of wells in State waters could also require construction of platforms and pipelines in waters of Alaska. The effects on fish would be similar to those described above for OCS oil and gas programs (Section 4.4.7.3.2). Other non-OCS activities that could impact fish communities include subsistence fishing, hardrock mining, sediment dredging and disposal of dredging spoils in OCS waters, and commercial shipping (tanker vessels) and anchoring. Many of these activities would result in bottom disturbance that would affect bottom dwelling fishes as well as their food sources in a manner similar to those described for OCS activities (MMS 2008; ADEC 2007a; Section 4.4.7.3.3). Commercial fishing does not occur in the Beaufort and Chukchi Sea Planning Areas, and sportfishing is minor in the Arctic but could increase if regulations change and if warming temperatures allow an increase in vessel traffic. Effects on fish resources from non-OCS dredging and marine disposal activities are expected to be similar to those described for OCS bottom disturbing activities (Section 4.4.7.3.3). Due to the small number and limited use of disposal sites in the vicinity of the Beaufort and Chukchi Sea Planning Areas, these activities are not expected to noticeably alter fish populations.

Beaufort and Chukchi Seas fall in the Kotzebue Sound and Northern Subsistence fishing areas. Subsistence fishing may contribute to the cumulative effects on the abundance of some fishery resources. Alaska State law defines subsistence as the "noncommercial customary and traditional uses" of fish and wildlife. The Alaska Department of Fish and Game defines subsistence fishing to include "the taking of, fishing for, or possession of fish, shellfish, or other fisheries resources by a resident of the state for subsistence uses with gill net, seine, fish wheel, long line, or other means defined by the Board of Fisheries." These fishing methods have more limited impacts on fish and fish habitat compared to commercial fishing methods. In addition, subsistence fishing is subject to harvest limits that reduce the potential for overfishing. Consequently, subsistence fishing makes a relatively minor contribution to the reduction in fish stocks.

Cumulative impacts on diadromous species could also occur as a result of activities that obstruct fish movement in marine environments during migration periods. For example, some structures along the Beaufort Sea mainland (e.g., the West Dock) have been shown to block the movements of diadromous fishes, particularly juveniles, under certain meteorological conditions (Fechhelm 1999; Fechelm et al. 1999). Causeways such as the 40 m wide and 60 m long structure associated with the Red Dog Mine may impede coastal movement either by directly blocking fish or by modifying nearshore water conditions to the point where they might become too cold and saline for some species (Fechhelm et al. 1999). Although the presence of causeways has been an issue associated with oil development activities in the Beaufort Sea, the small size of the Red Dog causeway would likely have little effect on the coastal movements and distributions of Chukchi Sea fishes and shellfishes. However, it is anticipated that proper placement and design considerations for future causeway construction along the North Slope would alleviate the potential for such effects on fish movement.

There are several contaminant sources in the Beaufort and Chukchi Sea Planning Areas. The Red Dog Mine in Alaska is the largest lead and zinc mine in the world, and is presently the only base-metal lode mine operating in northwest Alaska. A study for the National Park Service (Hasselbach et al. 2004) showed extensive airborne transport of cadmium and lead from Red Dog Mine; although the study was focused only on the limits of the Cape Krusenstern National Monument, these contaminants are probably carried out into the Chukchi Sea. There are also natural sources of metals and hydrocarbons. Sediments, peats, and soils from the Sagavanirktok, Kuparuk and Colville Rivers are the largest source of dissolved and particulate metals and saturated and polycyclic aromatic hydrocarbons in the development area. However, concentrations of metals and organics in fish sampled in the Arctic Planning Areas are typically at background levels (Neff & Associates 2010).

Climate change may affect fish communities in the Beaufort and Chukchi Sea Planning Areas. Climate would only be one of several factors that regulate fish abundance and distribution. Many fish populations are already subject to stresses, and global climate change may aggravate the impacts of ongoing and future human use of the coastal zone. Fish respond directly to climate fluctuations, as well as to changes in their biological environment including predators, prey, species interactions, and disease. Projected changes in hydrology and water temperatures, salinity, and currents can affect the growth, survival, reproduction, and spatial distribution of marine fish species and of the prey, competitors, and predators that influence the dynamics of these species (Watson et al. 1998). Changes in primary production levels in the ocean because of climate change may affect fish stock productivity. Climate change may have a number of effects on fish communities, including:

- Changes in the timing of seasonal fish migrations;
- Increased storm damage to nearshore areas as the amount of open water increases and their reduction or elimination by rising sea levels;
- Reduction in habitat for sea ice dependent species; and
- Replacement of true Arctic species such as Arctic cod and capelin by the range expansions of subarctic species.

Large-scale changes in oceanographic and ecosystem processes resulting from climate change could indirectly affect fish populations in the Arctic in several ways. For example, under the existing temperature regime, the Chukchi Sea has a food web dominated by benthic consumers and cryopelagic (sea ice-associated) fishes. The loss of sea ice and the increased surface water temperature may promote a shift to a pelagic-based food web with high phytoplankton and zooplankton productivity and greater numbers of predatory fish (Loeng 2005; Hopcraft et al. 2008). Ultimately, however, predictions about the indirect and cascading ecological impacts of climate change on specific species are subject to great uncertainty, given the complexity of the ecosystem.

Oil spills could result from OCS and non-OCS activities. The total number of oil spills and the extent of affected areas would likely increase under the proposed action in conjunction with increased levels of petroleum exploration and production. The potential impacts of OCS oil spills on fish communities in the Beaufort and Chukchi Sea are discussed in detail in Section 4.4.7.3.3. Non-OCS activities, such as oil and gas development in State waters, domestic transportation of oil or refined petroleum products, and commercial shipping (including tinkering), may also result in accidental spills that could potentially impact fish resources within the Beaufort and Chukchi Sea Planning Areas. While effects to fishery resources would depend on the timing, location, and magnitude of specific oil spills, it is anticipated that most small to medium spills that occur in OCS waters would have limited effects on fishery resources due to the relatively small areas likely to be exposed to high concentrations of hydrocarbons and the short period of time during which potentially toxic concentrations would be present. In general, adult fish in marine environments are highly mobile and capable of avoiding high concentrations of hydrocarbons although they may be subject to sublethal exposures. However, fish eggs and larvae as well as small benthic obligate fish species do not typically have the ability to avoid spills and may therefore suffer lethal or sublethal effects. Oil from large and catastrophic spills that reaches shallower, nearshore areas of these planning areas has the potential to be of greatest significance to fish communities. The potential impacts of OCS oil spills on fish communities in the Beaufort and Chukchi Sea Planning Areas are discussed in detail in Section 4.4.7.3.3.

Some diadromous species of the Beaufort and Chukchi Sea Planning Areas could be at greater risk from oil spills because of their unique life-history cycles. Oil spills occurring at constrictions in migration routes, nursery areas, and spawning areas would have an increased potential for adversely affecting diadromous fishes, and catastrophic spills could result in long-term, population-level impacts on diadromous fish communities. Pacific salmon are also able to detect and avoid oil spills in marine waters (see Section 4.4.7.3.2), which would help to reduce the potential for contact. Aggregations of salmon in marine waters typically consist of mixed stocks, so even in the unlikely event of contact with an oil spill, it is anticipated that only a small fraction of any unique spawning population would be adversely affected. Juveniles of some species of whitefish (including broad whitefish, humpback whitefish, and least cisco) are intolerant of highly saline marine conditions. During their summer feeding dispersals in the Beaufort Sea, these species tend to remain within a narrow band of warm, low-salinity water along the coast. Thus, unlike most subarctic fishes, North Slope whitefish have a reduced capacity to bypass localized disruptions to their migration corridor by moving offshore and around the impasses. An oil spill, even one of limited area, could block the narrow nearshore corridor and prevent fishes from either dispersing along the coast to feed or returning to their overwintering grounds in North Slope rivers.

Conclusion. Cumulative impacts on fish communities in the Beaufort and Chukchi Sea Planning Areas could result from OCS and non-OCS activities. It is anticipated that the cumulative effects of OCS and non-OCS activities on fish species in the Beaufort and Chukchi Sea Planning Areas would be similar to the effects of non-OCS activities alone, and the proposed action is expected to contribute only a small increment to the potential for overall cumulative effects on fish resources (see Section 4.4.7.3.3). because of existing regulations, the limited timeframe over which most individual activities would occur and the small proportion of available habitats that would be affected during a given period.

The magnitude and severity of potential effects to fish resources from oil spills would be small to large, depending on the location, timing, duration, and size of spills; the proximity of spills to particular fish habitats; and the timing and nature of spill containment and cleanup activities. Small spills, whether from OCS or non-OCS sources, are unlikely to have overall population-level effects on fish resources. However, oil from catastrophic spills that contacted shallow nearshore areas of these planning areas has the potential to be of greatest significance to fish communities. Such spills could result in long-term, population-level impacts on fish communities.

4.6.4.3.4 Invertebrates and Lower Trophic Levels. This section evaluates the cumulative effects of the proposed action, ongoing or planned OCS activities that would occur during the life of the Program, and non-OCS activities on invertebrates in the Beaufort and Chukchi Sea Planning Areas. The primary routine OCS activities that could result in impacts on invertebrates include seismic surveys, drilling, the placement of subsea wells, platforms, and pipelines; releases of permitted discharges from wells; and removal of existing structures. Potential environmental impacts associated with the building and operation of OCS facilities such as platforms, and pipelines would increase in conjunction with the increased number of wells. The impacts of routine activities (exploration and site development, production and decommissioning) on invertebrate communities are discussed in detail in Section 4.4.7.5.3. Overall, routine activities represent up to a moderate disturbance, primarily affecting benthic infaunal invertebrates, with the severity of the impacts generally decreasing dramatically with distance from bottom-disturbing activities.

The placement of new platforms over the life of the Program would allow the colonization of invertebrates requiring hard substrate. While some platforms may be allowed to remain as artificial reefs, removal of platforms will reduce available substrate and structures for invertebrates and injure or kill them during removal.

Oil and gas exploration and development in State waters could also contribute to cumulative effects on invertebrates in the Beaufort and Chukchi Sea Planning Areas. Drilling of wells in State waters could also require construction of platforms and pipelines in waters of Alaska. The effects on invertebrates would be similar to those described above for OCS oil and gas programs (Section 4.4.7.5.3). Other non-OCS activities that could impact invertebrate communities include land use practices, point and non-point source pollution, logging, dredging/ and disposal of dredging spoils in OCS waters, and anchoring. Commercial fishing does not occur in the Arctic and therefore is not expected to add to cumulative impacts on invertebrate communities. However, this could change if regulations change and if warming temperatures allow an increase in vessel traffic. Effects on invertebrates from non-OCS dredging and marine disposal activities are expected to be similar to those described for OCS bottom disturbing activities (Section 4.4.7.5.3). Recovery of benthic invertebrates at the dredge and disposal sites to their pre-disturbance composition would likely take multiple years. Many of these activities would affect bottom dwelling invertebrates at various life stages as well as their food sources in a manner similar to OCS bottom disturbing activities (Section 4.4.7.5.1). Other non-OCS activities generating pollution and noise may contribute to general habitat degradation (Section 4.6.3.2.2).

There are several contaminant sources in the Beaufort and Chukchi Sea Planning Areas. The Red Dog Mine in Alaska is the largest lead and zinc mine in the world, and is presently the only base-metal lode mine operating in northwest Alaska. A study for the National Park Service (Hasselbach et al. 2004) showed extensive airborne transport of cadmium and lead from Red Dog Mine; although the study was focused only on the limits of the Cape Krusenstern National Monument, these contaminants are probably carried out into the Chukchi Sea. There are also natural sources of contaminants. Sediments, peats, and soils from the Sagavanirktok, Kuparuk and Colville Rivers are the largest sources of dissolved and particulate metals and saturated and polycyclic aromatic hydrocarbons in the development area. However, contaminant concentrations in the benthic invertebrates collected in the Beaufort and Chukchi Sea Planning Areas are typically at background levels (Neff & Associates 2010).

It is predicted that physical and chemical changes to arctic and subarctic invertebrate habitat could result from climate change (Section 3.3). These changes could alter the existing distribution, composition, and abundance of invertebrates, since physical and chemical parameters are the primary influence on invertebrate communities. In general, the increase in seawater temperature will facilitate a northward expansion of subarctic invertebrate species from the Bering Sea. Weslawski et al. (2011) identified the Bering Strait as a major corridor through which new invertebrate species will expand their range northward. Such expansion will likely increase overall invertebrate species diversity in the Arctic, but the new species may displace existing species or alter existing inter-specific species interactions. The change in species composition may be greatest in the eastern Beaufort Sea where arctic species currently predominate. It is predicted that a decrease in sea ice habitat would result from increasing water temperature. This may have several impacts on invertebrate communities in the Arctic including:

- Loss of habitat for invertebrates specialized to inhabit sea ice;

- An increase in the productivity of water column invertebrates with increasing temperature and open water;

- An increase in the abundance of benthic invertebrates in nearshore areas with the reduction in ice scour extent and duration (Weslawski et al. 2011); and

- An increase in benthic disturbance from severe weather as the amount of open water increases.

Changes in the magnitude, frequency, and timing of river discharge into the Beaufort/Chukchi Shelf Ecoregion are expected to result from climate change (Arctic Council 2005). Invertebrates in marine ecoregions with strong riverine inputs — like the Beaufort Neritic Ecoregion — would likely be affected by alterations in the salinity, temperature, and sediment delivery regime. Hydrologic change can rapidly alter existing invertebrate communities in the water column and benthos, if the new chemical conditions are not within the physiological tolerance of the existing communities. The greater variability in hydrologic conditions could favor tolerant and opportunistic species, thereby homogenizing invertebrate species composition and decreasing overall species diversity in the Beaufort and Chukchi Seas (Weslawski et al. 20011).

The expected increase in ocean acidification is considered to be another significant source of physiological stress. Crustaceans, echinoderms, foraminiferans, and mollusks could have greater difficulty in forming shells, which could reduce their fitness, abundance, and distribution (Fabry et al. 2008).

Oil spills could result from OCS and non-OCS activities. The total number of oil spills and the extent of affected areas would likely increase under the proposed action in conjunction with increased levels of petroleum exploration and production (Table 4.6.1-3). The potential impacts of OCS oil spills on invertebrate communities in the Beaufort and Chukchi Sea are discussed in detail in Section 4.4.7.5.3. Non-OCS activities, such as oil and gas development in State waters, domestic transportation of oil or refined petroleum products, and commercial shipping, may also result in accidental spills that could potentially impact invertebrate resources within the Beaufort and Chukchi Sea Planning Areas. While effects to invertebrates would depend on the timing, location, and magnitude of specific oil spills, it is anticipated that most small to medium spills that occur in OCS waters would have limited effects due to the relatively small areas likely to be exposed to high concentrations of hydrocarbons. Oil from catastrophic spills that reach shallower, nearshore areas of these planning areas has the potential to be of greatest significance to invertebrate communities. Large, mobile epifaunal invertebrates are capable of avoiding high concentrations of hydrocarbons although they may be subject to sublethal exposures. However, infauna and invertebrate eggs and larvae do not typically have the ability to avoid spills and may therefore suffer lethal or sublethal effects. Catastrophic spills could result in long-term alterations in the abundance of intertidal and shallow subtidal invertebrate communities. The potential impacts of OCS oil spills on invertebrate communities in the Arctic planning areas are discussed in detail in Section 4.4.7.5.3.

Conclusion. Cumulative impacts on invertebrate communities in the Beaufort and Chukchi Sea Planning Areas could result from OCS and non-OCS activities. Multiple non-OCS activities could impact invertebrate populations. It is anticipated that the cumulative effects of OCS and non-OCS activities on invertebrates would be similar to the effects of non-OCS activities alone, and the proposed action is expected to contribute only a small increment to the potential for overall cumulative effects on invertebrate resources (see Section 4.4.7.5.3).

The magnitude and severity of potential effects to invertebrate resources from oil spills would be a function of the location, timing, duration, and size of spills; the proximity of spills to particular habitats; and the timing and nature of spill containment and cleanup activities. Spills in deeper water, whether from OCS or non-OCS sources, are unlikely to have overall population-level effects on invertebrate resources because of the relatively small proportion of similar available habitats that would come in contact with released oil at concentrations great enough to elicit toxic effects. Oil from catastrophic spills that reaches shallower, nearshore areas of these planning areas has the potential to be of greatest significance to invertebrate communities. Impacts from such spills could result in long-term, population level impacts on invertebrate communities.

4.6.4.3.5 Areas of Special Concern. Cumulative impacts to these areas of special concern include impacts from both OCS and non-OCS activities. Section 4.4.8.3 identifies potential impacts that could result from routine activities or accidents related to the proposed leasing program on areas of special concern adjacent to and in the Beaufort Sea and Chukchi Sea Planning Areas.

National Park Service Lands. In the Arctic, activities associated with the Red Dog Mine and its port facility south of Kivalina on the Chukchi Sea would contribute to cumulative impacts on the Cape Krusenstern National Monument. The road from the mine (located just outside the monument) to the port crosses the northern boundary of the monument. Impacts from this facility, such as habitat loss or disturbance, are expected to be minor due to the limited activity associated with the mine.

There is minor land and air traffic in the Arctic and most visitors would arrive by sea. Because the amount of traffic is restricted and activities within the parks regulated, traffic would likely create a minor addition to cumulative impacts on the NPS lands. It is anticipated that noise generated by OCS offshore construction activities would be at low levels, intermittent, and would not persist for more than a few months at any one time. It is considered unlikely that these additional activities would noticeably affect wildlife or park user values compared to current (non-OCS) activities within the Beaufort and Chukchi Sea Planning Areas.

Impacts on these areas could occur due to accidental releases of oil spilled from onshore facilities and offshore drilling rigs. Non-OCS activities, such as oil and gas development in State waters, the domestic transportation of oil or refined petroleum products, the production and storage of petroleum products, and commercial shipping (tanker traffic) could also result in accidental spills that could affect park lands. Naturally occurring seeps may also be a source of crude oil introduced into nearshore waters (Kvenvolden and Cooper 2003). Noatak National Preserve, Kobuuk River National Preserve, Cape Krusenstern National Monument, and Bering Land Bridge National preserve all have coastlines on or near the Chukchi Sea and could potentially be affected by spills from tanker traffic. Although not an NPS land, the National Petroleum Reserve is managed by BLM and has a large shoreline component that borders the Chukchi Sea. An oil spill would have the greatest effect if it came into contact with shoreline habitats. Impacts would depend primarily on the spill location, size, and time of year. In general, directly affected coastal fauna could include marine mammals; fishes that reproduce in, inhabit, or migrate through coastal areas; terrestrial mammals that feed on these fishes; and marsh birds and seabirds. Spilled oil could also affect subsistence harvests in those parks in which subsistence hunting and fishing are allowed and could affect the number of park visitors.

National Wildlife Refuges. NWRs in the vicinity of the Beaufort and Chukchi Sea Planning Areas are identified in 3.9.3.2 for the Beaufort and Chukchi Seas. NWRs (including three units of the Alaska Maritime NWR) potentially affected by OCS activities include the Arctic National Wildlife Refuge (ANWR) and the Alaska Maritime NWR (Chukchi Sea Unit, Gulf of Alaska Unit, Alaska Peninsula Unit).

Oil drilling and facility development are prohibited in the ANWR and are discretionary on all other refuges; however, refuges could potentially be affected by OCS oil and gas development from adjacent regions under the cumulative case scenario. These refuges could be contaminated by oil spilled from offshore projects, or could be subject to negative effects from routine operations associated with the development of onshore oil and gas support facilities. They could also be affected by non-OCS activities within or adjacent to refuges including State oil and gas development, the domestic transportation of oil or refined petroleum products, the production and storage of petroleum products and LNG, and commercial shipping. Numerous refuge lands have been conveyed to private owners and Native corporations. Section 22(g) of the Arctic Native Claims Settlement Act (1971) requires that new development on these lands must be in accordance with the purpose for which the refuge was formed. Thus, while development of onshore oil and gas support facilities is technically possible, such development would be subject to intensive review (as would any other development).

The potential cumulative effects of routine operations and accidental events on these NWR's are essentially the same as those discussed above for the NPS lands. In addition, subsistence hunting and fishing are permitted on all refuges in Alaska and could, therefore, be affected by accidents and routine operations in the immediate vicinity of refuge properties.

National Forests. There are no national forests in the Beaufort and Chukchi Sea Planning Areas.

Conclusion. Overall, routine OCS operations could result in small incremental increases in effects on national parks and wildlife refuges compared to existing non-OCS activities. Development of onshore facilities within national park lands in the vicinity of the areas included in the Program is considered unlikely, thereby making impacts from cumulative routine OCS operations unlikely in these areas. Offshore construction of pipelines and platforms could contribute to cumulative effects on wildlife and on scenic values for park visitors due to noise and activity levels. However, such effects would be localized, intermittent, and temporary. It is anticipated that lease stipulations applied at the lease sale stage could minimize the potential for cumulative impacts from routine operations on these areas.

Compared to the existing potential for oil spills to affect such areas, the activities under the proposed action would be expected to result in a small incremental increase in the risk of impacts from oil spills to areas of special concern. The cumulative level of impacts from spills would depend on spill frequency, location, and size; the type of product spilled; weather conditions; effectiveness of cleanup operations; and other environmental conditions at the time of the spill. Large and catastrophic oil spills in areas adjacent to the national parks or refuges, whether from OCS or non-OCS sources, could negatively impact coastal habitats and fauna and could also affect subsistence uses.

4.6.5 Social, Cultural, and Economic Resources

4.6.5.1 Gulf of Mexico Region

4.6.5.1.1 Population, Employment, and Income. Section 4.4.9.1 discusses the potential impacts from the proposed action (OCS program activities from 2012 to 2017) on population, employment, and income in the GOM coast region. Cumulative impacts on these resources result from the incremental impacts of the proposed action when added to impacts from existing and reasonably foreseeable future OCS program activities (that are not part of the proposed action) and other non-OCS program activities. Specific types of impact-producing factors related to OCS program activities considered in this analysis include total employment and regional income for counties in the 23 LMAs in the five States in the GOM coast region (described in Section 3.10). Non-OCS program activities affecting the region include employment and earnings related to various other industrial sectors (e.g., construction, manufacturing, services, and State and local government) and the high unemployment rates in the five GOM coast States.

The population in the GOM coast counties increased at an average annual rate of 1.6% between 1980 and 1990, 1.2% between 1990 and 2000, and 1.5% between 2000 and 2009. During each of these periods, the greatest increases consistently occurred in Texas (with an average annual increase of 2.1% between 2000 and 2009) and Florida (with an average annual increase of 1.6% between 2000 and 2009). The components of population increase include the natural increase due to births and net positive domestic and international migration; these trends will likely continue in the GOM coast region over the next 40 to 50 yr.

Although the proposed action would add an average of 9,084 to 14,839 jobs annually between 2012 and 2017, this increase is considered minor (though positive) since it would amount to less than 1% of total GOM coast regional employment. The largest increases would occur in Louisiana and Texas. Likewise, income produced in the region would range from $648.6 million to $1,066.2 million, with the greatest impacts occurring in Louisiana and Texas.

Population increases of 7,455 to 16,497 would be expected in Louisiana on average in each year of the proposed action, with increases of 6,260 to 14,131 occurring in Texas. Smaller population increases of 1,065 to 2,311 per new job would occur in Florida, with increases of 342 to 750 in Alabama and 283 to 620 in Mississippi. These increases also represent small changes (about 1% in the region overall), assuming a 1.5% average annual increase in population between 2009 and 2017.

Employment impacts of oil spills reaching landfall can vary considerably depending upon the total volume of oil reaching land, land area affected, and sensitivity of local environmental conditions to oil impacts. The primary impacts of oil spills would most likely fall on such activities as beach recreation, diving, commercial fishing, recreational fishing, and sightseeing. Oil spills reaching land can have both short- and long-term effects on these recreational coastal activities. Past studies (Sorenson 1990) have shown that there could be a one-time seasonal decline in tourist visits of 5 to 15% associated with a major oil spill. Since tourist movement to other coastal areas in the region often offsets a reduction in the number of visits to one area, the associated loss of business tends to be localized. As discussed in Section 4.4.9, the employment and regional income impact from an oil spill related to the proposed action would likely be greatest in Texas and Florida and this would likely continue over the next 40 to 50 yr. Oil spills will generate only temporary employment (and population) increases during cleanup operations, because such operations are expected to be of short duration.

Hurricanes are recurring events in the GOM area to which the demographic and economic patterns have adjusted. In 2005, however, Hurricanes Katrina and Rita resulted in major socioeconomic changes throughout the GOM region, affecting population, employment, and regional income. Katrina-related flooding affected 49 counties in Alabama, Louisiana, and Mississippi, resulting in estimated damage of more than $155 billion (Burton and Hicks 2005). Damage or loss of hundreds of thousands of homes has resulted in the out-migration of hundreds of thousands of individuals from the region, with varying levels of long-term population displacement. Estimated declines in employment due to hurricane damage and population displacement have ranged from 150,000 to 500,000 jobs, although employment is expected to increase as reconstruction of impacted areas proceeds (Congressional Budget Office 2005). Estimated declines in the 2005 total annual personal income in the GOM range from $10 million in Texas to more than $18 million in Louisiana (Bureau of Economic Analysis 2006).

Conclusion. The cumulative impacts of ongoing and future OCS program and non-OCS program activities would be considered beneficial because these activities would increase employment and earnings in the region over the next 40 to 50 yr. The proposed action would add to these beneficial impacts, especially in Texas and Louisiana. The incremental impact of the proposed action is expected to be small, however, because the added employment demands are less than 1% of the total GOM coast regional employment (see Section 4.4.9.1).

In areas with a large proportion of impact-sensitive industry (such as tourism), the cumulative impacts of accidental oils spills could be moderate to major, depending on the total volume of oil reaching land, the land area affected, and the sensitivity of local environmental conditions to oil impacts. The incremental impacts of oil spills associated with the proposed action would be small to medium relative to those associated with ongoing and future OCS program and non-OCS program activities.

4.6.5.1.2 Land Use and Infrastructure. Localized site-dependent impacts to land use and existing infrastructure are anticipated as a result of the construction of new OCS program oil and gas facilities in the GOM over the next 40 to 50 yr. Depending on the location selected, onshore development may necessitate minimal changes of existing or potential future uses, as well as minor increases in demands on roads, utilities, and public services (MMS 2007c). Land use generally would evolve over time, with a majority of change to occur from general, regional economic, and demographic growth rather than from activities associated with the existing OCS program and/or State offshore petroleum production or future planned OCS or State lease sales (BOEMRE 2011a).

Recently, deepwater gas production has increased while gas production along the coast has substantially decreased. These trends have combined to lower the need for new gas processing facilities along the GOM coast. As a result, BOEM has concluded that "spare capacity at existing facilities should be sufficient to satisfy new gas production for many years, although there remains a slim chance that a new gas processing facility may be needed" (BOEMRE 2011a). With some modifications, current facilities and land use classifications would be expected to support oil and gas production associated with new leases. Likewise, service-based infrastructure would be able to support offshore petroleum-related activities in both the OCS and State waters (BOEMRE 2011a).

Ongoing non-OCS program activities that could affect land use and onshore infrastructure are expected to continue into the foreseeable future. These include offshore and onshore construction, the discharge of municipal and other waste effluents, and vessel traffic (MMS 2007c).

Activities within the GOM may be affected by post-DWH event conditions. A significant amount of information has been generated regarding the consequences of the oil spill and subsequent drilling moratorium. As the post-DWH event situation is dynamic, BOEM has been conducting ongoing monitoring of post-DWH event impacts on land use and coastal infrastructure. BOEM plans to continue to conduct targeted and peer-reviewed research, as long as the monitoring identifies long-term impacts of concern (BOEMRE 2011a).

Accidental oil releases may occur as a result of both OCS and non-OCS activities. Oil is also released from naturally occurring seeps. The extent of the impacts would depend on the location and size of the releases, but could include stresses of spill response on the community infrastructure, increased traffic to respond to cleanup, and restricted access to particular lands while cleanup is conducted. In general, these releases would be expected to have a temporary impact on land use and infrastructure (MMS 2007c).

Conclusion. Localized site-dependent impacts to land use and existing infrastructure are anticipated as a result of ongoing and future OCS program and non-OCS program activities in the GOM. These impacts could range from minor to major depending on the nature (extent and duration) of the land use change. Minimal changes of existing or potential future uses, as well as minor increases in demands on roads, utilities, and public services would be expected at locations of OCS program development. Ongoing non-OCS program activities (e.g., offshore and onshore construction and municipal discharges) that could affect land use and onshore infrastructure are expected to continue into the foreseeable future (see Section 4.4.10.1). Activities within the GOM also may be affected by the post-DWH event conditions; BOEM continues to monitor the region to identify long-term impacts of concern.

The extent of land use-related impacts resulting from accidental oil spills and naturally occurring seeps could be minor to major, depending on the location and size of the releases.

4.6.5.1.3 Commercial and Recreational Fisheries.

Commercial Fisheries. Routine OCS activities over the next 40 to 50 yr could harm or kill individual fishes, resulting in temporary movements of fishes away from areas where activities were being conducted. Impacts would vary depending on the nature of a particular structure, the phase of operation, the fishing method or gear, and the target species group. Impacts would be higher for drifting gear such as purse nets, bottom longlines, and pelagic longlines than for trawls and handlines (MMS 2005). Nevertheless, areas in which commercial fishing would be affected are small relative to the entire fishing area available to surface longliners or purse seiners. Although long-term effects on populations of most fishes in the GOM as a whole are not anticipated, populations of rare fishes or those that have highly limited distributions within the GOM could be more substantially affected if activities occurred in areas with high concentrations of individuals.

Offshore oil and gas structures placed within the depth range 0 to 60 m (0 to 200 ft) would increase annual commercial fishing costs by between $1,993 and $3,819 in the Western Planning Area, while reducing costs by between $2,507 and $11,243 in the Central Planning Area. Currently, there are no data available on the placement of offshore platforms in the Eastern Planning Area; consequently, we can draw no conclusions regarding their impact on commercial fishing costs.

Depending upon the location, magnitude, and timing of accidental oil spills from OCS platforms or pipelines, lethal or sublethal toxic effects could occur, especially for species that have pelagic eggs and larvae. If spills occurred in areas with high concentrations of eggs or larvae of a particular species, the abundance of a particular year-class could be affected. The effects of spilled oil on commercial fisheries include fishing ground area closures, contaminated fish, fouled fishing gear and associated equipment, and degradation of fishing grounds. Accidental oil releases from non-OCS activities are possible anywhere on the OCS or in State waters (i.e., from vessel collisions or transfer/lightering operations); crude oil also enters the environment from naturally occurring seeps. Although such releases typically occur in deeper water, the released oil should rise to the surface relatively quickly, and although it is anticipated that most adult fish would be able to avoid the resulting plumes of oil, larvae or eggs of some fish species could be affected and commercial fishing gear could become fouled with oil. In many cases, commercial fisheries would be able to return to the area after slicks have been cleaned up or dispersed. However, shallow coastal spills could contaminate tissues of target organisms (e.g., oyster beds and shallow benthic fishes), and affected commercial fisheries could be closed for one or more seasons.

Non-OCS program activities and factors that could affect fish populations in the GOM include State oil and gas activities, commercial shipping, land development, dredging and dredge-disposal operations, marine mineral extraction, and water quality degradation from both point and nonpoint pollution sources. In particular, space-use conflicts resulting from exploration and delineation activities and establishment of development and production platforms could affect commercial fisheries, with some areas precluded from commercial fisheries. There are temporary exclusions from fishing in areas during exploration and delineation activities. Underwater OCS structures such as pipelines could also cause space- and gear-related conflicts, and increased vessel traffic to and from the rigs and platforms will also increase the amount of marine traffic and possible conflicts with commercial fishers. The potential for spatial preclusion also exists in both nearshore and offshore waters with increased levels of seismic survey activity.

Recreational Fisheries. While space-use conflicts with recreational fisheries caused by routine OCS operations would be minimal, there is recreational shrimp trawling for wild shrimp, and trawls could become entangled with OCS structures in the water. Deepwater recreational rod-and-reel anglers typically target oil and gas platforms because these structures usually attract target species. Noise from rig and platform installation and from seismic surveys during exploration and delineation activities could scatter target species away from some recreational fishing areas while activities are occurring and potentially for some period afterward. Temporary reductions in hook-and-line captures have been reported in some areas following seismic surveys. This may result in decreased recreational catch. Platform removal using explosives may also impact recreational fisheries. The noise would drive some fish away, some fish would be killed, and a structure that may be targeted as a fishing location by recreational anglers could be eliminated.

Oil spills from OCS or non-OCS sources could affect recreational fisheries by fouling gear with oil, tainting the catch, and degrading water quality and fishing grounds. Accidental oil releases from non-OCS activities are possible anywhere on the OCS or in State waters, and crude oil also enters the environment from naturally occurring seeps. The OCS oil spills most likely to affect recreational anglers would be shallow water spills, since recreational anglers are less likely to venture far offshore. Non-OCS oil and gas activities likely pose a greater risk in terms of potential oil spills that could affect recreational fisheries, because such activities are located closer to shore. Closure of some areas to fishing, perhaps for multiple seasons, could occur as a result of oil spills. In addition, public perception of the effects of a spill on marine life and its extent could result in a loss of revenue for the fishing-related recreation industry. Party and charter boat recreational fisheries often have losses of income because of reduced interest in fishing when a spill has occurred. Local hotels, restaurants, bait-and-tackle shops, and boat rental companies associated with recreational fisheries may experience reduced sales because of public perception related to an oil spill.

Conclusion. The proposed action would represent a small increment to the potential for overall cumulative effects on fisheries in the GOM. Routine OCS program activities would be unlikely to have cumulative population- or community-level effects on fishery resources because of the limited timeframe over which most individual activities would occur, because a small proportion of habitat, relative to similar available habitat, could be affected during a given period and because existing stipulations are in place to avoid impacts on sensitive habitats such as hard-bottom areas and topographic features. Non-OCS program activities, including State oil and gas development, commercial fishing, and sportfishing, could also contribute to cumulative effects on fisheries. Depending on specific conditions during a large spill, there could be substantial economic losses for commercial fisheries as a consequence of reduced catch, loss of gear, or loss of fishing opportunities during cleanup and recovery periods. Non-OCS program sources of spills, including State oil and gas production, have a potential to cause similar effects. The occurrence of a very large spill, such as could occur from a tanker accident, could have substantially greater effects on fisheries.

It is anticipated that the proposed action would represent a small increment to the overall cumulative effects on recreational fisheries in the GOM. Routine OCS activities from the proposed action, as well as from ongoing and planned OCS activities would be unlikely to have cumulative population- or community-level effects on fishery resources because of the limited timeframe over which most individual activities would occur, because only a small proportion of habitat, relative to similar available habitat, could be affected during a given period, and because of existing stipulations that are in place to avoid impacts to sensitive habitats such as hard bottom areas and topographic features. Construction of new platforms could represent a small increase in the availability of desirable recreational fishing locations for recreational anglers.

4.6.5.1.4 Tourism and Recreation. Noise from platform installation and platform removal can affect recreational fishing by temporarily disturbing fish and by possible fish kills if explosives are used to remove platforms. Platforms installed within 16 km (10 mi) of coastal recreation areas, such as beaches, parks, and wilderness areas, can affect recreational experiences by affecting ocean views. Transportation of oil and gas, combined with other commercial, industrial, and recreational transportation activities that continue to occur within the GOM, can impact recreational experiences through increased noise, boat wake disturbances, visual intrusions, and increased trash and debris washing ashore. In addition to transportation and oil and gas, other activities contribute to the trash and debris found on the beaches including (but not limited to) beach visitors, commercial and recreational fishing, merchant shipping, naval operations, and cruise lines.

Non-OCS activities that might impact recreation and tourism include offshore construction (e.g., dredging and marine disposal, extraction of non-energy minerals, State oil and gas development, domestic transportation of oil and gas, and foreign crude oil imports), onshore construction (e.g., coastal and community development), the discharge of municipal and other waste effluents, and vessel traffic (e.g., commercial shipping, recreational boating, and military training and testing).

Accidental oil releases may occur as a result of both OCS and non-OCS activities, and oil is also released from naturally occurring seeps. The magnitude of the impacts would depend on the location and size of the releases, as well as their timing with respect to peak tourism seasons. These releases are expected to have a temporary impact on recreation and tourism in the GOM region. Closures of recreational areas for up to 6 weeks could occur to accommodate cleanup operations. Releases identified under the proposed action are anticipated to be small, for the most part, and to occur in waters greater than 200 m (660 ft) in depth. These releases would be a small addition to releases associated with other OCS and non-OCS activities.

Severe storm events such as hurricanes have the potential to impact the recreation and tourism economy if they result in severe beach damage and/or destruction of existing public infrastructure. While hurricanes are regularly occurring events in the GOM, Hurricanes Katrina and Rita in 2005 caused unusually large amounts of damage to the tourism and recreation infrastructure in the area. These storms destroyed recreational beaches, public piers, hotels, casinos, marinas, recreational pleasure craft and charter boats, and numerous other recreational infrastructure. Almost 70% of the recreational fishing assets in Mississippi alone were damaged by Katrina (Posadas 2005). Of the 13 casino-barge structures present along the Mississippi coast prior to Katrina, most suffered severe external damage, seven broke completely free of their moorings, two partially broke free and damaged adjoining structures, one sank, and one was deposited inland by the storm surge (National Institute of Standards and Technology, draft). The full extent of impacts to tourism and recreation by the hurricanes has yet to be fully quantified, but it will likely take years for tourism and recreation to return to pre-hurricane levels.

Conclusion. Cumulative impacts on recreation and tourism from OCS and non-OCS program activities in the GOM would be limited for most routine activities, with the exception of impacts associated with large oil spills during the peak tourist season, which could be moderate (but short-term). The incremental contribution of routine Program activities to cumulative impacts would be minor, resulting from small incremental increases in construction and transportation noise and related visual intrusions, potential increases in trash and debris related to these activities, and the potential for a relatively small number of accidental releases (see Section 4.4.12.1).

4.6.5.1.5 Sociocultural Systems. The GOM coastal commuting zone is ethnically and culturally diverse and includes a well-established oil and gas industry focused mainly in Louisiana and Texas (Section 3.14.1.1). For the most part, oil and gas development on the OCS will make use of existing pipelines and onshore infrastructure. Increases in activities associated with OCS program development are anticipated to be incremental and qualitatively similar to current patterns. However, as deepwater drilling expands, jobs that require longer, unbroken periods of offshore work will increasingly attract a more international workforce promoting sociocultural heterogeneity in coastal support communities, particularly in Texas and Louisiana.

Non-OCS program activities and processes affecting sociocultural systems are expected to continue. These include oil and gas development in State waters, coastal habitat changes, coastal land loss, regional economic changes, and recovery from storms and major oil spills. These activities and processes can lead to major impacts related to population change, job creation and loss, and changes in social institutions including family, government, politics, and education.

Accidental oil and other spills could result from both OCS and non-OCS activities. The magnitude of spill impacts depends on their size, location, and timing. With the exception of major spills (such as occurred with the DWH event), they are expected to have only temporary physical and economic effects and therefore should not significantly alter sociocultural systems.

The wetlands that supply subsistence resources are susceptible to oil spills. The Louisiana parishes of St. Mary, Terrebonne, and Lafourche, are home to populations engaged in renewable resource harvesting, are also areas of heavy to moderate concentrations of oil and gas industry facilities. As discussed in Section 3.7, the wetlands in coastal Louisiana are rapidly diminishing because of engineering projects to control the Mississippi River, natural subsidence, the development of the oil and gas industry, and climate change (Field et al. 2007). Because of the construction of flood-control structures, the Mississippi River no longer floods Louisiana's wetlands; these floods previously deposited new silt to offset coastal erosion. Extraction of oil and gas from coastal areas may have resulted in some subsidence of bayou lands. In many areas, Louisiana's coastal wetlands have been cut by a network of canals constructed to lay pipes bringing oil and gas to onshore refining facilities (Field et al. 2007). Cut in straight lines from the shore, these canals exacerbate the erosive force of tides and storm surges. Climate change has resulted in slowly increasing sea levels and an increased intensity of coastal storms and hurricanes. The end result has been an overall decrease in Louisiana's wetlands and a reduction in fresh and brackish wetlands and the subsistence species they support, along with an increase in salt marshes. Cumulatively, these changes constitute major impacts on a way of life that was once common along the GOM coast.

It is anticipated that global climate change will result in increased temperatures and rising relative sea levels along the GOM coast and these changes will be accompanied by an increase in severe storms in the coming decades. Rising relative sea levels and increased erosion have been observed all along the coast (Field et al. 2007). Those who rely at least in part on harvesting renewable resources from the sea, either as subsistence or commercial fishers and shrimpers, are predicted to be most vulnerable to adverse effects resulting from these changes (Nicholls et al. 2007).

Conclusion. Absent a major oil spill, the greatest contribution to cumulative impacts from the proposed action is expected to come from the expansion of deepwater activities, which would create jobs that require longer, unbroken periods of work offshore, specialized skills, and in-migration of part of the workforce. These are already trends in the OCS oil and gas industry. Since these and other potential sociocultural effects are expected to be minimal additions to existing trends, the incremental impact on sociocultural systems during the life of the Program would not result in significant changes to these systems and would, therefore, be small (see Section 4.4.13.1).

In terms of subsistence and renewable resource harvesting, non-OCS activities such as flood control along the Mississippi River and natural trends such as global climate change have produced major adverse impacts on the GOM coast region. Ongoing and future OCS and non-OCS program activities would add to these impacts. The relative contribution of the proposed action to cumulative impacts on subsistence harvesting is expected to be small to medium.

4.6.5.1.6 Environmental Justice. Over the next 40 to 50 yr, air emissions from OCS and non-OCS onshore facilities and helicopter and vessel traffic traversing coastal areas would be highest in the States such as Texas and Louisiana that contain the greatest amounts of infrastructure. Lesser amounts of infrastructure would occur in Mississippi and Alabama. No onshore infrastructure supporting OCS operations currently exists in Florida, and none will be built as a result of the proposed action. It is assumed that 75% of the activity from the Program will occur in deep and ultra-deep waters, with offshore air emissions greatest in the coastal areas of Texas and Louisiana, the areas with the greatest amounts of oil and gas activity, with lesser amounts in occurring in Mississippi and Alabama. The coastal areas of Florida are located so far from OCS activities that no environmental justice issues from offshore air emissions are expected to impact the coastal parts of the State. The effects of the OCS program on air quality have been analyzed in Section 4.4.4. This analysis concluded that routine operations associated with the proposed 5-yr program would result in NO_2, SO_2, PM_{10}, and CO levels that are well within the NAAQS. Disproportionate impacts on low-income or minority populations would be minor, because the coastal effects from offshore activities are expected to be small, based on the established and increasing trend toward movement of oil and gas activities into deeper waters of the GOM.

The proposed action would result in levels of infrastructure use and construction similar to those which have already occurred in the GOM coast region during previous programs. These activities are not expected to expose residents to notably higher risks than currently occur. While the distribution of offshore-related activities and infrastructure indicates that some places and populations in the GOM region would continue to be of environmental justice concern, the incremental contribution of the Program is not expected to affect those places and populations.

Non-OCS activities and processes that are ongoing, expected to continue into the foreseeable future, and that have the potential for creating environmental justice impacts include non-OCS oil and gas development, coastal habitat changes, coastal land loss, economic development, regional economic changes, and recovery from storms. These activities and processes could disproportionately impact low-income and minority populations.

In addition to oil and chemical spills that could occur with the proposed action, oil releases and spills could also occur from other non-OCS sources such as natural oil seeps, State oil and gas activity, and petrochemical refining and processing. While the timing and location of these spills cannot be determined and some low-income and minority populations are resident in some areas of the GOM coast, in general the coasts are home to more affluent groups. Low-income and minority groups are not more likely to bear more negative impacts than are other groups.

Conclusion. In the GOM, ongoing and future OCS and non-OCS program activities in combination with the effects of storm and hurricane damage and regional economic issues would result in disproportionate moderate to major adverse cumulative impacts on low-income and minority populations. The incremental contribution of routine Program activities to these impacts would be small (see Section 4.4.14.1).

The incremental impacts of accidental oil spills associated with the proposed action would be small to large, depending on the size, location, and timing of the spill (see Section 4.4.14.1).

4.6.5.1.7 Archeological and Historic Resources. Section 4.4.1.5 discusses the potential impacts from the proposed action (OCS program activities from 2012 to 2017) on onshore and offshore environments in the GOM. Cumulative impacts on archeological and historic resources result from the incremental impacts of the proposed action when added to impacts from existing and reasonably foreseeable future OCS program activities (that are not part of the proposed action) and other non-OCS program activities. Table 4.6.1-1 presents the exploration and development scenario for the GOM cumulative case (encompassing the proposed action and other OCS program activities). Specific types of impact-producing factors related to OCS program activities considered in this analysis include drilling rig and platform emplacement, pipeline emplacement, anchoring, new onshore facilities, ferromagnetic debris associated with OCS activities, and oil spills. Non-OCS program activities include trawling, sport diving, commercial treasure hunting, and channel dredging. Natural phenomena such as waves, currents, and tropical storms are also considered.

Prehistoric Resources. Offshore development could result in an interaction between a drilling rig, platform, pipeline, or anchors and an inundated prehistoric site. This direct physical contact with a site could destroy artifacts or site features and could disturb the stratigraphic context of the site. The result would be the loss of archaeological data on prehistoric migrations, settlement patterns, subsistence strategies, and archaeological contacts for the Americas and the Caribbean.

Since 1973, BOEM (formerly the MMS) has required that an archaeological survey be conducted prior to development of mineral leases determined to have potential for cultural resources including prehistoric archaeological sites. High-probability areas for the occurrence of prehistoric sites in the GOM include the region of the OCS shoreward of the 45-m (50-ft) isobath. Although an archaeological survey would identify most of the cultural resources in the APE for the project and routine operations related to OCS program activities would avoid all known cultural resources, it is likely that impacts to prehistoric resources may have already occurred as a result of OCS program and non-program activities that took place before implementation of the 1973 archaeological survey requirement.

Onshore development could result in direct physical contact between the construction of new onshore facilities or pipeline trenches and previously unidentified prehistoric sites. This direct physical contact with a prehistoric site could cause physical damage to or complete destruction of information on the prehistory of the region and North America. Federal and State laws and regulations initiated in the 1960s began requiring archaeological surveys prior to permitting any activity that might disturb a significant archaeological site. Therefore, it can be assumed that, since the introduction of the archaeological resource protection laws, most coastal archaeological sites have been located, evaluated, and mitigated prior to construction. However, impacts to coastal prehistoric resources may have already occurred as a result of various onshore construction activities prior to enactment of the archaeological resource protection laws.

Trawling activity in the GOM affects only the uppermost portion of the sediment column (Garrison et al. 1989). This zone would already have been disturbed by natural factors relating to the destructive effects of marine transgression and continuing effects of wave and current action. Therefore, the effect of future trawling on most prehistoric archaeological sites is expected to be minor.

Tropical storms and hurricanes are yearly occurrences in the GOM and may be increasing in intensity as a result of global climate change (Section 3.3.1). Past storm events have affected all areas of the GOM, from west Texas to south Florida, and broad areas are affected by each storm (DeWald 1980). Prehistoric sites in shallow waters or coastal beach sites are exposed to the destructive effects of wave action and scouring currents during these events. Under such conditions, it is highly likely that artifacts would be dispersed and the site context disturbed, resulting in the loss of archaeological information. Overall, a significant loss of data from nearshore and coastal prehistoric sites may have occurred, and will continue to occur, from the effects of tropical storms and hurricanes. It is assumed that some of the data lost have been significant and/or unique, resulting in a moderate to major level of impact.

Most channel dredging occurs at the entrances to bays, harbors, and ports. These areas have a high probability for prehistoric archaeological sites, as they are associated with drowned river valleys, which are known to have a high probability for prehistoric sites. It is assumed that some of the archaeological data that have been lost as a result of dredging have been significant and unique; therefore, the impact to prehistoric archaeological sites as a result of past channel dredging activities has probably been moderate to major. In many areas, the USACE now requires remote-sensing surveys prior to dredging activities to minimize such impacts (Espey, Huston & Associates 1990).

An accidental oil spill could affect coastal prehistoric archaeological sites, but the direct impact of oil on most sites is uncertain. Protection of such sites during an oil spill event requires specific knowledge of its location, condition, nature, and extent prior to impact; however, the GOM coastline has not been systematically surveyed for archaeological sites. Existing information indicates that, in coastal areas of the GOM, prehistoric sites occur frequently along the barrier islands and mainland coast and along the margins of bays and bayous. Thus, any spill that contacts land would involve potential impacts on prehistoric sites.

Heavy oiling of a coastal area could conceal intertidal sites that may not be recognized until they are inadvertently damaged during cleanup (Whitney 1994). Crude oil may also contaminate organic material used in ^{14}C dating, and, although there are methods for cleaning contaminated ^{14}C samples, greater expense is incurred (Dekin et al. 1993). The major source of potential impacts from oil spills is the harm that could result from unmonitored shoreline cleanup activities. Unauthorized collecting of artifacts by cleanup crew members is also a concern, albeit one that can be mitigated with effective training and supervision. Damage or loss of significant archaeological information could result from the contact between an oil spill and a prehistoric archaeological site; therefore, cumulatively the level of impacts from oil spills (past, present, and future) to prehistoric archaeological sites ranges from moderate to high.

Historic Resources. Direct physical contact between a routine activity and a shipwreck site could destroy fragile ship remains, such as the hull and wooden or ceramic artifacts, and could disturb the site context. The result would be the loss of archaeological data on ship construction, cargo, and the social organization of the vessel's crew, and the concomitant loss of information on maritime culture for the time period from which the ship dates.

Since 1973, BOEM has required archaeological (historical) surveys be conducted prior to development of mineral leases determined to have potential for historic-period shipwrecks. The high-probability areas for the occurrence of historic-period shipwrecks in the GOM consist of nearshore areas, port vicinities, and ship-specific polygons. Based on experience from the last 10 years (as reported by Church and Warren [2008]; Ford et al. [2008]; Atauz et al. [2006]), archaeological surveys are now also being requested for the APE that includes any potential bottom-disturbing activities in deepwater areas that could be affected by a project. Although an archaeological survey would identify most of the cultural resources in the APE for the project and routine operations related to OCS program activities would avoid all known cultural resources, it is likely that impacts on historic-period shipwrecks may have already occurred as a result of OCS program and non-program activities that took place before implementation of the archaeological survey requirement in 1973.

Onshore development could result in direct physical contact between the construction of new onshore facilities or pipeline trenches and previously unidentified historic sites. Federal and State laws and regulations initiated in the 1960s began requiring archaeological surveys prior to permitting any activity that might disturb a significant archaeological site. Therefore, it can be assumed that, since the introduction of the archaeological resource protection laws, most coastal archaeological sites have been located, evaluated, and mitigated prior to construction. However, impacts to coastal historic sites may have already occurred as a result of various onshore construction activities prior to enactment of the archaeological resource protection laws.

Trawling activities in the GOM only affect the uppermost portion of the sediment column (Garrison et al. 1989). On many wrecks, this zone would already have been disturbed by natural factors and would contain only artifacts of low specific gravity (e.g., ceramics and glass) which have lost all original contexts. Therefore, the effect of future trawling on most historic shipwreck sites would be minor.

Sport diving and commercial treasure hunting are significant factors in the loss of historic data from shipwreck sites. While commercial treasure hunters generally affect wrecks having intrinsic monetary value, sport divers may collect souvenirs from all types of shipwrecks. It is assumed that some of the data lost have been significant and/or unique. The known extent of these activities suggests that they have resulted in a major impact to historic-period shipwrecks.

Tropical storms and hurricanes are yearly occurrences in the GOM and may be increasing as a result of global climate change (Section 3.3.1). Past storms have affected all areas of the GOM, from west Texas to south Florida, and broad areas are affected by each storm (DeWald 1980). Shipwrecks in shallow waters and coastal historic sites are exposed to greatly intensified longshore currents and high-energy waves during tropical storms (Clausen and Arnold 1975). Under such conditions, it is highly likely that artifacts of low specific gravity would be dispersed. Some of the original information contained in the site would be lost in this process, but a significant amount of information may also remain. BOEM-sponsored studies conducted specifically to examine the effect of hurricanes on shipwrecks in the GOM found that storm effects on wrecks varied, with some wrecks being damaged, some unaffected, and others protected because the storm caused sediment to be deposited on the wreck (Gearhart et al. 2011). Overall, a significant loss of data from historic sites has probably occurred, and will continue to occur, from the effects of tropical storms and hurricanes. It is assumed that some of the data lost has been significant and/or unique, resulting in a moderate to major level of impact.

Most channel dredging occurs at the entrances to bays, harbors, and ports. These areas have a high probability for historic shipwrecks, and the greatest concentrations of historic wrecks are likely to be associated with these features (Garrison et al. 1989). Assuming that some of the data lost have been unique, the impact to historic sites as a result of past channel dredging activities has probably been moderate to major. In many areas, the USACE requires remote-sensing surveys prior to dredging activities, to minimize such impacts (Espey, Huston & Associates 1990).

Past, present, and future oil and gas exploration and development on the OCS will result in the deposition of tons of ferromagnetic debris on the seafloor. This modern marine debris will tend to mask the magnetic signatures of historic shipwrecks, particularly in areas that were developed prior to requiring archaeological surveys. Such masking of the signatures characteristic of historic shipwrecks increases the potential that significant or unique historic information may be lost. However, BOEM requires avoidance or investigation of any unidentified magnetic anomaly that could be related to a shipwreck site prior to permitting bottom-disturbing activities. The increase in impacts to historic shipwrecks from magnetic masking could range from minor to moderate.

An accidental oil spill could affect a coastal historic site, but the direct impact of oil on most historic sites is uncertain. The primary source of potential impacts from oil spills is unmonitored shoreline cleanup activities (Bittner 1996; see Section 4.4.15.1.2). Unauthorized collecting of artifacts by cleanup crew members is also a concern, albeit one that can be mitigated with effective training and supervision. Damage or loss of significant historic information could result from oil spill cleanup activities; therefore, the cumulative impact from oil spills (past, present, and future) on historic sites could range from moderate to major.

Conclusion. The cumulative impacts of ongoing and future OCS and non-OCS program activities on prehistoric and historic archaeological sites in the GOM are currently unknown, but could range from minor to moderate, mainly because activities occurring on the OCS prior to BOEM's survey requirement (in effect since 1973) may already have affected significant archaeological sites. Other important impact-producing factors that likely have had, and will continue to have, an impact on both prehistoric and historic archaeological sites are channel dredging, tropical storms, and hurricanes. Commercial treasure hunting and sport diving may also result in a loss of artifacts at historic-period shipwreck sites. The incremental contribution of routine Program activities is expected to be small because required archaeological surveys would identify significant cultural resources to be avoided (see Section 4.4.15.1).

Cumulative impacts on prehistoric and historic sites due to accidental oil spills would result mainly from cleanup activities (direct impacts to the sites are uncertain) and could range from moderate to major. The incremental impacts of oil spills associated with the proposed action would be small to medium relative to those associated with ongoing and future OCS and non-OCS program activities.

4.6.5.2 Alaska – Cook Inlet

4.6.5.2.1 Population, Employment, and Income. Section 4.4.9 discusses the potential impacts from the proposed action (OCS program activities from 2012 to 2017) on population, employment, and income in the south-central Alaska region. Cumulative impacts on these resources result from the incremental impacts of the proposed action when added to impacts from reasonably foreseeable future OCS program activities (there are no existing OCS program activities) and other non-OCS program activities. Specific types of impact-producing factors related to OCS program activities considered in this analysis include total employment and regional income for the south Alaska region, which corresponds to the Cook Inlet Planning Area (described in Section 3.10). Non-OCS program activities affecting the region include employment and earnings related to various other industrial sectors (e.g., construction, manufacturing, services, and State and local government).

The population in the Cook Inlet Planning Area increased at an average annual rate of 3.2% between 1980 and 1990, 1.3% between 1990 and 2000, and 1.2% between 2000 and 2009. During each of these periods, the greatest increases consistently occurred on the Kenai Peninsula (with an average annual increase of 1.1% between 2000 and 2009) and in Anchorage (also with an average annual increase of 1.1% between 2000 and 2009). The components of population increase include the natural increase due to births and net positive domestic and international migration; these trends will likely continue in south central Alaska over the next 40 to 50 yr.

Although the proposed action would add an average of 83 to 113 jobs annually between 2012 and 2017, this increase is considered minor (though positive) since it would amount to less than 5% of total Alaska employment (additional jobs created in the rest of Alaska during the same period would range from 1,400 to 1,890). Likewise, income produced in the region would range from $2.8 million to $3.8 million annually in south central Alaska, which constitutes about 13% of income in Alaska overall.

Employment impacts of oil spills reaching landfall can vary considerably depending upon the total volume of oil reaching land, the land area affected, and the sensitivity of local environmental conditions to oil impacts. The primary impacts of oil spills would most likely fall on such activities as beach recreation, commercial fishing, recreational fishing, and sightseeing. Oil spills reaching land can have both short- and long-term effects on these recreational coastal activities. Past studies (Sorenson 1990) have shown that there could be a one-time seasonal decline in tourist visits of 5% to 15% associated with a major oil spill. Since tourist movement to other coastal areas in the region often offsets a reduction in the number of visits to one area, the associated loss of business tends to be localized. Although an oil spill could occur anywhere in the lease sale area, cleanup-related employment would likely occur in the area directly affected, generally in locations remote from communities. Oil spills will generate only temporary employment (and population) increases during cleanup operations, because such operations are expected to be of short duration.

Conclusion. The cumulative impacts of future OCS program and ongoing and future non-OCS program activities would be considered beneficial because these activities would increase employment and earnings in the region over the next 40 to 50 yr. The proposed action would add to these beneficial impacts, especially on the Kenai Peninsula and in Anchorage. The incremental impact of the proposed action is expected to be small, however, because the added employment demands are less than 5% of total Alaska employment (see Section 4.4.9.2).

In areas with a large proportion of impact-sensitive industry (such as commercial and recreational fishing), the cumulative impacts of accidental oils spills could be moderate to major, depending on the total volume of oil reaching land, the land area affected, and the sensitivity of local environmental conditions to oil impacts. The incremental impacts of oil spills associated with the proposed action would be small to medium relative to those associated with future OCS program and ongoing and future non-OCS program activities.

4.6.5.2.2 Land Use and Infrastructure. Localized and site-dependent impacts to land use and existing infrastructure are anticipated as a result of the construction of new OCS program oil and gas facilities in Cook Inlet over the next 40 to 50 yr. Impact-producing factors from OCS program activities would include increased vehicular traffic (e.g., helicopter trips); modifications to current land use designations to incorporate new facilities, if they are needed; and some infrastructure expansion. Ongoing non-OCS program activities affecting land use and onshore infrastructure are expected to continue into the foreseeable future. These include offshore construction, onshore construction, and vessel traffic. Where land is largely undeveloped and no established oil and gas infrastructure is present, development could result in land use and infrastructure impacts, such as the conversion of existing land use (e.g., undeveloped, residential, or commercial) to industrial land use to accommodate oil and gas production (MMS 2007e).

Accidental oil releases may occur as a result of both OCS and non-OCS activities, and oil is also released from naturally occurring seeps. The extent of the impacts would depend on the location and size of the releases, but could include stresses of spill response on the community infrastructure, increased traffic to respond to cleanup, and restricted access to particular lands while cleanup is conducted. In general, these releases would be expected to have a temporary impact on land use and infrastructure (MMS 2007c).

Conclusion. Localized and site-dependent impacts to land use and existing infrastructure are anticipated as a result of future OCS and ongoing and future non-OCS program activities in Cook Inlet. These impacts could range from minor to major depending on the nature (extent and duration) of the land use change. Ongoing non-OCS program activities that could affect land use and onshore infrastructure are expected to continue into the foreseeable future (see Section 4.4.10.2). Potential cumulative impacts to land use and infrastructure resulting from accidental oil spills include stresses of spill response on the community infrastructure, increased traffic to respond to cleanup, and restricted access to particular lands while cleanup is conducted.

The extent of land use-related impacts resulting from accidental oil spills and naturally occurring seeps could be minor to major, depending on the location and size of the releases.

4.6.5.2.3 Commercial Fisheries and Recreational Fisheries. Some OCS exploration, development, and production activities have a potential to result in space-use conflicts with fishing activities over the next 40 to 50 yr. In some cases, fishing vessels could be excluded from normal fishing grounds for safety reasons during construction periods or after facilities are in place. In other instances, fishery crews or anglers could decide to avoid certain areas to reduce the potential for gear loss. Such conflicts can sometimes be avoided by conducting construction activities or seismic surveys during closed fishing periods or seasons. A potential also exists for loss of gear or loss of access to fishing areas when floating drill rigs used for exploration are being moved and during other vessel operations.

Offshore construction of platforms or artificial islands could infringe on commercial fishing activities by excluding commercial fishing from adjacent areas due to safety considerations. Drilling discharges associated with exploration activities would likely affect only a small area near drilling platforms or islands, and are not expected to interfere with commercial fishing. During development and production phases, potential effects of such discharges would cease because all muds, cuttings, and produced waters would be discharged into wells instead of being released to open waters. Potential effects of platform construction and operation are expected to be highly localized. Because only a very small area of the individual planning areas would be affected, interference with commercial fisheries is expected to be small.

The impacts of oil and gas development on commercial fishing costs would vary considerably by placement depth. In the Kodiak area, the largest cost increases would occur with structures located in water between 300 and 1,500 m (984 and 4,921 ft) deep, with an annual increase of $43 in costs from a single structure; a single structure in each depth range would increase annual costs by $44. In the Cook Inlet area, the largest increase would come with a single structure placed in water between 150 and 300 m (492 and 984 ft), with an overall increase in costs of $57 per year. Cost impacts in the Gulf of Alaska area would be the largest, at $93 per year with a structure in each depth range, the largest cost increases occurring with a structure placed at between 300 to 1,500 m (984 and 4,921 ft). In each of the areas, single structures would have relatively insignificant impacts compared to fishery revenues in each depth range.

Various non-OCS activities, including State oil and gas programs, dredging and disposal of dredging spoils in OCS waters, logging operations, and commercial or sport fishing activities, could also contribute to cumulative effects on fisheries. Drilling of wells under State oil and gas programs would also require construction of pipelines and artificial islands or platforms in Alaskan waters. Potential effects on fishery resources and on space-use conflicts from State oil and gas activities would be similar to those described above for OCS program oil and gas activities. Dredging and marine disposal activities would involve excavation of nearshore sediments and subsequent disposal in offshore or nearshore areas, thereby disturbing seafloor habitats in some areas and burying benthic organisms that help to support fishery resources.

Logging operations have a potential to contribute to cumulative effects on fishery resources by degrading riverine habitats that are important for salmon reproduction and the rearing of juveniles.

Non-OCS activities, such as State oil and gas development, domestic transportation of oil or refined petroleum products, and commercial shipping, may also result in accidental spills that could affect fisheries within the waters of the south central Alaska region. Fisheries resources could become exposed to oil as a consequence of accidental oil spills, which could cause declines in subpopulations of some species inhabiting the affected planning areas. It is anticipated that there would be no long-term effects on overall fish populations in Alaskan waters as a result of such spills. However, even localized decreases in stocks of fish could have effects on some fisheries by reducing catches or increasing the amount of effort or the distances that must be traveled to obtain adequate catches.

Even if fish stocks are not reduced as a consequence of a spill, specific fisheries could be closed due to actual or perceived contamination of fish or shellfish. It is anticipated that most small to medium spills would have limited effects on fisheries because of the relatively small areas likely to be exposed to high concentrations of hydrocarbons and the short period of time during which oil slicks would persist. In the event of a large spill, commercial, recreational, or subsistence fisheries for shellfish in nearshore subtidal and intertidal areas that become oiled are likely to be affected. Fisheries for shellfish that occur in deeper waters, where oil concentrations would likely be too low to cause direct effects on biota, are less likely to be affected. Regardless, even shellfish from deeper areas could become commercially unacceptable for market due to actual or perceived contamination and tainting.

Oil spills that enter nearshore waters could also damage setnet fisheries, as evidenced by the *Exxon Valdez* oil spill of 1989. While only a relatively small volume of weathered oil entered the lower Cook Inlet region as a result of that spill, the commercial salmon fishery was closed to protect both gear and harvest from possible contamination. Within the Cook Inlet Planning Areas, a spill the size of the assumed largest OCS spill could result in temporary closures to commercial and subsistence setnet fishing until cleanup operations or natural processes reduced oil concentrations to levels considered safe.

Although pelagic fishes would be less likely to be affected than fishes in shallow subtidal or intertidal areas, spilled oil could contaminate gear used for pelagic fishing, such as purse seines and drift nets. A large oil spill before or during the season when such fishing gears are in use could result in closures of some short-period, high-value commercial fisheries in order to protect gear or harvests from potential contamination. Lines from longline fisheries for halibut, Pacific cod, black cod, and other fish species in the Cook Inlet Planning Area could also be affected by oil. Some lines and buoys fouled with small amounts of oil could be unfit for future use. Although it is unlikely that a trawler would be operating in an oiled area, the trawl catches could be contaminated by oil and rendered unfit for consumption and unprofitable if passed through such an area.

Conclusion. The proposed action would represent a small increment to the potential for overall cumulative effects on fisheries in Cook Inlet. Routine OCS program activities would be unlikely to have cumulative population- or community-level effects on fishery resources because of the limited time frame over which most individual activities would occur; because a small proportion of habitat, relative to similar available habitat, could be affected during a given period; and because of existing stipulations that are in place to avoid impacts to sensitive habitats such as hard bottom areas and topographic features. Non-OCS activities, including State oil and gas development, commercial fishing, and sportfishing, could also contribute to cumulative effects on fisheries. Depending on specific conditions during a large spill, there could be substantial economic losses for commercial fisheries as a consequence of reduced catch, loss of gear, or loss of fishing opportunities during cleanup and recovery periods. Non-OCS sources of spills, including State oil and gas production, have a potential to cause similar effects. The occurrence of a very large spill, such as could occur from a tanker accident in southern Alaskan waters, could have substantially greater effects on fisheries.

4.6.5.2.4 Tourism and Recreation. Platform, pipeline, causeway, and facility construction and vessel traffic could interfere with water-based recreational activities (fishing, boating, sightseeing, cruise ships) and could result in some disruption to land-based activities (hiking, picnicking, hunting, visiting Native communities, camping, wildlife viewing, and sightseeing), depending on the location of recreational activities relative to proposed development; increases in amounts of trash and debris from OCS activities; and possible competition between workers and tourists for local services, such as air transport, hotel accommodations, and other visitor services. Non-OCS activities that could have an impact on tourism and recreation include offshore construction (e.g., State oil and gas development, domestic transportation of oil and gas), onshore construction (e.g., coastal and community development), and vessel traffic (e.g., commercial shipping, recreational boating, military training and testing).

Non-OCS activities and proposed and future OCS activities represent a continuation of existing onshore and offshore oil and gas construction trends close to the Cook Inlet Planning Area. Substantial infrastructure for related oil and gas development already exists in this area, including platforms, exploration and production wells, pipelines to transport oil from offshore platforms to common-carrier pipeline systems onshore, and processing facilities. Therefore, there should not be additional visual disruption for the tourists in these areas. Pipeline construction would present a temporary disruption to tourism and recreation due to workers competing with tourists for short-term housing (hotels) and air transport; aesthetic impacts (visual and auditory) associated with construction sites; and possible temporary prevention of access to some recreational or wilderness areas. In addition, the new pipeline in the Arctic region could create road access into previously undeveloped lands used primarily for subsistence, creating a potential conflict between subsistence practices and recreational hunting or other possible tourist activities.

Oil spills associated with OCS and non-OCS activities, as well as oil from naturally occurring seeps, could also affect recreation and tourism, and could result in both short-term and long-term effects, depending on public perception and reaction. Potential cumulative impacts include direct land impacts (e.g., oil contamination of a national wildlife refuge or recreational port); aesthetic impacts of the spill and associated cleanup; increased traffic to respond to cleanup operations; and restricted access to particular lands while cleanup is being conducted.

Conclusion. Cumulative impacts on recreation and tourism from future OCS program and ongoing and future non-OCS program activities in Cook Inlet would be minor for most routine activities, with the exception of impacts associated with large oil spills during the peak tourist season, which could be moderate to major (but short-term). The incremental contribution of routine Program activities to cumulative impacts would be small, resulting from small incremental increases in construction and transportation noise and related visual intrusions, potential increases in trash and debris related to these activities, and the potential for a relatively small number of accidental releases (see Section 4.4.12.1).

Oil spills could affect recreation and tourism temporarily in all areas, but would not likely result in long-term effects, depending on public perception and reaction. The magnitude of impacts from an oil spill could range from minor to major, depending on the size, location, and timing of the spill. The greatest impacts would be expected to occur in popular tourist areas during the main tourist season.

4.6.5.2.5 Sociocultural Systems. The area surrounding the Cook Inlet Planning Area is demographically diverse and includes relatively remote Native villages that rely on subsistence harvesting, towns that rely on commercial fishing, and ethnically diverse cities (Section 3.14.1.2). Future non-OCS activities include oil and gas development on State submerged lands, changes in commercial fishing patterns and maritime shipping, and limited industrialization.

The Cook Inlet Planning Area is already the location of offshore oil and gas development. Supporting infrastructure and a trained workforce are already available in relative proximity. As part of this industrial mix, development of the OCS is likely to have minor cumulative impacts relative to development on the Arctic coast. No new shore bases are planned and only one new pipeline is projected under the Program.

Oil spills can cause damage to resources important to subsistence harvesters, affect fish populations important to commercial fishers, and have sociological impacts in affected communities. Most spills projected to result from exploration and development of the OCS would be a relatively minor component of the existing mix of oil and gas development and commercial shipping. However, as the *Exxon Valdez* event has shown, coastal communities are susceptible to sociocultural disruption as the result of large-scale spills that disrupt commercial fishing and subsistence harvesting.

OCS program development could temporarily displace fish and sea mammal populations harvested by subsistence hunters and fishers. Helicopter flights associated with development could disturb nesting and roosting sites of birds that are harvested, and temporarily and locally disturb terrestrial game animals.

Conclusion. Cumulative impacts on sociocultural systems as a result of future OCS and ongoing and future non-OCS activities would be minor to moderate. Important impacting factors include the displacement of fish and sea mammal populations and the disturbance of nesting and roosting sites and terrestrial game animals (e.g., by noise). The contribution of the proposed action to cumulative impacts on sociocultural systems in the Cook Inlet Planning Area would be small because no significant changes are anticipated (see Section 4.4.13.2).

4.6.5.2.6 Environmental Justice. Although no new pipe yards, pipeline landfalls, or gas processing facilities would be built as a result of the proposed 5-yr OCS program, additional offshore construction could include increased noise and traffic, air and water pollution, impacts to residential property values, and land use changes. Much of the Alaska Native population resides in the coastal areas of Alaska. New offshore infrastructure resulting from this program could be located near areas where subsistence hunting occurs. The OCS program would result in levels of infrastructure use and construction similar to what is occurring in south central Alaska. These activities are not expected to expose residents to notably higher risks than currently occur.

Any adverse environmental impacts to fish and mammal subsistence resources from installation of infrastructure and routine operations of these facilities could have disproportionately higher health or environmental impacts to Alaska Native populations. OCS activities could potentially disrupt marine mammal harvests (primarily walrus, seals, and beluga whales) by diverting marine migrations or by causing other behavioral changes such as increased wariness.

Air emissions from onshore facilities and helicopter and vessel traffic traversing coastal areas will be highest in areas containing the greatest amounts of infrastructure. It is assumed that the majority of the activity from the proposed action would occur in deep waters, with offshore air emissions greatest in the coastal areas with the greatest amounts of oil and gas activity, with lesser amounts occurring elsewhere. The effects of the OCS program on air quality have been analyzed in Section 4.4.4.2. This analysis concluded that routine operations associated with the proposed 5-yr program would result in NO_2, SO_2, PM_{10}, and CO levels that are well within the NAAQS. Disproportionate impacts on low-income or minority populations of the inlet would be minor, because coastal effects from offshore activities are expected to be small, based on the established and increasing trend toward movement of oil and gas activities into deeper waters of the inlet.

Oil spill events in the region and related cleanup activities pose the greatest potential for cumulative effects on low-income and minority population groups. It is reasonable to expect that most of these spills will occur in deepwater areas located away from the coast, based on the established trend for oil and gas activity to move into deep waters located for the most part at a substantial distance from the coast. The magnitude of impacts from such spills cannot be predicted, should they contact the coast, and depends on their location, size, and timing. While the location of possible oil spills cannot be determined and while low-income and minority populations are resident in some areas of the coast, in general, the coasts are home to more affluent groups. Low-income and minority groups are not more likely to bear more negative impacts than are other groups.

Conclusion. In the Cook Inlet Planning Area, future OCS program and ongoing and future non-OCS program activities in combination with the effects of onshore and offshore construction, increased marine vessel and helicopter traffic, and land use changes would result in disproportional moderate to major adverse cumulative impacts on low-income and minority populations (especially those dependent on subsistence harvesting and fishing). The incremental contribution of routine Program activities to these impacts would be small (see Section 4.4.14.2).

The incremental impacts of accidental oil spills associated with the proposed action would be small to large, depending on the size, location, and timing of the spill (see Section 4.4.14.2).

4.6.5.2.7 Archeological and Historic Resources. Section 4.4.15.2 discusses the potential impacts from the proposed action (OCS program activities from 2012 to 2017) on archeological and historic resources in the Cook Inlet Planning Area. Cumulative impacts on archeological and historic resources result from the incremental impacts of the proposed action when added to impacts from existing and reasonably foreseeable future OCS program activities (that are not part of the proposed action) and other non-OCS program activities. Table 4.6.1-2 presents the exploration and development scenario for the Cook Inlet cumulative case (encompassing the proposed action and future OCS program activities). Specific types of impact-producing factors related to OCS program activities considered in this analysis include drilling rig and platform emplacement, pipeline emplacement, new onshore facilities, and oil spills. Non OCS-program activities (e.g., oil and gas industry in State waters) and natural geologic processes such as ice gouging and erosion due to high-energy waves/currents and thermokarst collapse are also considered.

Archeological Resources. Offshore development could result in an interaction between a drilling rig, platform, pipeline, or anchors and an inundated prehistoric site. This direct physical contact with a site could destroy artifacts or site features and could disturb the stratigraphic context of the site. The result would be the loss of archaeological data on prehistoric migrations, settlement patterns, subsistence strategies, and archaeological contacts between northeast Asia and the Americas.

Since 1973, BOEM has required that an archaeological survey be conducted prior to development of mineral leases determined to have potential for cultural resources, including prehistoric archaeological sites. Relative sea-level data, which are used to define the portion of the continental shelf having potential for prehistoric sites, suggest that the portion of the continental shelf shoreward of about the 60-m (200-ft) isobath would have potential for prehistoric sites. Although an archaeological survey would identify most of the cultural resources in the APE for the project and routine operations related to OCS program activities would avoid all known cultural resources, it is likely that impacts to prehistoric resources may have already occurred as a result of non-OCS program activities prior to the implementation of the 1973 archaeological survey requirement.

Onshore development could result in direct physical contact between the construction of new onshore facilities or pipeline trenches and previously unidentified prehistoric sites. This direct physical contact with a prehistoric site could cause physical damage to or complete destruction of information on the prehistory of the region and North America. Federal and State laws and regulations initiated in the 1960s began requiring archaeological surveys prior to permitting any activity that might disturb a significant archaeological site. Therefore, it can be assumed that, since the introduction of the archaeological resource protection laws, most coastal archaeological sites have been located, evaluated, avoided, or mitigated prior to construction. However, impacts to coastal prehistoric resources may have already occurred as a result of various onshore construction activities prior to enactment of the archaeological resource protection laws.

Trawling activity in Cook Inlet only affects the uppermost portion of the sediment column (Krost et al. 1990). This zone would already be disturbed by natural factors relating to the destructive effects wave and current action (Cook Inlet is a high-energy wave environment; see Section 4.2.3.2.2). Therefore, the effect of trawling on most prehistoric archaeological sites would be minor.

Most channel dredging occurs at the entrances to bays, harbors, and ports. These areas have a high probability for prehistoric archaeological sites, as they are often associated with drowned river valleys, which are known to have a high probability for prehistoric sites. It is assumed that some of the archaeological data that have been lost as a result of dredging have been significant and unique; therefore, the impact to prehistoric archaeological sites as a result of past channel dredging activities has probably been moderate to major. In many areas, the USACE now requires remote-sensing surveys prior to dredging activities to minimize such impacts (Espey, Huston & Associates 1990).

Natural geologic processes such as ice gouging and thermokarst erosion may affect prehistoric archaeological sites associated with Cook Inlet. No specific studies examining the effects of geological processes on archaeological sites have been conducted in Cook Inlet. However, coastal prehistoric sites are exposed to the erosional effects of high-energy waves and thermokarst erosion. These natural processes could cause artifacts to be dispersed and the site context to be disturbed or even completely destroyed, resulting in the loss of archaeological information. Cook Inlet is a high-energy area affected by strong tidal movements. The seafloor of lower Cook Inlet contains characteristics such as lag gravels, sand ribbons, and sand wave fields (MMS 2003a). These features are formed only in areas of high energy. High-energy water movement may have removed the potential for archaeological resources to be present. Additional research is needed to determine the extent of the disturbance. Studies conducted in the Beaufort Sea indicate that seafloor sediments have been affected by ice gouging and by increased river flows resulting from glaciation (Darigo et al. 2007). It is likely that similar processes have operated in Cook Inlet and that they have affected the integrity of archaeological sites. Overall, some loss of data from submerged and coastal prehistoric sites has probably occurred, and will continue to occur, from the effects of natural geologic processes. It is assumed that some of the data lost have been significant and/or unique, resulting in a major level of impact. Additional studies specifically addressing these topics are required.

An accidental oil spill could affect coastal prehistoric archaeological sites, but the direct impact of oil on most sites is uncertain. Protection of such sites during an oil spill requires specific knowledge of their location, condition, nature, and extent prior to impact; however, the Cook Inlet coastline has not been systematically surveyed for archaeological sites.

Heavy oiling of a coastal area could conceal intertidal sites that may not be recognized until they are inadvertently damaged during cleanup (Whitney 1994). Crude oil may also contaminate organic material used in ^{14}C dating, and although there are methods for cleaning contaminated ^{14}C samples, greater expense is incurred (Dekin et al. 1993). The major source of potential impact from oil spills is the harm that could result from unmonitored shoreline cleanup activities. Unauthorized collecting of artifacts by cleanup crew members is also a concern, albeit one that can be mitigated with effective training and supervision. Damage or loss of significant archaeological information could result from the contact between an oil spill and a prehistoric archaeological site; therefore, cumulatively the level of impacts from oil spills (past, present, and future) to prehistoric archaeological sites ranges from moderate to high.

Historic Resources. Direct physical contact between a routine activity and a shipwreck site could destroy fragile ship remains, such as the hull and wooden or ceramic artifacts, and could disturb the site context. The result would be the loss of archaeological data on ship construction, cargo, and the social organization of the vessel's crew, and the concomitant loss of information on maritime culture for the time period from which the ship dates.

Since 1973, BOEM has required archaeological (historical) surveys be conducted prior to development of mineral leases when a historic-period shipwreck is reported to lie within or adjacent to the lease area. Although an archeological survey would identify most of the cultural resources in the APE for the project and routine operations related to OCS activities would avoid all known cultural resources, it is likely that impacts on historic-period shipwrecks may have already occurred as a result of non-OCS program activities that took place before implementation of the 1973 archaeological survey requirement.

Onshore development could result in direct physical contact between the construction of new onshore facilities or pipeline trenches and previously unidentified historic sites. Federal and State laws and regulations initiated in the 1960s began requiring archaeological surveys prior to permitting any activity that might disturb a significant archaeological site. Therefore, it can be assumed that, since the introduction of the archaeological resource protection laws, most coastal archaeological sites that would have been impacted have been located, evaluated, avoided, or mitigated prior to construction. However, impacts to coastal historic sites may have resulted from onshore construction activities prior to enactment of the archaeological resource protection laws, but the magnitude of this possible impact is impossible to quantify.

Trawling activity in south central Alaska affects only the uppermost portion of the sediment column (Krost et al. 1990). On many wrecks, this zone would already be disturbed by natural factors and would contain only artifacts of low specific gravity which have lost all original context. Therefore, the effect of trawling on most historic shipwreck sites would be minor.

Most channel dredging occurs at the entrances to bays, harbors, and ports. These areas have a high probability for historic shipwrecks. Assuming that some of the data lost have been unique, the impact on historic sites as a result of past channel dredging activities has probably been moderate to major. In many areas, the USACE now requires remote-sensing surveys prior to dredging activities to minimize such impacts (Espey, Huston & Associates 1990).

Natural geologic processes such as ice gouging and erosion due to high-energy waves/currents and thermokarst collapse affect historic sites in Cook Inlet. No specific studies addressing this topic have been undertaken. Coastal historic sites are exposed to the erosional effects of wave energy and thermokarst erosion, which can cause artifacts to be dispersed and the site context to be disturbed or even completely destroyed. Cook Inlet is a high-energy area affected by strong tidal movements. The seafloor of lower Cook Inlet contains seafloor characteristics such as lag gravels, sand ribbons, and sand wave fields (MMS 2003a). These features are only formed in areas of high energy. High-energy water movement may have removed the potential for historic resources to be present. Additional research is needed to determine the extent of the disturbance. Overall, a significant loss of data from submerged and coastal historic sites may have already occurred from the effects of natural geologic processes. It is assumed that some of the data lost have been significant and/or unique, resulting in a major level of impact. Additional studies specifically addressing these topics are required.

An accidental oil spill could affect a coastal historic site, but the direct impact of oil on most historic sites is uncertain. The primary source of potential impacts from oil spills is unmonitored shoreline cleanup activities (Bittner 1996; see Section 4.4.14.2.2). Unauthorized collecting of artifacts by cleanup crew members is also a concern, albeit one that can be mitigated with effective training and supervision. Damage or loss of significant historic information could result from oil spill cleanup activities; therefore, the cumulative impact of oil spills (past, present, and future) on historic sites could range from moderate to major.

Conclusion. The cumulative impacts of future OCS program and ongoing and future non-OCS program activities on prehistoric and historic archaeological sites in Cook Inlet are currently unknown, but could range from minor to moderate, mainly because activities occurring on the OCS prior to BOEM’s survey requirement (in effect since 1973) may already have affected significant archaeological sites. Other important impacting factors that have had, and will continue to have, an impact on both prehistoric and historic archaeological sites are channel dredging and geologic processes, such as ice gouging and erosion due to high-energy waves/currents and thermokarst collapse. Commercial treasure hunting and sport diving may also result in a loss of artifacts at historic-period shipwreck sites. The incremental contribution of routine Program activities is expected to be minor because required archaeological surveys would identify significant cultural resources to be avoided (see Section 4.4.15.2).

Cumulative impacts on prehistoric and historic sites due to accidental oil spills would result mainly from cleanup activities (direct impacts to the sites are uncertain) and could range from moderate to major. The incremental impacts of oil spills associated with the proposed action would be small to medium relative to those associated with future OCS program and ongoing and future non-OCS program activities.

4.6.5.3 Alaska Region – Arctic

4.6.5.3.1 Population, Employment, and Income. Section 4.4.9 discusses the potential impacts from the proposed action (OCS program activities from 2012 to 2017) on population, employment, and income in the Arctic region. Cumulative impacts on these resources result from the incremental impacts of the proposed action when added to impacts from reasonably foreseeable future OCS program activities (there are no existing OCS program activities) and other non-OCS program activities. Specific types of impact-producing factors related to OCS program activities considered in this analysis include total employment and regional income for the North Slope Borough, which corresponds to the Beaufort Sea and Chukchi Sea Planning Areas (described in Section 3.10). Non-OCS program activities affecting the region include employment and earnings related to various other industrial sectors (e.g., construction, manufacturing, services, and State and local government).

The population in the Beaufort Sea and Chukchi Sea Planning Areas is concentrated in Barrow. It increased at an average annual rate of 3.6% between 1980 and 1990, and 2.1% between 1990 and 2000; it decreased by 1.0% between 2000 and 2009. The components of population increase include the natural increase due to births and net positive domestic migration; the population trend is uncertain over the next 50 yr and will likely depend on the availability of jobs. Most communities in the borough have a high percentage of American Indian or Alaska Natives.

Although the proposed action would add an average of 167 to 225 jobs annually between 2012 and 2017, this increase is considered minor (though positive) since it would amount to less than 1% of total Alaska employment (additional jobs created in the rest of Alaska during the same period would range from 2,644 to 3,570). Likewise, income produced in the region would range from $5.6 million to $7.6 million annually in the Arctic region, which constitutes about 50% of income in Alaska overall. Most of the workers directly associated with OCS oil and gas activities would work offshore or onshore in worker enclaves separated from local communities, and most workers will likely commute to work sites from Alaska’s larger population centers or from outside the immediate area. While OCS jobs would be available to the local populations in all areas, rural Alaskan employment in the petroleum industry, especially among Alaska Natives, would likely remain relatively low. However, a contingent of Alaska Natives from the Fairbanks area and members of the Doyon Corporation do work in the oil fields of the North Slope, and these jobs are important to them.

Employment impacts of oil spills reaching landfall can vary considerably depending upon the total volume of oil reaching land, the land area affected, and the sensitivity of local environmental conditions to oil impacts. The primary impacts of oil spills would most likely fall on such activities as beach recreation, commercial fishing, recreational fishing, and sightseeing. Oil spills reaching land can have both short- and long-term effects on these recreational coastal activities. Although an oil spill could occur anywhere in the lease sale area, cleanup-related employment would likely occur in the area directly affected, generally in locations remote from communities. The hiring of cleanup workers would have a regional and State of Alaska emphasis. Oil spills will generate only temporary employment (and population) increases during cleanup operations, because such operations are expected to be of short duration. Employment generated by spills will be a function of the size and frequency of spills.

Conclusion. The cumulative impacts of future OCS program and ongoing and future non-OCS program activities would be considered beneficial because these activities would increase employment and earnings in the region over the next 40 to 50 yr (although rural Alaskan employment in the petroleum industry, especially among Alaska Natives, would likely remain relatively low). The proposed action would add to these beneficial impacts. The incremental impact of the proposed action is expected to be small, however, because the added employment demands are less than 1% of total Alaska employment (see Section 4.4.9.3).

The cumulative impacts of accidental oil spills could be minor to major, depending on the total volume of oil reaching land, the land area affected, and the sensitivity of local environmental conditions to oil impacts. The incremental impacts of oil spills associated with the proposed action would be small to medium relative to those associated with ongoing and future non-OCS program activities.

4.6.5.3.2 Land Use and Infrastructure. Localized and site-dependent impacts to land use and existing infrastructure are anticipated as a result of the construction of new oil and gas facilities in the Beaufort and Chukchi Sea Planning Areas. Impact-producing factors from OCS program activities would include increased vehicular traffic (e.g., helicopter trips); modifications to current land use designations to incorporate new facilities, if they are needed; and some infrastructure expansion.

Ongoing non-OCS program activities that could affect land use and onshore infrastructure are expected to continue into the foreseeable future. These include offshore construction, onshore construction, and vessel traffic. Where land is largely undeveloped and no established oil and gas infrastructure is present, development could result in land use and infrastructure impacts, such as the conversion of existing land use (e.g., undeveloped, residential, or commercial) to industrial land use to accommodate oil and gas production (MMS 2007e).

Accidental oil releases may occur as a result of both OCS and non-OCS activities. The extent of impacts would depend on the location and size of the releases, but could include stresses of spill response on the community infrastructure, increased traffic to respond to cleanup, and restricted access to particular lands while cleanup is conducted. In general, these releases would be expected to have a temporary impact on land use and infrastructure (MMS 2007c).

Conclusion. Localized and site-dependent impacts to land use and existing infrastructure are anticipated as a result of future OCS program and ongoing and future non-OCS program activities in the Beaufort and Chukchi Seas. Impacts from Program activities could range from minor to moderate depending on the nature (extent and duration) of the land use change. Ongoing non-OCS program activities that could affect land use and onshore infrastructure are expected to continue into the foreseeable future.

The extent of land use-related impacts resulting from accidental oil spills could be minor to major, depending on the location and size of the releases.

4.6.5.3.3 Recreational Fisheries. Given the importance of this fishing to local villages in the Arctic region, any impacts from the proposed action may directly affect the local economy by causing declines in salmon availability for harvest. Greater declines in the harvest would lead to greater impacts on local communities. However, it is anticipated that impacts from routine OCS operations would be minor as a result of adherence to mitigation measures and compliance with Federal, State, and local requirements.

The proposed action would represent a small increment to the potential for overall cumulative effects on fishing by local villages in the Arctic region. Routine OCS program activities would be unlikely to have cumulative population- or community-level effects on local fishery resources because of the limited time frame over which most individual activities would occur; because a small proportion of habitat, relative to similar available habitat, could be affected during a given period; and because of existing stipulations that are in place to avoid impacts to sensitive habitats such as hard bottom areas and topographic features. Non-OCS activities, including State oil and gas development, commercial fishing, and sportfishing, could also contribute to cumulative effects on local fisheries.

Depending on specific conditions during a large oil spill, there could be substantial economic losses for commercial fisheries as a consequence of reduced catch, loss of gear, or loss of fishing opportunities during cleanup and recovery periods. Non-OCS sources of spills, including State oil and gas production, have a potential to cause similar effects. The occurrence of a catastrophic spill, such as could occur from a tanker accident, could have substantially greater effects on fisheries.

Conclusion. The future OCS program in combination with ongoing and future non-OCS program activities could result in moderate to major impacts on recreational fisheries in the Arctic region. The incremental contribution of routine Program activities would be small (see Section 4.4.11.3).

The incremental impacts of accidental oil spills associated with the proposed action would be small to large, depending on the size, location, and timing of the spill (see Section 4.4.11.3).

4.6.5.3.4 Tourism and Recreation. Platform, pipeline, causeway, and facility construction and vessel traffic could interfere with water-based recreational activities (fishing, boating, sightseeing, cruise ships); cause some disruption to land-based activities (hiking, picnicking, hunting, visiting Native communities, camping, wildlife viewing, and sightseeing), depending on the location of recreational activities relative to proposed development; increase amounts of trash and debris from OCS activities; and cause possible competition between workers and tourists for local services, such as air transport, hotel accommodations, and other visitor services. Non-OCS activities that could have an impact on tourism and recreation include offshore construction (e.g., State oil and gas development, domestic transportation of oil and gas), onshore construction (e.g., coastal and community development), and vessel traffic (e.g., commercial shipping, recreational boating, military training and testing).

Non-OCS activities and proposed and future OCS activities represent a continuation of existing onshore and offshore oil and gas construction trends in the Beaufort Sea and Chukchi Sea Planning Areas. Substantial infrastructure for related oil and gas development already exists in both of these areas, including platforms, exploration and production wells, pipelines to transport oil from offshore platforms to common-carrier pipeline systems onshore, and processing facilities; therefore, there should not be additional visual disruption for the tourists in these areas. Pipeline construction would present a temporary disruption to tourism and recreation due to workers competing with tourists for short-term housing (hotels) and air transport; aesthetic impacts (visual and auditory) associated with construction sites; and possible temporary prevention of access to some recreational or wilderness areas. In addition, the new pipeline in the Arctic region could create road access into previously undeveloped lands used primarily for subsistence, creating a potential conflict between subsistence practices and recreational hunting or other possible tourist activities.

Oil spills associated with OCS and non-OCS activities, as well as oil releases from naturally occurring seeps, could also affect recreation and tourism, and could result in both short-term and long-term effects, depending on public perception and reaction. Potential cumulative impacts include direct land impacts (e.g., oil contamination of a National Wildlife Refuge); aesthetic impacts of the spill and associated cleanup; increased traffic to respond to cleanup operations; and restricted access to particular lands while cleanup is being conducted.

Conclusion. Infrastructure changes in the Beaufort Sea and Chukchi Sea Planning Areas would result in moderate to major impacts because they would be noticeable to the recreation and tourism community, as no similar infrastructure yet exists in that region, and competition for accommodations and air transport may slow tourism for a time. The incremental contribution of routine Program activities to cumulative impacts would be relatively large, resulting from large incremental increases in construction and transportation noise and related visual intrusions, potential increases in trash and debris related to these activities, and the potential for a relatively large number of accidental releases (see Section 4.4.12.1).

Oil spills could affect recreation and tourism temporarily in all areas, but would not likely result in long-term effects, depending on public perception and reaction. The magnitude of impacts would depend on the size, location, and timing of the spill. The greatest impacts would be expected to occur in popular tourist areas during the main tourist season (in the summer).

4.6.5.3.5 Sociocultural Systems. Small, primarily Alaska Native communities along the Arctic coast are heavily dependent on subsistence harvesting of sea mammals, fish, and terrestrial fauna. Enclaves of workers at Prudhoe Bay and nearby oil fields are employed by the oil and gas industry. They commute from mostly south-central Alaska, Fairbanks, and States outside of Alaska. For the most part, these two communities (Alaska Native communities and worker enclaves) have had little interaction because of the physical distance that separates them.

The exception is Nuiqsuit. Further development of the oil and gas industry, increases in marine shipping as a result of the diminishing polar ice caps, and the effects of climate change coupled with development of oil and gas resources on the OCS could have cumulative effects on the subsistence harvesting and sociocultural structure of the region.

A primary concern of Alaska Natives is the health and accessibility of sea mammals including whales, walrus, and seals. Warming climatic conditions have resulted in the early retreat of the polar ice pack. Ice flow haulouts used by seals and walrus are thus farther from shore, increasing the effort required for subsistence hunters to harvest them. More ice-free lanes along the coast have resulted in an increase in shipping in the Beaufort and Chukchi Seas, a pattern that is likely to continue. Increased shipping is likely to disturb bowhead and beluga whale migration patterns, already affected by the noise of seismic survey vessels during oil and gas exploration, and to a lesser extent during drilling and operation of wells. The whale harvest is central to Alaska Native culture, both in terms of the food it provides and its association with Native cultural identity and spirituality. Oil and gas exploration and development combined with increased shipping and the effects of climate change would have an adverse cumulative effect on subsistence harvesting.

The construction and operation of linear features such as oil and gas pipelines and roads can deflect migration patterns of terrestrial mammals such as caribou that are an important part of the subsistence harvest. As onshore oil and gas development expands from Prudhoe Bay, Native communities such as Nuiqsut feel increasingly cut off from traditional subsistence resource harvesting areas. To the extent that offshore oil development requires onshore support infrastructure, it contributes to a cumulative negative impact on onshore access to subsistence resources. As the distance between Native communities and oil and gas worker enclaves decreases, the interaction between these two groups is likely to increase, raising the potential for cross-cultural conflicts and changes in traditional culture.

Conclusion. Cumulative impacts on sociocultural systems as a result of future OCS and ongoing and future non-OCS activities would be moderate to major. Important impacting factors include early retreat of the polar ice pack (due to warming climate conditions), increased marine shipping (due to more ice-free lanes along the coast), and increased noise (due to seismic surveys and other oil and gas activities) — all of which disturb sea mammals and their migration patterns. Onshore linear features (e.g., pipelines and roads) affect the migration patterns of terrestrial mammals. Because of the high level of dependence on subsistence harvesting, the incremental contribution of the proposed action to cumulative impacts on sociocultural systems in the Beaufort and Chukchi Seas would be medium to large (see Section 4.4.13.3).

4.6.5.3.6 Environmental Justice. Additional offshore construction under the proposed action could include increased noise and traffic, air and water pollution, impacts on residential property values, and land use changes. Much of the Alaska Native population resides in the coastal areas of Alaska. New offshore infrastructure resulting from this program could be located near areas where subsistence hunting occurs. The proposed 5-year program will result in levels of infrastructure use and construction similar to what has occurred in the south Alaska region during previous programs. These activities are not expected to expose residents to notably higher risks than currently occur.

Any adverse environmental impacts on fish and mammal subsistence resources could have disproportionately higher health or environmental impacts on Alaska Native populations. OCS activities could potentially disrupt marine mammal harvests (primarily walrus, seals, and beluga whales) by diverting marine migrations or by causing other behavioral changes, such as increased wariness or having to go further from shore because of the diminishing polar ice cap, and whales migrating further from shore or the synergistic effects of all these factors combined.

Air emissions from onshore facilities and helicopter and vessel traffic traversing coastal areas will be highest in areas containing the greatest amounts of infrastructure. It is assumed that the majority of the activity from the proposed 5-yr program will occur in waters no more than 100 m (30 ft) deep, with the most offshore air emissions occurring in the coastal areas with the greatest amounts of oil and gas activity and with fewer emissions occurring elsewhere. The effects of the OCS program on air quality have been analyzed in Section 4.4.4. This analysis concluded that routine operations associated with the proposed 5-year program would result in NO_2, SO_2, PM_{10}, and CO levels that are well within the NAAQS. Coastal effects from offshore activities are expected to be small, based on the established and increasing trend toward movement of oil and gas activities into deeper waters.

Oil spill events in the region, and related cleanup activities, pose the greatest potential for impacts on low-income and minority population groups. It is reasonable to expect that most of these spills would occur in deepwater areas located away from the coast, based on the established trend for oil and gas activities to move into deep waters located for the most part at a substantial distance from the coast. The magnitude of impacts from such spills cannot be predicted, should they contact the coast, and depends on their location, size, and timing. However, according to MMS (2002), the probability that an offshore oil spill occurring and impacting coastal populations is low. While the location of possible oil spills cannot be determined, low-income and minority populations are resident in some areas of the coast. Low-income and minority groups could bear more negative impacts than other population groups.

Conclusion. In the Beaufort and Chukchi Sea Planning Areas, OCS and non-OCS program activities in combination with increased marine traffic and climate change could result in major adverse cumulative impacts on human health and the environment, especially if a large oil spill were to occur, because oil spill contamination of subsistence foods is the main concern regarding potential effects on Native health. Impacts on marine and terrestrial ecosystems in the region (described in Section 4.6.4) could affect subsistence resources, traditional culture, and community infrastructure; indigenous communities that are subsistence-based would likely experience disproportionate, highly adverse environmental and health effects. However, the incremental change due to impacts from Program activities is expected to be negligible to minor.

The incremental impacts of accidental oil spills associated with the proposed action would be small to large, depending on the size, location, and timing of the spill (see Section 4.4.14.3).

4.6.5.3.7 Archeological and Historic Resources. Section 4.4.15.3 discusses the potential impacts from the proposed action (OCS program activities from 2012 to 2017) on onshore and offshore environments in the Beaufort and Chukchi Sea Planning Areas. Cumulative impacts on archeological and historic resources result from the incremental impacts of the proposed action when added to impacts from existing and reasonably foreseeable future OCS program activities (that are not part of the proposed action) and other non-OCS program activities. Table 4.6.1-2 presents the exploration and development scenario for the Arctic region cumulative case (encompassing the proposed action and future OCS program activities). Specific types of impact-producing factors related to OCS program activities considered in this analysis include drilling rig and platform emplacement, pipeline emplacement, new onshore facilities, and oil spills. Non-OCS program activities (e.g., oil and gas industry in State waters) and natural geologic processes such as ice gouging and thermokarst erosion are also considered (see also Section 4.2.2.2).

Archeological Resources. Offshore development could result in an interaction between a drilling rig, platform, pipeline, or anchors and an inundated prehistoric site. This direct physical contact with a site could destroy artifacts or site features and could disturb the stratigraphic context of the site. The result would be the loss of archaeological data on prehistoric migrations, settlement patterns, subsistence strategies, and archaeological contacts between northeast Asia and the Americas.

Since 1973, BOEM has required that an archaeological survey be conducted prior to development of mineral leases determined to have potential for cultural resources, including prehistoric archaeological sites. Relative sea-level data, which are used to define the portion of the continental shelf having potential for prehistoric sites, suggest that the portion of the continental shelf shoreward of about the 60-m (200-ft) isobath would have potential for prehistoric sites. Although an archaeological survey would identify all cultural resources in the APE for the project and routine operations related to OCS program activities would avoid all known cultural resources, it is likely that impacts to prehistoric resources may have already occurred as a result of non-OCS program activities prior to the implementation of the archaeological survey requirement.

Onshore development could result in direct physical contact between the construction of new onshore facilities or pipeline trenches and previously unidentified prehistoric sites. This direct physical contact with a prehistoric site could cause physical damage to or complete destruction of information on the prehistory of the region and North America. Federal and State laws and regulations initiated in the 1960s began requiring archaeological surveys prior to permitting any activity that might disturb a significant archaeological site. Therefore, it can be assumed that, since the introduction of the archaeological resource protection laws, most coastal archaeological sites have been located, evaluated, avoided, or mitigated prior to construction. However, impacts to coastal prehistoric resources may have already occurred as a result of various onshore construction activities prior to enactment of the archaeological resource protection laws.

Trawling activity in the Arctic region affects only the uppermost portion of the sediment column (Krost et al. 1990). This zone would already be disturbed by natural factors relating to the destructive effects of ice gouging and scouring (see Section 4.2.2). Therefore, the effect of trawling on most prehistoric archaeological sites would be minor.

Most channel dredging occurs at the entrances to bays, harbors, and ports. These areas have a high probability for prehistoric archaeological sites, as they are often associated with drowned river valleys, which are known to have a high probability for prehistoric sites. It is assumed that some of the archaeological data that have been lost as a result of dredging have been significant and unique; therefore, the impact to prehistoric archaeological sites as a result of past channel dredging activities has probably been moderate to major. In many areas, the USACE now requires remote-sensing surveys prior to dredging activities to minimize such impacts (Espey, Huston & Associates 1990).

Natural geologic processes such as ice gouging and thermokarst erosion have caused and will continue to cause a significant loss of prehistoric archaeological data in the Alaska region. For example, ice gouges on the Beaufort Sea shelf can create a furrow up to 67 m (220 ft) wide and 4 m (13 ft) deep; however, the average ice gouge is about 8 m (26 ft) wide and 0.5 m (1.6 ft) deep (Barnes 1984). Coastal prehistoric sites are exposed to the destructive effects of thermokarst erosion. These natural processes would cause artifacts to be dispersed and the site context to be disturbed or even completely destroyed, resulting in the loss of archaeological information. Overall, a significant loss of data from submerged and coastal prehistoric sites has probably occurred, and will continue to occur, from the effects of natural geologic processes. It is assumed that some of the data lost have been significant and/or unique, resulting in a major level of impact.

An accidental oil spill could affect coastal prehistoric archaeological sites, but the direct impact of oil on most sites is uncertain. Protection of such sites during an oil spill requires specific knowledge of their location, condition, nature, and extent prior to impact; however, the Beaufort and Chukchi Sea coastlines have not been systematically surveyed for archaeological sites.

Heavy oiling of a coastal area could conceal intertidal sites that may not be recognized until they are inadvertently damaged during cleanup (Whitney 1994). Crude oil may also contaminate organic material used in ^{14}C dating, and, although there are methods for cleaning contaminated ^{14}C samples, greater expense is incurred (Dekin et al. 1993). The major source of potential impact from oil spills is the harm that could result from unmonitored shoreline cleanup activities. Unauthorized collecting of artifacts by cleanup crew members is also a concern, albeit one that can be mitigated with effective training and supervision. Damage or loss of significant archaeological information could result from the contact between an oil spill and a prehistoric archaeological site; therefore, the cumulative impact from oil spills to prehistoric archaeological sites could range from moderate to major.

Historic Resources. Direct physical contact between a routine activity and a shipwreck site could destroy fragile ship remains, such as the hull and wooden or ceramic artifacts, and could disturb the site context. The result would be the loss of archaeological data on ship construction, cargo, and the social organization of the vessel's crew, and the concomitant loss of information on maritime culture for the time period from which the ship dates.

Since 1973, BOEM has required archaeological (historical) surveys be conducted prior to development of mineral leases when a historic-period shipwreck is reported to lie within or adjacent to the lease area. Although an archeological survey would identify all cultural resources in the APE for the project and routine operations related to OCS activities would avoid all known cultural resources, it is likely that impacts to historic-period shipwrecks may have already occurred as a result of non-OCS program activities that took place before implementation of the 1973 archaeological survey requirement.

Onshore development could result in direct physical contact between the construction of new onshore facilities or pipeline trenches and previously unidentified historic sites. Federal and State laws and regulations initiated in the 1960s began requiring archaeological surveys prior to permitting any activity that might disturb a significant archaeological site. Therefore, it can be assumed that, since the introduction of the archaeological resource protection laws, most coastal archaeological sites that would have been impacted have been located, evaluated, avoided, or mitigated prior to construction. However, impacts to coastal historic sites may have resulted from onshore construction activities prior to enactment of the archaeological resource protection laws.

Trawling activity in the Alaska subregion only affects the uppermost portion of the sediment column (Krost et al. 1990). On many wrecks, this zone would already be disturbed by natural factors and would contain only artifacts of low specific gravity which have lost all original context. Therefore, the effect of trawling on most historic shipwreck sites would be minor.

Most channel dredging occurs at the entrances to bays, harbors, and ports. These areas have a high probability for historic shipwrecks. Assuming that some of the data lost have been unique, the impact to historic sites as a result of past channel-dredging activities has probably been moderate to major. In many areas, the USACE now requires remote-sensing surveys prior to dredging activities to minimize such impacts (Espey, Huston & Associates 1990).

Natural geologic processes such as ice gouging and thermokarst erosion may cause a loss of historic data in the Beaufort and Chukchi Seas (see study conducted in the Beaufort Sea by Darigo et al. [2007]). For example, ice gouges on the Beaufort Sea shelf can create furrows up to 67 m (220 ft) wide and 4 m (13 ft) deep; however, the average ice gouge is about 8 m (26 ft) wide and 0.5 m (1.6 ft) deep (Barnes 1984). Darigo et al. (2007) suggest that areas close to islands and the shore may be protected from the effects of ice gouging. Coastal historic sites are exposed to the erosional effects of wave energy and thermokarst erosion, which would cause artifacts to be dispersed and the site context to be disturbed or even completely destroyed. No specific studies have examined the effect of geological processes on site integrity. Overall, a significant loss of data from submerged and coastal historic sites may have already occurred from the effects of natural geologic processes. It is possible that some of the data lost may have been significant and/or unique, resulting in a major level of impact. Additional studies are needed to assess the effect of geological processes on cultural resources.

An accidental oil spill could affect a coastal historic site, but the direct impact of oil on most historic sites is uncertain. The primary source of potential impact from oil spills is unmonitored shoreline cleanup activities (Bittner 1996; see Section 4.4.15.3.2). Unauthorized collecting of artifacts by cleanup crew members is also a concern, albeit one that can be mitigated with effective training and supervision. Damage or loss of significant historic information could result from oil spill cleanup activities; therefore, the cumulative impact from oil spills (past, present, and future) on historic sites could range from moderate to major.

Conclusion. The cumulative impacts of future OCS program and ongoing and future non-OCS program activities on prehistoric and historic archaeological sites in the Beaufort and Chukchi Seas are currently unknown, but could range from minor to moderate, mainly because activities occurring on the OCS prior to BOEM's survey requirement (in effect since 1973) may already have affected significant archaeological sites. Other important impact-producing factors that likely have had, and will continue to have, an impact on both prehistoric and historic archaeological sites are channel dredging and geologic processes, such as ice gouging and thermokarst erosion. Commercial treasure hunting and sport diving may also result in a loss of artifacts at historic-period shipwreck sites. The incremental contribution of routine Program activities is expected to be small because required archaeological surveys would identify significant cultural resources to be avoided (see Section 4.4.15.3).

Cumulative impacts on prehistoric and historic sites due to accidental oil spills would result mainly from cleanup activities (direct impacts to the sites are uncertain) and could range from moderate to major. The incremental impacts of oil spills associated with the proposed action would be small to medium relative to those associated with future OCS program and ongoing and future non-OCS program activities.

4.6.6 Cumulative Impacts Summary Tables

The cumulative impacts are incremental contributions of routine Program activities for resources in the GOM, Cook Inlet Planning Area, and Arctic region are summarized in Tables 4.6.6-1, 4.6.6-2, and 4.6.6-3.

TABLE 4.6.6-1 Summary of Cumulative Impacts and Incremental Contributions of the Proposed Action, GOM

	Cumulative Impact				Incremental Contribution			
Resource	Negligible	Minor	Moderate	Major	Small	Medium	Large	Comments
Water Quality			X		X			
Air Quality		X	X		X			
Acoustic Environment		X	X	X	X	X	X	Magnitude of cumulative impacts depends on the ambient acoustic conditions and the nature and combination of OCS and non-OCS program activities taking place.
Coastal and Estuarine Habitat			X	X	X			
Marine Benthic Habitat		X			X			
Essential Fish Habitat		X			X			Magnitude of cumulative impacts depends on size of affected EFH. Impacts from OCS activities would be limited by specific lease stipulations.
Marine Mammals		X	X		X			
Terrestrial Mammals		X	X		X			
Marine and Coastal Birds			X		X			
Fish		X	X		X			
Reptiles		X	X		X			
Invertebrates and Lower Trophic Levels			X		X			

TABLE 4.6.6-1 (Cont.)

Resource	Cumulative Impact				Incremental Contribution			Comments
	Negligible	Minor	Moderate	Major	Small	Medium	Large	
Areas of Special Concern		X			X			
Population, Employment, and Income		X			X			Cumulative impacts would be considered beneficial because past, present, and foreseeable future activities would generally increase employment and earnings in the region over the next 40 to 50 yr. The proposed action would add to these beneficial impacts.
Land Use and Infrastructure		X	X	X	X			The magnitude of cumulative impacts depends on the extent and duration of land use change.
Tourism and Recreation			X	X	X			Cumulative impacts minor for most routine activities except for large oil spills occurring during the peak tourist season (which could result in major impacts).
Commercial and Recreational Fishing		X	X		X			
Sociocultural Systems		X			X			
Environmental Justice		X	X		X			
Archeological and Historic Resources		X	X		X			Incremental contribution from routine Program activities expected to be small because required archaeological surveys would identify significant resources to be avoided.

TABLE 4.6.6-2 Summary of Cumulative Impacts and Incremental Contributions of Proposed Action, Cook Inlet Planning Area

	Cumulative Impact				Incremental Contribution			
Resource	Negligible	Minor	Moderate	Major	Small	Medium	Large	Comments
Water Quality		X	X		X			Cumulative impacts may lessen with time since oil and gas production is currently on the decline.
Air Quality		X	X		X			
Acoustic Environment		X	X	X	X	X	X	Magnitude of cumulative impacts depends on the ambient acoustic conditions and the nature and combination of OCS and non-OCS program activities taking place.
Coastal and Estuarine Habitat			X	X	X			
Marine Benthic Habitat		X			X			
Essential Fish Habitat		X	X		X			Magnitude of cumulative impacts depends on size of affected EFH. Impacts from OCS activities would be limited by specific lease stipulations.
Marine Mammals		X	X		X			
Terrestrial Mammals		X	X		X			
Marine and Coastal Birds		X	X		X			Magnitude of cumulative impacts depends on nature and duration of activities that could reduce bird survival and productivity.
Fish		X			X			

TABLE 4.6.6-2 (Cont.)

	Cumulative Impact				Incremental Contribution			
Resource	Negligible	Minor	Moderate	Major	Small	Medium	Large	Comments
Invertebrates and Lower Trophic Levels			X		X			
Areas of Special Concern		X			X			
Population, Employment, and Income		X			X			Cumulative impacts would be considered beneficial because past, present, and foreseeable future activities would generally increase employment and earnings in the region over the next 40 to 50 yr. The proposed action would add to these beneficial impacts.
Land Use and Infrastructure		X	X	X	X			The magnitude of cumulative impacts depends on the extent and duration of land use change.
Tourism and Recreation		X			X			
Commercial and Recreational Fishing		X	X		X			
Sociocultural Systems		X	X		X			
Environmental Justice		X	X		X			
Archeological and Historic Resources		X	X		X			Incremental contribution from routine Program activities expected to be small because required archaeological surveys would identify significant resources to be avoided.

TABLE 4.6.6-3 Summary of Cumulative Impacts and Incremental Contributions of Proposed Action, Arctic Region

Resource	Cumulative Impact				Incremental Contribution			Comments
	Negligible	Minor	Moderate	Major	Small	Medium	Large	
Water Quality			X		X	X		
Air Quality		X	X		X			
Acoustic Environment		X	X	X	X	X	X	Magnitude of cumulative impacts depends on the ambient acoustic conditions and the nature and combination of OCS and non-OCS program activities taking place.
Coastal and Estuarine Habitat			X	X	X			
Marine Benthic Habitat		X			X			
Essential Fish Habitat		X	X		X			Magnitude of cumulative impacts depends on size of affected EFH. Impacts from OCS activities would be limited by specific lease stipulations.
Marine Mammals		X	X		X			
Terrestrial Mammals		X	X		X			
Marine and Coastal Birds		X	X		X			Magnitude of cumulative impacts depends on nature and duration of activities that could reduce bird survival and productivity. Population-level effects could result from the tendency of large numbers of individuals of some bird species to concentrate in certain coastal arctic locations.
Fish		X	X		X			

TABLE 4.6.6-3 (Cont.)

	Cumulative Impact				Incremental Contribution			
Resource	Negligible	Minor	Moderate	Major	Small	Medium	Large	Comments
Invertebrates and Lower Trophic Levels		X	X		X			
Areas of Special Concern		X			X			Lease stipulations applied at the lease sale stage could minimize the potential for cumulative impacts.
Population, Employment, and Income		X			X			Cumulative impacts would be considered beneficial because past, present, and foreseeable future activities would generally increase employment and earnings in the region over the next 40 to 50 yr. The proposed action would add to these beneficial impacts.
Land Use and Infrastructure		X	X	X	X			The magnitude of cumulative impacts depends on the extent and duration of land use change.
Commercial and Recreational Fishing			X	X	X			
Tourism and Recreation		X					X	
Sociocultural Systems		X	X			X	X	
Environmental Justice		X	X			X	X	
Archeological and Historic Resources		X	X		X			Incremental contribution from routine Program activities expected to be small because required archaeological surveys would identify significant resources to be avoided.

4.7 REFERENCES

Abraham, K.S., 2005, "Battering of US GOM Structures Brings Discussion of Standards," *World Oil* 226(11):51–60.

Adcroft, A., R. Hallberg, J.P. Dunne, B.L. Samuels, J.A. Galt, C.H. Barker, and D. Payton, 2010, "Simulations of Underwater Plumes of Dissolved Oil in the Gulf of Mexico," *Geophysical Research Letters* 37:L18605.

Addison, R., J. Dower, J. Hall, and I. Jordan, 2004, *Report of the Expert Panel on Science Issues Related to Oil and Gas Activities, Offshore British Columbia*, the Royal Society of Canada, Ottawa, Feb. Available at http://www.rsc.ca/documents/fullreportEN.pdf. Accessed July 15, 2011.

ADEC (Alaska Department of Environmental Conservation), 2007a, *Summary of Oil and Hazardous Substance Spills by Subarea (July 1, 1995 to June 30, 2005)*, Oct.

ADEC, 2007b, *Alaska's Nonpoint Source Water Pollution Control Strategy*, Feb. 15.

ADEC (Alaska Department of Environmental Conservation), 2010, *Alaska's Final 2010 Integrated Water Quality Monitoring and Assessment Report*, July 15.

ADFG (Alaska Department of Fish and Game), 2011, "Cook Inlet Area," Alaska Department of Fish and Game. Available at http://www.adfg.alaska.gov/index.cfm?adfg=ByAreaSubsistence CookInlet.main. Accessed August 31, 2011.

ADN (Anchorage Daily News), 2009, *Redoubt Ash Dusts Anchorage, Airport Closed*, March 29.

ADNR (Alaska Department of Natural Resources), 1999, *Beaufort Sea Areawide 1999 Oil and Gas Lease Sale*, *Finding of the Director*, *State of Alaska*, Division of Oil and Gas, Department of Natural Resources, Anchorage, Alaska, July 15.

ADNR, 2009a, *Cook Inlet Areawide Oil and Gas Lease Sale, Final Finding of the Director, January 20, 2009*, Division of Oil and Gas.

ADNR, 2009b, *Final Best Interest Finding: 2009 Cook Inlet Areawide Oil and Gas Lease Sale*. Available at http://www.dog.dnr.state.ak.us/oil/products/publications/cookinlet/ciaw_2009_final_finding/ciaw09-ff_toc.html. Accessed April 26, 2011.

ADNR, 2009c, *Alaska Oil and Gas Report, Annual Report of the Division of Oil and Gas*, Nov.

ADNR, 2011, *Red Dog Mine*, Division of Mining, Land, and Water, April 25. Available at http://dnr.alaska.gov/mlw/mining/largemine/reddog/index.htm. Accessed July 12, 2011.

Alexander-Bloch, B., 2010, "Vietnamese-American Fishers Fight for Oil Spill Claim Approval," *nola.com.* Available at http://www.nola.com/news/gulf-oil-spill/index.ssf/2010/12/vietnamese-american_fishermen.html. Accessed December 15, 2010.

Allen, B.N., and R.P. Angliss, 2010, *Alaska Marine Mammal Stock Assessments, 2009*, NOAA Technical Memorandum NMFS-AFSC-206, National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, Washington, Feb.

Allen, B.N., and R.P. Angliss, 2011, *Alaska Marine Mammal Stock Assessments, 2010*, NOAA, Technical Memorandum NMFS-AFSC-223, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, Wash., May. REPLACES ALLEN AND ANGLISS 2010.

AMAP (Arctic Monitoring and Assessment Programme), 1997, "Acidification and Arctic Haze," in *Arctic Pollution Issues: A State of the Arctic Environment Report*. Available at http://iwlearn.net/iw-projects/Msp_112799491731/reports/arctic-pollution-issues-a-state-of-the-arctic-environment-report-1997. Accessed September 5, 2011.

AMAP, 2007, *Arctic Oil and Gas 2007*. Available at http://www.amap.no/oga/. Accessed May 10, 2011.

AMAP, 2010, Asssessment 2007: *Oil and Gas Activities in the Arctic – Effects and Potential Effects*, Vol. 2. Available at http://www.amap.no/oga/. Accessed May 10, 2011.

Amstrup, S.C., 1993, "Human Disturbances of Denning Polar Bears in Alaska," *Arctic* 46:246–250.

Anchorage Daily News, 2010, "Shell, Native Corporations Team Up for Offshore Operations," *adn.com*, Jan. 13.

Anderson, C.M., and R.P. LaBelle, 2000, "Update of Comparative Occurrence Rates for Offshore Oil Spill," *Spill Science and Technology* 65(6):303–321.

Anderson, D.E., O.J. Rongstead, and W.R. Mytton, 1986, "The Behavioral Response of a Red-Tailed Hawk to Military Training Activity," *Raptor Research* 20: 65–68.

Anderson, D.E., O.J. Rongstead, and W.R. Mytton, 1989, "Response of Nesting Red-Tailed Hawks to Helicopter Overflights," *The Condor* 91: 296–299.

Anderson, J., 2010, *Corps of Engineers Alaska District 2011 Dredging Projects*, Alaska District Corps of Engineers, Elmendorf Air Force Base, Alaska, Oct. 27.

Andre, M., M. Terada, and Y. Watanabe, 1997, *Sperm Whale (*Physeter macrocephalus*) Behavioral Response after the Playback of Artificial Sounds*, Reports of the International Whaling Commission 47, SC/48/NA 13:499–504.

Antoine, J.W., 1972, "Structure of the Gulf of Mexico," in *Contributions on the Geological and Geophysical Oceanography of the Gulf of Mexico*, Vol. 3, Texas A&M University Oceanographic Studies, R. Resak and V.J. Henry (eds.), Gulf Publishing Company, Houston, Texas.

API (American Petroleum Institute), 1989, *Effects of Offshore Petroleum Operations on Cold Water Marine Mammals: A Literature Review*, Washington, D.C.

APTA (American Public Transportation Association), *2010, 2010 Public Transportation Fact Book*. Available at http://www.apta.com/RESOURCES/STATISTICS/Pages/transitstats.aspx. Accessed April 2010.

Archer, A.W., and M.S. Hubbard, 2003, "Highest Tides of the World," *Special Paper – Geological Society of America* 370:151–173.

Arctic Council and IASC (International Arctic Science Committee), 2005, *Arctic Climate Impact Assessment*, Cambridge University Press, New York, N.Y.

Asplin, M.G., J.V. Lukovich, and D.G. Barber, 2009, "Atmospheric Forcing of the Beaufort Sea Ice Gyre: Surface Pressure Climatology and Sea Ice Motion," *Journal of Geophysical Research* 114:C00A06.

Astakhov, A.S., A.A. Bosin, A.N. Kolesnik, D.A. Korshunov, K. Crane, and E.A. Logvina, 2010, "Geological Investigations in the Chukchi Sea and the Adjacent Areas of the Arctic Ocean during the RUSALCA-2009 Expedition," *Russian Journal of Pacific Geology* 4(6):532–537.

Atauz, A.D., W. Bryant, T. Jones, and B. Phaneuf, 2006, *Mica Shipwreck Project: Deepwater Archaeological Investigation of a 19th Century Shipwreck in the Gulf of Mexico*, OCS Study MMS 2006-072, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La.

Atchinson, A.D., P.W. Sammarco, and D.A. Brazeau, 2008, "Genetic Connectivity in Corals on the Flower Garden Banks and Surrounding Oil/Gas Platforms, Gulf of Mexico." *Journal of Experimental Marine Biology and Ecology* 365: 1–12.

Auerbach, N.A., M.D. Walker, and D.A. Walker. 1997. Effects of Roadside Disturbance on Substrate and Vegetation Properties in Arctic Tundra. Ecol. Appl. 7(1):218-235.

Aurell, J., and B.K. Gullett, 2010, "Aerostat Sampling of PCDD/PCDF Emissions from the Gulf Oil Spill In Situ Burns," *Environ. Sci. Tech.* 44(24):9431–9437.

Austin, D., et al., 2002, *Social and Economic Impacts of Outer Continental Shelf Activities on Individuals and Families*, OCS Study MMS 2002-022, prepared by University of Arizona, Bureau of Applied Research in Anthropology.

Avens, L., J. Braun-McNeill, S. Epperly, and K.J. Lohmann, 2003, "Site Fidelity and Homing Behavior in Juvenile Loggerhead Sea Turtles (*Caretta caretta*)," *Marine Biology* 143:211–220.

Bak, R.P.M., 1987, "Effects of Chronic Oil Pollution on a Caribbean Coral Reef," *Marine Pollution Bulletin* 18:534–539.

Baker, J.D., C.L. Littnan, and D.W. Johnston, 2006, "Potential Effects of Sea Level Rise on the Terrestrial Habitats of Endangered and Endemic Megafauna in the Northwestern Hawaiian Islands," *Endangered Species Research* 4:1–10.

Barber, D.G., R. Galley, M.G. Asplin, R. De Abreu, K.-A. Warner, M. Puc´ko, M. Gupta, S. Prinsenberg, and S. Julien, 2009, "Perennial Pack Ice in the Southern Beaufort Sea Was Not as It Appeared in the Summer of 2009," *Geophysical Research Letters* 36:L24501, doi:10.1029/2009GL041434.

Barnes, P.W., 1984, "Ice Gouging Characteristics and Processes," pp. 185–212 in *The Beaufort Sea: Ecosystems and Environments*, P.W. Barnes, D.M. Schell, and E. Reimnitz (eds.), Academic Press, New York, N.Y.

Barnes, P.W., and E. Reimnitz, 1979, *Ice Gouge Obliteration and Sediment Redistribution Event, 1977-1978, Beaufort Sea, Alaska,* Open File Report 79-848, U.S. Geological Survey.

Bartol, S.M., J. Musick, and M. Lenhardt, 1999, "Auditory Evoked Potentials of the Loggerhead Sea Turtle (*Caretta caretta*)," *Copeia* 99(3):836–840.

Bartol, S.M., and D.R. Ketten, 2006, "Turtle and Tuna Hearing," pp. 98–103 in *Sea Turtle and Pelagic Fish Sensory Biology: Developing Techniques to Reduce Sea Turtle Bycatch in Longline Fisheries,* NOAA Technical Memorandum NMFS-PIFSC-7, December.

Bartsch-Winkler, S., 1982, *Physiography, Texture, and Bedforms in Knik Arm, Upper Cook Inlet, Alaska during June and July, 1980*, U.S. Geological Survey Open File Report 82-464.

Battelle, 2001, *An Initial Survey of Aquatic Invasive Species Issues in the Gulf of Mexico Region*, Version 4.0, EPA 855-R-00-003, submitted by Battelle, Coastal Resources and Ecosystems Management, New Orleans, La., to U.S. Environmental Protection Agency, Gulf of Mexico Program, Stennis Space Center, Mississippi, August 31. Available at http://nis.gsmfc.org/pubs/Initial%20Survey%20of%20Invasive%20Species.pdf. Accessed September 6, 2011.

Baust, J.G., A.H. Benton, and G.D. Aumann, 1981, "The Influence of Off-shore Platforms on Insect Dispersal and Migration," *Journal of Economic Entomology* 27: 23–25.

Bean, D., 2005, *Past and Present Deepwater Contour-Current Bedforms at the Base of the Sigsbee Escarpment, Northern Gulf of Mexico,* dissertation, Texas A&M University, College Station, Texas, Aug.

Becker, E.L., E.E. Cordes, S.A. Macko, and C.R. Fisher, 2009, "Importance of Seep Primary Production to *Lophelia pertusa* and Associated Fauna in the Gulf of Mexico," *Deep Sea Research Part I* 56:786–800.

Behrenfeld, M.J., R.T. O'Malley, D.A. Siegel, C.R. McClain, J.L. Sarmiento, G.C. Feldman, A.J. Milligan, P.G. Falkowski, R.M. Letelier, and E.S. Boss, 2006, "Climate-Driven Trends in Contemporary Ocean Productivity," *Nature* 444:752–755.

Berner, J., 2011, *Integrating Health Impact Assessments into the Federal Environmental Impact Process with a Focus on Alaska Native Communities*. Prepared by the Alaska Inter-Tribal Council for the Robert Wood Johnson Foundation. Available at http://www.rwjf.org/files/research/63350.pdf. Accessed July 20, 2011.

Bhatia, R., 2007, "Protecting Health Using an Environmental Impact Assessment: A Case Study of San Francisco Land Use Decisionmaking," *American Journal of Public Health*, Vol. 97, No. 3, March.

Bierman, V.J., Jr., S.C. Hinz, D. Justić, D. Scavia, J.A. Veil, K. Satterlee, III, M.E. Parker, and S. Wilson, 2007, "Predicted Impacts from Offshore Produced Water Discharges on Hypoxia in the Gulf of Mexico," prepared for 2007 SPE E&P Environmental and Safety Conference, Galveston, Texas, March 5–7.

Billings, R., and D. Wilson, 2004, *Data Quality Control and Emissions Inventories of OCS Oil and Gas Production Activities in the Breton Area of the Gulf of Mexico, Final Report*, OCS Study MMS 2004-071.

Bittner, J.E., 1996, "Cultural Resources and the *Exxon Valdez* Oil Spill: An Overview," *American Fisheries Society Symposium* 18:814–818.

Black, B.B., M.W. Collopy, H.F. Percival, A.A. Tiller, and P.G. Bohall, 1984, *Effect of Low-Level Military Training Flights on Wading Bird Colonies in Florida. Tech. Rep. 7*, Florida Cooperative Fish and Wildlife Research Unit, University of Florida, Gainesville.

Blackwell, S.B., J.W. Lawson, and M.T. Williams, 2004, "Tolerance of Ringed Seals (*Phoca hispida*) to Impact Pipe-Driving and Construction Sounds at an Oil Production Island," *The Journal of the Acoustical Society of America* 115(5):2346–2357.

Blake, E.S., E.N. Rappaport, and C.W. Landsea, 2007, *The Deadliest, Costliest, and Most Intense United States Tropical Cyclones from 1851 to 2006*, Technical Memorandum NWS TPC-5, National Weather Service, National Hurricane Center, Miami, Fla.

BLM (Bureau of Land Management), 2002, *Renewal of the Federal Grant for the Trans-Alaska Pipeline System Right-of-Way, Final Environmental Impact Statement*, BLM/AK/PT-03/005+2880+990, BLM, Anchorage, Alaska.

BLM, 2007, *Northeast National Petroleum Reserve-Alaska (NPR-A) Draft Supplemental Integrated Activity Plan/Environmental Impact Statement*, Bureau of Land Management, Alaska State Office, Anchorage. Available at http://www.blm.gov/ak/st/en/prog/planning/npra_general/ne_npra.html.

Blum, M.D., and H.H. Roberts, 2009, "Drowning of the Mississippi Delta due to Insufficient Sediment Supply and Global Sea-level Rise," *Nature Geoscience*, Vol. 2, July.

Blumer, M., H.L. Sanders, J.F. Grassie, and G.R. Hampson, 1971, "A Small Oil Spill," *Environment* 13:2–12.

Boatman, M.C., and J. Peterson, 2000, *Oceanic Gas Hydrate Research and Activities Review*, MMS Gulf of Mexico OCS Region, OCS Report MMS 2000-017, Feb.

Bodkin, J.L., B.E. Ballachey, T.A. Dean, A.K. Fukuyama, S.C. Jewett, L. McDonald, D.H. Monson, C.E. O'Clair, and G.R. VanBlaricom, 2002, "Sea Otter Population Status and the Process of Recovery from the 1989 'Exxon Valdez' Oil Spill," *Marine Ecology Progress Series* 241:237–253.

Boehm, P.D., J.M. Neff, and D.S. Page, 2007, "Assessment of Polycyclic Aromatic Hydrocarbon Exposure in the Waters of Prince William Sound after the *Exxon Valdez* Oil Spill: 1989-2005," *Marine Pollution Bulletin* 54:339–356.

BOEM, unpublished, *Draft Programmatic EIS for the Geological and Geophysical Exploration of Mineral and Energy Resources in the Gulf of Mexico*, Bureau of Ocean Energy Management, Gulf of Mexico Region, New Orleans, La.

BOEMRE (Bureau of Ocean Energy Management, Regulation, and Enforcement), 2008, *Beaufort Sea and Chukchi Sea Planning Area Oil and Gas Lease Sales 209, 212, 217 and 221, Draft Environmental Impact Statement*, OCS EIS/EA BOEMRE 2008-0055.

BOEMRE, 2010a, *Chukchi Sea Planning Area, Oil and Gas Lease Sale 193 in the Chukchi Sea, Alaska, Draft Supplemental Environmental Impact Statement*, OCS EIS/EA, BOEMRE 2010-034, September.

BOEMRE, 2010b, *Installations and Removals – Offshore Production Facilities in Federal Water*, BOEMRE TIMS GOM and Pacific databases. Available at http://www.boemre.gov/stats/PDFs/OCSPlatformActivity.pdf. Accessed April 21, 2011.

BOEMRE, 2010c, *Draft Programmatic Environmental Impact Statement for the Geological and Geophysical Exploration of Mineral Resources in the Gulf of Mexico Outer Continental Shelf*.

BOEMRE, 2010d, *Revised Offshore Environmental Cost Model (OECM): Guide to Cost Benefit Calculations*, prepared by Industrial Economics, Dec.

BOEMRE, 2010e, *Alaska Outer Continental Shelf Chukchi Sea Planning Area Statoil USA E&P Inc. Geological & Geophysical Permit 2010 3D/2D Seismic Acquisition Chukchi Sea, Alaska Environmental Assessment*, OCS EIS/EA BOEMRE 2010-020, Bureau of Ocean Energy Management, Regulation and Enforcement, Alaska OCS Region, Office of Leasing and Environment, June.

BOEMRE, 2011a, *Gulf of Mexico OCS Oil and Gas Lease Sale: 2011, Western Planning Area Lease Sale 218, Draft Supplemental Environmental Impact Statement*, OCS EIS/EA, BOEMRE 2011-018. Available at http://www.gomr.boemre.gov/PDFs/2011/2011-018.pdf. Accessed April 22, 2011.

BOEMRE, 2011b, "Catastrophic Spill Event Analysis: High-Volume, Extended-Duration Oil Spill Resultilng from Loss of Well Control on the Gulf of Mexico Outer Continental Shelf," Appendix B in *Gulf of Mexico OCS Oil and Gas Lease Sale: 2011, Western Planning Area Lease Sale 218, Draft Supplemental Environmental Impact Statement*, OCS EIS/EA BOEMRE 2011-018, Bureau of Ocean Energy Management, Regulation and Enforcement, Gulf of Mexico Region, New Orleans, La.

BOEMRE, 2011c, *2012-2017 Five-Year Scoping Meeting for Programmatic Environmental Impact Statement Bureau of Ocean Energy Management, Regulation and Enforcement, U.S. Department of the Interior, Kaktovik, Alaska,* transcript reported by Mary A. Vavrik, Midnight Sun Court Reporters, February 23.

BOEMRE, 2011d, *2012-2017 Five-Year Scoping Meeting for Programmatic Environmental Impact Statement Bureau of Ocean Energy Management, Regulation and Enforcement, U.S. Department of the Interior, Nuiqsut, Alaska*, transcript reported by Mary A. Vavrik, Midnight Sun Court Reporters, February 22.

BOEMRE, 2011e, *2012-2017 Five-Year Scoping Meeting for Programmatic Environmental Impact Statement Bureau of Ocean Energy Management, Regulation and Enforcement, U.S. Department of the Interior, Wainwright, Alaska*, transcript reported by Mary A. Vavrik, Midnight Sun Court Reporters, February 15.

BOEMRE, 2011f, *2012-2017 Five-Year Scoping Meeting for Programmatic Environmental Impact Statement Bureau of Ocean Energy Management, Regulation and Enforcement, U.S. Department of the Interior, Barrow, Alaska,* transcript reported by Mary A. Vavrik, Midnight Sun Court Reporters, February 21.

BOEMRE, 2011g, *Fact Sheet: Renewable Energy on the Outer Continental Shelf*. Available at http://www.boemre.gov/offshore/RenewableEnergy/PDFs/ BOEMREAlternativeEnergyfactsheet.pdf. Accessed July 20, 2011.

BOEMRE, 2011h, *Initial Interim Policy Proposed Projects*. Available at http://www.boemre.gov/offshore/RenewableEnergy/InitialInterimPolicyProposedProject.htm. Accessed July 20, 2011.

BOEMRE, 2011i, *Gulf of Mexico OCS Oil and Gas Lease Sale 216/222 Draft Supplemental Environmental Impact Statement*, OCS EIS/EA BOEMRE 2011-027, Bureau of Ocean Energy Management, Regulation and Enforcement, Gulf of Mexico OCS Region.

BOEMRE, 2011j, *Gulf of Mexico Region: Offshore Statistics by Water Depth*. Available at www.gomr.boemre.gov/homepg/fastfacts/WaterDepth/WaterDepth.html. Accessed July 18, 2011.

BOEMRE, 2011k, *Chukchi Sea Planning Area, Oil and Gas Lease Sale 193 in the Chukchi Sea, Alaska, Final Supplemental Environmental Impact Statement*, OCS EIS/EA, BOEMRE 2011-041, August.

BOEMRE, 2011l, *Gulf of Mexico OCS Oil and Gas Lease Sale: 2011, Western Planning Area Lease Sale 218, Final Supplemental Environmental Impact Statement*, OCS EIS/EA BOEMRE 2011-034, Bureau of Ocean Energy Management, Regulation and Enforcement, Gulf of Mexico OCS Region.

BOEMRE, 2011m, *Coastal Impact Assistance Program (CIAP).* Available at http://www.boemre.gov/offshore/CIAPmain.html. Accessed August 31, 2011.

BOEMRE, 2011n, *Seismic Water Bottom Anomalies Map Gallery (and Figure 4).* Available at http://www.boemre.gov/offshore/mapping/SeismicWaterBottomAnomolies.htm. Accessed September 4, 2011.

Boehm, P.D., 2001, *ANIMIDA Phase I: Arctic Nearshore Characterization and Monitoring of the Physical Environment in the Northstar and Liberty Development Areas*, Final Report, OCS Study MMS 2001-104, prepared by Arthur D. Little, Inc., Cambridge, Mass., for Minerals Management Service, Alaska Region, Anchorage, Alaska.

Bohnsack, J.A., 1989, "Are High Densities of Fishes at Artificial Reefs the Result of Habitat Limitation or Behavioral Preference?" *Bulletin of Marine Science* 44:631–645.

Bolam, S.G., and H.L. Rees, 2003, "Minimizing Impacts of Maintenance Dredged Material Disposal in the Coastal Environment: A Habitat Approach," *Environmental Management* 32(2):171–188.

Bonsal, B.R., and B. Kochtubajda, 2009, "An Assessment of Present and Future Climate in the Mackenzie Delta and the Near-Shore Beaufort Sea Region of Canada," *International Journal of Climatology* 29(12):1780–1795.

Boston Consulting Group, 2010, *Batteries for Electric Cars: Challenges, Opportunities, and the Outlook to 2020*. Available at http://www.bcg.com/documents/file36615.pdf. Accessed January 2010.

Born, E.W., F.F. Riget, R. Dietz, and D. Andriashek, 1999, "Escape Responses of Hauled Out Ringed Seals (*Phoca hispida*) to Aircraft Disturbance," *Polar Biology* 21:171–178.

Bouma, A.H., 1981, *Submarine Topography and Physiography of Lower Cook Inlet*, U.S. Geological Survey Open File Report 81-1335.

Bouma, A.H., and M.A. Hampton, 1986, "Environmental Geology," in *Geologic Studies of the Lower Cook Inlet Cost No. 1 Well, Alaska Outer Continental Shelf,* L.B. Magoon (ed.), U.S. Geological Survey Bulletin 1596.

Bouma, A.H., and H.H. Roberts, 1990, "Northern Gulf of Mexico Continental Slope," *Geo-Marine Letters* 10:177–181.

Bouma, A.H., M.A. Hampton, J.W. Whitney, and W.G. Noonan, 1978a, *Physiography of Lower Cook Inlet, Alaska*, U.S. Geological Survey Open File Report 78-728, Aug.

Bouma, A.H., M.A. Hampton, T.P. Frost, M.E. Torreson, R.C. Orlando, and J.W. Whitney, 1978b, *Bottom Characteristics of Lower Cook Inlet, Alaska*, U.S. Geological Survey Open File Report 78-236.

Bowles, A.E., B. Smultea, B. Würsig, D.P. DeMaster, and D. Palka, 1994, "Relative Abundance and Behavior of Marine Mammals Exposed to Transmissions from the Heard Island Feasibility Test," *Journal of the Acoustical Society of America* 96(4):2469–2484.

Bowman, T.D., R.A. Stein, and K.T. Scribner, 2000, "Glaucous Gull Predation of Goslings on the Yukon-Kuskokwim Delta, Alaska," *Condor* 106: 288–298.

BP Exploration (Alaska), Inc., 1998a, *Part 55 Permit Application for the BP Exploration (Alaska) Inc. Liberty Development Project*, Anchorage, Alaska, Jan.

BP Exploration (Alaska), Inc., 1998b, *Part 55 Permit Application for the BP Exploration (Alaska) Inc. Northstar Development Project*, Anchorage, Alaska, Jan.

Brabets, T.P., G.L. Nelson, J.M. Dorova, and A.M. Milner, 1999, *Water Quality Assessment of the Cook Inlet Basin, Alaska — Environmental Setting*, Water Resources Investigation Report 99-4025, U.S. Geological Survey, Anchorage, Alaska.

Braddock, J.F., J.E. Lindstrom, and R.C. Price, 2003, "Weathering of a Subarctic Oil Spill over 25 years: the Caribou-Poker Creeks Research Watershed Experiment," *Cold Regions Science and Technology* 36(1-3):11–23.

Braddock, J., K. Gannon, and B. Rasley, 2004, *Petroleum Hydrocarbon-Degrading Microbial Communities in Beaufort-Chukchi Sea Sediments*, OCS Study MMS 2004-061, University of Alaska, Fairbanks, Alaska.

Bradner, T., 2011, *LNG Plant Closure Heightens Concern about Gas*, Alaska Journal of Commerce, Feb. 18. Available at http://www.alaskajournal.com/stories/021811/oil_lpchcag.shtml. Accessed July 18, 2011.

Brannon, E.L., T.P. Quinn, R.P. Whitman, A.E. Nevissi, R.E. Nakatani, and C.D. McAuliffe, 1986, "Homing of Adult Chinook Salmon after Brief Exposure to Whole and Dispersed Crude Oil," *Transactions of the American Fisheries Society* 115:823–827.

Brooke, S., and C.M. Young, 2009, "In Situ Measurement of Survival and Growth of *Lophelia pertusa* in the Northern Gulf of Mexico," *Marine Ecology Progress Series* 397:153–161.

Brooke, S.D., M.W. Holmes, and C.M. Young, 2009, "Sediment Tolerance of Two Different Morphotypes of the Deep-Sea Coral *Lophelia pertusa* from the Gulf of Mexico," *Marine Ecology Progress Series* 390:137–144.

Brooks, D.A., 1983, "The Wake of Hurricane Allen in the Western Gulf of Mexico," *Journal of Physical Oceanography* 13:117–129.

Brooks, D.A., 1984, "Current and Hydrographic Variability in the Northwestern Gulf of Mexico," *Journal of Geophysical Research* 89(C5):8022–8032.

Brooks, J.M., and C.P. Giammona, 1991, *Mississippi-Alabama Continental Shelf Ecosystem Study Data Summary and Synthesis, Volume II: Technical Narrative*, OCS Study 91-0063, MMS, Gulf of Mexico OCS Region, New Orleans, La.

Brown, B.T., G.S. Mills, C. Powels, W.A. Russell, G.D. Therres, and J.J. Pottie, 1999, "The Influence of Weapons-Testing Noise on Bald Eagle Behavior," *Journal of Raptor Research*, 33: 227–232.

Brown, J., 2005, *ANIMIDA Task 2: Hydrocarbon and Metal Characterization of Sediments, Bivalves and Amphipods in the ANIMIDA Study Area*, Final Report, OCS Study MMS 2004-024, submitted by Exponent, Inc., Maynard, Mass., to Minerals Management Service, Alaska Outer Continental Shelf Region, Anchorage, Alaska. Available at http://www.alaska.boemre.gov/reports/2004Reports/2004_024/ANIMIDA%20Task%202%20Final%20Report.pdf. Accessed June 24, 2011.

Brown, E.D., B.L. Norcross, and J.W. Short, 1996, "An Introduction to Studies on the Effects of the Exxon Valdez Oil Spill on Early Life History Stages of Pacific Herring, *Clupea Pallasi*, in Prince William Sound, Alaska," *Canadian Journal of Fisheries and Aquatic Sciences* 53:2337–2342.

Bryant, W.R., and J.Y. Liu, 2000, "Chapter 3: Geology," in *Deepwater Gulf of Mexico Environmental and Socioeconomic Data Search and Literature Synthesis, Volume I: Narrative Report*, OCS Study MMS 2000-049, prepared by Continental Shelf Associates, Inc. for Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La.

Bryant, W.R., J. Lugo, C. Cordova, and A. Salvador, 1991, "Physiography and Bathymetry," in *The Gulf of Mexico Basin*, A. Salvador (ed.), Geological Society of America, *The Geology of North America* Vol. J, pp. 13–30.

Buckstaff, K.C., 2004, "Effects of Watercraft Noise on the Acoustic Behavior of Bottlenose Dolphins, *Tursiops truncatus*, in Sarasota Bay, Florida," *Marine Mammal Science* 20:709–725.

Bue, B.G., S. Sharr, and J.E. Seeb, 1998, "Evidence of Damage to Pink Salmon Populations Inhabiting Prince William Sound, Alaska, Two Generations after the Exxon Valdez Oil Spill," *Transactions of the American Fisheries Society* 127:35–43.

Buist, I., R. Belore, D. Dickins, D. Hackenberg, A. Guarino and Z. Wang, 2008, *Empirical Weathering Properties of Oil in Ice and Snow*, OCS study, MMS 2008-033, Anchorage, Alaska.

Burgess, R.M., 2000, "Arctic Fox," *The Natural History of an Arctic Oil Field*, pp. 159–178, J.C. Truett and S.R. Johnson (eds). Academic Press, San Diego, CA.

Burns, J.J., and K.J. Frost, 1979, *Natural History and Ecology of the Bearded Seal, Erignathus barbatus*, Environ. Assess. Alaskan Cont. Shelf, Final Rep. Princ. Invest., NTIS PB 85-200939, NOAA, Juneau, Alaska.

Burwell, M., 2011, e-mail from Burwell (BOEMRE, Anchorage, Alaska) to B.T. Verhaaren (Argonne National Laboratory, Argonne, Ill.).

California Energy Commission, undated a, *Consumer Energy Center: Choices at Home*. Available at http://www.consumerenergycenter.org/home/. Accessed August 20, 2011.

California Energy Commission, undated b, *Consumer Energy Center: Water Heaters*. Available at http://www.consumerenergycenter.org/home/appliances/waterheaters.html. Accessed August 20, 2011.

California Energy Commission, undated c, *Consumer Energy Center: Stoves, Ranges and Ovens*. Available at http://www.consumerenergycenter.org/home/appliances/ranges.html. Accessed August 20, 2011.

Calkins, D.G., E. Becker, T.R. Spraker, and T.R. Loughlin, 1994, "Impacts on Steller Sea Lions," pp. 119–139.in *Marine Mammals and the* Exxon Valdez, Academic Press, San Diego, Calif.

Calleson, C.S., and R.K. Frohlich, 2007, "Slower Boat Speeds Reduce Risks to Manatees," *Endangered Species Research* 3:295–304.

Cameron, M., and P. Boveng, 2009, *Habitat Use and Seasonal Movements of Adult and Sub-adult Bearded Seals*, Alaska Fisheries Science Center Quarterly Report October November December 2009. Available at http://www.afsc.noaa.gov/Quarterly/ond2009/OND09feature.pdf. Accessed March 17, 2011.

Cameron, R.D., W.T. Smith, R.G. White, and B. Griffith, 2002, "Section 4: The Central Arctic Caribou Herd," pp. 38–45 in *Arctic Refuge Coastal Plain Terrestrial Wildlife Research Summaries*, D.C. Douglas, P.E. Reynolds, and E.B. Rhodes (eds.), Biological Science Report USGS/BRD/BSR-2002-0001, U.S. Geologic Survey, Biological Resources Division.

Camilli R., C.M. Reddy, D.R. Yoerger, B.A. S. Van Mooy, M.V. Jakuba, J.C. Kinsey, C.P. McIntyre, S.P. Sylva and J.V. Maloney, 2010, "Tracking Hydrocarbon Plume Transport and Biodegradation at Deepwater Horizon," *Science* 330:201–204.

Carmack, E., R. Macdonald, R. Perkin, F. McLaughlin, and R. Pearson, 1995, "Evidence for Warming of Atlantic Water in the Southern Canadian Basin of the Arctic Ocean: Results from the Larsen-93 Expedition," *Geophysical Research Letters* 22(9):1061–1064.

Carney, R.S., 1997, *Workshop on Environmental Issues Surrounding Deepwater Oil and Gas Development,* Final Report, OCS Study MMS 98-0022, Minerals Management Service, Gulf of Mexico Outer Continental Shelf Region, New Orleans, La.

Carretta, J.V., K.A. Forney, E. Leson, K. Martien, M.M. Muto, M.S. Lowry, J. Barlow, J. Baker, B. Hanson, D. Lynch, L. Carswell, R.L. Brownell, Jr., J. Robbins, D.K. Matilla, K. Ralls, and M.C. Hill, 2011, *U.S. Pacific Marine Mammal Stock Assessments: 2010*, NOAA-TM-NMFS-SWFSC-476, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center. Available at http://www.nmfs.noaa.gov/pr/pdfs/sars/po2010.pdf. Accessed August 1, 2011.

Casale, P., D. Freggi, D. Basso, C. Vallini, and R. Argano, 2007, "A Model of Area Fidelity, Nomadism, and Distribution Patterns of Loggerhead Sea Turtles (*Caretta caretta*) in the Mediterranean Sea," *Marine Biology* 152(5):1039–1049.

Ceresana Research, 2009, *Market Study: Bioplastics*, June. Available at http://www.ceresana.com/en/market-studies/plastics/bioplastics/. Accessed August 21, 2011.

Chang, Y.L., and L.Y. Oey, 2010, "Why Can Wind Delay the Shedding of Loop Current Eddies?" *Journal of Physical Oceanography* 40(11):2481–2495.

Church, R.A., and D.J. Warren, 2008, *Viosca Knoll Wreck: Discovery and Investigation of an Early Nineteenth Century Sailing Ship in 2,000 feet of Water*, OCS Study MMS 2008-018, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La.

Church, J., J.M. Gregory, P. Huybrechts, M. Kuhn, K. Lambeck, M.T. Nhuan, D. Qin, and P.L. Woodworth, 2001, *Changes in Sea Level, in Climate Change 2001: The Scientific Basis, Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change*, J.T. Houghton et al. (eds.), pp. 639–693, Cambridge University Press, New York, N.Y.

CIBSE (Chartered Institution of Building Services Engineers), undated, "Indicative Life Expectancy for Building Services Plant, Equipment and Systems." Available at http://www.cibse.org/pdfs/newOOMtable1.pdf. Accessed August 21, 2011.

Clark, C.E., and J.A. Veil, 2009, *Produced Water Volumes and Management Practices in the United States*, ANL/EVS/R-09/1, prepared for the U.S. Department of Energy, Office of Fossil Energy, National Environmental Technology Laboratory, Environmental Science Division, Argonne National Laboratory, Argonne, Ill., September.

Clausen, C.J., and J.B. Arnold III, 1975, "Magnetic Delineation of Individual Shipwreck Sites; A New Control Technique," *Bull. of the Texas Archaeological Soc.* 46:69-86.

Claypool, G.E., et al., 1980, "Biogenic and Thermogenic Origins of Natural Gas in Cook Inlet Basin, Alaska," *American Association of Petroleum Geologists Bull*. 64(6), Aug.

Clean Edge, Inc. and Co-op America, 2008, *Utility Solar Assessment (USA) Study: Reaching Ten% Solar by 2025*, June. Available at http://www.cleanedge.com/reports/reports-solarUSA2008.php.

Clough, C., 2011, *Fault Data for the Cook Inlet*, GIS data transmittal from C. Clough, Senior GIS tech, Kenai Peninsula Borough, GIS Division, Soldotna, Alaska, to E. Zvolanek, Argonne National Laboratory.

Coastal Response Research Center, 2010, *Deepwater Horizon Dispersant Use Meeting Report*, University of New Hampshire, Durham, N.H.

Cochrane, J.D., and F.J. Kelly, 1986, "Low-Frequency Circulation on the Texas-Louisiana Continental Shelf," *Journal of Geophysical Research* 91(C9):10645–10659.

Coleman, J.M., and D.B. Prior, 1988, "Mass Wasting on Continental Margins," *Ann. Rev. Earth Planet. Sci.* 16:101–119.

Coleman, J.M., H.H. Roberts, and W.R. Bryant, 1991, "Late Quaternary Sedimentation," in *The Gulf of Mexico Basin*, A. Salvador (ed.), Geological Society of America, *The Geology of North America* Vol. J, pp. 325–352.

Collier, T.K., C.A. Krone, M.M. Krahn, J.E. Stein, S. Chan, and U. Varanasi, 1996, "Petroleum Exposure and Associated Biochemical Effects in Subtidal Fish after the *Exxon Valdez* Oil Spill," *American Fishery Society Symposium* 18:671–683.

Combellick, R., and W.E. Long, 1983, *Geologic Hazards in Southeastern Alaska, an Overview: State of Alaska*, Alaska Report of Investigations 83-17, Division of Geological and Geophysical Surveys.

Combellick, R.A., R.D. Reger, and C.J. Nye, 1995, *Geologic Hazards in and near Proposed State of Alaska Oil and Gas Lease Sale 85A (Cook Inlet)*, Public Data File 95-36, Alaska Department of Natural Resources, Nov.

Comiso, J.C., 2002, "A Rapidly Declining Perennial Sea Ice Cover in the Arctic," *Geophysical Research Letters* 29(20):1956.

Comiso, J.C., 2003, "Warming Trends in the Arctic from Clear Sky Satellite Observations," *Journal of Climate* 16(21):3498–3510.

Comiso, J., J. Yang, S. Honjo, and R.A. Krishfield, 2003, "Detection of Change in the Arctic Using Satellite and In Situ Sata," *Journal of Geophysical Research* 108(C12).

Conlan, K., and R.G. Kvitek, 2005, "Recolonization of Soft-Sediment ice Scours on an Exposed Arctic Coast," *Marine Ecology Progress Series* 286:21–42.

Continental Shelf Associates, Inc., 1992, *Analysis of Potential Effects of Oil Spilled from Texaco's Proposed Pipeline on the Biota of the East Flower Garden, West Flower Garden, Rankin, and MacNeil Banks*, prepared for Texaco, New Orleans, La.

Continental Shelf Associates, Inc., 1994, *Analysis of Potential Effects of Oil Spilled from Proposed Structures Associated with Oryx's High Island Block 384 Unit on the Biota of the East Flower Garden Bank and on the Biota of Coffee Lump Bank*, prepared for Oryx Energy Company, Dallas, Texas.

Continental Shelf Associates, Inc., 1997, *Gulf of Mexico Produced Water Bioaccumulation Study, Definitive Component*, prepared for the Offshore Operators Committee, New Orleans, La.

Continental Shelf Associates, Inc., 2004a, *Final Report: Gulf of Mexico Comprehensive Synthetic Based Muds Monitoring Program, Volume 1: Technical*.

Continental Shelf Associates, Inc., 2004b, *Explosive Removal of Offshore Structures — Information Synthesis Report*, OCS Study MMS 2003-070, Minerals Management Service, Gulf of Mexico Outer Continental Shelf Region, New Orleans, La.

Continental Shelf Associates, Inc., 2004c, *Gulf of Mexico Comprehensive Synthetic Based Muds Monitoring Program*, Technical Report, Vol. 1, prepared for the Synthetic Based Muds Research Group.

Continental Shelf Associates, Inc., 2004d, *Geological and Geophysical Exploration for Mineral Resources on the Gulf of Mexico Outer Continental Shelf Final Programmatic Environmental Assessment*, OCS EIS/EA MMS 2004-054, prepared for Minerals Management Service, Gulf of Mexico OCS Region, New Orleans. La., July.

Continental Shelf Associates, Inc., 2006, *Effects of Oil and Gas Exploration and Development at Selected Continental Slope Sites in the Gulf of Mexico*, Volume I: Executive Summary, OCS Study MMS 2006-044, Minerals Management Service, Gulf of Mexico Outer Continental Shelf Region, New Orleans, La.

Continental Shelf Associates, Inc., and Texas A&M University, Geochemical and Environmental Research Group, 2001, *Mississippi/Alabama Pinnacle Trend Ecosystem Monitoring, Final Synthesis Report*, USGS/BR 2001-0007 prepared for U.S. Geological Survey, Biological Resources Division, and OCS Study MMS 2001-080 prepared for Minerals Management Service, Gulf of Mexico Outer Continental Shelf Region, New Orleans, La.

Cooper, C., G.Z. Forristall, and T.M. Joyce, 1990, "Velocity and Hydrographic Structure of Two Gulf of Mexico Warm-Core Rings," *Journal of Geophysical Research* 95(C2):1663–1679.

Cooke, S.J., and I.G. Cowx, 2006, "Contrasting Recreational and Commercial Fishing: Searching for Common Issues to Promote Unified Conservation of Fisheries Resources and Aquatic Environments," *Biological Conservation* 128:93–108.

Costello, J.A., 1985, *Tsunamis: Hazard Definition and Effects on Facilities*, U.S. Geological Survey Open File Report 85-533.

Cox, T.M., T.J. Ragen, A.J. Read, E. Vos, R.W. Baird, K. Balcomb, J. Barlow, J. Caldwell, T. Cranford, L. Crum, A. D'Amico, G.D. Spain, A. Fernandez, J. Finneran, R. Gentry, W. Gerth, F. Gulland, J. Hildebrand, D. Houser, T, Hullar, P.D. Jepson, D. Ketten, C.D. MacLeod, P. Miller, S. Moore, D.C. Mountain, D. Palka, P. Ponganis, S. Rommel, T. Rowles, B. Taylor, P. Tyack, D. Wartzok, R. Gisiner, J. Mead, and L. Benner, 2006, "Understanding the Impacts of Anthropogenic Sound on Beaked Whales," *Journal of Cetacean Research and Management* 7(3):177–187.

Coyne, J.M., and J.J. Dollar, 2005, "Shell Pipeline's Response and Repairs after Hurricane Ivan," *Proc. Offshore Technology Conference*, Houston, Texas, OTC Paper No. 17734.

Crane, N.L., and K. Lashkari, 1996, "Sound Production of Gray Whales Along Their Migration Route, a New Approach to Signal Analysis," *Journal of the Acoustical Society of America* 100(3):1878–1886.

Craig et al., 1985, *Geologic Report for the Beaufort Sea Planning Area, Alaska: Regional Geology, Petroleum Geology, Environmental Geology*, OCS Report MMS 85-0111, Dec.

Crouse, D.T., L.B. Crowder, and H. Caswell, 1987, "A Stage-Based Population Model for Loggerhead Sea Turtles and Implications for Conservation," *Ecology* 68:1412–1423.

Crout, R.L., 2009, "Oil and Gas Platform Ocean Current Profile Data from the Northern Gulf of Mexico," *Marine Technology Society Journal* 43(2):13–20.

Cruz, A.M., and E. Krausmann, 2008, "Damage to Offshore Oil and Gas Facilities Following Hurricanes Katrina and Rita: An Overview," *Journal of Loss Prevention in the Process Industries* 21(6):620–626.

Cudahy, E., and W.T. Ellison, 2002, *A Review of the Potential for In Vivo Tissue Damage by Exposure to Underwater Sound*, white paper report for the Department of Navy, Washington, D.C. Available at http://www.dymedso.ca/pdf/Lung%20resonant%20frequency.pdf. Accessed July 12, 2011.

Culbertson, J.B., I. Valiela, M. Pickart, E.E. Peacock, and C.M. Reddy, 2008, "Long-Term Consequences of Residual Petroleum on Salt Marsh Grass," *Journal of Applied Ecology* 45(4):1284–1292.

Curry, T., and E. Murphy, 1995, "Impacts of Aircraft Disturbance on Reproductive Success of Thick-Billed Murres: Major Threat or Minor Stressor," *Pacific Seabirds* 22(1): 28.

Daggett et al., 2006, *Alternative Fuels and Their Potential Impact on Aviation*, NASA Technical Memorandum 2006-214365, October. Available at http://gltrs.grc.nasa.gov/reports/2006/TM-2006-214365.pdf. Accessed August 20, 2011.

Dalen, J., and G.M. Knutse, 1986, *Scaring Effects in Fish and Harmful Effects on Eggs, Larvae and Fry by Offshore Seismic Explorations*. Symposium on Underwater Acoustics, Halifax.

Dahlheim, M.E., 1987, *Bio-Acoustics of the Gray Whale (Eschrichtius robustus)*, Ph.D. Thesis. Vancouver, B.C.: University of British Columbia 315 pp.

Dahlin, J., et al., 1994, *Recovery of Mangrove Habitats at the Vesta Bella Spill Site*, Hazmat Report 95-3, National Oceanic Atmospheric Administration, Hazardous Materials Response and Assessment Division.

Darigo, N., O. Mason, and P. Bowers, 2007, *Review of Geological/Geophysical Data and Core Analysis to Determine Archaeological Potential of Buried Landforms, Beaufort Sea Shelf, Alaska*, OCS Study MMS 2007-004, prepared by Northern Land Use Research, Inc., URS Corporation, and GeoArch Alaska for MMS, Alaska OCS Region.

Dau, J.R., and R.D. Cameron, 1986, "Effects of a Road System on Caribou Distribution and Calving," *Rangifer* Special Edition 1:95–101.

Davis, R.A., D.H. Thompson, and C.I. Malme, 1998, *Environmental Assessment of Seismic Exploration on the Scotian Shelf*, Canada/Nova Scotia Offshore Petroleum Board, Halifax, Nova Scotia.

Davis, R.W., W.E. Evans, and B. Würsig (eds.), 2000, *Cetaceans, Sea Turtles and Seabirds in the Northern Gulf of Mexico: Distribution, Abundance and Habitat Associations, Volume II: Technical Report*, U.S. Geological Survey, Biological Resources Division, USGS/BRD/CR-1999-0006 and OCS Study MMS 2000-002, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La.

Day, J., N. Psuty, and B. Perez, 2000, "The Role of Pulsing Events in the Functioning of Coastal Barriers and Wetlands: Implications for Human Impact, Management and the Response to Sea Level Rise," in *Concepts and Controversies in Tidal Marsh Ecology*, M. Weinstein and D. Kreeger (eds.), Kluwer Academic Publishers, Dordrecht.

Day, R.H., 1998, *Predator Populations and Predation Intensity on Tundra-Nesting Birds in Relation to Human Development*. Prepared by ABR, Inc., Fairbanks, AK, for Northern Alaska Ecological Services, U.S Fish and Wildlife Service, Fairbanks, AK.

Day, R.H., and D.A. Nigro, 1999, *Status and Ecology of Kittlitz's Murrelet in Prince William Sound, 1996–1998*. *Exxon Valdez* Oil Spill Restoration Project 98142, Final Report No. 435.

Day, R.H., S.M. Murphey, J.A. Wiens, G.D. Hayward, E.J. Harner, and B.E. Lawhead, 1997a, "Effects of the *Exxon Valdez* Oil Spill on Habitat Use by Birds Along the Kenai Peninsula, Alaska," *The Condor* 99: 728–742.

Day, R.H., S.M. Murphy, J.A. Wiens, G.D. Hayward, E.J. Harner, and L.N. Smith, 1997b, "Effects of the *Exxon Valdez* Oil Spill on Habitat Use by Birds in Prince William Sound, Alaska." *Ecological Applications* 7: 593–613.

Day, R.H., D.A. Nigro, and A.K. Prichard, 2000b, "At-Sea Habitat Use by the Kittlitz's Murrelet *Brachyramphus brevirostris* in Nearshore Waters of Prince William Sound, Alaska," *Marine Ornithology* 28: 105–114.

de Gouw, J.A., et al., 2011, "Organic Aerosol Formation Downwind from the Deepwater Horizon Oil Spill," *Science* 331:1295–1299.

Dean, T.A., and S.C. Jewett, 2001, "Habitat-Specific Recovery of Shallow Subtidal Communities following the *Exxon Valdez* Oil Spill," *Ecological Applications* 11:1456–1471.

Dekin, A.A., Jr., M.S. Cassell, J.I. Ebert, E. Camilli, J.M. Kerley, M.R. Yarborough, P.A. Stahl, and B.L. Turcy, 1993, Exxon Valdez *Oil Spill Archaeological Damage Final Report*, Contract No. 53-0109-1-00325, U.S. Forest Service.

Delany, D.K., T.G. Grubb, P. Beier, L.L. Pater, and M.H. Reiser, 1999, "Effects of Helicopter Noise on Mexican Spotted Owls," *Journal of Wildlife Management* 63: 60–76.

Derksen, D.V., K.S. Bollinger, D. Esler, K.C. Jensen, E.J. Taylor, M.W. Miller, and M.W. Weller, 1992, *Effects of Aircraft on Behavior and Ecology of Molting Black Brant Near Teshekpuk Lake, Alaska. Final Report*. U.S. Department of the Interior, U.S Fish and Wildlife Service, Anchorage, AK.

Derraik, J.G.B., 2002, "The Pollution of the Marine Environment by Plastic Debris: a Review," *Marine Pollution Bulletin* 44: 842–852.

Det Norske Veritas, 2007, *Pipeline Damage Assessment from Hurricanes Katrina and Rita in the Gulf of Mexico*, Report No. 44814183, MMS.

DeWald, O., 1980, "Severe Storm and Hurricane Impacts along the Gulf and Lower Atlantic Coasts," in *Environmental Information on Hurricanes, Deepwater Technology, and Mississippi Delta Mudslides in the Gulf of Mexico, Section III*, Bureau of Land Management Open File Report 80-02, New Orleans, La.

DF Dickens Associates, Ltd., 2004, *Advancing Oil Spill Response in Ice-Covered Waters*, prepared for Prince William Sound Oil Spill Recovery Institute, Cordova, Alaska, and U.S. Arctic Research Commission, Arlington, Virginia, and Anchorage Alaska, March.

DFO (Department of Fisheries and Oceans), 2004, *Review of Scientific Information on Impacts of Seismic Sound on Fish, Invertebrates, Marine Turtles and Marine Mammals*, Department of Fisheries and Oceans, Canadian Science Advisory Secretary Habitat Status Report 2004/002.

Di Iorio, L., and C.W. Clark, 2010, "Exposure to Seismic Survey Alters Blue Whale Acoustic Communication," *Biology Letters* 6:51–54.

Dickerman, R.W., and R.G. Goelet, 1987, "Northern Gannet Starvation After Swallowing Styrofoam," *Marine Pollution Bulletin* 13: 18–20.

Dickerson, D.D., 1990, "Workgroup 1 Summary," pp. 74–75 in *Proceedings of the National Workshop on Methods to Minimize Dredging Impacts on Sea Turtles*, May 11 and 12, 1988, Jacksonville, Fla., Dickerson, D.D., and D.A. Nelson (comp.), Miscellaneous Paper EL-90-5, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Dickerson, D.D., D.A. Nelson, M. Wolff, and L. Manners, 1992, "Summary of Dredging Impacts on Sea Turtles: King's Bay, Georgia, and Cape Canaveral, Florida," pp. 148–151 in *Proceedings of the Eleventh Annual Workshop on Sea Turtle Biology and Conservation*, February 26–March 2, 1991, Jekyll Island, Ga., M. Salmon, and J. Wyneken (comp.), NOAA Technical Memorandum NMFS-SEFSC-302.

Dimarco, S.F., M.K. Howard, W.D. Nowlin, Jr., and R.O. Reid, 2004, *Subsurface, High-Speed Current Jets in the Deepwater Region of the Gulf of Mexico, Final Report*, OCS Study 2004-022, MMS, Gulf of Mexico OCS Region, New Orleans, La.

Ditty, J.G., 1986, "Ichthyoplankton in Neretic Waters of the Northern Gulf of Mexico off Louisiana: Composition, Relative Abundance, and Seasonality," *Fishery Bulletin* 84:935–946.

Ditty, J.G., G.G. Zieske, and R.F. Shaw, 1988, "Seasonality and Depth Distribution of Larval Fishes in the Northern Gulf of Mexico above 26°00' N," *Fishery Bulletin* 86:811–823.

Dixon, E.J., G. Sharma, and S. Stoker, 1986, *Alaskan Outer Continental Shelf Cultural Resource Compendium*, Technical Report No. 119, OCS Study MMS 86-0018, MMS, Alaska Outer Continental Shelf Office, Anchorage, Alaska.

Dodge, R.E., B.J. Baca, A.H. Knap, S.C. Snedaker, and T.D. Sleeter, 1995, *The Effects of Oil and Chemically Dispersed Oil in Tropical Ecosystems: 10 Years of Monitoring Experimental Sites*, MSRC Tech Rep Ser 95-014, Marine Spill Response Corporation, Washington, D.C.

Dolman, S., V. Williams-Grey, R. Asmutis-Silvia, and S. Issac, 2006, *Vessel Collisions and Cetaceans: What Happens When They Don't Miss the Boat?*, a Whale and Dolphin Conservation Society report. Available at http://www.wdcs.org/submissions_bin/shipstrikes.pdf. Accessed July 15, 2011.

Donohue, K., P. Hamilton, R. Leben, R. Watts, and E. Waddell, 2008, *Survey of Deepwater Currents in the Northwestern Gulf of Mexico*, OCS Study, MMS 2008-031, MMS, Gulf of Mexico OCS Region, Raleigh, N.C.

Dow, W.E., D.A. Mann, T.T. Jones, S.A. Eckert, and C.A. Harms, 2008, "In-Water and In-Air Hearing Sensitivity of the Green Sea Turtle (*Chelonia mydas*)," abstract, Acoustic Communication by Animals, 2nd International Conference, August 12–15, 2008, Corvallis, Ore.

Doyle, L.R., B. McCowan, S.F. Hanser, C. Chyba, T. Bucci, and J.E. Blue, 2008, "Applicability of Information Theory to the Quantification of Response to Anthropogenic Noise by Southeast Alaskan Humpback Whales" *Entropy* 10:33–46.

Draggan, S., 2010, "Deepwater Horizon Oil Spill and Marine Mammals," in *The Encyclopedia of Earth*, C.J. Cleveland (topic ed.), Environmental Information Coalition, National Council for Science and the Environment, Washington, D.C. Available at http://www.eoearth.org/article/ Deepwater_Horizon_Oil_Spill_and_Marine_Mammals?topic=50359. Accessed March 16, 2011.

Dunn, E.H., 1993, "Bird Mortality from Striking Residential Windows in Winter," *Journal of Field Ornithology* 64: 302–309.

Dunton, K., K. Iken, S. Shonberg, and D.W. Funk, 2009, *Long-Term Monitoring of the Kelp Community in the Stefansson Sound Boulder Patch: Detection of Change Related to Oil and Gas Development*, OCS Study MMS 2009-040, continuation of Arctic Near shore Impact Monitoring in the Development Area (cANIMIDA) Task 006, final report to the Minerals Management Service.

Dunton, K.H., 1984, "An Annual Carbon Budget for an Arctic Kelp Community," pp. 1–65 in *The Alaskan Beaufort Sea Ecosystems and Environments*, P.W. Barners, D.M. Schell, and E. Reimnitz (eds.), Academic Press, New York, N.Y.

Duronslet, M.J., C.W. Caillouet, S. Manzella, K.W. Indelicato, C.T. Fontaine, D.B. Revera, T. Williams, and D. Boss, 1986, *The Effects of Underwater Explosion on the Sea Turtles* Lepidochelys kempi *and* Caretta caretta *with Observations of Effects on Other Marine Organisms*, report submitted to National Marine Fisheries Service Biological Laboratory, Galveston, Texas.

EERE (U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy) 2008, *Natural Gas Reforming*.

EERE, 2010, *Energy Cost Calculator for Electric and Gas Water Heaters*, Federal Energy Management Program, November 3. Available at http://www1.eere.energy.gov/femp/technologies/eep_waterheaters_calc.html#output. Accessed August 2011.

EERE, 2011a, "Table 2.1.20: Residential Buildings Share of U.S. Petroleum Consumption (Percent)," and "Table 3.1.15: Commercial Buildings Share of U.S. Petroleum Consumption (Percent)Buildings," *Energy Data Book 2010*, March. Available at http://buildingsdatabook.eren.doe.gov/. Accessed August 2011.

EERE, 2011b, "Table 2.1.19: Residential Buildings Share of U.S. Natural Gas Consumption (Percent)," and "Table 3.1.14: Commercial Buildings Share of U.S. Natural Gas Consumption (Percent)," *Buildings Energy Data Book 2010*, March. Available at http://buildingsdatabook.eren.doe.gov/. Accessed August 2011.

EERE, 2011c, "Table 3.1.4: 2008 Commercial Energy End-Use Splits, by Fuel Type (Quadrillion Btu)," in *Buildings Energy Data Book 2010*, March. Available at http://buildingsdatabook.eren.doe.gov/. Accessed August 20, 2011.

EERE, 2011d, *Energy Savers: Furnaces and Boilers*, February 9. Available at http://www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12530. Accessed August 20, 2011.

EIA, (U.S. Energy Information Administration), 2000, *Petroleum Supply Annual, 1999*, U.S. Department of Energy. Available at http://www.eia.gov/pub/oil_gas/petroleum/data_publications/petroleum_supply_annual/psa_volume1/historical/1999/psa_volume1_1999.html. Accessed July 21, 2011.

EIA, 2003, The *Global Liquefied Natural Gas Market: Status and Outlook*, U.S. Department of Energy DOE/EIA-0637, Dec.

EIA, 2007a, *Alternatives to Traditional Transportation Fuels 2007*, DOE/EIA-0585(2007).

EIA, 2007b, *Alternatives to Traditional Transportation Fuels 2007*, DOE/EIA-0585(2007).

EIA, 2007c, *Alternatives to Traditional Transportation Fuels 2007*, DOE/EIA-0585(2007).

EIA, 2008a, *Annual Energy Review 2008*, DOE/EIA-0384(2008). Available at http://www.eia.doe.gov/aer/. Accessed June 26, 2009.

EIA, 2008b, "Table 2.8: Motor Vehicle Mileage, Fuel Consumption, and Fuel Rates, 1949-2007," in *Annual Energy Review 2008*, DOE/EIA-0384(2008). Available at http://www.eia.doe.gov/aer/. Accessed June 26, 2009.

EIA, 2008c, "Table ES1: Summary Statistics for the United States," in *Electric Power Annual with Data for 2006*, July 7.

EIA, 2009a, *Energy Perspectives Overview, U. S. Energy Information Administration Annual Energy Review 2009*, DOE/EIS-0384 (2009), Available at http://www.eia.gov/emeu/aer/contents.html. Accessed August 19, 2010.

EIA, 2009b, "Table 5.14c: Heat Content of Petroleum Consumption: Transportation and Electric Power Sectors, 1949-2009," in *Annual Energy Review 2009*, DOE/EIA-0384(2009). Available at http://www.eia.doe.gov/aer/. August 19, 2010.

EIA, 2009c, Table 5.14c: Heat Content of Petroleum Consumption: Transportation and Electric Power Sectors, 1949-2008," in *Annual Energy Review 2008*, DOE/EIA-0384(2008). Available at http://www.eia.doe.gov/aer/. Accessed August 20, 2011.

EIA, 2009d, *Annual Energy Outlook Early Release Overview* December 14. Available at http://www.eia.doe.gov/oiaf/aeo/overview.html. Accessed August 20, 2011.

EIA, 2009e, "Table 5.14b: Heat Content of Petroleum Consumption: Industrial Sector, 1949-2008," in *Annual Energy Review 2008*, DOE/EIA-0384(2008), June 26. Available at http://www.eia.doe.gov/aer/. Accessed August 20, 2011.

EIA, 2009f, "Table 2.1d: Industrial Sector Energy Consumption, 1949-2008," in *Annual Energy Review 2008*, DOE/EIA-0384(2008), June 26, 2009 Available at http://www.eia.doe.gov/aer/. Accessed August 20, 2011.

EIA, 2009g, "Table 5.13b: Estimated Petroleum Consumption: Industrial Sector, 1949-2008," *Annual Energy Review 2008*, DOE/EIA-0384(2008), June 26. Available at http://www.eia.doe.gov/aer/. Accessed August 20, 2011.

EIA, 2009h, "Table 5.2: End Use of Fuel Consumption, 2006," in *Manufacturing Energy Consumption Survey 2006*, June. Available at http://www.eia.gov/emeu/mecs/mecs2006/2006tables.html. Accessed August 20, 2011.

EIA, 2009i, "Table 2.2: Nonfuel (Feedstock) Use of Combustible Energy, 2006," in *Manufacturing Energy Consumption Survey 2006*, June. Available at http://www.eia.gov/emeu/mecs/mecs2006/2006tables.html. Accessed August 20, 2011.

EIA, 2009j, "Table 5.2: End Use of Fuel Consumption, 2006," in *Manufacturing Energy Consumption Survey 2006*, June. Available at http://www.eia.gov/emeu/mecs/mecs2006/2006tables.html. Accessed August 2011.

EIA, 2009k, "Table 2.2: Nonfuel (Feedstock) Use of Combustible Energy, 2006," in *Manufacturing Energy Consumption Survey 2006*, June. Available at http://www.eia.gov/emeu/mecs/mecs2006/2006tables.html. Accessed August 2011.

EIA, 2009l, "Table 2.1b: Residential Sector Energy Consumption, 1949-2008," and "Table 2.1c: Commercial Sector Energy Consumption, 1949-2008," in *Annual Energy Review 2008*, DOE/EIA-0384(2008), June 26. Available at http://www.eia.doe.gov/aer/. Accessed August 21, 2011.

EIA, 2009m, "Table 5.13a: Estimated Petroleum Consumption: Residential and Commercial Sectors, 1949-2008," in *Annual Energy Review 2008*, DOE/EIA-0384(2008), June 26. Available at http://www.eia.doe.gov/aer/. Accessed August 21, 2011.

EIA, 2009n, "Table 2.5: Household Energy Consumption and Expenditures by End Use and Energy Source, Selected Years, 1978-2005," in *Annual Energy Review 2008*, DOE/EIA-0384(2008), June 26. Available at http://www.eia.doe.gov/aer/. Accessed August 20, 2011.

EIA, 2009o, "Table 5.14a: Heat Content of Petroleum Consumption: Residential and Commercial Sectors, 1949-2008," in *Annual Energy Review 2008*, DOE/EIA-0384(2008), June 26. Available at http://www.eia.doe.gov/aer/. Accessed August 20, 2011.

EIA, 2009p, "Table 2.6: Household End Uses: Fuel Types and Appliances, Selected Years, 1978-2005," in *Annual Energy Review 2008*, DOE/EIA-0384(2008), June 26. Available at http://www.eia.doe.gov/aer/. Accessed August 20, 2011.

EIA, 2009q, *Bringing Alaska North Slope Natural Gas to Market*, Annual Energy Outlook Analyses papers, U.S. Department of Energy. Available at http://www.eia.gov/oiaf/aeo/otheranalysis/aeo_2009analysispapers/aeo_analyses.html. Accessed July 18, 2011.

EIA, 2010a, *Petroleum Supply Annual, 2009 (released July 29)*, U.S. Department of Energy. Available at http://www.eia.gov/oil_gas/petroleum/data_publications/petroleum_supply_annual/psa_volume1/psa_volume1.html. Accessed July 20, 2011.

EIA, 2010b, *Natural Gas Annual Supply and Disposition by State, 2009*, U.S. Department of Energy. Available at http://www.eia.gov/dnav/ng/ng_sum_snd_a_EPG0_FPD_Mmcf_a.htm. Accessed July 20, 2011.

EIA, 2010c, "Table ES1: Summary Statistics for the United States," in *Electric Power Annual with Data for 2008*, January 21. Available at http://www.eia.doe.gov/cneaf/electricity/epa/epa_sum.html. Accessed August 20, 2011.

EIA, 2010d, "Table ES1: Summary Statistics for the United States," *Electric Power Annual with Data for 2008*. Available at January 21, 2010. Available at http://www.eia.doe.gov/cneaf/electricity/epa/epa_sum.html. Accessed August 20, 2011.

EIA, 2011a, *Petroleum and Other Liquids: U.S. Imports of Crude Oil and Petroleum Products (released June 29)*, U.S. Department of Energy. Available at http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=MTTIMUS1&f=M. Accessed July 20, 2011.

EIA, 2011b, *Annual Energy Outlook 2011 with Projections to 2035*, U.S. Department of Energy DOE/EIA-0383 (2011), April.

EIA, 2011c, *Special Report – EIA Report on Alaska Prudhoe Bay Crude Oil Shut-In: Facts and Impacts on the U.S. Oil Markets*. Available at http://205.254.135.24/oog/special/eia_sr_alaska.html. Accessed August 19, 2011.

EIC and NCSE (Environmental Information Coalition and National Council for Science and the Environment), 2010, "Surface Washing Agents," in *The Encyclopedia of Earth*, C.J. Cleveland (ed.), Washington, D.C., last revised Oct. 7, 2010. Available at http://www.eoearth.org/article/Surface_washing_agents. Accessed January 5, 2011.

Ejechi, B.O., 2003, "Biodegradation of Wood in Crude Oil-Polluted Soil," *World Journal of Microbiology & Biotechnology* 19(8):799–804.

Eley, W.D., 2006, Cook Inlet Vessel Traffic Study: A Report to Cook Inlet Regional Citizens Advisory Council, Cape International, Inc., Dec.

Ellis, D.H., C.H. Ellis, and D.P. Mindell, 1991, "Raptor Responses to Low-Level Jet Aircraft and Sonic Boom," *Environmental Pollution* 74: 53–83.

Encyclopedia of Life, 2011, "North Pacific Right Whale," in *Encyclopedia of Life,* C.J. Cleveland (ed.), , Environmental Information Coalition, National Council for Science and the Environment, Washington, D.C. Available at http://www.eoearth.org/article/North_Pacific_Right_Whale?topic=49540. Accessed September 6, 2011.

Engelhardt, F.R., 1981, "Oil Pollution in Polar Bears. Exposure and Clinical Effects," pp. 139–179 in *Proceedings of the Fourth Arctic Marine Oil Spill Program Technical Seminar*, 16–18 June 1981, Edmonton, Alberta, Canada.

EnerNex Corporation, 2010, *Eastern Wind Integration and Transmission Study: Executive Summary and Project Overview*, prepared for the National Renewable Energy Laboratory, January. Available at http://www.nrel.gov/wind/systemsintegration/pdfs/2010/ewits_executive_summary.pdf. Accessed August 20, 2011.

Epstein, N., R.P.M. Bak, and B. Rinkevich, 2000, "Toxicity and Third Generation Dispersants and Dispersed Egyptian Crude Oil on Red Sea Coral Larvae," *Marine Pollution Bulletin* 40:497–503.

Erbe, C., 2002, "Underwater Noise of Whale-Watching Boats and Potential Effects on Killer Whales (*Orcinus orca*), Based on an Acoustic Impact Model," *Marine Mammal Science* 18(2):394–418.

Erbe, C., A.R. King, M. Yedlin, and D.M. Farmer, 1999, "Computer Models for Masked Hearing Experiments with Beluga Whales (*Delphinapterus leucas*)," *Journal of the Acoustical Society of America* 105(5):2967–2978.

ERCO (Energy Resources Co., Inc.), 1982, *Ixtock Oil Spill Assessment Final Report*. Prepared for Bureau of Land Management, Contract No. AA851-CTO-71.

Esler, D., J.A. Schmutz, R.L. Jarvis, and D.M. Mulcahy, 2000, "Winter Survival of Adult Harlequin Ducks in Relation to History of Contamination by the *Exxon Valdez* Oil Spill," *Journal of Wildlife Management* 64: 839–847.

Esler, D., T.D. Bowman, K.A. Trust, B.E. Ballachey, T.A. Dean, S.C. Jewett, and C.E. O'Clair, 2002, "Harlequin Duck Population Recovery Following the 'Exxon Valdez' Oil Spill: Progress, Process and Constraints," *Marine Ecology Progress Series* 241: 271–286.

Espey, Huston & Associates, Inc., 1990, *California, Oregon, and Washington Archaeological Resource Study*, OCS Study MMS 90-0087 to 90-0092, prepared for Pacific OCS Region, Austin, Texas.

Eurobserv'er 2011, *Solar Thermal and Concentrated Solar Power Barometer*, May. Available at http://www.eurobserv-er.org/pdf/solar_thermal_barometer_2011.pdf. Accessed August 21, 2011.

Evans, D.D., 1988, "Combustion of Oil Spills on Water," in *Technology Assessment and Research Program for Offshore Minerals Operations*, OCS Study MMS 86-0057, MMS, Washington, D.C.

Everett, K.R. 1980. Distribution and Properties of Road Dust Along the Northern Portions of the Haul Road. In: Environmental Engineering and Ecological Baseline Investigations Along the Yukon River- Prudhoe Bay Haul Road, J. Brown, and R.L. Berg, eds. CRREL Rep. 80-19. Hanover NH: U.S. Army Corps of Engineers Cold Regions Research and Engineering Laboratory. pp. 101-128.

Ewing, R., et al., 2008, *Growing Cooler: The Evidence on Urban Development and Climate Change*, Urban Land Institute.

Exxon Valdez Oil Spill Trustees, 1992, "Summary of Injury," *Alaska's Marine Resources* VII(3):2–11.

Exxon Valdez Oil Spill Trustee Council, 2003, *Update on Injured Resources and Services*, August 2002, with June 2003 additions.

Exxon Valdez Oil Spill Trustee Council, 2009a, Exxon Valdez *Oil Spill Trustee Council 2009 Status Report*, Anchorage, Alaska. Available at http://www.evostc.state.ak.us/universal/documents/publications/20th%20Anniversay%20Report/2009%20Status%20Report%20(Low-Res).pdf. Accessed June 24, 2011.

Exxon Valdez Oil Spill Trustee Council, 2009b, *Legacy of an Oil Spill 20 Years after* EXXON VALDEZ, Exxon Valdez *Oil Spill Trustee Council 2009 Status Report*.

Exxon Valdez Oil Spill Trustee Council, 2010a, Exxon Valdez *Oil Spill Restoration Plan, 2010 Update on Injured Resources and Services*, May 14.

Exxon Valdez Oil Spill Trustee Council, 2010b, *Lingering Oil Report*, January.

Exxon Valdez Oil Spill Trustee Council, 2010c, Exxon Valdez *Oil Spill Restoration Plan, 2010 Update, Injured Resources and Services*, Anchorage, Alaska. May 14. Available at http://www.evostc.state.ak.us/universal/documents/publications/2010IRSUpdate.pdf. Accessed June 24, 2011.

FAA (Federal Aviation Administration), 2004, "Chapter 9: Helicopter Oceanic Operations. 1. Gulf of Mexico," in *Advisory Circular 91-70: Oceanic Operations, an Authoritative Guide to Oceanic Operations (09-06-94)*, updated July 9, 2004, Federal Aviation Administration, Washington, D.C.

FAA, 2008, *2009-2013 FAA Flight Plan*. Available at http://www.faa.gov/about/plans_reports/media/flight_plan_2009-2013.pdf Accessed August 20, 2011.

FAA, 2010, *Advisory Circular AC No: 91-70A, Oceanic and International Operations*, U.S. Department of Transportation, Washington, D.C. Available at http://rgl.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/MainFrame?OpenFrameSet. Accessed September 11, 2011.

Fabricius, K.E., 2005, "Effects of Terrestrial Runoff on the Ecology of Corals and Coral Reefs: Review and Synthesis," *Marine Pollution Bulletin* 50:125–146.

Fair, P.A., and P.R. Becker, 2000, "Review of Stress in Marine Mammals," *Journal of Aquatic Ecosystem Stress and Recovery* 7:335–354.

Fall, J.A., 2009, "Long-Term Consequences of the *Exxon Valdez* Oil Spill for Subsistence Uses of Fish and Wildlife," pp. 245–277 in *Synthesis: Three Decades of Research on Socioeconomic Effects Related to Offshore Petroleum Development in Coastal Alaska*, S.R. Braund and J. Kruse (eds.), MMS OCS Study No. 2009-006, Stephen R. Braund and Associates, Anchorage, Alaska.

Fall, J.A., and C.J. Utermohle, 1999, *Subsistence Harvests and Uses in Eight Communities Ten Years After the Exxon Valdez Oil Spill*, Technical Paper No. 252, State of Alaska, Department of Fish and Game, Division of Subsistence, Juneau, Alaska.

Fall, J.A., L.J. Field, T.S. Nighswander, N. Peacock, and U. Varansi (eds.), 1999, "Overview of Lessons Learned from the Exxon Valdez Oil Spill: A 10-Year Retrospective," in *Evaluating and Communicating Subsistence Seafood Safety in a Cross-Cultural Context*, SETAC Press, Pensacola, Fla.

Fall, J.A., C. Brown, M.F. Turek, N.Braem, J.J. Simon, W.E. Simeone, D.L. Holen, L. Naves, L. Hutchinson-Scarbrough, T. Lemons, V. Ciccone, T.M. Kreig, and D. Koster, 2009, *Alaska Subsistence Salmon Fisheries 2007 Annual Report*, Technical Paper No. 346, Alaska Department of Fish and Game, Division of Subsistence, Anchorage.

Fan, S., G. Jeans, C. Yetsko, and L. Oey, 2007, "Submerged Jet Currents in the Gulf of Mexico," *Proceedings of Oceans 2007*. Available at http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4449299&isnumber=4449115. Accessed May 18, 2011.

Fay, F.H., B.P. Kelly, P.H. Gehnrich, J.L. Sease, and A.A. Hoover, 1984, *Modern Populations, Migrations, Demography, Trophics, and Historical Status of the Pacific Walrus*, USDOC/NOAA, OCSEAP Final Rep. 37 (1986):231-376, prepared for MMS, OCS Study MMS 86-0021.

FFWCC (Florida Fish and Wildlife Conservation Commission), 2003, *Florida's Breeding Bird Atlas: A Collaborative Study of Florida's Birdlife*. Available at http://www.wildflorida.org/bba. Accessed May 5, 2005.

Field, C.B., L.D. Mortsch,, M. Brklacich, D.L. Forbes, P. Kovacs, J.A. Patz, S.W. Running, and M.J. Scott, 2007, *North America, Climate Change 2007: Impacts, Adaptation, and Vulnerability, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson (eds.), Cambridge University Press, Cambridge, U.K., pp. 617–652.

Field, L.J., J.A. Fall, T.J. Nighswander, N. Peacock, and U. Varanasi (eds.), 1999, *Evaluating and Communicating Subsistence Seafood Safety in a Cross-Cultural Context*, SETAC Press, Pensacola, Fla.

Fingas, M., 2008, *A Review of Literature Related to Oil Spill Dispersants 1997-2008*, prepared for Prince William Sound Regional Citizens' Advisory Council, Anchorage, Alaska, Sept. Available at http://www.pwsrcac.org/docs/d0053000.pdf. Accessed July 3, 2011.

Fingas, M., F. Ackerman, P. Lambert, K. Li, Z. Wang, J. Mullin, L. Hannon, D. Wang, A. Steenkammer, R. Hiltabrand, R. Turpin, and P. Campagna, 1995, "The Newfoundland Offshore Burn Experiment: Further Results of Emissions Measurement," in *Proceedings of the Eighteenth Arctic and Marine Oilspill Program (AMOP) Technical Seminar*, Vol. 2, June 14–16, 1995, Edmonton, Alberta, Canada.

Fischer, A., 1968, "History and Current Status of the Houma Indians," pp. 133–147 in *The American Indian Today*, S. Levine and S. Oestreich Lurie (eds.), Everett Edwards, Deland, Fla.

Fissel, D.B., J.R. Marko, and M.M. de Saavedra Alvarez, 2009, "The Changing Met-Ocean and Ice Conditions in the Beaufort Sea: Implications for Offshore Oil and Gas," in *Proceedings of the International Offshore and Polar Engineering Conference*, Osaka, Japan, June 21–26.

Fodrie, F.F., and K.L. Heck, Jr., 2011, "Response of Coastal Fishes to the Gulf of Mexico Oil Disaster," PLoS ONE 6(7):e21609. doi10.1371/journal.pone.0021609.

Folger, P., 2010, *Gas Hydrates: Resource and Hazard*, Congressional Research Service, May 25.

Follmann, E.H., and J.L. Hechtel, 1990, "Bears and Pipeline Construction in Alaska," *Arctic* 43:103–109.

Foote, R.Q., and R.G. Martin, 1981 "Potential Geologic Hazards in the Gulf of Mexico Maritime Boundary Region," in *Geologic Framework, Petroleum Potential, Petroleum-Resource Estimates, Mineral and Geothermal Resources, Geologic Hazards, and Deep-Water Drilling Technology of the Maritime Boundary Region in the Gulf of Mexico*, R.B. Powers (ed.), U.S. Geological Survey Open File Report 81-265.

Ford, B., A. Borgens, W. Bryant, D. Marshall, P. Hitchcock, C. Arias, and D. Hamilton, 2008, *Archaeological Excavation of the Mardi Gras Shipwreck (16GM01), Gulf of Mexico Continental Slope*, OCS Report MMS 2008-037, prepared by Texas A&M University, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La.

Fox, D.A., J.E. Hightower, and F.M. Paruka, 2000, "Gulf Sturgeon Spawning Migration and Habitat in the Choctawhatchee River System, Alabama-Florida," *Transactions of the American Fisheries Society* 129:811–826.

Frankel, A.S., and W.T. Ellison, 2005, *Explosive Removal Scenario Simulation Results: Final Report*, OCS Study MMS 2004-064, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La.

Fried, N., and B. Windisch-Cole, 2004, "The Kenai Peninsula Borough: An Economy that Benefits from Diversity," *Alaska Economic Trends*, J. Erskine (ed.), November. Available at http://www.cookinletoilandgas.org/State/Economic%20Data/DLWD%20Trends%20November%202004.pdf. Accessed April 25, 2011.

Fritts, T.H., and M.A. McGehee, 1982, *Effects of Petroleum on the Development and Survival of Marine Turtle Embryos*, FWS-OBS-82/37, U.S. Fish and Wildlife Service, Office of Biological Services, Washington, D.C.

Frost, K.J., and L.F. Lowry, 1994, *Assessment of Injury to Harbor Seals in Prince William Sou8nd, Alaska, and Adjacent Areas following the Exxon Valdez Oil Spill*, Final Report, Marine Mammals Study Number 5, State-Federal Natural Resource Damage Assessment for 1 April 1989 through 31 September 1991.

Frost, K.J., L.F. Lowry, and G. Carroll, 1993, "Beluga Whale and Spotted Seal Use of a Coastal Lagoon System in the Northeastern Chukchi Sea," *Arctic* 46:8–16.

Fry, D.M., and L.J. Lowenstine, 1985, "Pathology of Common Murres and Cassin's Auklets Exposed to Oil," *Archives of Environmental Contamination and Toxicology* 14: 725–737.

Fry, D.M., R. Boekelheide, J. Swensen, A. Kang, J. Young, and C.R. Grau, 1985, "Long-Term Responses of Breeding Seabirds to Oil Exposure," *Pacific Seabird Group Bulletin* 10: 48–49.

Frye, M. (compiler), 2008, *Preliminary Evaluation of In-Place Gas Hydrate Resources: Gulf of Mexico Outer Continental Shelf*, MMS Resource Evaluation Division, OCS Report MMS 2008-004, Feb. 1.

Garrison, E.G., C.P. Giammona, F.J. Kelly, A.R. Tripp, and G.A. Wolff, 1989, *Historic Shipwrecks and Magnetic Anomalies of the Northern Gulf of Mexico: Reevaluation of Archaeological Resource Management Zone*, OCS Study MMS 89-0023, 89-0024, and 89-0025, Gulf of Mexico OCS Region, New Orleans, La.

Garrott, R.A., L.E. Eberhardt, and W.C. Hanson, 1983, "Summer Food Habits of Juvenile Arctic Foxes in Northern Alaska," *Journal of Wildlife Management* 47(2): 540–545.

Gass, S.E., and J.M. Roberts, 2006, "The Occurrence of the Cold-Water Coral *Lophelia pertusa* (Scleractinia) on Oil and Gas Platforms in the North Sea: Colony Growth, Recruitment, and Environmental Controls on Distribution," *Marine Pollution Bulletin* 52:549–559.

Gatto, L.W., 1975, *Baseline Data on the Oceanography of Cook Inlet, Alaska*, Technical Report 76-25, USACE, CRREL (Cold Regions Research and Engineering Laboratory), Hanover, N.H.

GCCF (Gulf Coast Claims Facility), 2011, *Overall Program Statistics*, as of May 05, 2011. Available at http://www.GulfCoastClaimsFacility.com. Accessed June 15, 2011.

GE Energy, 2010, *Western Wind and Solar Integration Study: Executive Summary*, prepared for the National Renewable Energy Laboratory, May. Available at http://www.nrel.gov/wind/systemsintegration/pdfs/2010/wwsis_executive_summary.pdf. Accessed August 20, 2011.

Geoplatform, 2011a, *Shoreline Cleanup and Assessment Team (SCAT), Latest Ground Observations, 01-12-11, Louisiana Sector,* Environmental Response Management Application (ERMA) Dataset Results. Available at www.geoplatform.gov\gulfresponse. Accessed January 13, 2011.

Geoplatform, 2011b, *Shoreline Cleanup and Assessment Team (SCAT), Latest Ground Observations, 01-12-11, Mobile Sector,* Environmental Response Management Application (ERMA) Dataset Results. Available at www.geoplatform.gov\gulfresponse. Accessed January 13, 2011.

Geraci, J.R., 1990, "Physiologic and Toxic Effects on Cetaceans," pp. 167–197 in *Sea Mammals and Oil: Confronting the Risks*, J.R. Geraci and D.J. St. Aubin (eds.), Academic Press, San Diego, Calif.

Geraci, J.R., and D.J. St. Aubin, 1982, *Study of the Effects of Oil on Cetaceans, Final Report*, Bureau of Land Management, New York OCS Office, July 20.

Geraci, J.R., and D.J. St. Aubin, 1985, *Expanded Studies of the Effects of Oil on Cetaceans, Part I, Final Report*, Minerals Management Service, Washington, DC.

Geraci, J.R., and D.J. St. Aubin, 1987, "Effects of Offshore Oil and Gas Development on Marine Mammals and Turtles," pp. 587–617. in *Long Term Environmental Effects of Offshore Oil and Gas Development*, D.F. Boesch and N.N. Rabalais (eds.), Elsevier Applied Science Publ. Ltd., London and New York.

GESAMP (Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection), 1995, *The Sea-Surface Microlayer and Its Role in Global Change*, GESAMP Reports and Studies 59, Joint Group of Experts (IMO/FAO/Unesco-IOC/WMO/WHO/IAEA/UN/UNEP) on the Scientific Aspects of Marine Environmental Protection.

Gitschlag, G., 2000, *Fisheries Impacts of Underwater Explosives Used in Platform Salvage in the Gulf of Mexico 1993–1998*, pp. 53–59 in *Proceedings: Eighteenth Annual Gulf of Mexico Information Transfer Meeting, December 1998*, M. McKay and J. Nides (eds.), OCS Study MMS 2000-030, Minerals Management Service, Gulf of Mexico Outer Continental Shelf Region, New Orleans, La.

Gitschlag, G.R., and B.A. Herczeg, 1994, "Sea Turtle Observations at Explosive Removals of Energy Structures," *Mar. Fish. Rev*. 56(2):1–8.

Gittings, S.R., 1998, "Monitoring at the Flower Gardens: History and Status," pp. 623–630 in *Proceedings of the 17th Information Transfer Meeting*, Minerals Management Service, Gulf of Mexico Outer Continental Shelf Region, New Orleans, La.

Gladwin, D.N., K.M. Manci, and R. Villella, 1988, *Effects of Aircraft Noise and Sonic Booms on Domestic Animals and Wildlife: Bibliographic Abstracts*. NERC-88/32, U.S. Fish and Wildlife Service, National Ecology Research Center, Ft. Collins, CO.

Glass, A., T.V.N. Cole, M. Garron, R.L. Merrick, and R.M. Pace, 2008, *Mortality and Serious Injury Determinations for Baleen Whale Stocks Along the United States Eastern Seaboard and Adjacent Canadian Maritimes, 2002-2006*, National Oceanic and Atmospheric Administration, Northeast Fisheries Science Center Reference Document 08-04.

Goldstein, B.D., H.J. Osofsky, and M.Y. Lichtveld, 2011, "The Gulf Oil Spill," *New England Journal of Medicine* 364:1344–1348.

Golet, G.H., P.E. Seiser, A.D. McGuire, D.D. Roby, J.B. Fischer, K.J. Kuletz, D.B. Irons, T.A. Dean, S.J. Jewett, and S.H. Newman, 2002, "Long-Term Direct and Indirect Effects of the 'Exxon Valdez' Oil spill on Pigeon Guillemots in Prince William Sound, Alaska," *Marine Ecology Progress Series* 241: 287–304.

Goold, J.C., and S.E. Jones, 1995, "Time and Frequency Domain Characteristics of Sperm Whale Clicks," *Journal of the Acoustical Society of America* 98(3):1279–1281.

Gordon, J.C.D., D. Gillespie, J. Potter, A. Frantzis, M. Simmonds, and R. Swift, 1998, "The Effects of Seismic Surveys on Marine Mammals," in M.L. Tasker and C. Weir (eds.), *Proceedings of the Seismic and Marine Mammals Workshop, London*, June 23–25, 1998.

Gordon, J., D. Gillespie, J. Potter, A. Frantzis, M.P. Simmonds, R. Swift, and D. Thompson, 2003/2004, "A Review of the Effects of Seismic Surveys on Marine Mammals," *Marine Technology Society Journal* 37:16–34.

Gow, A.J., and W.B. Tucker III, 1991, *Physical and Dynamic Properties of Sea Ice in the Polar Oceans*, monograph 91-1, USACE, CRREL (Cold Regions Research and Engineering Laboratory), Hanover, N.H.

Graedel, T.E., and J.A. Howard-Grenville, 2005, *Greening the Industrial Facility: Perspectives, Approaches, and Tools*, Springer, New York.

Grantz, A., et al., 1994, "Geology of the Arctic Continental Margin of Alaska," in *The Geology of North America, Vol. G-1, The Geology of Alaska*, G. Plafker and H.C. Berg (eds.), The Geological Society of America.

Grantz, A., D.A., Dinter, E.R. Hill, R.E. Hunter, S.D. May, R.H. McMullin, and R.L. Phillips, 1982a, *Geologic Framework, Hydrocarbon Potential, and Environmental Conditions for Exploration and Development of Proposed Oil and Gas Lease Sale 85 in the Central and Northern Chukchi Sea – A Summary Report*, U.S. Geological Survey Open File Report 82-1053.

Grantz, A., D.A. Dinter, E.R. Hill, S.D. May, R.H. McMullin, R.L. Phillips, and E. Reimnitz, 1982b, *Geologic Framework, Hydrocarbon Potential, and Environmental Conditions for Exploration and Development of Proposed Oil and Gas Lease Sale 87 in the Beaufort and Northeast Chukchi Sea – A Summary Report*, U.S. Geological Survey Open File Report 82-482.

Grantz, A., and D.A. Dinter, 1980, "Constraints of Geologic Processes on Western Beaufort Sea Oil Developments," *Oil and Gas Journal* 78(18):304–319.

Greb, S.F., and A.W. Archer, 2007, "Soft-Sediment Deformation Produced by Tides in a Meizoseismic Area, Turnagain Arm, Alaska," *Geology* 35:435–438.

Grieb, T.M., T.E. Donn, J. Collins, J. Radde, C. Perez, J.B. Smith, G. Rowe, S. Scott, and G.T. Ririe, 2008, *Effects of Subsea Processing on Deepwater Environments in the Gulf of Mexico*, OCS Study MMS 2008-022, Minerals Management Service, Gulf of Mexico Outer Continental Shelf Region, New Orleans, La.

Greene, C.R., Jr., N.S. Alman, and W.J. Richardson, 1999, "The Influence of Seismic Survey Sounds on Bowhead Whale Calling Rates," *Journal of the Acoustical Society of America* 106(4):2280.

Griffith, B., D.C. Douglas, N.E. Walsh, D.D. Young, T.R. McCabe, D.E. Russell, R.G. White, R.D. Cameron, and K.R. Whitten, 2002, "Section 3: The Porcupine Caribou Herd," pp. 8–37 in D.C. Douglas, *Arctic Refuge Coastal Plain Terrestrial Wildlife Research Summaries*, P.E. Reynolds and E.B. Rhodes (eds.), U.S. Geologic Survey, Biological Resources Division, Biological Science Report USGS/BRD/BSR-2002-0001.

Grotefendt, K., K. Logermann, D. Quadfasel, and S. Ronski, 1998, "Is the Arctic Ocean Warming?" *Journal of Geophysical Research* 103C(12):679–687.

GulfBase, 2011, *General Facts about the Gulf of Mexico*. Available at http://www.gulfbase.org/facts.php. Accessed February 4, 2011.

Gunn, J., and R. Muench, 2001, "Observed Changes in Arctic Ocean Temperature Structure over the Past Half Decade," *Geophysical Research Letters* 28(6):1035–1038.

Guzman, H.M., J.B.C. Jackson, and E. Weil, 1991, "Short-Term Ecological Consequences of a Major Oil Spill on Panamanian Subtidal Reef Corals," *Coral Reefs* 10:1–12.

Haapkylai, J., F. Ramade, and B. Salvat, 2007, "Oil Pollution on Coral Reefs: A Review of the State of Knowledge and Management Needs," *Vie Milieu* 57:95–111.

Haddad, R., and S. Murawski, 2010, *Analysis of Hydrocarbons in Samples Provided from the Cruise of the R/V WEATHERBIRD II, May 23–26, 2010,* National Oceanic and Atmospheric Administration, Silver Spring, Md. Available at http://www.noaanews.noaa.gov/stories2010/PDFs/noaa_weatherbird_analysis.pdf. Accessed June 24, 2011.

Haeussler, P.J., and R.W. Saltus, 2004, "26 km Offset on the Lake Clark Fault since Late Eocene Time," Professional Paper 1709-A in *Studies by the U.S. Geological Survey in Alaska*.

Haeussler, P.J., R.L. Bruhn, and T.L. Pratt, 2000, "Potential Seismic Hazards and Tectonics of the Upper Cook Inlet Basin, Alaska, Based on Analysis of Pliocene and Younger Deformation," *GSA Bulletin* 112(9):1414–1429.

Haley, B., G. Tomlins, O. Smith, W. Wilson, and M. Link, 2000, *Mapping Cook Inlet Rip Tides Using Local Knowledge and Remote Sensing*, OCS study, MMS 2000-025, MMS, Anchorage, Alaska.

Hamilton, P., 1990, "Deep Currents in the Gulf of Mexico," *Journal of Physical Oceanography* 20(7):1087–1104.

Hamilton, P., 2007, "Deep-Current Variability near the Sigsbee Escarpment in the Gulf of Mexico," *Journal of Physical Oceanography* 37(3):708–726.

Hamilton, P., 2009, "Topographic Rossby Waves in the Gulf of Mexico," *Progress in Oceanography* 82:1–31.

Hamilton, P., and A. Badan, 2009, "Subsurface Jets in the Northwestern Gulf of Mexico," *Journal of Physical Oceanography* 39(11):2875–2891.

Hamilton, C.I., S.J. Starr, and L.L. Trasky, 1979, *Recommendations for Minimizing the Impacts of Hydrocarbon Development on Fish, Wildlife and Aquatic Plant Resources of Lower Cook Inlet*, Alaska Department of Fish and Game, Marine and Coastal Habitat Management, Anchorage, Alaska.

Hamilton, P., T.J. Berger, J. Singer, B. Waddell, J. Churchill, R. Leben, T. Lee, and W. Sturges, 2000, *Desoto Canyon Eddy Intrusion Study, Final Report, Volume II: Technical Report*, OCS Study 2000-080, MMS, Gulf of Mexico OCS Region, New Orleans, La.

Hampton, M.A., 1982a, *Synthesis Report: Environmental Geology of Lower Cook Inlet Alaska*, U.S. Geological Survey Open File Report 82-197.

Hampton, M.A., 1982b, *Synthesis Report: Environmental Geology of Kodiak Shelf, Alaska*, U.S. Geological Survey Open File Report 82-59.

Hampton, M.A., A.H. Bouma, M.E. Torresan, and I.P. Colburn, 1978, "Analysis of Microtextures on Quartz Sand Grains from Lower Cook Inlet, Alaska," *Geology*, 6:105–110.

Hampton, M.A., K.H. Johnson, M.E. Torresan, and W.J. Winters, 1981, *Description of Seafloor Sediment and Preliminary Geo-Environmental Report, Shelikof Strait, Alaska*, U.S. Geological Survey Open File Report 81-1133.

Hance, J.J., 2003, *Development of a Database and Assessment of Seafloor Stability Based on Published Literature*, Offshore Technology Research Center, Texas A&M University, College Station, Texas.

Haney, J.L., Y. Wei, and S.G. Douglas, 2004, *A Preliminary Assessment of On-shore Air Quality Impacts for the Eastern Gulf Coast (Louisiana to Florida) Using the 2000 Gulf-wide Emissions Inventory, Draft Report*, May 28.

Haney, J.L., Y. Wei, and S.G. Douglas, 2004, *A Preliminary Assessment of On-shore Air Quality Impacts for the Eastern Gulf Coast (Louisiana to Florida) Using the 2000 Gulfwide Emissions Inventory, Draft Report*, prepared by ICF Consulting, San Rafael, Calif., for MMS, New Orleans, La., May 28.

Hanna, S.R., and P.J. Drivas, 1993, "Modeling VOC Emissions and Air Concentrations from the Exxon Valdez Oil Spill," *J. Air Waste Manage. Assoc.* 43:298–309.

Hansen, D.J., 1981, *The Relative Sensitivity of Seabird Populations in Alaska to Oil Pollution*. BLMYK-ES-006-1792. U.S. Department of the Interior, Bureau of Land Management, Anchorage, AK.

Harbinson, D., and R. Knight, 2002, "Floating Production Growth Continues into 2003," *Offshore Magazine* 62:12.

Hardage, B., 2011, *Multicomponent and Multifrequency Seismic for Assessment of Fluid-Gas Expulsion Geology and Gas Hydrate Deposits: Gulf of Mexico*, Bureau of Economic Geology Research. Available at http://www.beg.utexas.edu/resprog/geophysics/fluid-gasexpulsion.htm. Accessed January 28, 2011.

Harting, A.L., 1987, "Road, Highway, Aircraft, and Garbage Impacts," pp. 69−74 in *Grizzly Bear Compendium*, M.N. LeFranc et al. (eds.), sponsored by the Interagency Grizzly Bear Committee, produced by the National Wildlife Federation, Washington, D.C.

Hartung, R., 1995, "Assessment of the Potential for Long-Term Toxicological Effects of the *Exxon Valdez* Oil Spill on Birds and Mammals," *Exxon Valdez Oil Spill: Fate and Effects in Alaskan Waters, ASTM STP 1219*, pp. 693–725, P.G. Wells et al. (eds.), American Society for Testing and Materials, Philadelphia, PA.

Harvey, J.T., and M.E. Dahlheim, 1994, "Cetaceans in Oil," pp. 257–264 in *Marine Mammals and the* Exxon Valdez, T.R. Loughlin, (ed.), Academic Press, San Diego.

Hayes, M., et al., 1992, *An Introduction to Coastal Habitats and Biological Resources for Oil Spill Response*, Report No. HMRAD 92-4, National Oceanic and Atmospheric Administration, Hazardous Materials Response and Assessment Division.

Hayes, M.O., R. Hoff, J. Michel, D. Scholz, and G. Shigenaka, 1992, *An Introduction to Coastal Habits and Biological Resources for Oil Spill Response*, Report No. HNRAD 92-4, Hazardous Materials Response and Assessment Division, National Oceanic and Atmospheric Administration, Seattle, Wash.

Hawkes, L.A., A.C. Broderick, M.H. Godfrey, and B.J. Godley, 2009, "Climate Change and Marine Turtles," *Endangered Species Research* 7:137–154.

Hazel, J., I.V. Lawler, H. Marsh, and S. Robson, 2007, "Vessel Speed Increases Collision Risk for the Green Turtle *Chelonia mydas*," *Endangered Species Research* 3:105–113.

Hearon, G., D. Dickins, K. Ambrosius, and K. Morris, 2009, *Mapping Sea Ice Overflood Using Remote Sensing: Smith Bay to Camden Bay*, OCS study, MMS 2009-017, MMS, Anchorage, Alaska.

Heathershaw, A.D., P.D. Ward, and A.M. David, 2002, "The Environmental Impact of Underwater Sound," *Proceedings of the Institute of Acoustics* 23(4):1–13.

Hemmer, M.J., M.G. Barron, and R.M. Greene, 2010a, *Comparative Toxicity of Eight Oil Dispersant Products on Two Gulf of Mexico Aquatic Test Species*, U.S. Environmental Protection Agency, Office of Research and Development. Available at http://www.epa.gov/bpspill/reports/ComparativeToxTest.Final.6.30.10.pdf. Accessed June 3, 2011.

Hemmer, M.J., M.G. Barron, and R.M. Greene, 2010b, *Comparative Toxicity of Louisiana Crude Oil (LSC) and Chemically Dispersed LSC of Two Gulf of Mexico Aquatic Test Species*, U.S. Environmental Protection Agency, Office of Research and Development. Available at http://www.epa.gov/bpspill/reports/phase2dispersant-toxtest.pdf. Accessed June 3, 2011.

Hemmerling, S.A., and C.E. Colton, 2004, *Environmental Justice Considerations in Lafourche Parish, Louisiana,* OCS Study MMS 2003-038, prepared by Louisiana State University Coastal Studies Institute, Baton Rouge, La., for Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La., Jan.

Heneman, B., and the Center for Environmental Education, 1988, *Persistent Marine Debris in the North Sea, Northwest Atlantic Ocean, Wider Caribbean Area, and the West Coast of Baja California. Final Report*, Contract MM3309598-5, Marine Mammal Commission, Washington, D.C.

Hensel, P., et al., 2002, *Oil Spills in Mangroves, Planning and Response Considerations*, National Oceanic and Atmospheric Administration, Office of Response and Restoration.

Hepler, K.R., P.A. Hansen, and D.R. Bernard, 1993, *Impact of Oil Spilled from the* Exxon Valdez *on Survival and Growth of Dolly Varden and Cutthroat Trout in Prince William Sound, Alaska*, Exxon Valdez *Oil Spill State/Federal Natural Resource Damage Assessment Final Report*, Fish/Shellfish Study Number 5, Restoration Study Number 90, Alaska Department of Fish and Game, Division of Sport Fish, Anchorage, Alaska.

Herkhof, D., 2011, *Air Emissions Table for Five-Year DEIS*, personal communication from D. Herkhof (Bureau of Ocean Energy Management, Regulation and Enforcement, Herndon, Va.) to Y.-S. Chang (Argonne National Laboratory, Argonne, Ill.), Sept. 2.

Hess, G., 2011, "Congress Stalls on Oil-Spill Response," *Chemical and Engineering News* 89(34):31–33.

Hiett, R.L., and J.W. Milon, 2002, *Economic Impact of Recreational Fishing and Diving Associated with Offshore Oil and Gas Structures in the Gulf of Mexico*, final report, OCS Study MMS 2002-010, prepared by QuanTech, Inc. for the MMS, Gulf of Mexico OCS Region, New Orleans, La. Available at http://www.gomr.mms.gov/PI/PDFImages/ESPIS/2/3058.pdf. Accessed June 22, 2011.

Highsmith, R.C., S.M. Saupe, and A.L. Blanchard, 2001, *Kachemak Bay Experimental and Monitoring Studies: Recruitment, Succession, and Recovery in Seasonally Disturbed Rocky-Intertidal Habitat*, OCS Study MMS 2001-053, MMS, Alaska OCS Region, Anchorage, Alaska.

Hildebrand, J., 2004, *Sources of Anthropogenic Sound in the Marine Environment*, International Policy Workshop on Sound and Marine Mammals, London, September 28–30.

Hildebrand, J.A., 2005, "Impacts of Anthropogenic Sound," pp. 101–124in *Marine Mammal Research: Conservation beyond Crisis,* J.E. Reynolds, W.F. Perrin, R.R. Reeve, S. Montgomery, and T.J. Ragen (eds.), The Johns Hopkins University Press, Baltimore, Md. Available at http://www.awionline.org/ht/a/GetDocumentAction/i/10158. Accessed July 11, 2011.

Hill, P.S., and D.P. DeMaster, 1998, *Alaska Marine Mammal Stock Assessments 1998,* National Marine Mammal Laboratory, Alaska Fisheries Science Center, Seattle, Wash.

Hitchcock, C., et al., 2010, "GIS-Based Assessment of Submarine Mudflow Hazard Offshore of the Mississippi Delta," in *Submarine Mass Movements and Their Consequences, Advances in Natural and Technological Hazards Research*, D. Mosher et al. (eds.), Springer Science+Business Media.

Hoff, R., 1995, *Responding to Oil Spills in Coastal Marshes: The Fine Line between Help and Hindrance*, HAZMAT Report 96-1, National Oceanic and Atmospheric Administration, Hazardous Materials Response and Assessment Division.

Hoffecker, J.F., and S.A. Elias, 2003, "Environment and Archaeology in Beringia," *Evolutionary Anthropology* 12:34–49.

Holland-Bartels, L., and J.J. Kolak, 2011, "Oil-spill, Risk, Reponse, and Impact," in *An Evaluation of the Science Needs to Inform Decisions on Outer Continental Shelf Energy Development in the Chukchi and Beaufort Seas*, Chapter 5. Alaska: U.S. Geological Survey Circular 1370, p. 13–40.

Holliday, D.V., R.E. Pieper, M.E. Clarke, and C.F. Greenlaw, 1987, *The Effects of Airgun Energy Releases on the Eggs, Larvae, and Adults of the Northern Anchovy* (Engraulis mordax), API Publication 4453. Report by Tracor Applied Sciences for American Petroleum Institute, Washington, D.C.

Hom, W., et al., 1999, "Measuring the Exposure of Subsistence Fish and Marine Mammal Species to Aromatic Compounds following the Exxon Valdez Oil Spill," in *Evaluating and Communicating Subsistence Seafood Safety in a Cross-Cultural Context,* L.J. Field, J.A. Fall, T.S. Nighswander, N. Peacock, and U. Varanasi (eds), SETAC Press, Pensacola, Fla.

Hooker, S.K., T.L. Metcalfe, C.D. Metcalfe, C.M. Angell, J.Y. Wilson, M.J. Moore, and H. Whitehead, 2008, "Changes in Persistent Contaminant Concentration CYP1A1 Protein Expression in Biopsy Samples from Northern Bottlenose Whales, *Hyperoodon ampullatus*, Following the Onset of Nearby Oil and Gas Development," *Environmental Pollution* 151:205–216.

Hoose, P.J., and J. Whitney, 1980, *Map Showing Selected Geologic Features of Outer Continental Shelf, Shelikof Strait, Alaska*, U.S. Geological Survey Open File Report 80-2035.

Hopkins, D.M., and R.W. Hartz, 1978, *Coastal Morphology, Coastal Erosion, and Barrier Islands of the Beaufort Sea Coast, Alaska*, Open File Report 78-1063, U.S. Geological Survey.

Hopkinson, C., 2010, *Outcome/Guidance from Georgia Sea Grant Program: Current Status of BP Oil Spill*, Georgia Sea Grant Oil Spill Update, August 17.

Howarth, R.W., 1991, "Assessing the Ecological Effects of Oil Pollution from Outer Continental Shelf Oil Production," *American Fisheries Society Symposium* 11:1–8.

Hsiao, S.I., D.W. Kittle, and M.G. Foy, 1978, "Effects of Crude Oils and the Oil Dispersant Corexit on Primary Production of Arctic Marine Phytoplankton and Seaweed," *Environmental Pollution* 15:209–221.

Hsu, S.A., and B.W. Blanchard, 2005, *Visibility and Atmospheric Dispersion Capability over the Northern Gulf of Mexico: Estimations and Observations of Boundary Layer Parameters*, OCS Study MMS 2005-008, prepared by Coastal Marine Institute, Louisiana State University, Baton Rouge, La., for MMS, Gulf of Mexico OCS Region, New Orleans, La., March.

Huffman, A.R., and J.P. Castagna, 2001, "The Petrophysical Basis for Shallow-Water Flow Prediction Using Multicomponent Seismic Data," *The Leading Edge* 20(9):1030–1035.

Hunter, J.A., and G.O. Hobson, 1974, "Seismic Refraction Method of Detecting Subsea Bottom Permafrost, the Coast and Shelf of the Beaufort Sea," *Proceedings of a Symposium on Beaufort Sea Coast and Shelf Research*, J.C. Reed and J.E. Sater (Eds.), Arctic Institute of North America, Arlington Va.

IACMST (Inter-Agency Committee on Marine Science and Technology), 2006, *Underwater Sound and Marine Life*, Report No. 6, report of the Inter-Agency Committee on Marine Science and Technology Working Group, Southampton, U.K.

IATA (International Air Transport Association), 2011, *Fuel Efficiency*. Available at http://www.iata.org/whatwedo/environment/Pages/fuel_efficiency.aspx. Accessed August 20, 2011.

IMG Golder Corp., 2004, *Review of Potential Effects of Dredging in the Beaufort Sea*, prepared for the Fisheries and Oceans Canada, Inuvik, Northwest Territories, June.

Impact Assessment, Inc., 1990, *Northern Institutional Profile Analysis: Beaufort Sea*, OCS Study MMS 90-0023, MMS, Alaska OCS Region, Anchorage, Alaska.

Impact Assessment, Inc., 2001, Exxon Valdez *Oil Spill, Cleanup and Litigation: A Collection of Social-Impact Information and Analysis*, OCS Study MMS 2001-058, MMS, Alaska OCS Region, Anchorage, Alaska.

Invasive Species Advisory Committee, 2010, *Invasive Species and Climate Change*, White Paper. U.S. Department of the Interior, Invasive Species Advisory Committee, Washington, D.C. Available at http://www.invasivespecies.gov/ISAC/White%20Papers/Climate_Change_White_Paper_FINAL_VERSION.pdf.

IPCC (International Panel on Climate Change), 2007, *Climate Change 2007: Synthesis Report, Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, R.K. Pachauri and A. Reisinger, (eds.), Geneva, Switzerland. Available at http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf. Accessed April 22, 2011.

Irvine, G., 2000, "Persistence of Spilled Oil on Shores and Its Effects on Biota," in *Seas at the Millennium: An Environmental Evaluation, Volume III: Global Issues and Processes*, Elsevier Science Ltd., Oxford.

Jay, C.V., and A.S. Fischbach, 2008, *Pacific Walrus Response to Arctic Sea Ice Losses*, fact sheet, USGS, Alaska Science Center, Anchorage, Alaska, May. Available at http://pubs.usgs.gov/fs/2008/3041/pdf/fs20083041.pdf. Accessed May 26, 2011.

Jensen, A.S., and G.K. Silber, 2004, *Large Whale Ship Strike Database*, NOAA Technical Memorandum NMFS-OPR-January 2004, Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Silver Spring, Md.

Jeong, C., and V.G. Panchang, 2008, "Measurement-Based Estimates of Extreme Wave Conditions for the Gulf of Mexico," *Proceedings of Oceans 2008*. Available at http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5151997&isnumber=5151799. Accessed May 18, 2011.

Jernelöv, A., 2010, "The Threats from Oil Spills: Now, Then, and in the Future," *Ambio* 39:353–366.

Ji, Z.-G., 2004, "Use of Physical Sciences in Support of Environmental Management," *Environmental Management* 34(2):159–169

Jochens, A.E., and S.F. DiMarco, 2008, "Physical Oceanographic Conditions in the Deepwater Gulf of Mexico in Summer 2000-2000," *Deep-Sea Research Part II: Topical Studies in Oceanography* 55(24-26):2541–2554.

Jochens, A.E., S.F. DiMarco, W.D. Nowlin, Jr., R.O. Reid, and M.C. Kennicutt II, 2002, *Northeastern Gulf of Mexico Chemical Oceanography and Hydrography Study*, OCS Study MMS 2002-055, MMS, Gulf of Mexico OCS Region, New Orleans, La.

Johannesen, O., M. Miles, and E. Bjørgo, 1995, "The Arctic's Shrinking Ice," *Nature* 376:126–127.

Johnson, S.R., 1994, *The Status of Lesser Snow Geese in the Sagavanirktok River Delta Area, Alaska: 1980–1993*. Prepared by LGL Alaska Research Associates, Inc., for BP Exploration (Alaska), Inc., Anchorage, AK.

Johnson, S.R., 2000, "Pacific Eider," *Natural History of An Arctic Oil Field: Development and the Biota*. J.C. Truett and S.R. Johnson (eds), Academic Press, San Diego, CA.

Johnson, S.R., R.J. Rodrigues, and R.H. Pollard, 1993a, *Video Analysis of Predators and Nesting Snow Geese on Howe Island, Sagavanirktok River Delta, Alaska, 1992*. Report to BP Exploration (Alaska) Inc., by LGL Alaska Research Associates, Inc.

Johnson, S.R., D. Wiggins, and R.J. Rodrigues, 1993b, *Use of Gravel Causeways by Nesting Common Eiders, Beaufort Sea, Alaska, 1992*. Report to BP Exploration (Alaska) Inc., by LGL Alaska Research Associates, Inc.

Jones, K.F., and E.L. Andreas, 2009, *Sea Spray Icing of Drilling and Production Platforms*, ERDC/CRREL TR-09-3, USACE, CRREL (Cold Regions Research and Engineering Laboratory), Hanover, N.H.

Jorgenson, M.T., and J. Brown, 2005, "Classification of the Alaskan Beaufort Sea Coast and Estimation of Carbon and Sediment Inputs from Coastal Erosion," *Geo-Mar Lett* 25:69–80.

Judd, A.G., and M. Hovland, 2007, *Seabed Fluid Flow: The Impact of Geology, Biology and the Marine Environment*, Cambridge University Press.

Kaiser, M.J., and A.G. Pulsipher, 2007, "The Impact of Weather and Ocean Forecasting on Hydrocarbon Production and Pollution Management in the Gulf of Mexico," *Energy Policy* 35:966–983.

Karl, K.J., 2007, *Gulf of Mexico Oil and Gas Production Forecast: 2007-2016*, MMS Report 2007-020, Gulf of Mexico Region, May.

Karl, K.J., R.D. Baud, A.G. Boice, R. Bongiovanni, T.M. DeCort, R.P. Desselles, and E.G. Kazanis, 2007, *Gulf of Mexico Oil and Gas Production Forecast: 2007–2016*, MMS Report 2007-020, Gulf of Mexico OCS Region, May.

Kastak, D., and R.J. Schusterman, 1998, "Low-Frequency Amphibious Hearing in Pinnipeds: Methods, Measurements, Noise and Ecology," *Journal of the Acoustical Society of America* 103:2216–2228.

Kay, J.E., M.M. Holland, and A. Jahn, 2011, "Inter-annual to Multi-decadal Arctic Sea Ice Extent Trends in a Warming World," *Geophysical Research Letters* 38:L15708.

Keenan, S.F., M.C. Benfield, and J.K. Blackburn, 2007, "Importance of the Artificial Light Field around Offshore Petroleum Platforms for the Associated Fish Community," *Marine Ecology Progress Series* 331:219–231.

Keller, B.D., and J.B.C. Jackson, 1993, *Long-Term Assessment of the Oil Spill at Bahia Las Minas, Panama*, Synthesis Report, Volume I: Executive Summary OCS Study MMS93-0047, U.S. Department of the Interior, Minerals Management Service, Gulk of Mexico, OCS Region, New Orleans, La.

Keller, J.M., J.R. Kucklick, C.A. Harms, and P.D. McClellan-Green, 2004, "Organochlorine Contaminants in Sea Turtles: Correlations between Whole Blood and Fat," *Environmental Toxicology and Chemistry* 23:726–738.

Kelly, B.P., J.J. Burns, and L.T. Quakenbush, 1988, "Response of Ringed Seals (*Phoca hispida*) to Noise Disturbance," pp. 27–38 in *Port and Ocean Engineering Under Arctic Conditions, Vol. 2*, W.M. Sackinger and M.O. Jeffires (eds.), Geophysical Institute, University of Alaska, Fairbanks, Alaska.

Kenai Peninsula Borough, 2005, *Comprehensive Plan*. Available at http://www.borough.kenai.ak.us/planningdept/plan/2005/plan.htm. Accessed April 26, 2011.

Kenai Peninsula Borough, 2008. *Coastal Management Plan*, June. Available at http://www.kenairivercenter.org/Agencies/coastal/2008CMP/CZM_content_full.pdf. Accessed April 26, 2010.

Kennicutt, M.C. (ed.), 1995, *Gulf of Mexico Offshore Operations Monitoring Experiment, Phase I: Sublethal Responses to Contaminant Exposure*, Final Report, OCS Study MMS 95-0045, MMS, Gulf of Mexico OCS Region New Orleans, La.

Kennicutt II, M.C., and J.M. Brooks, 1990, "Recognition of Areas Effected [Affected – sic] by Petroleum Seepage: Northern Gulf of Mexico Continental Slope," *Geo-Marine Letters* 10:221–224.

Ketten, D.R., 1998, *Marine Mammal Auditory Systems: A Summary of Audiometric and Anatomical Data and Its Implications for Underwater Acoustic Impacts*, NOAA Technical Memorandum NMFS-SWFSC-256.

Kienle, J., Z. Kowalik, and T.S. Murty, 1986, "Tsunamis Generated by Eruptions from Mount St. Augustine Volcano, Alaska," *Science* 236:1442–1447.

King, J.A., and G.A. Sanger, 1979, "Oil Vulnerability Index for Marine Oriented Birds. Conservation of Marine Birds in Northern North America," *Wildlife Research Report II*, J.C. Bartonek and D.N. Nettleship (eds.), U.S. Fish and Wildlife Service, U.S. Department of the Interior, Washington, D.C.

Kingsford, M.J., 1996, "Influence of Pollutants and Oceanography on Abundance and Deformities of Wild Fish Larvae," pp. 235–256 in *Detecting Ecological Impacts, Concepts and Applications in Coastal Habitats,* R.J. Schmitt and C.W. Osenberg (eds.), Academic Press, San Diego, Calif.

Kinkhart, E., K. Pitcher, and G. Blundell, 2008, *Alaska Wildlife Notebook Series: Harbor Seal*, Alaska Department of Fish and Game, Juneau, Alaska. Available at http://www.adfg.alaska.gov/static/education/wns/harbor_seal.pdf. Accessed April 11, 2011.

Klem, D., Jr., 1989, "Bird–Window Collisions," *Wilson Bulletin* 101: 606–620.

Klem, D., Jr., 1990, "Collisions between Birds and Windows: Mortality and Prevention," *Journal of Field Ornithology* 61: 120–128.

Klima, E.F., G.R. Gitschlag, and M.L. Renaud, 1988, "Impacts of the Explosive Removal of Offshore Petroleum Platforms on Sea Turtles and Dolphins," *Mar. Fish. Rev.* 50(3):33–42.

Kovacs, A., and D.S. Sodhi, 1980, "Shore Ice Pile-up and Ride-up: Field Observations, Models, Theoretical Analyses," *Cold Regions Science and Technology* 2:210–288.

Kowalik, Z., 1984, "Storm Surges in the Beaufort and Chukchi Seas," *Journal of Geophysical Research* 89(C10):10,570–10,578.

Kowalik, Z., and A. Proshutinsky, 2010, "Tsunami-Tide Interactions: A Cook Inlet Case Study," *Continental Shelf Research* 30:633–642.

KPB (Kenai Peninsula Borough), 2011, "Tsunamis and Seiches," Chapter 6 in *KPB All-Hazard Mitigation Plan.* Available at http://www.borough.kenai.ak.us/emergency/hazmit/plan.htm. Accessed May 25, 2011.

Krost, P., M. Bernhard, F. Werner, and W. Hukriede, 1990, "Otter Trawl Tracks in Kiel Bay (Western Baltic) Mapped by Side-Scan Sonar," *Meereforschung* 32:344–353.

Kryter, K.D., 1985, *The Effects of Noise on Man*, 2nd Ed. Academic Press, Orlando.

Kujawinski, E.B., M.C. Kido Soule, D.L. Valentine, A.K. Boysen, K. Longnecker, and M.C. Redmond, 2011, "Fate of Dispersants Associated with the Deepwater Horizon Oil Spill," *Environmental Science and Technology* 45:1298–1306.

Kvenvolden, K.A., and C.K. Cooper, 2003, "Natural Seepage of Crude Oil into the Marine Environment," *Geo-Marine Letters* 23:140–146.

Kyle, R.E., and T.P. Brabets, 2001, *Water Temperature of Streams in the Cook Inlet Basin, Alaska, and Implications of Climate Change*, Water Resources Investigations Report 01-4109, U.S. Geological Survey.

Kyle, R.J., 2002, "A Century of Fire and Brimstone: the Rise and Fall of the Frasch Sulphur Industry of the Gulf of Mexico Basin, " in *Industrial Minerals and Extractive Industry Geology*, P.W. Scott and C.M. Bristow (editors), Geological Society of London.

Labay, K., and P.J. Haeussler, 2001, *GIS Coverages of the Castle Mountain Fault, South Central Alaska*, U.S. Geological Survey Open File Report 01-504.

Laist, D.W., A.R. Knowlton, J.G. Mead, A.S. Collet, and M. Podesta, 2001, "Collisions between Ships and Whales," *Marine Mammal Science* 17(1): 35–75.

Lance, B.K., D.B. Irons, S.J. Kendall, and L.L. McDonald, 2001, "An Evaluation of Marine Bird Population Trends Following the *Exxon Valdez* Oil Spill, Prince William Sound, Alaska," *Marine Pollution Bulletin* 42: 298–309.

Lange, J.L., D.A. Schwartz, B.N. Doebbeling, J.M. Heller, and P.S. Thorne, 2002, "Exposures to the Kuwait Oil Fires and Their Association with Asthma and Bronchitis among Gulf War Veterans," *Environ. Health Perspect.* 110(11):1141–1146.

Larkin, R.P., 1996, *Effects of Military Noise on Wildlife: a Literature Review*, Technical Report 96/21, U.S. Army Construction Engineering Research Laboratory, Champaign, Ill.

Laws, E.A., 1993, "Oil Pollution." Chapter 13 in *Aquatic Pollution, An Introductory Text*. 2nd ed. John Wiley and Sons, Inc.

LCWCRTF (Louisiana Coastal Wetlands Conservation and Restoration Task Force), 1998, *Coast 2050: Toward a Sustainable Coastal Louisiana, Report of the Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority*, Louisiana Department of Natural Resources, Baton Rouge, La.

LCWCRTF, 2001, *The 2000 Evaluation Report to the U.S. Congress on the Effectiveness of Louisiana Coastal Wetland Restoration Projects*, Louisiana Department of Natural Resources, Baton Rouge, La.

LCWCRTF, 2003, *The 2003 Evaluation Report to the U.S. Congress on the Effectiveness of Coastal Wetland Planning, Protection, and Restoration Act Projects*, Louisiana Department of Natural Resources, Baton Rouge, La.

Leber, J., 2010, "Economics Improve for First Commercial Cellulose Ethanol Plants," *ClimateWire*. Available at http://www.nytimes.com/cwire/2010/02/16/16climatewire-economics-improve-for-first-commercial-cellu-93478.html. Accessed February 16, 2010.

Lee, D.S., and M. Socci, 1989, *Potential Impact of Oil Spills on Seabirds and Selected Other Oceanic Vertebrates Off the North Carolina Coast*. NCSM Biological Survey Report No. 90-1. North Carolina State Museum of Natural Sciences, Raleigh, NC.

Lee, R.F., and D.S. Page, 1997, "Petroleum Hydrocarbons and Their Effects in Subtidal Regions after Major Oil Spills," *Marine Pollution Bulletin* 34:928–940.

Leighton, F.A., 1990, *The Toxicity of Petroleum Oils to Birds: An Overview*. Oil Symposium, Herndon, VA.

Lemke, P., J. Ren, R.B. Alley, I. Allison, J. Carrasco, G. Flato, Y. Fujii, G. Kaser, P. Mote, R.H. Thomas, and T. Zhang, 2007, "Observations: Changes in Snow, Ice and Frozen Ground," in *Climate Change 2007: The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.), Cambridge University Press, Cambridge, U.K., and New York, N.Y.

Lesage, V., C. Barrette, M.C.S. Kingsley, and B. Sjare, 1999, "The Effects of Vessel Noise on the Vocal Behavior of Belugas in the St. Lawrence River Estuary, Canada," *Marine Mammal Science* 15:65–84.

Lewis, J.P., R. Sellers, S. Miller, D. McAllister, and D. Calkins, 1991, *Assessment of the Exxon Valdez Oil Spill on Brown Bears on the Alaska Peninsula*, Terrestrial Mammal Study Number Four, Final Report.

Lessard-Pilon, S., M.D. Porter, E.E. Cordes, I.R. MacDonald, and C.R. Fisher, 2010, "Community Composition and Temporal Change at Deep Gulf of Mexico Cold Seeps," *Deep-Sea Research II* 57:1891–1903.

Lincoln, F.C., S.R. Peterson, and J.L. Zimmerman, 1998, *Migration of Birds*. Circular 16, U.S. Department of the Interior, U.S. Fish and Wildlife Service, Washington, D.C.

Linnell, J.D.C., J.E. Swenson, R. Andersen, and B. Barnes, 2000, "How Vulnerable Are Denning Bears to Disturbance?" *Wildlife Society Bulletin* 28:400–413.

Liu, J., 2011, personal communication via e-mail from J. Liu (Louisiana Department of Environmental Quality, Baton Rouge, La.) to Y.-S. Chang (Argonne National Laboratory, Argonne, Ill.), July 22.

Ljungblad, D.K., B. Würsig, S.L. Swartz, and J.M. Keene, 1988, "Observations on the Behavioral Responses of Bowhead Whales (*Balaena mysticetus*) to Active Geophysical Vessels in the Alaskan Beaufort Sea," *Arctic* 41(3):183–194.

Lloyd, J.M. et al., 1991, *Part I: 1988 and 1989 Florida Petroleum Production and Exploration Including Florida Petroleum Reserve Estimates and Part II: Petroleum Exploration and Development Policies in Florida – Response to Public Concern for Sensitive Environments*, Information Circular No. 107, Florida Department of Natural Resources, published for the Florida Geological Survey, June.

Loehefener, R.R., W. Hoggard, C.L. Roden, K.D. Mullin, and C.M. Rogers, 1989, "Petroleum Structures and the Distribution of Sea Turtles," in *Proceedings Spring Ternary Gulf of Mexico Studies Meeting*, Minerals Management Service.

Lohoefener, R., W. Hoggard, K. Mullin, C. Roden, and C. Rogers, 1990, *Association of Sea Turtles with Petroleum Platforms in the North-Central Gulf of Mexico*, OCS Study/MMS 90-00025, Minerals Management Service, Gulf of Mexico OCS Regional Office, New Orleans, La.

Longwell, A.C., 1977, "A Genetic Look at Fish Eggs and Oil," *Oceanus* 20(4):46–58.

Lorne, J.K., and M. Salmon, 2007, "Effects of Exposure to Artificial Lighting on Orientation of Hatchling Sea Turtles on the Beach and in the Ocean," *Endangered Species Research* 3:23–30.

Loughlin, T.R., B.E. Ballachey, and B.A. Wright, 1996, "Overview of Studies to Determine Injury Caused by the Exxon Valdez Oil Spill to Marine Mammals," pp. 798–808 in *Proceedings of the* Exxon Valdez *Oil Spill Symposium,* S.D. Rice, R.B. Spies, D.A. Wolfe, and B.A. Wright (eds.), American Fisheries Society Symposium 18, Bethesda, Md.

Loya, Y., and B. Rinkevitch, 1980, "Effects of Oil Pollution on Coral Reef Communities," *Marine Ecology Progress Series* 3:167–180.

Lu, S., G.A. McMechan, and A. Liaw, 2005, "Identification of Shallow-Water-Flow Sands by V_p Inversion of Conventional 3D Seismic Data," *Geophysics* 70(5):29–37.

Lubchenco, J., M. McNutt, B. Lehr, M. Sogge, M. Miller, S. Hammond, and W. Conner, 2010, "BP Deepwater Horizon Oil Budget: What Happened To the Oil?." Available at http://www.restorethegulf.gov/sites/default/files/imported_pdfs/posted/2931/Oil_Budget_description_8_3_FINAL.844091.pdf. Accessed July 21, 2011.

Lugo-Fernandez, A., 2007, "Is the Loop Current a Chaotic Oscillator?" *Journal of Physical Oceanography* 37(6):1455–1469.

Lugo-Fernandez, A., and R.E. Green, 2011, "Mapping the Intricacies of the Gulf of Mexico's Circulation," *EOS* 92(3):21–22.

Lugo-Fernandez, A., and R.R. Leben, 2010, "On the Linear Relationship between Loop Current Retreat Latitude and Eddy Separation Period," *Journal of Physical Oceanography* 40(12):2778–2784.

Lukina, L., S. Matisheva, and V. Shapunov, 1996, "Ecological Monitoring of the Captivity Sites as a Means of Studying the Influence of Contaminated Environment on Cetaceans," pp. 52–54 in *Proceedings, First International Symposium on the Marine Mammals of the Black Sea,* B. Öztürk (ed.), June 27–30, 1994, Istanbul, Turkey.

Lutcavage, M.E., P.L. Lutz, G.D. Bossart, and D.M. Hudson, 1995, "Physiologic and Clinicopathologic Effects of Crude Oil on Loggerhead Sea Turtles," *Archives of Environmental Contamination and Toxicology* 28:417–422.

Lutcavage, M.E., P. Plotkin, B. Witherington, and P.L. Lutz, 1997, "Human Impacts on Sea Turtle Survival," pp. 387–410 in *The Biology of Sea Turtles*, P.L. Lutz and J.A. Musick (eds.), CRC Press, Boca Raton, Fla.

Luton, H., and R. Cluck, 2003, *Social Impact Assessment of Offshore Oil and Gas in the Gulf of Mexico*, draft, Mineral Management Service.

Lutz, P.L., and M. Lutcavage, 1989, "The Effects of Petroleum on Sea Turtles: Applicability to Kemp's Ridley," in *Proceedings of the First International Symposium on Kemp's Ridley Sea Turtle Biology, Conservation, and Management*, C.W. Caillouet and A.M. Landry (eds.), TAMU-SG-89-105.

Lynch, A.H., L.R. Lestak, P. Uotila, E.N. Cassano, and L. Xie, 2008, "A Factorial Analysis of Storm Surge Flooding in Barrow, Alaska," *Monthly Weather Review* 136(3):898–912.

Macdonald, K.B., 1977, "Plant and Animal Communities of Pacific North American Salt Marshes," pp. 167–192 in *Wet Coastal Ecosystems. Ecosystems of the World*, V.J. Chapman (ed.), Elsevier, Amsterdam, the Netherlands.

Macreadie, P., A. Fowler, and D. Booth, 2011, "Rigs-to-Reefs: Will the Deep Sea Benefit from Artificial Habitat?," *Frontiers in Ecology and the Environment* 110324084539019. Available at http://www.esajournals.org/doi/abs/10.1890/100112. Accessed June 21, 2011.

Madsen, P.T., B. Mohl, B.K. Nielsen, and M. Wahlberg, 2002, "Male Sperm Whale Behaviour During Exposures to Distant Seismic Survey Pulses," *Aquatic Mammals* 28(3):231–240.

Maffione, R.A., 2000, "Deep Problems in Optically Shallow Waters," *Backscatter* 11:28–31.

Mahoney, A., H. Eicken, A.G. Gaylord, and L. Shapiro, 2007, "Alaska Landfast Sea Ice: Links with Bathymetry and Atmospheric Circulation," *Journal of Geophysical Research* 112:C02001.

Maier, J.A.K., S.M. Murphy, and M.D. Smith, 1998, "Response of Caribou to Overflights by Low-altitude Jet Aircraft," *Journal of Wildlife Management* 62:752–766.

Malins, D.C. (ed.), 1977, *Effects of Petroleum on Arctic and Subarctic Marine Environments and Organisms, Vol. II, Biological Effects*, Academic Press, New York, N.Y.

Malm, W.C., 1999, *Introduction to Visibility*, Cooperative Institute for Research in the Atmosphere (CIRA), NPS Visibility Program, Colorado State University, Fort Collins, Colo., May.

Malm, W.C., 2000, *Spatial and Seasonal Patterns and Temporal Variability of Haze and Its Constituents in the United States, Report III*, Colorado State University, Fort Collins, May.

Malme, C.I., P.R. Miles, C.W. Clark, P. Tyack, and J.E. Bird, 1984, *Investigations of the Potential Effects of Underwater Noise from Petroleum Industry Activities on Migrating Gray Whale Behavior, Phase II: January 1984 Migration*, BBN Rep. 5586, report for MMS, Anchorage, Alaska, NTIS PB86-218377.

Malme, C.I., P.R. Miles, G.W. Miller, W.J. Richardson, D.G. Roseneau, D.H. Thomson, and C.R. Greene, Jr., 1989, *Analysis and Ranking of the Acoustic Disturbance Potential of Petroleum Industry Activities and Other Sources of Noise in the Environment of Marine Mammals in Alaska*, OCS Study MMS 89-0006, Minerals Management Service, Anchorage, Alaska.

Marine Mammal Commission, 2003, *Annual Report to Congress 2002*, Bethesda, Md.

Marine Mammal Commission, 2004, *Annual Report to Congress 2003*, Bethesda, Md.

Markus, T., J.C. Stroeve, and J. Miller, 2009, "Recent Changes in Arctic Sea Ice Melt Onset, Freeze Up, and Melt Season Length," *Journal of Geophysical Research* 114(C12).

Mars, J., and D. Houseknecht, 2007, "Quantitative Remote Sensing Study Indicates Doubling of Coastal Erosion Rate in Past 50 yr along a Segment of the Arctic Coast of Alaska," *Geology* 35:583–586.

Mason, W.T., Jr., and J.P. Claxton, 1993, "Foods of the Gulf Sturgeon in the Suwanee River, Florida," *Transactions of the American Fisheries Society* 122:378–385.

Matkin, C.O., E.L. Saulitis, G.M. Ellis, P. Olesiuk, and S.D. Rice, 2008, "Ongoing Population-level Impacts on Killer Whales *Orcinus orca* following the 'Exxon Valdez' Oil Spill in Prince William Sound, Alaska," *Marine Ecology Progress Series* 356:269–281.

McCammon, M., P. Mundy, and B. Spies, 2002, *The Gulf of Alaska Ecosystem Monitoring and Research (GEM) Program Document*, *Exxon Valdez* Oil Spill Trustee Council, July 9.

McCauley, R.D., J. Fewtrell, A.J. Duncan, C. Jenner, M-N. Jenner, J.D. Penrose, R.I.T. Prince, A. Adhitya, J. Murdoch, and K. McCabe, 2000, "Marine Seismic Surveys – A Study of Environmental Implications," *APPEA Journal* 40:692–708.

McCauley, R.D., J. Fewtrell, A.J. Duncan, C. Jenner, M-N. Jenner, J.D. Penrose, R.I.T. Prince, A. Adhitya, J. Murdoch, and K. McCabe, 2000, "Marine Seismic Surveys: A Study of Environmental Implications," *Australian Petroleum Production & Exploration Association Journal* 2000:692–708.

McClory, J., and T. Gotthardt, 2008, *Non-native and Invasive Animals of Alaska: A Comprehensive List and Select Species Status Reports – Final Report*, Alaska Natural Heritage Program, Anchorage, Alaska, January. Available at http://www.adfg.alaska.gov/static/species/nonnative/invasive/pdfs/invasivespp-report.pdf. Accessed September 6, 2011.

McColluch, D.S., 1966, *Slide-Induced Waves, Seiching and Ground Fracturing Caused by the Earthquake of March 27, 1964 at Kenai Lake, Alaska*, U.S. Geological Survey Professional Paper 543-A.

McDonald, M.A., J.A. Hildebrand, and S.C. Webb, 1995, "Blue and Fin Whales Observed on a Seafloor Array in the Northeast Pacific," *Journal of the Acoustical Society of America* 98(2):712–721.

McGrattan, K.B., et al., 1995, "Smoke Plume Trajectory from In Situ Burning of Crude Oil in Alaska – Field Experiments," in *Proceedings of the Eighteenth Arctic and Marine Oilspill Program (AMOP) Technical Seminar*, Vol. 2, June 14–16, 1995, Edmonton, Alberta, Canada.

McGurk, M.D., and E.D. Brown, 1996, "Egg–Larval Mortality of Pacific Herring in Prince William Sound, Alaska, after the *Exxon Valdez* Oil Spill," *Canadian Journal of Fisheries and Aquatic Sciences* 53:2343–2354.

McKechnie, A.M., and D.N. Gladwin, 1993, *Aircraft Overflight Effects on Wildlife Resources*, Report NPOA-93-8, HMMH-290940.22 (NTIS Number: PB94-149994), November 1993.

McKone, K.P., N.D. Walker, and E. Weeks, 2007, *Full-Water Column Currents Near the Sigsbee Escarpment (91-92° W. longitude) and Relationships with the Loop Current and Associated Warm-and Cold-Core Eddies*, OCS Study, MMS 2007-058, MMS, Gulf of Mexico OCS Region, Baton Rouge, La.

McNutt, M., R. Camilli, G. Guthrie, H. Hsieh, V. Labson, B. Lehr, D. Maclay, A. Ratzel, and M. Sogge, 2011, *Assessment of Flow Rate Estimates for the Deepwater Horizon/Macondo Well Oil Spill*, Flow Rate Technical Group, report to the National Incident Command, Interagency Solutions Group, U.S. Department of Interior, Washington, D.C. Available at http://www.doi.gov/deepwaterhorizon/loader.cfm?csModule=security/getfile&PageID=237763. Accessed September 20, 2011.

Mendelssohn, I., and Q. Lin (eds.), 2003, *Coastal Marine Institute, Development of Bioremediation for Oil Spill Cleanup in Coastal Wetlands*, prepared by Louisiana State University, Wetland Biogeochemistry Institute, Center for Coastal, Energy, and Environmental Resources, for Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La.

Miksis-Olds, J.L., P.L. Donaghay, J.H. Miller, P.L. Tyack, and J.A. Nystuen, 2007, "Noise Level Correlates with Manatee Use of Foraging Habitats," *Journal of the Acoustical Society of America* 121:3011–3020.

Miller, F.L., and A. Gunn, 1979, *Responses of Peary Caribou and Muskoxen to Helicopter Harassment*, Prince of Wales Island, Northwest Territories, July−August 1976, Canadian Wildlife Service Progress Notes, No. 79.

Miller, F.L., and A. Gunn, 1980, "Behavioral Responses of Muskox Herds to Simulation of Cargo Slinging by Helicopter, Northwest Territories," *Canadian Field Naturalist* 94:52–60.

Miller, M.W., K.C. Jensen, W.E. Grant, and M.W. Weller, 1994, "A Simulation Model of Helicopter Disturbance of Molting Pacific Black Brant," *Ecological Modelling* 73 (3/4): 293–309.

Miller, W.W., 1994, "Route Selection to Minimize Helicopter Disturbance of Molting Pacific Black Brant: A Simulation," *Arctic* 47(4): 341–349.

Milton, S.L., A.A. Schulman, and P.L. Lutz, 1997, "The Effect of Beach Nourishment with Aragonite Versus Silicate Sand on Beach Temperature and Loggerhead Sea Turtle Nesting Success," *Journal of Coastal Research* 13:904–915.

MMS (Minerals Management Service), undated, *Leasing Oil and Natural Gas Resources, Outer Continental Shelf*, U.S. Department of the Interior. Available at http://www.boemre.gov/ld/PDFs/GreenBook-LeasingDocument.pdf. Accessed September 15, 2011.

MMS, 1985, *Geologic Report for the Beaufort Sea Planning Area, Alaska*, OCS Report, MMS 85-0111, Alaska OCS Region, Anchorage, Alaska.

MMS, 1987, *Geologic Report for the Chukchi Sea Planning Area, Alaska*, OCS Report 87-0046, Alaska OCS Region, Anchorage.

MMS, 1991, *Alaska Outer Continental Shelf Chukchi Sea Oil & Gas Lease Sale 126, Final Environmental Impact Statement*, OCS EIS/EA MMS 90-0095, Minerals Management Service, Alaska OCS Region, Anchorage, Alaska, Jan.

MMS, 1992, *Geologic Report for the Gulf of Alaska Planning Area*, Report 92-0065, R.F. Turner (ed.), U.S. Department of the Interior, Alaska Outer Continental Shelf Region.

MMS, 1995a, *Cook Inlet Planning Area Oil and Gas Lease Sale 149*, Vol. 1, Report 95-0066, U.S. Department of the Interior, Alaska Outer Continental Shelf Region.

MMS, 1995b, *Gulf of Mexico Air Quality Study, Final Report, Volume I: Summary of Data Analysis and Modeling*, OCS Study MMS 95-0038, MMS, Gulf of Mexico OCS Region, New Orleans, La., Aug.

MMS, 1996, *Beaufort Sea Planning Area Oil and Gas Lease Sale 144, Final Environmental Impact Statement*, OCS EIS/EA MMS 96-0012, USDOI/MMS, Alaska OCS Region, Anchorage, Alaska.

MMS, 1996a, *Cook Inlet Planning Area Oil and Gas Lease Sale 149, Final Environmental Impact Statement*, OCS EIS/EA MMS 95-0066, Alaska Outer Continental Shelf Region, Anchorage, Alaska, Jan.

MMS, 1996b, *Outer Continental Shelf Oil & Gas Leasing Program: 1997-2002, Final Environmental Impact Statement*, OCS EIS/EA, MMS 96-0043, MMS, Environmental Projects Coordination Branch, Herndon, Va.

MMS, 1997a, *Beaufort Sea Planning Area Oil and Gas Lease Sale 170, Draft Environmental Impact Statement*, OCS EIS/EA MMS 97-0011, MMS, Alaska OCS Region, Anchorage, Alaska, May.

MMS, 1997b, *Gulf of Mexico OCS Oil and Gas Lease Sales 169, 172, 175, 178, and 182, Central Planning Area, Final Environmental Impact Statement*, OCS EIS/EA 97-0033, MMS, Gulf of Mexico OCS Region, New Orleans, La., Nov.

MMS, 1998, *Beaufort Sea Planning Area, Oil and Gas Lease Sale 170, Final Environmental Impact Statement*, OCS EIS/EA, MMS 98-0002, Minerals Management Service, Alaska Outer Continental Shelf Region, Anchorage, Alaska.

MMS, 2001a, *Sediment Quality in Depositional Areas of Shelikof Strait and Outermost Cook Inlet,* OCS Study MMS 2000-024, Alaska Outer Continental Shelf Region, Anchorage, Alaska.

MMS, 2001b, *Brief Overview of Gulf of Mexico OCS Oil and Gas Pipelines: Installation, Potential Impacts, and Mitigation Measures*, OCS Report, MMS 2001-067, Gulf of Mexico OCS Region, New Orleans, La.

MMS, 2001c, *Gulf of Mexico OCS Oil and Gas Lease Sale 181, Eastern Planning Area, Final Environmental Impact Statement*, OCS EIS/EA MMS 2001-051, MMS, Gulf of Mexico OCS Region, New Orleans, La, June.

MMS, 2001d, *Programmatic Environmental Assessment for Grid 10 Site-Specific Evaluation of BP Exploration and Production Inc.'s Joint Initial Development Operations Coordination Document*, N-7216 Holstein Project Green Canyon Blocks 644 and 645. Available at http://scholar.google.com/scholar?hl=en&lr=&q=cache: ai_wARiqbbYJ:mms.gov/homepg/regulate/environ/nepa/grid10ea.pdf+link:IuAQ9j0cEg4J:scholar.google.com/#25. Accessed Oct. 2005.

MMS, 2002a, *Outer Continental Shelf Oil & Gas Leasing Program: 2002-2007, Final Environmental Impact Statement*, OCS EIS/EA MMS 2002-006, Minerals Management Service, Herndon, Va., April. 2 vols.

MMS, 2002b, *Oil Spill Risk Analysis: Cook Inlet Planning Area, OCS Lease Sales 191 and 199,* OCS Report MMS 2002-074, MMS, Environmental Division, Herndon, Va.

MMS, 2002c, *Liberty Development and Production Plan, Final Environmental Impact Statement*, OCS Report 2002-019, Minerals Management Service, Alaska OCS Region, Anchorage, Alaska, May.

MMS, 2002d, *Environmental Sensitivity Index Shoreline Classification of the Alaskan Beaufort Sea and Chukchi Sea*, OCS Study MMS 2003-006, prepared for MMS, Alaska OCS Region, by Research Planning, Inc.

MMS, 2003a, *Alaska Outer Continental Shelf, Cook Inlet Planning Area, Oil and Gas Lease Sales 191 and 199, Final Environmental Impact Statement*, OCS EIS/EA MMS 2003-055, Minerals Management Service, Alaska OCS Region, Anchorage.

MMS, 2003b, *Vessel Strike Avoidance and Injured/Dead Protected Species Reporting: Notice to Lessees and Operators of Federal Oil, Gas, and Sulphur Leases in the Outer Continental Shelf, Gulf of Mexico OCS Region*. June 19. Available at http://www.ocsbbs.com/ntls/ntl04-g01.asp. Accessed April 15, 2011.

MMS 2003c, *Official Trnscript – Public Hearing Homer, Minerals Management Office, January 23, 2003, Draft Environmental Impact Statement for Cook Inlet Planning Area Oil and Gas Lease Sales 191 and 199*, transcribed by S. Hile, Computer Matrix Court Reporters, LLC, Anchorage, Alaska.

MMS, 2003d, *Final Environmental Impact Statement for Lease Sales 189 and 197*, Volumes I & II, OCS Study OCS EIS/EA MMS 2003-020, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La.

MMS, 2003e, *Alaska Outer Continental Shelf Beaufort Sea Planning Area Oil and Gas Lease Sales 186, 195, and 202 Final Environmental Impact Statement*, OCS EIS/EA MMS 2003-001, Minerals Management Service, Alaska OCS Region, Anchorage, Alaska, Feb.

MMS, 2004a, *Geological and Geophysical Exploration for Mineral Resources on the Gulf of Mexico Outer Continental Shelf, Final Programmatic Environmental Assessment*, OCS EIS/EA MMS 2004-054, Gulf of Mexico Outer Continental Shelf Region, New Orleans, La.

MMS, 2004b, *Implementation of Seismic Survey Mitigation Measures and Protected Species Observer Program: Notice to Lessees and Operators of Federal Oil, Gas, and Sulphur Leases in the Outer Continental Shelf, Gulf of Mexico OCS Region*, March 1. Available at http://www.ocsbbs.com/ntls/ntl04-g01.asp. Accessed April 15, 2011.

MMS, 2004c, *Environmental Assessment Proposed Oil and Gas Lease Sale 195 Beaufort Sea Planning Area*, OCS EIS/EA MMS 2004-028, Minerals Management Service, Alaska OCS Region, Anchorage, Alaska, July.

MMS, 2005a, "A Hurricane on the OCS: Planning for Worst," *MMS Ocean Science* 2(6):4.

MMS, 2005b, "Powerful New Lessons: Hurricanes on the OCS," *MMS Ocean Science* 2(6):10–11.

MMS, 2005c, "Taking Another Look: Ivan the Terrible," *MMS Ocean Science* 2(6):6.

MMS, 2005d, *Programmatic Environmental Assessment: Structure-Removal Operations on the Gulf of Mexico Outer Continental Shelf*, OCS EIS/EA 2005-013, Gulf of Mexico OCS Region, New Orleans, La.

MMS, 2005e, *Proposed Geophysical Survey, Cosmopolitan Unit, Cook Inlet. Environmental Assessment*, OCS EIS/EA, MMS 2005-045. U.S. Department of the Interior, Minerals Management Service, Alaska OCS Region.

MMS, 2006a, *Gulf of Mexico OCS Oil and Gas Lease Sales: 2007-2012, Western Planning Area Sales 204, 207, 210, 215, and 218 and Central Planning Area Sales 205, 206, 208, 213, 216, and 222, Draft Environmental Impact Statement*, MMS 2006-062, Minerals Management Service Gulf of Mexico OCS Region, Nov. Available at http://www.gomr.boemre.gov/PDFs/2006/2006-062-Vol1.pdf. Accessed April 22, 2011.

MMS, 2006b, *Outer Continental Shelf Oil and Gas Leasing Program: 2007-2012, Draft Environmental Impact Statement*, July.

MMS, 2006c, *Programmatic Environmental Assessment on Arctic Ocean Outer Continental Shelf Seismic Surveys – 2006*, OCS EIS/EA MMS 2006-019, MMS, Alaska OCS Region, Anchorage, Alaska.

MMS, 2007a, *Alaska Outer Continental Shelf Chukchi Sea Planning Area, Oil and Gas Lease Sale Area 193 and Seismic Surveying Activities in the Chukchi Sea Final Environmental Impact Statement*, OCS EIS/EA MMS 2007-026, Minerals Management Service, Alaska OCS Region, Anchorage, Alaska.

MMS, 2007b, *Gulf of Mexico OCS Oil and Gas Lease Sales: 2007-2012 Final Environmental Impact Statement*, OCS EIS/EA MMS 2007-018, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans.

MMS, 2007c, *Outer Continental Shelf Oil and Gas Leasing Program: 2007-2012, Final Environmental Impact Statement*, Volume I, OCS EIS/EA, MMS 2007-003, April.

MMS, 2007d, *Programmatic Environmental Impact Statement for Alternative Energy Development and Production and Alternate Use of Facilities on the Outer Continental Shelf (Final*), OCS EIS/EA MMS 2007-046, Oct.

MMS, 2007e, *Outer Continental Shelf Oil and Gas Leasing Program: 2007-2012, Final Environmental Impact Statement*, Vol. II, OCS EIS/EA, MMS 2007-003, April.

MMS, 2008a, *Gulf of Mexico OCS Oil and Gas Lease Sales: 2009-2012, Central Planning Area Sales 208, 213, 216, and 222, Western Planning Area Sales 210, 215, and 218, Final Supplemental Environmental Impact Statement*, OCS EIS/EA, MMS 2008-41, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La., Sept. Available at http://www.gomr.boemre.gov/PDFs/2008/2008-041.pdf. Accessed April 22, 2011.

MMS, 2008b, *Alaska Outer Continental Shelf Beaufort Sea and Chukchi Planning Areas Oil and Gas Lease Sales 209, 212, 217, and 221, Draft Environmental Impact Statement*, OCS EIS/EA MMS 2008-055, Minerals Management Service, Alaska OCS Region, Nov.

MMS, 2008c, *Design Options for Offshore Pipelines in the U.S. Beaufort and Chukchi Seas*, Report R-07-078-519, April.

MMS, 2009a, *Possible Effects of OCS Gas and Oil Activities on the California Gray Whale*, Minerals Management Service, Pacific OCS Region.

MMS, 2009b, *Arctic Oil Spill Response Research and Development Program – A Decade of Achievement*.

MMS, 2010, *Chukchi Sea Planning Area – Oil and Gas Lease Sale 193 in the Chukchi Sea, Alaska, Draft Supplemental Environmental Impact Statement*, OCS EIS/EA BOEMRE 2010-034, Alaska OCS Region Office of Leasing and Environment.

Mitchell, D.A., W.J. Teague, E. Jarosz, and D.W. Wang, 2005, "Observed Currents over the Outer Continental Shelf during Hurricane Ivan," *Geophysical Research Letters* 32:L11610.

Mobley, C.M., J.C. Haggarty, C.J. Utermohle, M. Eldridge, R.E. Reanier, A. Crowell, B.A. Ream, D.R. Yesner, J.M. Erlandson, and P.E. Buck, 1990, *The 1989* Exxon Valdez *Cultural Resource Program*, Exxon Shipping Company and Exxon Company, USA (a Division of Exxon Corporation), Anchorage, Alaska.

Moein, S.E., J.A. Musick, J.A. Keinath, D.E. Barnard, M.L. Lenhardt, and R. George, 1995, "Evaluation of Seismic Sources for Repelling Sea Turtles from Hopper Dredges," pp. 90–93 in *Sea Turtle Research Program: Summary Report*, L.Z. Hales (comp.), Technical Report CERC-95, prepared for U.S. Army Engineer Division, South Atlantic, Atlanta, Ga., and U.S. Naval Submarine Base, Kings Bay, Ga.

Moles, A., and B.L. Norcross, 1998, "Effects of Oil-Laden Sediments on Growth and Health of Juvenile Flatfishes," *Canadian Journal of Fisheries and Aquatic Sciences* 55:605–610.

Molnia, B.F., et al., 1979, "Gas-Charged Sediment Areas in the Northern Gulf of Alaska," in *Geological Survey Research 1979*, U.S. Geological Survey Professional Paper 1150.

Montagna, P.A., and P.E. Harper, Jr., 1996, "Benthic Infaunal Longterm Response to Offshore Production Platforms in the Gulf of Mexico," *Can. J. Fish. Aquat. Sci.* 53:2567–2588.

Morison, J., K. Aagaard, and M. Steele, 2000, "Recent Environmental Changes in the Arctic: A Review," *Arctic* 53(4):359–371.

Morreale, S.J., and E.A. Standora, 1998, *Early Life Stage Ecology of Sea Turtles in Northeastern U.S. Waters*, NOAA Technical Memorandum NMFS-SEFSC-413.

Morreale, S.J., E.A. Standora, J.R. Spotila, and F.V. Paladino, 1996, "Migration Corridor for Sea Turtles," *Nature* 384:319–320.

Motavalli, J., 2010, Cellulosic Ethanol's Time May Finally Have Come. BNET. Available at http://www.bnet.com/blog/electric-cars/cellulosic-ethanol-8217s-time-may-finally-have-come/1475. Accessed August 20, 2011.

Moulton, V.D., W.J. Richardson, and M.T. Williams, 2003, "Ringed Seal Densities and Noise near an Icebound Artificial Island with Construction and Drilling," *Acoustics Research Letters Online* 4(4):112–117.

Mrosovksy, N., 1972, "Spectrographs of the Sounds of Leatherback Turtles," *Herpetologica* 28:256–258.

Muench, R., and J. Schumacher, 1980, *Physical Oceanographic and Meteorologic Conditions in the Northwest Gulf of Alaska*, NOAA Technical Memorandum ERL PMEL-22 USDOC/NOAA, PMEL, NOAA (National Oceanic and Atmospheric Administration), Seattle, Wash.

Mulherin, N.D., W.B. Tucker III, O. Smith, and W. Lee, 2001, *Marine Ice Atlas for Cook Inlet, Alaska*, ERDC/CRREL Technical Report 01-10, USACE, CRREL (Cold Regions Research and Engineering Laboratory), Hanover, N.H.

Municipality of Anchorage, 2011, *Port of Anchorage*. Available at http://www.muni.org/departments/port/pages/default.aspx. Accessed on July 18, 2011.

Muller-Karger, F.E., F. Vukovich, R. Leben, B. Nababan, C. Hu, and D. Myhre, 2001, *Surface Circulation and the Transport of the Loop Current into the Northeastern Gulf of Mexico*, OCS Study, MMS 2001-102, MMS, Gulf of Mexico OCS Region, New Orleans, La.

Murphy, S.M., R.H. Day, J.A. Wiens, and K.R. Parker, 1997, "Effects of the *Exxon Valdez* Oil Spill on Birds: Comparison of Pre- and Post-Spill Surveys in Prince William Sound, Alaska," *The Condor* 99: 299–313.

Murton, J.B., 2008 "Global Warming and Thermokarst," in *Soil Biology: Permafrost Soils*, R. Margesin (ed.), Springer, 185–204.

Nakatani, R.E., and A.E. Nevissi, 1991, "Effect of Prudhoe Bay Crude Oil on the Homing of Coho Salmon in Marine Waters," *North American Journal of Fisheries Management* 11:160–166.

National Academy of Sciences, 1983, *Drilling Discharges in the Marine Environment*, Coastal Zone Information Center. Available at http://www.gpo.gov/fdsys/pkg/CZIC-td195-p4-n36-1983/html/CZIC-td195-p4-n36-1983.htm. Accessed July 11, 2011.

National Climatic Data Center (NCDC). 2011. *2010 Local Climatological Data, Annual Summary with Comparative Data, Barrow, Alaska (PABR)*. National Oceanic and Atmospheric Administration. Available at http://www7.ncdc.noaa.gov/IPS/lcd/lcd.html. Accessed May 27, 2011.

National Commission (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling), 2011, *Deep Water, The Gulf Oil Disaster and the Future of Offshore Drilling, Report to the President*, Jan.

National Science Foundation and USGS (U.S. Geological Survey), 2010, *Draft Programmatic Environmental Impact Statement/Overseas Environmental Impact Statement for Marine Seismic Research Funded by the National Science Foundation or Conducted by the U.S. Geological Survey*, Oct. Available at http://www.nsf.gov/geo/oce/envcomp/peis_marine_seismic_research/nsf-usgs_draft_prog_eis-oies_oct_2010.pdf. Accessed June 24, 2011.

N.C. Solar Center and Interstate Renewable Energy Council, undated, *Database of State Incentives for Renewables & Efficiency*. Available at http://www.dsireusa.org/. Accessed August 21, 2011.

NCDC (National Climatic Data Center), 2011a, *2010 Local Climatological Data, Annual Summary with Comparative Data, Kodiak, Alaska (PADQ)*, National Oceanic and Atmospheric Administration. Available at http://www7.ncdc.noaa.gov/IPS/lcd/lcd.html. Accessed May 27, 2011.

Neal, C.A., T.L. Murray, J.A. Power, J.N. Adleman, P.M. Whitmore, and J.M. Osiensky, 2011, "Hazard Information Management, Interagency Coordination, and Impacts of the 2005–2006 Eruption of Augustine Volcano," Chapter 28 in *The 2006 Eruption of Augustine Volcano, Alaska*, J.A. Powers et al. (eds.), U.S. Geological Survey Professional Paper 1769.

Neff, J.M., N.N. Rabalais, and D.F. Boesch, 1987, "Offshore Oil and Gas Development Activities Potentially Causing Long-Term Environmental Effects," pp. 149–174 in *Long Term Effects of Offshore Oil and Gas Development*, D.F. Boesch and N.N. Rabalais, (eds.), Elsevier Applied Science Publishers, London.

Neff, J.M., 1997a, "Metals and Organic Chemicals Associated with Oil and Gas Well Produced Water: Bioaccumulation, Fates, and Effects in the Marine Environment," in *Gulf of Mexico Produced Water Bioaccumulation Study,* report prepared by Continental Shelf Associates, Inc., Jupiter, Fla., for the Offshore Operators Committee.

Neff, J.M., 1997b, "Ecotoxicology of Arsenic in the Marine Environment," *Environmental Toxicology and Chemistry* 16:917–927.

Neff, J.M., 2002, *Bioaccumulation in Marine Organisms, Effects of Contaminants from Oil Well Produced Water*, Elsevier Science Ltd., United Kingdom.

Neff, J.M., 2005, *Composition, Environmental Fates, and Biological Effects of Water-Based Drilling Muds and Cuttings Discharged to the Marine Environment: A Synthesis and Annotated Bibliography*, prepared for Petroleum Environmental Research Forum (PERF) and American Petroleum Institute.

Neff, J.M., and W.A. Stubblefield, 1995, "Chemical and Toxicological Evaluation of Water Quality Following the Exxon Valdez Oil Spill," in *Exxon Valdez Oil Spill: Fate and Effects in Alaskan Waters*, P.G. Wells, J.M. Butler, and J.S. Hughes (eds.), ASTM STP 1219, American Society for Testing and Materials, Philadelphia, Pa.

Neff & Associates, 2010, *Continuation of the Arctic Nearshore Impact Monitoring in the Development Area (cANIMIDA): Synthesis, 1999–2007: Final Report*, prepared for Bureau of Ocean Energy Management, Regulation and Enforcement, Alaska Outer Continental Shelf Region, Anchorage, Alaska.

Neff, J.M., S. McKelvie, and R.C. Ayers, 2000, *Environmental Impacts of Synthetic Based Drilling Fluids*, OCS Study MMS 2000-064, prepared by Robert C. Ayers and Associates, Inc., for Minerals Management Service, Gulf of Mexico Outer Continental Shelf Region, New Orleans, La., August.

Neff, J.M., A.D. Hart, J.P. Ray, J.M. Limia, and T.W. Purcell, 2005, *An Assessment of Seabed Impacts of Synthetic-Based Drilling-Mud Cuttings in the Gulf of Mexico*, SPE 94086, paper presented at the 2005 SPE/EPA/DOE Exploration and Production Environmental Conference, Galveston, Texas, March 7–9.

Nelson, R.H., 1991, "Salt Tectonics and Listric-Normal Faulting," in *The Gulf of Mexico Basin*, A. Salvador (ed.), Geological Society of America, *The Geology of North America* Vol. J, pp. 73–89.

Neurauter T.W., and W.R. Bryant, 1990, "Seismic Expression of Sedimentary Volcanism on the Continental Slope, Northern Gulf of Mexico," *Geo-Marine Letters* 10:225–231.

Nicholls, R.J., P.P. Wong, V.R. Burkett, J.O. Codignotto, J.E. Hay, R.F. McLean, S. Ragoonaden, and C.D. Woodroffe, 2007, "Coastal Systems and Low-Lying Areas," pp. 315–356 in *Climate Change 2007: Impacts, Adaptation and Vulnerability, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson (eds.), Cambridge University Press, Cambridge, U.K.

Nieukirk, S.L., K.M. Stafford, D.K. Mellinger, R.P. Dziak, and C.G. Fox, 2004, "Low Frequency Whale and Seismic Airgun Sounds Recorded in the Mid-Atlantic Ocean," *Journal of the Acoustical Society of America* 115(4):1832–1843.

Nighswander, T.S., and N. Peacock, 1999, "The Communication of Health Risk from Subsistence Food in a Cross Cultural Setting: Lessons Learned from the Exxon Valdez Oil Spill," in *Evaluating and Communicating Subsistence Seafood Safety in a Cross-Cultural Context*, L.J. Field, J.A. Fall, T.S. Nighswander, N. Peacock, and U. Varanasi (eds.), SETAC Press, Pensacola, Fla.

Nightingale, B., and C.A. Simenstad, 2001, *White Paper: Dredging Activities: Marine Issues (Executive Summary)*, Research Project T1803, Task 35, University of Washington, prepared for the Washington State Transportation Commission in cooperation with the U.S. Department of Transportation, July.

Nikolopoulos, A., R.S. Pickart, P.S. Fratantoni, K. Shimada, D.J. Torres, and and E.P. Jones, 2009, "The Western Arctic Boundary Current at 152°W: Structure, Variability, and Transport," *Deep Sea Rersearch II* 56:1164–1181.

Niven, K., and R. McLeod, 2009, "Offshore Industry: Management of Health Hazards in the Upstream Petroleum Industry," *Occupational Medicine* 59 (5):304–309.

NMFS (National Marine Fisheries Service), 1988, *Consultation for Removal of Certain Outer Continental Shelf Oil and Gas Structures in the Gulf of Mexico. Biological Opinion*. National Marine Fisheries Service, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Washington, D.C. Issued July 25, 1988.

NMFS, 2001, *Endangered Species Act – Section 7 Consultation Biological Opinion on the Construction and Operation of the Liberty Oil Production Island*, Alaska Regional Office, Office of Protected Resources, Anchorage, Alaska.

NMFS, 2005, *Recovery Plan for the North Atlantic Right Whale (Eubalaena glacialis)*, National Marine Fisheries Service, Silver Spring, Md.

NMFS, 2006, *National Marine Fisheries Service's Biological Opinion for Federal Oil and Gas Leasing and Exploration by the Minerals Management Service within the Alaskan Beaufort and Chukchi Seas*, National Marine Fisheries Service Juneau, Alaska, June 16.

NMFS, 2008a, "Endangered and Threatened Species; Endangered Status for the Cook Inlet Beluga Whale," *Federal Register* 73(205):62919–62930.

NMFS, 2008b, "Taking of the Cook Inlet, Alaska Beluga Whale Stock by Alaska Natives," *Federal Register* 73(200):60976–60986.

NMFS, 2008c, *Conservation Plan for the Cook Inlet Beluga Whale (Delphinapterus leucas)*, National Marine Fisheries Service, Juneau, Alaska, October. Available at http://www.fakr.noaa.gov/protectedresources/whales/beluga/mmpa/final/cp2008.pdf. Accessed on March 17, 2011.

NMFS, 2011a, *Dolphins and Whales and the Gulf of Mexico Oil Spill*, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Md. Available at http://www.nmfs.noaa.gov/pr/health/oilspill/mammals.htm. Accessed July 1, 2011.

NMFS, 2011b, *Marine Mammals Unusual Mortality Events*, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Md. Available at http://www.nmfs.noaa.gov/pr/health/mmume. Accessed September 7, 2011.

NMFS and USFWS (National Marine Fisheries Service and the U.S. Fish and Wildlife Service), 2008, *Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle (*Caretta caretta*)*, Second Revision, December 8.

NOAA (National Oceanic and Atmospheric Administration), 1994, *Shoreline Countermeasures Manual, Alaska*, NOAA Hazardous Materials Response and Assessment Division.

NOAA, 1995, *Gulf of Mexico Land-Based Pollution Sources Inventory — Point Sources and Non-Point Sources of Pollution*.

NOAA, 1997, *Integrating Physical and Biological Studies of Recovery from the* Exxon Valdez *Oil Spill, Case Studies of Four Sites in Prince Wiliam Sound, 1989-1994*, NOAA Technical Memorandum NOS ORCA 114.

NOAA, 1998, *Oil Spill Impacts and the Biological Basis for Response Guidance: An Applied Synthesis of Research on Three Subarctic Intertidal Communities*, Technical Memorandum NOS ORCA 125.

NOAA, 2000, *Characteristic Coastal Habitats, Choosing Spill Response Alternatives*, National Ocean Service, Office of Response and Restoration, Hazardous Materials Response Division.

NOAA, 2002, *Trajectory Analysis Handbook*, technical report, NOAA Ocean Service, Office of Response and Restoration, Hazardous Materials Response Division, Seattle, Wash.

NOAA, 2003, *Oil and Sea Turtles*, G. Shigenaka (ed.), NOAA National Ocean Service, Office of Response and Restoration, Washington, D.C.

NOAA, 2005, *Trajectory Analysis Handbook*, Office of Response and Restoration, Hazardous Materials Response Division, Seattle, Wash. Available at http://response.restoration.noaa.gov/. Accessed February 2005. (will need to update the above with data from DWH)

NOAA, 2010a, *Sea Turtle Strandings and the Deepwater Oil Spill*. Available at http://www.noaa.gov/factsheets/new%20version/sea_turtles.pdf. Accessed April 15, 2011.

NOAA, 2010b, *Deepwater BP Oil Spill, Natural Resource Damage Assessment (NRDA), NRDA By the Numbers – November 1, 2010*. Available at http://www.gulfspillrestoration.noaa.gov/wp-content/uploads/2010/11/FINAL-NRDA_by_the_Numbers_11.03.pdf.pdf. Accessed November 10, 2010.

NOAA, 2010c, *Sea Turtles, Dolphins, and Whales and the Gulf of Mexico Oil Spill. Turtles Documented by Species*. Available at http://www.nmfs.noaa.gov/pr/health/oilspill/turtles.htm. Accessed November 23, 2010.

NOAA, 2010d, "Intent to Prepare a Supplemental Environmental Impact Statement on the *Exxon Valdez* Oil Spill Trustee Council's Restoration Efforts," *Federal Register* 75:3706–3709.

NOAA, 2010e, *NOAA's Oil Spill Response Effects of Oil on Marine Mammals and Sea Turtles*. Available at http://www.noaa.gov/factsheets/new%20version/marinemammals_seaturtles.pdf. Accessed January 24, 2011.

NOAA, 2011a, *Ice Breakup Reconnaissance in Alaska*, National Weather Service, Alaska-Pacific River Forecast Center. Available at http://aprfc.arh.noaa.gov/resources/docs/brkup.php. Accessed June 2, 2011.

NOAA, 2011b, *Storm Surge Overview*, National Weather Service, National Hurricane Center. Available at http://www.nhc.noaa.gov/ssurge/ssurge_overview.shtml. Accessed May 18, 2011.

NOAA, 2011c, *The Gulf Region's Contribution to U.S. Energy Production*. Available at http://stateofthecoast.noaa.gov/energy/gulfenergy.html. Accessed July 18, 2011.

NOAA, 2011d, *Responding to Oil Spills – In Situ Burning – Questions about Environmental Impacts – What Are the Potential Ecological Effects of In-Situ Burning (ISB)*, NOAA Office of Response and Restoration website. Available at http://response.restoration.noaa.gov. Accessed September 7, 2011.

Nodine, M.C., et al., 2006, *Mudslides during Hurricane Ivan and an Assessment of the Potential for Future Mudslides in the Gulf of Mexico*, Offshore Technology Research Center, Texas A&M University, College Station, Texas.

Northern Economics, 1993, *Commercial Fishing Industry of the Gulf of Alaska*, Technical Report No. 159, prepared for the MMS, Alaska OCS Office, Alaska OCS Socioeconomic Studies Program, Anchorage, Alaska.

Nomack, M., 2010, "Effects of Oil on Wildlife and Habitat," in *The Encyclopedia of Earth*, C.J. Cleveland (topic ed.), Environmental Information Coalition, National Council for Science and the Environment, Washington, D.C. Available at http://www.eoearth.org/articles/view/158446/?topic=50359. Accessed March 15, 2011.

Nova Institute, 2009, *Bioplastics Market Worldwide 2007-2025*. Available at http://innovation-bioplastique.com/2009/02/13/bioplastics-market-worldwide-2007-2025/. Accessed August 2011.

Novozymes Bioenergy, 2011, *The POET/Novozymes Collaboration*. Available at http://www.bioenergy.novozymes.com/cellulosic-ethanol/partner-case-studies/poet/the-poet-novozymes-collaboration/. Accessed August 20, 2011.

Nowacek, S.M., and R.S Wells, 2001, "Short-Term Effects of Boat Traffic on Bottlenose Dolphins, *Tursiops truncatus*, in Sarasota Bay, Florida," *Marine Mammal Science* 17:673–688.

Nowacek, S.M., R.S. Wells, E.C.G. Owen, T.R. Speakman, R.O. Flamm, and D.P. Nowacek, 2004, "Florida Manatees, *Trichechus manatus latirostris*, Respond to Approaching Vessels," *Biological Conservation* 119:517–523.

Nowlin, W.D. Jr., A.E. Jochens, R.O. Reid, and S.F. DiMarco, 1998, *Texas-Louisiana Shelf Circulation and Transport Processes Study: Synthesis Report, Volume I: Technical Report*, OCS Study MMS 98-0035, MMS, Gulf of Mexico OCS Region, New Orleans, La.

Nowlin, W.D., Jr., A.F. Jochens, S.F. DiMarco, and R.O. Reid, 2000, "Chapter 4: Physical Oceanography, in *Deepwater Gulf of Mexico Environmental and Socioeconomic Data Search and Literature Synthesis, Volume I: Narrative Report*, Continental Shelf Associates (eds.), OCS Study MMS 2000-049, MMS, Gulf of Mexico OCS Region, New Orleans, La.

NRC (National Research Council), 1983, *Drilling Discharges in the Marine Environment. Panel on Assessment of Fates and Effects of Drilling Fluids and Cuttings in the Marine Environment*. Marine Board, Commission on Engineering and Technical Systems, National Research Council, National Academy Press, Washington, D.C.

NRC, 1990, *Decline of Sea Turtles: Causes and Prevention*, National Academy Press, Washington, D.C.

NRC, 1992, *Rethinking the Ozone Problem in Urban and Regional Air Pollution*, National Academy Press, Washington, D.C.

NRC, 2003a, *Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope*, National Academies Press, Washington, D.C.

NRC, 2003b, *Oil in the Sea III: Inputs, Fates, and Effects*, Committee on Oil in the Sea: Inputs, Fates, and Effects, Ocean Studies Board and Marine Board, Divisions of Earth and Life Studies and Transportation Research Board, National Research Council, National Academies Press, Washington, D.C.

NRC, 2003c, *Ocean Noise and Marine Mammals*, National Academies Press, Washington, D.C.

NRC, 2005a, *Marine Mammal Populations and Ocean Noise: Determining When Noise Causes Biologically Significant Effects*, National Academies Press, Washington, D.C.

NRC, 2005b, *Oil Spill Dispersants – Efficacy and Effects*, National Academies Press, Washington, D.C.

NRC, 2010, *Transitions to Alternative Transportation Technologies—Plug-in Hybrid Electric Vehicles*. Available at http://www.nap.edu/catalog.php?record_id=12826. Accessed August 20, 2011.

NREL (National Renewable Energy Laboratory), 2007, *Validation of Hydrogen Fuel Cell Vehicle and Infrastructure Technology*, October. Available at http://www.afdc.energy.gov/afdc/pdfs/42284.pdf. Accessed August 20, 2011.

NREL, 2010, *Large-Scale Offshore Wind in the United States: Assessment of Opportunities and Barriers*, National Renewable Energy Laboratory, Golden, Colo. Available at http://www.nrel.gov/wind/pdfs/40745.pdf. Accessed September 12, 2011.

NSF and USFGS (National Science Foundation and U.S. Geological Survey), 2010, *Draft Programmatic EIS for Marine Seismic Research Funded by the National Science Foundation or Conducted by the U.S. Geological Survey*, draft, October.

Nugues, M.M., and C.M. Roberts, 2003, "Partial Mortality in Massive Reef Corals as an Indicator of Sediment Stress on Coral Reefs," *Marine Pollution Bulletin* 46:314–323.

Nuka Research and Planning Group, 2007, *Oil Spill Response Challenges in Arctic Waters*, report commissioned and published by WWF International Arctic Programme, Oslo, Norway, Oct. Available at http://wwf.panda.org/what_we_do/where_we_work/arctic/publications/?122240/Oil_Spill_Response_Challenges_in_Arctic_waters. Accessed July 11, 2011.

Nuka Research and Planning Group, LLC and Pearson Consulting, LLC, 2010, *Oil Spill Prevention and Response in the U.S. Arctic Ocean: Unexamined Risks, Unacceptable Consequences*, Commissioned by U.S. Arctic Program, Pew Environment Group.

Oey, L.Y., 2008, "Loop Current and Deep Eddies," *Journal of Physical Oceanography* 38(7):1426–1449.

Oey, L.Y., P. Hamilton, and H.C. Lee, 2004, *Modeling and Data Analyses of Circulation Processes in the Gulf of Mexico*, OCS Study, MMS 2003-074, MMS, Gulf of Mexico OCS Region, New Orleans, La.

Oey, L.Y., T. Ezer, and H.C. Lee, 2005, "Loop Current, Rings and Related Circulation in the Gulf of Mexico: A Review of Numerical Models and Future Challenges," in *Circulation in the Gulf of Mexico: Observations and Models*, Volume 161 of Geophysical Monograph Series, W. Sturges and A. Lugo-Fernandez (eds.), American Geophysical Union, Washington, D.C.

Oey, L.-Y., T. Ezer, C. Hu, and F.E. Muller-Karger, 2007, "Baroclinic Tidal Flows and Inundation Processes in Cook Inlet, Alaska: Numerical Modeling and Satellite Observations" *Ocean Dynamics* 57(3):205–221.

O'Hara, J., and J.R. Wilcox, 1990, "Avoidance Responses of Loggerhead Turtles, *Caretta caretta*, to Low Frequency Sound," *Copeia* 1990(2):564–567.

Ohnsman, A., 2010, "Toyota Targets $50,000 Price for First Hydrogen Car," *Bloomberg Businessweek*, May 6, 2010.

Okkonen, S., S. Pegau, and S. Saupe, 2009, *Seasonality of Boundary Conditions for Cook Inlet*, OCS study, MMS 2009-041, Alaska Coastal Marine Institute, University of Alaska.

Okkonen, S.R., C.J. Ashjian, R.G. Campbell, W. Maslowski, J.L. Clement-Kinney, and R. Potter, 2009, "Intrusion of Warm Bering/Chukchi Waters onto the Shelf in the Western Beaufort Sea," *Journal of Geophysical Research* 114:C00A11.

Online Code Environment & Advocacy Network, undated, *Code Status*. Available at http://www.bcap-energy.org/node/5. Accessed August 20, 2011.

OSAT (Operational Science and Advisory Team of the Unified Area Command), 2010, *Summary Report for Sub-Sea and Sub-Surface Oil and Dispersant Detection: Sampling and Monitoring*, Dec. 17.

OSAT, 2011, *Summary Report for Fate and Effects of Remnant Oil in the Beach Environment*, prepared for L.D. Stroh, Capt., U.S. Coast Guard, Federal On-Scene Coordinator, Deepwater Horizon MC252, Feb. 10. Available at http://www.restorethegulf.gov/sites/default/files/u316/OSAT-2%20Report%20no%20ltr.pdf. Accessed March 17, 2011.

OSAT-2 (Operational Science and Advisory Team-2 of the Unified Area Command), 2011, *Summary Report for Fate and Effects of Remnant Oil in the Beach Environment*, Gulf Coast Incident Management Team, Feb. 10.

Osborn, S.G., A. Vengosh, N.R. Warner, and R.B. Jackson, 2011, "Methane Contamination of Drinking Water Accompanying Gas-Well Drilling and Hydraulic Fracturing," *PNAS*, Vol. 108, No. 20, May.

Ostermeier, R.M., et al., 2002, "Dealing with Shallow-Water Flow in the Deepwater Gulf of Mexico," *The Leading Edge* 21(7):660–668.

Owens, E., and J. Michel. 2003, "Environmental Sensitivity Index (ESI) Classification for the Beaufort Sea and Chukchi Sea Coasts, Alaska OCS Region," in *Ninth Information Transfer Meeting and Barrow Information Update Meeting, Final Proceedings, March 10, 11, and 12, 2003, Anchorage, Alaska; March 14, 2003, Barrow, Alaska*, OCS Study MMS 2003-042, MMS, Alaska OCS Region.

Page, H.M., J.E. Dugan, C.S. Culver, and J.C. Hoestery, 2006, "Exotic Invertebrate Species on Offshore Oil and Gas Platforms," *Marine Ecology Progress Series* 325:101–107.

Palinkas, L., J. Russell, M. Downs, and J. Petterson, 1992, "Ethnic Differences in Stress, Coping, and Depressive Symptoms after the *Exxon Valdez* Oil Spill," *J. Nerv. Mental Disease* 180:287–295.

Pamplin, W.L., 1979, *Construction-Related Impacts of the Trans-Alaska Pipeline System on Terrestrial Wildlife Habitats*, Special Report Number 24, Joint State/Federal Fish and Wildlife Advisory Team.

Parfomak, P.W., and A. Vann, 2009, *Liquefied Natural Gas (LNG) Import Terminals: Siting, Safety, and Regulation*, Congressional Research Service 7-5700, Dec. 14.

Parkinson, C., D. Cavalieri, P. Gloersen, H. Zwally, and J. Cosimo, 1999, "Arctic Sea Ice Extents, Areas, and Trends, 1978-1996," *Journal of Geophysical Research* 104C(9):20,837–20,856.

Parkinson, C.L., 2000, "Variability of Arctic Sea Ice: The View from Space, an 18-Year Record," *Arctic* 53(4):341–358.

Parks, S.E., C.W. Clark, and P.L. Tyack, 2007, "Short- and Long-term Changes in Right Whale Calling Behavior: The Potential Effects of Noise on Acoustic Communication," *Journal of the Acoustical Society of America* 122:3725–3731.

Payne, J.R., D. McNabb, Jr., and J.R. Clayton, Jr., 1991, "Oil-Weathering Behavior in Arctic Environments," *Polar Research* 10(2):631–662.

Payne, J.R., G.D. McNabb. Jr., L.E. Hachmeister, B.E. Kirstein, J.R. Clayton Jr., C.R. Phillips, R.T. Redding, C.L. Clary, G.S. Smith, and G.H. Farmer, 1987, *Development of a Predictive Model for the Weathering of Oil in the Presence of Sea Ice*, Outer Continental Shelf Environmental Assessment Program, Research Unit 664, MMS.

Payne, J., S. Guyer, and B. Keating, 2003, "The Impact of Ice Roads on Tundra Ecosystems, National Petroleum Reserve, Alaska (NPRA) (Abstract)," in *Draft Proceedings of a Workshop on the Impacts of Winter Exploration Activities on Tundra Soils and Vegetation of Alaska's North Slope*, D. Yokel (ed.), BLM, Fairbanks, Alaska.

Perovich, D.K., J.A. Richeter-Menge, K.F. Jones, and B. Light, 2008, "Sunlight, Water, and Ice: Extreme Arctic Sea Ice Melt during the Summer of 2007," *Geophysical Research Letters* 35(11):L11501.

Perovich, D., W. Meier, J. Maslanik, and J. Richter-Menge, 2010, "Sea Ice Cover: Arctic Report Card: Update for 2010." Available at http://www.arctic.noaa.gov/reportcard/seaice.html. Accessed September 2, 2011.

Peterson, C.H., M.C. Kennicutt II, R.H. Green, P. Montagna, D.E. Harper, Jr., E.N. Powell, and P.F Roscigno, 1996, "Ecological Consequences of Environmental Perturbations Associated with Offshore Hydrocarbon Production: A Perspective on Long-Term Exposures in the Gulf of Mexico," *Canadian Journal of Fisheries and Aquatic Sciences* 53:2637–2654.

Peterson, C.H., 2000, "The *Exxon Valdez* Oil Spill in Alaska: Acute, Indirect, and Chronic Effects on the Ecosystem," *Adv. Mar. Biol.* 39:3–84.

Peterson, C.H., S.D. Rice, J.W. Short, D. Esler, J.L. Bodkin, B.E. Ballachey, and D.B. Irons, 2003, "Long-Term Ecosystem Responses to the *Exxon Valdez* Oil Spill," *Science* 302:2082–2086.

Petrae, G. (ed.), 1995, *Barge Morris J. Berman Spill, NOAA; Scientific Response*, Hazmat Report No. 95-10, National Oceanic and Atmospheric Administration, Hazardous Materials Response and Assessment Division, Seattle, Wash.

Pew Center on Global Climate Change, 2010, *What is Black Carbon?*, April. Available at http://www.pewclimate.org/global-warming-basics/blackcarbon-factsheet. Accessed September 5, 2011.

Pezeshki, S.R., M.W. Hester, Q. Lin, and J.A. Nyman, 2000, "The Effects of Oil Spill and Clean-up on Dominant U.S. Gulf Coast Marsh Macrophytes: A Review," *Environmental Pollution* 108:129–139.

Phillips, R.L., et al., 1988, *Geologic Investigations in the Chukchi Sea, 1984, NOAA Ship SURVEYOR Cruise*, Open File Report 88-25, U.S. Geological Survey.

Piatt, J.F., and P. Anderson,1996, "Response of Common Murres to the *Exxon Valdez* Oil Spill and Long-Term Changes in the Gulf of Alaska Marine Ecosystem," *Proceedings of the Exxon Valdez Oil Spill Symposium*, pp. 720–737, S.D. Rice et al. (eds.), American Fisheries Society Symposium 18, Bethesda, MD.

Piatt, J.F., and R.G. Ford, 1996, "How Many Seabirds Were Killed by the *Exxon Valdez* Oil Spill?," *Proceedings of the Exxon Valdez Oil Spill Symposium*, pp. 712–719. S.D. Rice et al. (eds.), American Fisheries Society Symposium 18, Bethesda, MD.

Pickart, R.S., 2004, "Shelfbreak Circulation in the Alaskan Beaufort Sea: Mean Structure and Variability," *Journal of Geophysical Research* 109(C4):C04024.

Pickart, R.S., L.J. Pratt, D.J. Torres, T.E. Whitledge, A.Y. Proshutinsky, K. Aagaard, T.A. Agnew, G. Moore, and H.J. Dail, 20110, "Evolution and Dynamics of the Flow through Herald Canyon in the Western Chukchi Sea," *Deep-Sea Research Part II: Topical Studies in Oceanography* 57(1-2)5–26.

Picou, S., 2010, *Helping Others: A Community Peer Listener Training Program,* training session presented at Louisiana State University, Baton Rouge, La., July 28. Available at http://gulfseagrant.tamu.edu/oilspill/index.htm. Accessed June 15, 2011.

Picou, J.S., and C. Arata, 1997, "Chronic Psychological Impacts of the Exxon Valdez Oil Spill: Resource Loss and Commercial Fishers," Appendix J in *Coping with Technological Disasters: A User Friendly Guidebook*, Prince William Sound Regional Citizens' Advisory Council, Anchorage, Alaska.

Picou, J.S., and D.A. Gill, 1996, "The *Exxon Valdez* Oil Spill and Chronic Psychological Stress," pp. 879–893 in *Proceedings of the* Exxon Valdez *Oil Spill Symposium*, Anchorage, Alaska, Feb. 2–5, 1993, American Fisheries Society, Bethesda, Md.

Picou, J.S., G.D. Johnson, and D.A. Gill, 1999, "Mitigating the Chronic Community Impacts of Localized Environmental Degradation: A Case Study of the *Exxon Valdez* Oil Spill," Appendix K in *Coping with Technological Disasters: A User Friendly Guidebook,* Prince William Sound Regional Citizens' Advisory Council, Anchorage, Alaska.

Picou, J.S., C. Formichella, B.K. Marshall, and C. Arata, 2009 "Community Impacts of the *Exxon Valdez* Oil Spill: A Synthesis and Elaboration of Social Science Research," pp. 279–310 in *Synthesis: Three Decades of Research on Socioeconomic Effects Related to Offshore Petroleum Development in Coastal Alaska,* S.R. Braud and J. Kruse (eds.), MMS OCS Study No. 2009-006, Stephen R. Braud & Associates, Anchorage, Alaska.

Pike Research, 2009, *Electric Vehicle Batteries — Lithium Ion batteries for Plug-in Hybrid and Battery Electric Vehicles: Market Analysis and Forecast*. Available at http://www.pikeresearch.com/research/electric-vehicle-batteries. Accessed August 20, 2011.

Pimentel, D., L. Lach, R. Zuniga, and D. Morrison. 2000. "Environmental and Economic Costs of Non-Indigenous Species in the United States." *Bioscience* 50(1): 53–65.

Pimentel, D., R. Zuniga, and D. Morrison. 2005. "Update on the Environmental and Economic Costs Associated with Alien-Invasive Species in the United States." *Ecological Economics* 52(3):273–288.

Ping, C.-L., G.J. Michaelson, L. Guo, M.T. Jorgenson, M. Kanevskiy, Y. Shur, F. Dou, and J. Liang, 2011, "Soil Carbon and Material Fluxes across the Eroding Alaska Beaufort Sea Coastline," *Journal of Geophysical Research* 116:G0200.

Pira International, 2010, *The Future of Bioplastics for Packaging to 2020*, December 13. Available at http://www.pira-international.com/pha-and-bio-derived-pe-to-drive-bioplastic-packaging-market-to-2020.aspx. Accessed August 21, 2011.

PlasticsEurope, EuPC, EuPR, and EPRO, 2010, *Plastics – the Facts 2010*. Available at http://www.plasticseurope.org/documents/document/20101006091310-final_plasticsthefacts_28092010_lr.pdf. Accessed August 21, 2011.

Popper, A.N., and M.C. Hastings, 2009, "The Effects of Anthropogenic Sources of Sound on Fishes," *Journal of Fish Biology* 75:455–489.

Potter, R.A., and T.J. Weingartner, 2010, *Surface Circulation Radar Mapping in Alaskan Coastal Waters: Beaufort Sea and Cook Inlet*, OCS Study MMS 2009-049, School of Fisheries and Ocean Sciences, University of Alaska, Fairbanks, Alaska.

Prince, P.K., 1990, "Current Drilling Practice and the Occurrence of Shallow Gas," in *Safety in Offshore Engineering: Proceedings of an International Conference*, April 25–26, London.

Prince, R.C., E.H. Owens, and G.A. Sergy, 2002, "Weathering of an Arctic Oil Spill over 20 Years: The BIOS Experiment Revisited, Baffin Island Oil Spill," *Marine Pollution Bulletin* 44(11):1236–1242.

Proffitt, C.E. (ed.), 1998, *Effects and Management of Oil Spills in Marsh Ecosystems: A Review Produced from a Workshop Convened July 1996 at McNeese State University*, OCS Study MMS 98-0018, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La.

Proshutinsky, A., M.A. Johnson, T.O. Proshutinsky, and J.A. Maslanik, 2003, *Beaufort and Chukchi Sea Seasonal Variability for Two Arctic Climate States*, OCS Study MMS 20030-024, MMS, Fairbanks, Alaska.

Proshutinsky, A., V. Pavlov, and R.H. Bourke, 2001, "Sea Level Rise in the Arctic Ocean," *Geophysical Research Letters* 28(11):2237–2240.

Pugh, R.S., and P.R. Becker, 2001, *Sea Turtle Contaminants: A Review with Annotated Bibliography*, NISTIR 6700, Charleston, S.C.

Pullman, E.R., M.T. Jorgenson, T.C. Cater, W.A. Davis, and J.E. Roth, 2003, *Assessment of Ecological Effects of the 2002-2003 Ice Road Demonstration Project*, unpublished report, ConocoPhilips Alaska, Inc., Anchorage, Alaska.

Quigley, D.C., J.S. Hornafius, B.P. Luyendyk, R.D. Francis, J. Clark, and L. Washburn, 1999, "Decrease in Natural Marine Hydrocarbon Seepage near Coal Oil Point, California, Associated with Offshore Oil Production," *Geology* 27:1047–1050.

Quigley, R., L. den Broeder, P. Furu, A. Bond, B. Cave, and R. Bos, 2006, *Health Impact Assessment International Best Practice Principles*, Special Publication Series No. 5, International Association for Impact Assessment, Fargo.

Rabalais, N.N., 2005, *Relative Contribution of Produced Water Discharge in the Development of Hypoxia*, OCS Study MMS 2005-044, Minerals Management Service, Gulf of Mexico Outer Continental Shelf Region, New Orleans, La.

Rabalais, N.N., L.E. Smith, C.B. Henry, Jr., P.O. Roberts, and E.B. Overton, 1998, *Long-Term Effects of Contaminants from OCS-Produced Water Disharges at Pelican Island Facility, Louisiana*, OCS Study MMS 98-0039. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA.

Rabalais, N.N., B.A. McKee, D.J. Reed, and J.C. Means, 1991, *Fate and Effects of Nearshore Discharges of OCS Produced Waters, Volume II: Technical Report*, OCS Study MMS 91-0005, Minerals Management Service, Gulf of Mexico Outer Continental Shelf Region, New Orleans, La.

Rahn, K.A. 1982. "On the Causes, Characteristics and Potential Environmental Effects of Aerosol in the Arctic Atmosphere," In: *The Arctic Ocean: The Hydrographic Environment and the Fate of Pollutants*, L. Ray (editor), John Wiley and Sons, New York, N.Y., pp.163–195.

Rappeport, M.L., 1982, *An Analysis of Oceanographic and Meteorological Conditions for Central Lower Cook Inlet, Alaska*, U.S. Geological Survey, Open-File Report 82-128.

Ray, G.L., 2005, *Invasive Animal Species in Marine and Estuarine Environments: Biology and Ecology*, ERDC/EL TR-05-2, Aquatic Nuisance Species Research Program, January. Available at http://dodreports.com/pdf/ada430308.pdf. Accessed September 6, 2011.

RDC (Resource Development Council), 2011, *Alaska's Oil and Gas Industry – Background*. Available at http://www.akrdc.org/issues/oilgas/overview.html. Accessed July 19, 2011.

Reger, D.R., J.D. McMahan, and C.E. Holmes, 1992, *Effect of Crude Oil Contamination on Some Archaeological Sites in the Gulf of Alaska, 1991 Investigations*, Office of History and Archaeology Report No. 30, Alaska Department of Natural Resources, Division of Parks and Outdoor Recreation, Anchorage, Alaska.

Regulations for Implementing NEPA. 40 CFR 1508.8; 1978.

Reimnitz, E., and E.W. Kempema, 1982, *High Rates of Bedload Transport Measured from Infilling Rate of Large Strudel-Scour Craters in the Beaufort sea Alaska*, U.S. Geological Survey, Open-File Report 82-588.

Reimnitz, E., and P.W. Barnes, 1974, "Sea Ice as a Geologic Agent on the Beaufort Sea Shelf of Alaska," pp. 301–351in *The Coast and Shelf of the Beaufort Sea*, Arctic Institute of North America, Arlington, Va.

Research Development Council, 2007, *Alaska's Mining Industry – Background*. Available at http://www.akrdc.org/issues/mining/overview.html. Accessed September 25, 2011.

Restore the Gulf, 2010a, *Deepwater Horizon Response Consolidated Fish and Wildlife Collection Report*, November 2. Available at http://www.restorethegulf.gov/sites/default/files/documents/pdf/Consolidated%20Wildlife%20Table%20110210.pdf. Accessed November 10, 2010.

Restore the Gulf, 2010b. *America's Gulf Coast: A Long Term Recovery Plan after the Deepwater Horizon Oil Spill*. Available at http://www.restorethegulf.gov/sites/default/files/documents/pdf/gulf-recovery-sep-2010.pdf. Accessed April 22, 2011.

Reynolds, P.E., K.J. Wilson, and D.R. Klein, 2002, "Section 7: Muskoxen," pp. 54–64 in *Arctic Refuge Coastal Plain Terrestrial Wildlife Research Summaries*, D.C. Douglas, P.E. Reynolds, and E.B. Rhodes (eds.), U.S. Geologic Survey, Biological Resources Division, Biological Science Report USGS/BRD/BSR-2002-0001.

Rhea, S., et al., 2010, *Seismicity of the Earth 1900–2007, Aleutian Arc and Vicinity*, U.S. Geological Survey Open-File Report 2010-1083-B (map sheet 1:5,000,000).

Richards, W.J., and T. Potthoff, 1980, "Distribution and Seasonal Occurrence of Larval Pelagic Stages of Spiny Lobsters (*Palinuridae, Panulirus*) in the Western Tropical Atlantic," *Proceedings of the Gulf and Caribbean Fishery Institute* 33:244–252.

Richards, W.J., M.F. McGowan, T. Leming, J.T. Lampkin, and S. Kelley, 1993, "Larval Fish Assemblages at the Loop Current Boundary in the Gulf of Mexico," *Bulletin of Marine Science* 53:475–537.

Richardson, W.J., and B. Würsig, 1997, "Influences of Man-made Noise and Other Human Actions on Cetacean Behaviour," *Marine and Freshwater Behaviour and Physiology* 29:183–209.

Richardson, W.J., B. Würsig, and C.R. Greene, Jr., 1986, "Reactions of Bowhead Whales, *Balaena mysticetus*, to Seismic Exploration in the Canadian Beaufort Sea," *Journal of the Acoustical Society of America* 79(4):1117–1128.

Richardson, W.J., B. Würsig, and C.R. Greene, Jr., 1990, "Reactions of Bowhead Whales, *Balaena mysticetus*, to Drilling and Dredging Noise in the Canadian Beaufort Sea," *Marine Environmental Research* 29:135–160.

Richardson, W.J., C.R. Greene, Jr., W.R. Koski and M.A. Smultea, with G. Cameron, C. Holdsworth, G. Miller, T. Woodley, and B. Würsig, 1991, *Acoustic Effects of Oil Production Activities on Bowhead and White Whales Visible During Spring Migration Near Pt. Barrow, Alaska – 1990 Phase*, OCS Study MMS 91-0037, report prepared for Minerals Management Service, Herndon, Va. Available at http://www.alaska.boemre.gov/reports/1990rpts/91_0037/91_0037_1.pdf. Accessed May 22, 2011.

Richardson, W.J., C.R. Greene, Jr., C.I. Malme, and D.H. Thomson, 1995, *Marine Mammals and Noise*, Academic Press, San Diego.

Richardson, W.R., G.W. Miller, and C.R. Greene, Jr., 1999, "Displacement of Migrating Bowhead Whales by Sounds from Seismic Surveys in Shallow Waters of the Beaufort Sea," *Journal of the Acoustical Society of America* 106(4):2281.

Richter-Menge and M. Jeffries (eds.), 2010, *The Arctic* in "State of the Climate in 2010," *Bull. Amer. Meteor. Soc*. 92(6):S143–S160.

Ridgway, S.H., E.G. Wever, J.G. McCormick, J. Palin, and J.H. Anderson, 1969, "Hearing in the Giant Sea Turtle, *Chelonia mydas*," *Proc. Nat. Acad. Sci.* 64(3):884–890.

Riedman, M.L., 1983, *Studies of the Effects of Experimentally Produced Noise Associated with Oil and Gas Exploration and Development on Sea Otters in California*, NTIS No. PB86-21-8575. University of California, Santa Cruz, Calif.

Roberts, H.H., 2001a, "Fluid and Gas Expulsion on the Northern Gulf of Mexico Continental Slope: Mud-Prone to Mineral-Prone Responses," *Geophysical Monograph* 124:145–161.

Roberts, H.H., 2001b, *Improved Geohazards and Benthic Habitat Evaluations: Digital Acoustic Data with Ground Truth Calibrations, Final Report*, OCS Study MMS 2001-050, Coastal Marine Institute, MMS Gulf of Mexico OCS Region, July.

Roberts, H.H., and P. Aharon, 1994, "Hydrocarbon-Derived Carbonate Buildups of the Northern Gulf of Mexico Continental Slope: A Review of Submersible Investigations," *Geo-Marine Letters* 14:135–148.

Roberts, H.H., J.M. Coleman, and R.H. Peele, 2005, *Mapping Areas of Hard Bottom and Other Important Bottom Types: Outer Continental Shelf and Upper Continental Slope*, OCS Study MMS 2005-067, prepared by Coastal Studies Institute, Louisiana State University, for Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La., Dec.

Roth, A.-M.F., and D.M. Baltz, 2009, "Short-Term Effects of an Oil Spill on Marsh-Edge Fishes and Decapod Crustaceans." *Estuaries and Coasts* 32:565–572.

Rothrock, D., Y. Yu, and G. Maykut, 1999, "Thinning of the Arctic Sea-Ice Cover," *Geophysical Research Letters* 26(23):3469–3472.

Rothrock, D.A., and J. Zhang, 2005, "Arctic Ocean Sea Ice Volume: What Explains Its Recent Depletion?" *Journal of Geophysical Research* 110(C1):C01002.

Rovegno, P.S., C.A. Edwards, and K.W. Bruland, 2009, "Observations of a Kenai Eddy and a Sitka Eddy in the Northern Gulf of Alaska," *Journal of Geophysical Research* 114(C11):C11012.

Royal Society of Canada, 2004, *Report of the Expert Panel on Science Issues Related to Oil and Gas Activities, Offshore Brittish Columbia*, Ottawa, Ontario, February.

Rozas, L.P., T.J. Minello, and C.B. Henry, 2000, "An Assessment of Potential Oil Spill Damage to Salt Marsh Habitats and Fishery Resources in Galveston Bay, Texas," *Marine Pollution Bulletin* 40:1148–1160.

Rumbold, D.G., P.W. Davis, and C. Perretta, 2001, "Estimating the Effect of Beach Nourishment on Caretta caretta (*Loggerhead Sea Turtle*) Nesting," *Restoration Ecology* 9:304–310.

Russell, R.W., 2005, *Interactions between Migrating Birds and Offshore Oil and Gas Platforms in the Northern Gulf of Mexico: Final Report*, OCS Study MMS 2005-009. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA.

Ryan, P.G., 1987, "The Incidence and Characteristics of Plastic Particles Ingested by Sea Birds," *Marine and Environmental Research* 23: 175–206.

Ryan, P.G., 1988, "Effects of Ingested Plastic on Seabird Feeding: Evidence from Chickens," *Marine Pollution Bulletin* 19: 174–176.

Ryan, P.G., 1990, "The Effects of Ingested Plastic and Other Marine Debris on Seabirds," *Proceedings of the Second International Conference on Marine Debris*, April 2–7, 1989, Honolulu, HI, pp. 623–634, R.S. Shomura and M.L. Godfrey (eds.), NOAA Technical Memorandum NMFS-NOAA-TM-NMFS-SWFSC-154, U.S. Department of Commerce, Washington, D.C.

Sammarco, P.W., A.D. Atchison, and G.S. Boland, 2004, "Expansion of Coral Communities within the Northern Gulf of Mexico via Offshore Oil and Gas Platforms," *Marine Ecology Progress Series* 280:129–143.

SCADA (South Central Alaska Dipnetters Association), 2011, "Home Page South Central Alaska Dipnetters Association," Wasilla, Alaska. Available at http://www.donbowers.com/DipNet/menu1.htm. Accessed September 19, 2011.

Schaum, J., M. Cohen, S. Perry, R. Artz, R. Draxler, J.B. Frithsen, D. Heist, M. Lorber, and L. Phillips, 2010, "Screening Level Assessment of Risks Due to Dioxin Emissions from Burning Oil from the BP Deepwater Horizon Gulf of Mexico Spill," *Environ. Sci. Tech.* 44(24):9483–9389.

Schick, R.S., and D.L. Urban, 2000, "Spatial Components of Bowhead Whale (*Balaena mysticetes*) Distribution in the Alaskan Beaufort Sea, *Canadian Journal of Fisheries and Aquatic Sciences* 57:2193–2200.

Schmahl, G.P., E.L. Hickerson, D.C. Weaver, and J.V. Gardner, 2011, *High-Resolution Multibeam Mapping and Habitat Characterization of Topographic Features in the Northwestern Gulf of Mexico*, GulfBase.org — Resource Database for Gulf of Mexico Research. Available at http://www.thsoa.org/hy03/2_2.pdf. Accessed January 20, 2011.

Serreze, M., J. Maslanik, T. Scambos, F. Fetterer, J. Stroeve, K. Knowles, C. Fowler, S. Drobot, R. Barry, and T. Haran, 2003, "A Record Minimum Arctic Sea Ice Extent and Area in 2002," *Geophysical Research Letters* 30(3):1110.

Shapiro, L.H., and P.W. Barnes, 1991, "Correlation of Nearshore Ice Movement with Seabed Ice Gouges near Barrow, Alaska," *Journal of Geophysical Research* 96(C9):16,979–16,9889.

Sharma, G.D., and D.C. Burrell, 1970, "Sedimentary Environment and Sediments of Cook Inlet, Alaska," *The American Association of Petroleum Geologists Bulletin* 54(4):647–654.

Shelden, K.E.W., and D.J. Rugh, 1995, "The Bowhead Whale, *Balaena mysticetus*: Its Historic and Current Status," *Marine Fisheries Review* 57 (3-4):1–20.

Shell, 2009a, *Exploration Plan, 2010 Exploration Drilling Program, Posey Blocks 6713, 6714, 6763, 6764, and 6912; Karo Blocks 6864 and 7007; Burger Crackerjack, and SW Shoebill Prospects, OCS Lease Sale 193, Chukchi Sea, Alaska*, Public Information Copy submitted to Minerals Management Service, Alaska OCS Region by Shell Gulf of Mexico, Anchorage, July.

Shell 2009b, *Environmental Impact Analysis, 2010 Exploration Drilling Program, Posey Blocks 6713, 6714, 6763, 6764, and 6912; Karo Blocks 6864 and 7007; Burger Crackerjack, and SW Shoebill Prospects, OCS Lease Sale 193, Chukchi Sea, Alaska*, Shell Gulf of Mexico, Anchorage, July.

Shen, H.T., and P.D. Yapa, 1988, "Oil Slick Transport in Rivers," *Journal of Hydraulic Engineering* 114(5):529–533.

Sherwood, K.W., and J.D. Craig, 2001, *Prospects for Development of Alaska Natural Gas: A Review (as of January 2001)*, U.S. Department of the Interior Minerals Management Service, Resource Evaluation Office.

Shideler, G.L., 1985, "Regional Geologic Framework of Eastern Gulf of Mexico OCS Region," in *Summary Report on the Regional Geology, Petroleum Geology, and Estimates of Undiscovered Recoverable Oil and Gas Resources in the Planning Area of the Proposed Outer Continental Shelf Oil and Gas Lease No. 94, Eastern Gulf of Mexico*, U.S. Geological Survey Open File Report 85-669, R.Q. Foote (ed.).

Shideler, D., 1993, "Chapter 5 Deterrent Methods," pp. 35–50 in *Guidelines for Oil and Gas Operations in Polar Bear Habitats*, Truett, J.C. (ed.),. OCS Study MMS 93-0008, report for Minerals Management Service, Washington, D.C. Available at http://www.alaska.boemre.gov/reports/1990rpts/93_0008.pdf. Accessed April 22, 2011.

Shiels, W.E., J.J. Goering, and D.W. Hood, 1973, "Crude Oil Phytotoxicity Studies," pp. 143–446 in *Environmental Studies of Port Valdez*, D.W. Hood, W.E. Shiels, and E.J. Kelley (eds.), Occasional Publication 3, University of Alaska, Institute of Marine Sciences.

Shinn, E.A., B.H. Lidz, and C.D. Reich, 1993, *Habitat Impacts of Offshore Drilling: Eastern Gulf of Mexico,* OCS Study MMS 93-0021, Minerals Management Service, Gulf of Mexico Outer Contintental Shelf Region, New Orleans, La.

Short, J.W., G.V. Irvine, D.H. Mann, J.M. Maselko, J.J. Pella, M.R. Lindeberg, J. R. Payne, W.B. Driskell, and S.D. Rice, 2007, "Slightly Weathered *Exxon Valdez* Oil Persists in Gulf of Alaska Beach Sediments after 16 Years," *Environmental Science and Technology* 41:1245–1250.

Short, J.W., M.R. Lindberg, P.M. Harris, J.M. Maselko, J.J. Pella, and S.D. Rice, 2004, "Estimate of Oil Persisting on the Beaches of Prince William Sound 12 Years after the *Exxon Valdez* Oil Spill," *Environmental Science and Technology* 38(1)19–25.

Sis, R.F., A.M. Landry, and G.R. Bratton, 1993, "Toxicology of Stranded Sea Turtles," in *Proceedings, 24th Annual International Association of Aquatic Animal Medicine Conference*, Chicago, Ill.

Skolnik, J. and C.D. Holleyman, 2005, *Modeling the Economic Impacts of Offshore Activities in the Alaska Arctic*. Available at http://www.mms.gov/ld/OCS_EIM_Upgrade/Arctic%20IMPAK%20Journal%20Article.pdf. Accessed January 26, 2011.

Smith, M.E., A.S. Kane, and A.N. Popper, 2004, "Noise-Induced Stress Response and Hearing Loss in Goldfish (*Carassius auratus*)," *Journal of Experimental Biology* 207:427–435.

Smith, T.S., S.T. Partridge, S.C. Amstrup, and S. Schliebe, 2007, "Post-Den Emergence Behavior of Polar Bears (*Ursus maritimus*) in Northern Alaska," *Arctic* 60:187–194.

Solar Rating and Certification Corporation, undated, *Solar Facts – System Ratings: OG-300 Certification of Solar Water Heating Systems*. Available at http://www.solar-rating.org/facts/system_ratings.html. Accessed August 20, 2011.

Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene, Jr., D. Kastak, D.R. Ketten, J.H. Miller, P.E. Nachtigall, W.J. Richardson, J.A. Thomas, and P.L. Tyack, 2007, "Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations" *Aquatic Mammals* 33:411–522.

Spall, M.A., R.S. Pickart, P.S. Fratantoni, and A.J. Plueddemann, 2008, "Western Arctic Shelfbreak Eddies: Formation and Transport," *Journal of Physical Oceanograph*y 38(8):1644–1668.

Stabeno, P., N. Bond, A. Hermann, N. Kachel, C. Mordy, and J. Overland, 2004, "Meteorology and Oceanography of the Northern Gulf of Alaska," *Continental Shelf Research* 24(7-8):859–897.

Stafford, K.M., C.G. Fox, and D.S. Clark, 1998, "Long Range Acoustic Detection and Localization of Blue Whale Calls in the Northeast Pacific Ocean," *Journal of the Acoustical Society of America* 104(6): 3616–3625.

Starr, S.J., M.N. Kuwada, and L.L. Trasky, 1981, *Recommendations for Minimizing the Impacts of Hydrocarbon Development on Fish, Wildlife and Aquatic Plant Resources of the Northern Bering Sea and Norton Sound, State of Alaska*, Alaska Department of Fish and Game, Habitat Division, Anchorage, Alaska.

State of Alaska, 2011, *Major Oil Spills to Coastal Waters, Division of Spill Prevention and Response – Prevention and Emergency Response*. Available at http://www.dec.state.ak.us/spar/perp/bigspills.htm. Accessed Aug. 19, 2011.

Stevens, D.S.P., and P.A. Craw, 2004, *Geologic Hazards on and near the Northern Coast of the Alaska Peninsula*, Miscellaneous Publication 134, Alaska Division of Geological and Geophysical Surveys, May.

Stevens, M.A., and D.J. Boness, 2003, "Influences of Habitat Features and Human Disturbance on the Use of Breeding Sites by a Declining Population of Southern Fur Seals (*Arctocephalus australis*)," *Journal of Zoology* 260:145–152.

Stewart, E.J., S.E.L. Howell, D. Draper, J. Yackel, and A. Tivy, 2007, "Sea Ice in Canada's Arctic: Implications for Cruise Tourism," *Arctic* 60(4):370–380.

Stickney, A., 1991, "Seasonal Patterns of Prey Availability and the Foraging Behavior of Arctic Foxes (*Alopex lagopus*) in a Waterfowl Nesting Area," *Canadian Journal of Zoology* 69(11): 2853–2859.

Stone, G.W., N.D. Walker, S.A. Hsu, A. Babin, B. Liu, B.D. Keim, W. Teague, D. Mitchell, and R. Leben, 2005, "Hurricane Ivan's Impact along the Northern Gulf of Mexico," *EOS* 86(48):497.

Stover, C.W., and J.L. Coffman, 1993, *Seismicity of the United States 1568-1989 (Revised),* U.S. Geological Survey Professional Paper 1527.

Stringer, W.J., 1980, *The Role of Sea Ice as a Physical Hazard and a Pollutant Transport Mechanism in the Bering Sea, A Special Report to Outer Continental Shelf Environmental Assessment Program*, Arctic Research Unit 267, Geophysical Institute, University of Alaska.

Stringer, W.J., and W.M. Sackinger, 1976, "Ice Hazards to Offshore Oil Operations in Arctic Alaskan Waters," in *31st Annual Petroleum Mechanical Engineering Conference*, Mexico City, Mexico, September 16–19.

Stroeve, J., M. Serreze, F. Fetterer, T. Arbetter, W. Meier, J. Maslanik, and K. Knowles, 2005, "Tracking the Arctic's Shrinking Ice Cover: Another Extreme September Minimum in 2004," *Geophysical Research Letters* 32(4):1–4.

Sturges, W., 1993, "The Annual Cycle of the Western Boundary Current in the Gulf of Mexico," *Journal of Geophysical Research* 98(C10):18053–18068.

Sturges, W., and J. Blaha, 1975, "A Western Boundary Current in the Gulf of Mexico," *Science* 192:367–369.

Sturges, W., and K.E. Kenyos, 2008, "Mean Flow in the Gulf of Mexico," *Journal of Physical Oceanography* 38(7):1501–1514.

Sturges, W., E. Chassignet, and T. Ezer, 2004, *Strong Mid-depth Currents and a Deep Cyclonic Gyre in the Gulf of Mexico: Final Report*, OCS Study MMS 2004-040, MMS, Gulf of Mexico OCS Region, New Orleans, La.

Sturges, W., N.G. Hoffmann, and R.R. Leben, 2010, "A Trigger Mechanism for Loop Current Ring Separations," *Journal of Physical Oceanography* 40(5):900–913.

Suleimani, E.N., et al., 2002, *Tsunami Hazard Maps of the Kodiak Area, Alaska*, Report of Investigations 2002-01, Alaska Department of Natural Resources, Division of Geological and Geophysical Surveys. Available (with 1:12,500 maps) at http://www.dggs.alaska.gov/webpubs/dggs/ri/text/ri2002_001.PDF. Accessed June 23, 2011.

Suydam, R.S., and J.C. George, 1992, "Recent Sightings of Harbour Porpoises, *Phocoena phocoena*, near Point Barrow, Alaska," *Canadian Field-Naturalist* 106(4):489–492.

Suleimani, E.N., et al., 2005, *Tsunami Hazard Maps of the Homer and Seldovia Areas, Alaska*, Report of Investigations 2005-2, Alaska Department of Natural Resources, Division of Geological and Geophysical Surveys. Available (with 1:12,500 maps) at http://www.dggs.dnr.state.ak.us/pubs/pubs?reqtype=citation&ID=14474. Accessed June 15, 2011.

Taylor, E., and D. Reimer, 2008, "Oil Persistence on Beaches in Prince William Sound – A Review of SCAT Surveys Conducted from 1989 to 2002," *Marine Pollution Bulletin* 56:458–474.

Teague, W., E. Jarosz, D. Wang, and D. Mitchell, 2007, "Observed Oceanic Response over the Upper Continental Slope and Outer Shelf during Hurricane Ivan," *Journal of Physical Oceanography* 37(9):2181–2206.

Teague, W.J., E. Jarosz, M. Carnes, D. Mitchell, and P. Hogan, 2006a, "Low-Frequency Current Variability Observed at the Shelfbreak in the Northeastern Gulf of Mexico: May-October, 2003," *Continental Shelf Research* 26:2559–2582.

Teague, W.J., E. Jarosz, T.R. Keen, D.W. Wang, and M.S. Hulbert, 2006b, "Bottom Scour Observed under Hurricane Ivan," *Geophysical Research Letters* 33:L07607.

Tech Environmental, Inc., 2006, *Final EIR Underwater Noise Analysis*, Report No. 5.3.2-2, Appendix 3.13-B, Cape Wind Energy Project, Nantucket Sound, Waltham, Mass.

Teo, S.L.H., AM. Boustany, and B.A. Block, 2007, "Oceanographic Preferences of Atlantic Bluefin Tuna, *Thunnus thynnus*, on Their Gulf of Mexico Breeding Grounds," *Marine Biology* 152:1105–1119.

TEWG (Turtle Expert Working Group), 2007, *An Assessment of the Leatherback Turtle Population in the Atlantic Ocean*, NOAA Technical Memorandum NMFS-SEFSC-555.

Thomas, D.R., 1983, "Interaction of Oil with Arctic Sea Ice," in *The Alaskan Beaufort Sea*, P. Barnes, E. Reimnitz, and D. Schell (eds.), Academic Press, New York, N.Y.

Thompson, J.J., E.A. Shinn, and T.J. Bright, 1980, *Effects of Drilling Mud on Seven Species of Reef-Building Corals as Measured in the Field and Laboratory*, Elsevier Scientific Publishing Company, Amsterdam.

Thompson, J., et al., 2005, "Sonar Surveys for Pipeline Inspection Show Extent of Pipeline Displacement and Seafloor Instability Following Hurricane Ivan," *Proc. Offshore Technology Conference*, Houston, Texas, OTC Paper No. 17738.

Thurston, D.K., and L.A. Theiss, 1987, *Geologic Report for the Chukchi Sea Planning Area, Alaska – Regional Geology, Petroleum Geology, and Environmental Geology*, OCS Report MMS 87-0046, March.

Till, A.B., et al., 1990, *Redoubt Volcano, Cook Inlet, Alaska: A Hazard Assessment Based on Eruptive Activity through 1968*, U.S. Geological Survey Open File Report 90-246.

Todd, S., P. Stevick, J. Lien, F. Marques, and D. Ketten, 1996, "Behavioral Effects of Exposure to Underwater Explosions in Humpback Whales (*Megaptera novaeangliae*)," *Canadian Journal of Zoology* 74:1661–1672.

Toimil, L.J., 1978, *Ice-Gouged Microrelief on the Floor of the Eastern Chukchi Sea, Alaska: A Reconnaissance Survey*, Open File Report 78-693, U.S. Geological Survey.

Tornfelt, E.E., and M. Burwell, 1992, *Shipwrecks of the Alaskan Shelf and Shore: The April 1, 1999 Database*, OCS Study MMS 92-0002, MMS, Alaska OCS Region, Anchorage, Alaska.

Trefry, J.H., K.L. Naito, R.P. Trocine, and S. Metz, 1995, "Distribution and Bioaccumulation of Heavy Metals from Produced Water Discharges to the Gulf of Mexico," *Water Science and Technology* 32: 31–36.

Trefry, J.H., R.D. Rember, R.P. Trocine, and M. Savoie, 2004, *Sources, Concentrations and Dispersion Pathways for Suspended Sediment in the Coastal Beaufort Sea*, OCS Study MMS 2004-032, Minerals Management Service, Alaska Outer Continental Shelf Region, Anchorage, Alaska.

Troutman, S.M., and R.G. Stanley, 2003, *Maps Showing Sedimentary Basins, Surface Thermal Maturity, and Indications of Petroleum in the Central Alaska Province*, U.S. Geological Survey Miscellaneous Field Studies Map, MF-2428.

Truett, J.C., M.E. Miller, and K. Kertell, 1997, "Effects of Arctic Alaska Oil Development on Brant and Snow Geese," *Arctic* 50(2): 138–146.

Tucker and Associates, 1990, "Sea Turtles and Marine Mammals of the Gulf of Mexico," in *Proceedings of a Workshop Held in New Orleans*, August 1–3, 1989, OCS Study MMS 90-009.

Tucker & Associates, Inc., 1990, *Sea Turtles and Marine Mammals of the Gulf of Mexico, Proceedings of a Workshop Held in New Orleans, August 1-3, 1989*, OCS Study MMS 90-0009, Minerals Management Service, Gulf of Mexico OCS Region. Available at http://www.gomr.boemre.gov/PI/PDFImages/ESPIS/3/3661.pdf. Accessed April 16, 2011.

Turner, C., and M. Frankel, 2008, *Energy Performance of LEED for New Construction Buildings*, New Buildings Institute, March 4. Available at http://www.usgbc.org/ShowFile.aspx?DocumentID=3930. Accessed August 21, 2011.

Turner, R.E., J.M. Lee, and C. Neill, 1994, "Backfilling Canals to Restore Wetlands: Empirical Results in Coastal Louisiana," *Wetlands Ecology and Management* 3(1):63–78.

Tunez, J.I., H.L. Cappozzo, and M.H. Cassini, 2008, "Natural and Anthropogenic Factors Associated with the Distribution of South American Sea Lion along the Atlantic Coast," *Hydrobiologia* 598:191–202.

Tyack, P.L., 2009, "Human-Generated Sound and Marine Mammals," *Physics Today* 62(11):39–44.

U.K. National Nonfood Crop Centre, 2010, *Renewable Polymers Factsheet: Bioplastics*, February 19. Available at http://www.nnfcc.co.uk/publications/nnfcc-renewable-polymers-factsheet-bioplastics. Accessed August 21, 2011.

United Health Foundation, 2009, *America's Health Rankings 2009: Louisiana*. Available at http://www.dhh.louisiana.gov/offices/publications/pubs-81/American_Health_Rankings_Louisiana.pdf. Accessed September 26, 2011.

United Nations Educational, Scientific and Cultural Organization – Intergovernmental Oceanographic Commission (UNESCO-IOC). 2010. M*arine Spatial Planning Initiative*. Available at http://www.unesco-ioc-marinesp.be.

URS Corporation, 2005, *North Slope Borough Comprehensive Plan*, prepared for The North Slope Borough, October. Available at http://www.north-slope.org/information/comp_plan/MasterTOC_%20Mayors%20Forward06.pdf. Accessed April 27, 2011.

U.S. Green Building Council, 2011a, *About LEED*, March. Available at http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1720 Accessed August 21, 2011.

U.S. Green Building Council, 2011b, *LEED for Homes*, May. Available at http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1720. Accessed August 21, 2011.

USACE (U.S. Army Corps of Engineers), 1999, *Final Environmental Impact Statement: Beaufort Sea Oil and Gas Development/Northstar Project,* U.S. Army Engineer District, Anchorage, Alaska.

USACE, 2010, *Navigation Data Center: U.S. Waterborne Container Traffic by Port/Waterway in 2009*. Accessed at http://www.ndc.iwr.usace.army.mil/wcsc/by_porttons09.html. Accessed July 27, 2011.

USACE, 2011, *Ocean Disposal Database — Alaska District (Pacific Ocean Division), Galveston District (Southwestern Division), New Orleans District (Mississippi Valley Division), and Mobile and Jacksonville Districts (South Atlantic Division)*. Available at http://el.erdc.usace.army.mil/odd/. Accessed July 12, 2011.

USCB (U.S. Census Bureau), 2009a, *Annual Estimates of the Resident Population for the United States, Regions, States, and Puerto Rico: April 1, 2000 to July 1, 2009,* NST-EST2009-01. Available at http://www.census.gov/popest/states/NST-ann-est.html. Accessed December 2009.

USCB, 2009b, *Annual Estimates of the Population of Metropolitan and Micropolitan Statistical Areas: April 1, 2000 to July 1, 2009.* Available at http://www.census.gov/popest/metro/CBSA-est2009-annual.html. Accessed March 2010.

USCG (U.S. Coast Guard), 2011, *2008 – 2010 Arctic Activity* (2010 Arctic Traffic Slide). Available at http://www.institutenorth.org/calendar/events/bering-strait-access-workshop. Accessed September 8, 2011.

USDOE and USDA (U.S. Department of Energy and U.S. Department of Agriculture), 2005, *Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical feasibility of a Billion-Ton Annual Supply*, April.

USDOE and USEPA (U.S. Department of Energy and U.S. Environmental Protection Agency), undated a, *Energy Star Solar Water Heaters*. Available at http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=WSE. Accessed August 20, 2011.

USDOE and USEPA, undated b, *Energy Star Certified Buildings and Plants*. Available at http://www.energystar.gov/index.cfm?fuseaction=labeled_buildings.locator. Accessed August 20, 2011.

USDOE and USEPA, undated c, *Energy Star Qualified New Homes*. Available at http://www.energystar.gov/index.cfm?c=new_homes.hm_index. Accessed August 21, 2011.

USDOI (U.S. Department of the Interior), 2001, *Department of the Interior-Alaska Policy on Government-to-Government Relations with Alaska Native Tribes*, January 18.

USDOT (U.S. Department of Transportation), 2008, *Vessel Calls at U.S. Ports, Snapshot, 2007*, Office of Policy and Plans, Maritime Administration, Washington, D.C.

USDOT, 2009a, "Table 1-11. Number of U.S. Aircraft, Vehicles, Vessels, and Other Conveyances," in *National Transportation Statistics 2009*. http://www.bts.gov/publications/national_transportation_statistics/. Accessed June 2009.

USDOT, 2009b, "Table 4-23. Average Fuel Efficiency of U.S. Passenger Cars and Light Trucks," in *National Transportation Statistics 2009*. Available at http://www.bts.gov/publications/national_transportation_statistics/. Accessed January 2010.

USDOT, 2009c, Table 4-21: Energy Intensity of Certificated Air Carriers, All Services," in *National Transportation Statistics 2009*. Available at http://www.bts.gov/publications/national_transportation_statistics/. Accessed January 2010.

USDOT, 2009d, "Table 1-11: Number of U.S. Aircraft, Vehicles, Vessels, and Other Conveyances," in *National Transportation Statistics 2009*. Available at http://www.bts.gov/publications/national_transportation_statistics/. Accessed June 2009.

USDOT, 2010, "Table 4-6: Energy Consumption by Mode of Transportation (Trillion Btu)," in *National Transportation Statistics 2010*. Available at http://www.bts.gov/publications/national_transportation_statistics/. Accessed April 2010.

USDOT, 2011a, *Maritime Administration – Deepwater Port Licensing Program: Pending Applications.* Available at http://www.marad.dot.gov/ports_landing_page/deepwater_port_licensing/dwp_planned_ports/dwp_planned_ports.htm. Accessed July 18, 2011.

USDOT, 2011b, *Vessel Calls Snapshot, 2010*, Maritime Administration, Office of Policy and Plans, May.

USDOT, 2011c, *Maritime Administration — Deepwater Port Licensing Program: Pending Applications.* Available at http://www.marad.dot.gov/ports_landing_page/deepwater_port_licensing/dwp_planned_ports/dwp_planned_ports.htm. Accessed July 18, 2011.

USEPA (U.S. Environmental Protection Agency), 1992, *Workbook for Plume Visual Impact Screening and Analysis (Revised)*, EPA-454/R-92-023, Office of Air Quality Planning and Standards, Research Triangle Park, N.C., Oct.

USEPA, 1993, *Preliminary Determination Document, Prevention of Significant Deterioration Outer Continental Shelf, Proposed Exploratory Drilling for ARCO Alaska, Inc. in the Beaufort Sea, Alaska*, EPA Region 10, Seattle, Wash., June.

USEPA, 2001, *Visibility in Mandatory Federal Class I Areas (1994-1998) – A Report to Congress*, EPA-452/R01-008, Office of Air Quality Planning and Standards, Nov.

USEPA, 2008a, *Red Dog Mine Extension – Aqqaluk Project, Draft Supplemental Environmental Impact Statement*, Prepared by Tetra Tech, Inc., for the U.S. Environmental Protection Agency, Seattle, Washington.

USEPA, 2008b, *National Coastal Condition Report III*, EPA/842-R-08-002, Office of Research and Development/Office of Water, Washington D.C., Dec.

USEPA, 2008c, *Latest Findings on National Air Quality: Status and Trends Through 2006*, EPA-454/R-07-007, Jan.

USEPA, 2009, *Red Dog Mine Extension – Aqqaluk Project Final Supplemental Environmental Impact Statement*, prepared by Tetra Tech, Anchorage, Alaska, for the U.S. EPA Region 10, Oct. Available at http://www.reddogseis.com/Final_SEIS.asp. Accessed July 12, 2011.

USEPA, 2010a, *EPA Finalizes Regulations for the National Renewable Fuel Standard Program for 2010 and Beyond*, Office of Transportation and Air Quality, February. Available at http://www.epa.gov/otaq/renewablefuels/420f10007.pdf. Accessed August 20, 2011.

USEPA, 2010b, "Table 2: Recovery of Municipal Solid Waste, 1960 to 2009," in *Municipal Solid Waste in the United States: 2009 Facts and Figures*, December. Available at http://www.epa.gov/wastes/nonhaz/municipal/pubs/msw2009rpt.pdf. Accessed August 2011.

USEPA, 2010c, *Region 10: The Pacific Northwest – Current NPDES Permits in Alaska*. Available at http://yosemite.epa.gov/r10/water.nsf/NPDES+Permits/CurrentAK822. Accessed August 20, 2011.

USEPA, 2011a, *What Are the Six Common Air Pollutants?*. Available at http://www.epa.gov/oaqps001/urbanair/. Accessed July 18, 2011.

USEPA, 2011b, *Acid Rain*. Available at http://www.epa.gov/acidrain/. Accessed July 18, 2011.

USEPA, 2011c, *Ocean Dumping and Dredging Material Management.* Available at http://water.epa.gov/type/oceb/oceandumping/dredgedmaterial/dumpdredged.cfm. Accessed July 12, 2011.

USEPA, 2011d, *Region 6: Ocean Dumping Sites for Dredged Material*. Available at http://water.epa.gov/type/oceb/oceandumping/dredgedmaterial/regionsix.cfm. Accessed July 12, 2011.

USEPA, 2011e, *Region 4: Ocean Dumping Sites for Dredged Material*. Available at http://water.epa.gov/type/oceb/oceandumping/dredgedmaterial/regionfour.cfm. Accessed July 12, 2011.

USEPA, 2011f, *Hypoxia in the News — 2011 Forecast: Summer Hypoxic Zone Size, Northern Gulf of Mexico*. Available at http://water.epa.gov/type/watersheds/named/msbasin/gulfnews.cfm#2011forecast. Accessed July 28, 2011.

USEPA 2011g, *Beyond the Marine Protection Research and Sanctuaries Act (MPRSA)*. Available at http://water.epa.gov/type/oceb/mprsa_beyond.cfm. Accessed July 12, 2011.

USEPA, 2011h, *Air Data: Emissions by Category Report – Criteria Air Pollutants*. Searchable database (by geographic area, pollutant emitted, and year of data). Available at http://www.epa.gov/oar/data/emcatrep.html. Accessed August 16, 2011.

USEPA, 2011i, *2008 Highlights: Overview of the Acid Rain Program*. Available at http://www.epa.gov/airmarkets/progress/ARP_4.html. Accessed August 17, 2011.

USEPA, 2011j, *Cross-State Air Pollution Rule (CSAPR).* Available at http://www.epa.gov/crossstaterule/. Accessed on August 17, 2011.

USEPA, 2011k, *Regional Planning Organizations*. Available at http://www.epa.gov/visibility/regional.html. Accessed on August 17, 2011.

USEPA, 2011l, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2009*, EPA 430-R-11-005, April 15. Available at http://www.epa.gov/climatechange/emissions/downloads11/US-GHG-Inventory-2011-Complete_Report.pdf. Accessed August 31, 2011.

USFWS (United States Fish and Wildlife Service), 1999, *South Florida Multi-Species Recovery Plan*. U.S. Fish and Wildlife Service, Atlanta, GA.

USFWS, 2004, *Effects of Oil Spills on Wildlife and Habitat*, U.S. Fish and Wildlife Service, Alaska Region, Dec. Available at http://alaska.fws.gov/media/unalaska/Oil%20Spill%20Fact%20Sheet.pdf. Accessed March 12, 2011.

USFWS, 2008, "Endangered and Threatened Wildlife and Plants; Determination of Threatened Status for the Polar Bear (*Ursus maritimus*) Throughout Its Range," *Federal Register* 73(95):28212–28303.

USGS (U.S. Geological Survey), undated, *North Pacific Pelagic Seabird Database (NPPSD)*. Alaska Science Center, Anchorage, AK.

USGS, 1970, *Earthquake Information Bulletin (Alaska)*, Vol.2 (2): March–April.

USGS, 1999, *Alaska Seismic Hazard Maps — 1999, Peak Horizontal Acceleration (%g) with 10% Probability of Exceedance in 50 Years*, interactive map. Available at http://gldims.cr.usgs.gov/akshmp/viewer.htm. Accessed June 6, 2011.

USGS, 2010, *Glossary of Terms on EQ Maps, Magnitude*. Available at http://earthquake.usgs.gov/earthquakes/glossary.php#magnitude. Accessed August 8, 2010.

USGS, 2011a, *National Earthquake Information Center (NEIC) — Earthquake Hazards Program, Circular Area Earthquake Search, Geographic Grid Search (Latitude 58.811N to 56.507N; Longitude 150.957W to 156.832W)*. Available at http://earthquake.usgs.gov/earthquakes/eqarchives/epic/epic_circ.php. Accessed June 6, 2011.

USGS, 2011b, *Alaska Volcano History*, volcano information, interactive map, Alaska Volcano Observatory, Anchorage, Alaska. Available at http://avo.alaska.edu/map/. Accessed March 3, 2011.

USGS, 2011c, *The Gulf of Mexico Hypoxic Zone*. Available at http://toxics.usgs.gov/hypoxia/hypoxic_zone.html. Accessed Aug. 4, 2011.

USGS, 2011d, *Alaska Earthquake History*. Available at http://earthquake.usgs.gov/earthquakes/states/alaska/history.php. Accessed on August 31, 2011.

Valkenburg, P., and J.L. Davis, 1984, "The Reaction of Caribou to Aircraft: A Comparison of Two Herds," pp. 7−9 in *Caribou and Human Activity, Proceedings of the 1st North American Caribou Workshop, Whitehorse, Yukon Territories*, A.M. Martell and D.E. Russell (eds.), Sept. 28−29, 1983, Canadian Wildlife Service, Special Publication, Ottawa, Ontario, Canada.

Van Pelt, T.I., and J.F. Piatt, 2003, *Population Status of Kittlitz's and Marbled Murrelets and Surveys for Other Marine Bird and Mammals Species in the Kenai Fjords Area, Alaska*. USGS Science Support Project, Species at Risk Annual Report for U.S. Fish and Wildlife Service, USGS Alaska Science Center, Anchorage, AK.

Vanderlaan, A.S.M., and C.T. Taggart, 2007, "Vessel Collisions with Whales: The Probability of Lethal Injury Based on Vessel Speed," *Marine Mammal Science* 23(1):144–156.

Vargo, S., P. Lutz, D. Odell, E. Van Vleet, and G. Bossart, 1986, *Study of the Effects of Oil on Marine Turtles, Final Report*, OCS Study MMS 86-0070, MMS, Atlantic OCS Region.

Vasconcelos, R.O., M.C.P. Amorim, and F. Ladich, 2007, "Effects of Ship Noise on the Detectability of Communication Signals in the Lusitanian Toadfish," *Journal of Experimental Biology* 210:2104–2112.

Veil, J.A., T.A. Kimmell, and A.C. Rechner, 2005, *Characteristics of Produced Water Discharged to the Gulf of Mexico Hypoxic Zone,* ANL/EAD/05-3, Argonne National Laboratory, Argonne, Ill., Aug. Available at http://www.osti.gov/bridge. Accessed September 2005.

VesselTrax, 2007, *Crude Oil Imports into U.S. Gulf Coast Ports*. Available at http://vesseltrax.com/crude_oil_imports.html. Accessed July 19, 2011.

Viereck, L.A., C.T. Dyrness, A.R. Batten, and K.J. Wenzlick, 1992, *The Alaska Vegetation Classification,* General Technical Report PNW-GTR-286, USDOA, Pacific Northwest Research Station.

Vukovich, F.M., 2007, "Climatology of Ocean Features in the Gulf of Mexico Using Satellite Remote Sensing Data," *Journal of Physical Oceanography* 37(3):689–707.

Wald, D.J., B.C. Worden, V. Quitoriano, and K.L. Pankow, 2005, *Shake Map Manual — Technical Manual, Users Guide, and Software Guide,* Version 1.0, June 19.

Wald, M.L., 2010, "Offshore Wind Power Line Wins Backing," *New York Times* October 12. Available at http://www.nytimes.com/2010/10/12/science/earth/12wind.html?ref=business. Accessed August 20, 2011.

Walker, D.A., and K.R. Everett, 1987, "Road Dust and Its Environmental Impact on Alaskan Taiga and Tundra," *Arc. Alpine Res.* 19:479–489.

Walker, D.A., D. Cate, J. Brown, and C. Racine, 1987a, *Disturbance and Recovery of Arctic Alaskan Tundra Terrain: A Review of Recent Investigations*, CRREL Report 87-11, U.S. Army Corps of Engineers, CRREL, Hanover, N.H.

Walker, D.A., P.J. Webber, E.F. Binnian, K.R. Everett, N.D. Lederer, E.A. Nordstrand, and M.D. Walker, 1987b, "Cumulative Impacts of Oil Fields on Northern Alaska Landscapes," *Science* 238: 757–761.

Walther, G., E. Post, P. Convey, A. Menzel, C. Parmesan, T.J.C. Beebee, J. Fromentin, O. Hoegh-Guldberg, and F. Bairlein, 2002, "Ecological Responses to Recent Climate Change," *Nature* 416:389–395.

Wang, G., and P.T. Pedersen, 2007, "A Literature Review of Risk Assessment of Ship-FPSO Collisions," OMAE 2007-29760, *Proceedings of OMAE2007, The 26th Offshore Mechanics and Arctic Engineering Conference*, Offshore Mechanics and Arctic Engineering, San Diego, Calif., June 10–15, 2007.

Wang, J., R. Kwok, F.J. Saucier, J. Hutchings, M. Ikeda, I.W. Hibler, J. Haapala, M.D. Coon, H.E.M. Meir, H. Eicken, N. Tanaka, R.T. Prentki, and W. Johnson, 2003, "Working Toward Improved Small-Scale Sea Ice-Ocean Modeling in the Arctic Seas," *EOS* 84(34), 325, 329–330.

Wang, J.L., V. Vivatrat , and J.R. Rusher, 1982, "Geotechnical Properties of Alaska OCS Silts," *Proceedings of 14th Offshore Technology Conference*, Houston, Texas, Vol. 4, OTC Paper 4412.

Ward, D.H., and R.A. Stein, 1989, *Response of Brant and Other Geese to Aircraft Disturbance at Izembek Lagoon, Alaska*. U.S. Fish and Wildlife Service Anchorage, AK.

Ward, D.H., R.A. Stein, and D.V. Derksen, 1994, "Response of Staging Brant to Disturbance at the Izembek Lagoon, Alaska," *Wildlife Society Bulletin* 22: 220–228.

Waring, G.T., E. Josephson, K. Maze-Foley, and P.E. Rosel (eds.), 2010, *U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments — 2010*, NOAA Tech Memo NMFS-NE 213, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Science Center, Dec. Available at http://www.nefsc.noaa.gov/publications/tm/tm219. Accessed July 29, 2011.

Watkins, W.A., and W.E. Schevill, 1975, "Sperm Whales React to Pingers," *Deep Sea Research* 22:123-129.

Waythomas, C.F., and R.B. Waitt, 1998, *Preliminary Volcano-Hazard Assessment for Augustine Volcano, Alaska*, U.S. Geological Survey Open File Report 98-0106.

Waythomas, C.F., J.M. Dorava, T.P. Miller, C.A. Neal, and R.G. McGimsey, 1997, *Preliminary Volcano-Hazard Assessment for Redoubt Volcano, Alaska*, U.S. Geological Survey Open File Report 97-0857.

Weber, D.D., D.J. Maynard, W.D. Gronlund, and V. Konchin, 1981, "Avoidance Reactions of Migrating Adult Salmon to Petroleum Hydrocarbons," *Canadian Journal of Fisheries and Aquatic Sciences* 38:779–781.

Weeks, W.F., and G. Weller, 1984, "Offshore Oil in the Alaskan Arctic," *Science* 225(4660):371–378.

Weilgart, L.S., 2007, "A Brief Review of Known Effects of Noise on Marine Mammals," *International Journal of Comparative Psychology* 20:159–168.

Weingartner, T., 2003, "Physical Oceanography of the Beaufort Sea: An Overview," in *Physical Oceanography of the Beaufort Sea-Workshop Proceedings*, T. Weingartner (ed.), OCS Study MMS 2003-045, Anchorage, Alaska.

Weingartner, T., K. Aagaard, R. Woodgate, S. Danielson, Y. Sasaki, and D. Cavalieri, 2005, "Circulation on the North Central Chukchi Sea Shelf," *Deep-Sea Research Part II: Topical Studies in Oceanography* 52(24-26):3150–3174.

Weingartner, T.J., and S.R. Okkonen, 2001, *Beaufort Sea Nearshore Under-Ice Currents: Science, Analysis, and Logistics*, OCS Study MMS 2001-068, Institute of Marine Science, University of Alaska Fairbanks, Fairbanks, Alaska.

Weingartner, T.J., D.J. Cavalieri, K. Aagaard, and Y. Sasaki, 1998, "Circulation, Dense Water Formation, and Outflow on the Northeast Chukchi Shelf," *Journal of Geophysical Research* 103(C4):7647–7661.

Weingartner, T.J., R.S. Pickart, and M.A. Johnson, 2010, *Recommended Physical Oceanographic Studies in the Alaskan Beaufort Sea*, OCS Study MMS-2010-018, Anchorage, Alaska.

Weingartner, T.J., S.L. Danielson, J.L. Kasper, and S.R. Okkonen, 2009, *Circulation and Water Property Variations in the Nearshore Alaskan Beaufort Sea (1999-2007),* OCS Study MMS 2009-035, MMS, Fairbanks, Alaska.

Wells, P.G., 1989, *Using Oil Spill Dispersants on the Sea – Issues and Answers*, Workshop on Technical Specifications for Oil and Dispersants Toxicity, January 17-19, 1989, New Orleans, La., Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La.

Wells, P.G., 1989, "Using Oil Spill Dispersants on the Sea – Issues and Answers," in *Oil and Dispersant Toxicity Testing, Proceedings of a Workshop on Technical Specifications*, T.W. Duke and G. Petrazzuolo (eds.), held in New Orleans, January 17–19, 1989.

Wesson, R.L., O.S. Boyd, C.S. Mueller, C.G. Bufe, A.D.Frankel, and M.D. Peterson, 2007, *Revision of Time-Dependent Probabilistic Seismic Hazard Maps for Alaska*, U.S Geological Survey Open File Report 2007-1043.

Wheeler, N.J.M., S.B. Reid, K.J. Craig, J.R. Zielonka, D.R. Stauffer, and S.R Hanna, 2008, *Cumulative Increment Analysis for the Breton National Wilderness Area*, OCS Study MMS 2008-058, prepared by Sonoma Technology, Inc., Petaluma, Calif., for MMS, Gulf of Mexico OCS Region, New Orleans, La., Dec.

Whitmeyer, S.J., and D.M. FitzGerald, 2008, "Episodic Dynamics of a Sand Wave Field," *Marine Geology* 252:24–37.

Whitney, J., 1994, *Shoreline Countermeasures Manual*, NOAA, Hazardous Materials Response & Assessment Division, March.

Whitney, J., 2000, "What Actual Movement of Oil in Cook Inlet Tells Us about the Circulation in Cook Inlet," in *Cook Inlet Oceanography Workshop*, S.R. Johnson, M.A. Okkonen (eds.), November 9, Kenai, Alaska, pp. 25–47, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.

Whitney, J.H., et al., 1979, *Lower Cook Inlet, Alaska: Do Those Large Sand Waves Migrate?*, presented at Offshore Technology Conference, Houston, Texas, April 30–May 7.

Whitney, J.W., and D.K. Thurston, 1977, "Geologic Constraints for Petroleum Development of the Lower Cook Inlet, Alaska, Outer Continental Shelf Lease Area," in *The U.S. Geological Survey in Alaska: Accomplishments during 1979*, U.S. Geological Survey Circular 823-B, N.R.D. Albert and T. Hudson (eds).

Whitney, J.W., and D.K. Thurston, 1981, "Geologic Constraints for Petroleum Development of the Lower Cook Inlet, Alaska, Outer Continental Shelf Lease Area," in *The United States Geological Survey in Alaska: Accomplishments during 1979*, N.R.D. Albert and T. Hudson (eds.), U.S. Geological Survey Circular 823-B.

Whitney, J., 1994, *Shoreline Countermeasures Manual*, U.S. Department of Commerce/National Oceanic and Atmospheric Administration, Hazardous Materials Response & Assessment Division, March.

Wicker, K.M., R.E. Emmer, D. Roberts, and J. van Beek, 1989, *Pipelines, Navigation Channels, and Facilities in Sensitive Coastal Habitats, An Analysis of Outer Continental Shelf Impacts, Coastal Gulf of Mexico, Volume I: Technical Narrative*, OCS Report MMS 89-0051, MMS, Gulf of Mexico OCS Region, New Orleans, La.

Wiedmer, M., M.J. Fink, J.J. Stegeman, R. Smolowitz, G.D. Marty, and D.E. Hinton, 1996, "Cytochrome P-450 Induction and Histopathology in Preemergent Pink Salmon from Oiled Spawning Sites in Prince William Sound," *American Fisheries Society Symposium* 18:509–517.

Wijesekera, H.W., D.W. Wang, W.J. Teague, and E. Jarosz, 2010, "High Sea-Floor Stress Induced by Extreme Hurricane Waves," *Geophysical Research Letters* 37:L11604.

Wilhelm, O., and M. Ewing, 1972, "Geology and History of the Gulf of Mexico," *Geological Society of American Bulletin* 83:575–600.

Wilkinson, T., E. Wiken, J.B. Creel, T.F. Hourigan, T. Agardy, H. Herrmann, L. Janishevski, C. Madden, L. Morgan, and M. Padilla, 2009, *Marine Ecoregions of North America*, Commission for Environmental Cooperation, Montreal, Canada.

Wilson, D., R. Billings, R. Oommen, B. Lange, J. Marik, S. McClutchey, and H. Perez, 2010, *Year 2008 Gulfwide Emission Inventory Study*, OCS Study BOEMRE 2010-045, BOEMRE, Gulf of Mexico OCS Region, New Orleans, La., Dec.

Wilson, D.L., J.N. Fanjoy, and R.S. Billings, 2004, *Gulfwide Emission Inventory Study for the Regional Haze and Ozone Modeling Efforts, Final Report*, OCS Study MMS 2004-072, prepared by Eastern Research Group, Inc., Morrisville, N.C., for the MMS, Gulf of Mexico OCS Region, New Orleans, La., Oct.

Wilson, S., 2007, "USEPA's Produced Water Permitting Requirements," pp. 32–33 in *Exploration & Production: The Oil and Gas Review 2007*, Offshore Technology Conference (OTC) Edition, April.

Wilson, C.A., A. Pierce, and M.W. Miller, 2003, *Rigs and Reefs: A Comparison of the Fish Communities at Two Artificial Reefs, a Production Platform, and a Natural Reef in the Northern Gulf of Mexico*, OCS Study MMS 2003-009, prepared by the Coastal Fisheries Institute, School of the Coast and Environment, Louisiana State University, for MMS, Gulf of Mexico OCS Region, New Orleans, La.

Witherington B.E., 1994, "Some 'Lost-Year' Turtles Found," in *Proceedings of theThirteenth Annual Symposium on Sea Turtle Biology and Conservation*, B.A. Schroeder and B.E. Witherington (comps), NOAA Tech Memo NMFS-SEFSC-341.

Witherington, B.E., and R.E. Martin, 1996, *Understanding, Assessing, and Resolving Light-Pollution on Sea Turtle Nesting Beaches*, FMRI Technical Report TR-2, Florida Department of Environmental Protection.

Woodgate, R.A., K. Aagaard, and T.J. Weingartner, 2005, "A Year in the Physical Oceanography of the Chukchi Sea: Moored Measurements from Autumn 1990-1991," *Deep Sea Research Part II: Topical Studies in Oceanography* 52(24-26):3116–3149.

Woodward-Clyde Consultants, 1996, *The 1995 Northstar Unit Sampling Program, Final Report*, prepared for BP Exploration (Alaska) Inc., Anchorage, Alaska.

Wooley, C., S. Hillman, and D. O'Brien, 1997, "Mapping Cultural Resource Sites for the Prince William Sound Graphical Resource Database," *Proceedings of the 20th Arctic and Marine Pollution (AMOP) Technical Seminar*, Vancouver, B.C.

Word, J., M. Pinza, and W. Gardiner, 2008, *Literature Review of the Effects of Dispersed Oil with Emphasis on Cold Water Environments of the Beaufort and Chukchi Seas*, prepared for Shell Global Solutions, Houston, Texas, and American Petroleum Institute, Washington D.C.

Wright, A.J., N.A. Soto, A.L. Baldwin, M. Bateson, C.M. Beale, C. Clark, T. Deak, E.F. Edwards, A. Fernandez, A. Godinho, L.T. Hatch, A. Kakuschke, D. Lusseau, D. Martineau, L.M. Romero, L.S. Weilgart, B.A. Wintle, G. Notarbartolo-di-Sciara, and V. Martin, 2007, "Do Marine Mammals Experience Stress Related to Anthropogenic Noise?" *International Journal of Comparative Psychology* 20:274–316.

Würsig, B., 1990, "Cetaceans and Oil: Ecologic Perspectives," pp. 129–165 in *Sea Mammals and Oil: Confronting the Risks*, J.R. Geraci and D.J. St. Aubin (eds.), Academic Press, San Diego, Calif.

Würsig, B., T.A. Jefferson, and D.J. Schmidly, 2000, *The Marine Mammals of the Gulf of Mexico*, Texas A&M University Press, College Station, Texas.

Yamamoto-Kawai, M., F.A. McLaughlin, E.C. Carmack, S. Nishino, K. Shimada, and N. Kurita, 2009, "Surface Freshening of the Canada Basin, 2003-2007: River Runoff versus Sea Ice Meltwater," *Journal of Geophysical Research* 114:C00A05.

Yanez-Arancibia, S., and J. Day, 2004, "Environmental Sub-regions in the Gulf of Mexico Coastal Zone: The Ecosystem Approach as an Integrated Management Tool," *Ocean and Coastal Management* 47(11-12): 727–757.

Yarwood, G., G. Mansell, M. Jimenez, and S. Lau, 2004, *2000 Gulf-Wide Emissions Inventory – OCS On-Shore Impacts Modeling (Texas), A Preliminary Look*, prepared by ENVIRON International Corporation, Novato, Calif., for MMS, New Orleans, La. Sept. 1.

Zavala-Hidalgo, J., S.L. Morey, and J.J. O'Brien, 2003, "Seasonal Circulation on the Western Shelf of the Gulf of Mexico Using a High-Resolution Numerical Model," *Journal of Geophysical Research* 108(C12):3389.

5 UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS

5.1 IMPACTS ON PHYSICAL RESOURCES

Some unavoidable adverse effects on water and sediment quality would be expected to occur as a result of the proposed action. Operational discharges of drilling muds and cuttings, produced water, and small amounts of hydrocarbons into the water column during routine offshore oil and gas operations would lower local water and sediment quality. These discharges could temporarily raise the levels of some water quality and sediment parameters above normal within 100 to 2,000 m (328 to 6,562 ft) of the discharge point during drilling, and intermittently/continuously during the production period.

An increase in emissions of air pollutants would be expected to occur, particularly in areas that do not already have extensive oil and gas activities. Emissions of nitrogen oxides and reactive hydrocarbons would increase ozone concentrations in the immediate vicinity of the offshore operations for intermittent periods during the term of the proposal.

Seismic surveys, infrastructure construction and removal, and support vehicle traffic would result in unavoidable but short-term increases in ambient noise levels in the survey areas, project locations, and vessel and helicopter routes. More long-term increases in ambient noise levels would occur during normal operations; the duration of increased ambient noise levels would correspond directly to the duration of production operations.

5.2 IMPACTS ON ECOLOGICAL RESOURCES

Marine mammals would be adversely affected by noise and disturbances associated with routine offshore activities (seismic surveys, vessels, aircraft, drilling, and dredging) during relatively brief periods of time. Some marine mammals would exhibit short-term responses to noises and disturbance, such as confusion or avoidance. Bowhead whales, for example, will exhibit avoidance behavior to noise-producing activities. Should an oil spill contact marine mammals, some individuals would experience short-term effects, while a small number could die. An oil spill would also adversely affect local marine mammal prey resources in small areas affected by a spill.

Disturbances of terrestrial mammals by offshore related aircraft, vehicles, facilities, human presence, and habitat alteration from construction activities are unavoidable. Disturbance of caribou, bears, and other animals in Alaska would be temporary and would not affect their overall distribution and abundance.

Marine and coastal birds would be adversely affected by noise and disturbances associated with routine offshore and onshore activities. Habitat alteration from the construction of onshore facilities would affect a small portion of the available habitat. Should an oil spill contact marine and coastal bird habitat, some birds would experience short-term effects, while some birds that feed in or rest on the water could be coated with oil and die. An oil spill could also adversely affect local marine and coastal bird prey resources.

Wetland and estuarine habitat alteration resulting from pipeline and other related coastal construction could have an unavoidable adverse impact on fish nursery areas and terrestrial mammals; however, regulations are in place to minimize these impacts. An oil spill contacting fish habitat would have an adverse effect on local fishery stocks and food webs.

Although individual sea turtles may be injured or killed by support vessel collisions, population-level effects would be minimal. The most likely impacts from noise would be short-term behavioral changes such as diving and evasive swimming. If an oil spill were to contact sea turtles, some individuals might not recover from exposure, but sea turtle populations as a whole would not be threatened.

Unavoidable adverse effects on seafloor habitats and associated organisms could occur from anchoring, drilling discharges, structure emplacement and removal, and pipeline emplacement.

5.3 IMPACTS ON SOCIAL, CULTURAL, AND ECONOMIC RESOURCES

Commercial and, to a lesser extent, recreational fisheries will be adversely affected by loss of fishing areas occupied by offshore vessels, platforms, and exposed pipelines, particularly in areas where oil and gas activities have not previously occurred. Oil spills could contaminate, injure, or kill shellfish, finfish, eggs, and larvae in the vicinity.

Unavoidable adverse effects could be expected to occur to tourism and recreation areas from floating debris and oil spills that contact beach areas. Effects on scenic quality could also be expected to occur.

The proposed action with its ancillary activities will place increased demands on coastal communities, particularly in areas where oil and gas activities are not currently occurring. A large oil spill could disrupt their economies. Some unavoidable adverse effects on subsistence harvests in the Alaska region may result from routine offshore oil and gas activities. These offshore and onshore activities could cause localized displacement or loss of small numbers of subsistence resources. If oil spills were to contact bowhead and beluga whales and walruses, there could be a reduction of total annual harvests of these species. In such a case, short-term loss of some subsistence resources and potential repercussions on the culturally significant sharing system would be unavoidable.

Unavoidable adverse effects to archaeological resources could occur as a result of the proposed action. Construction and siting of offshore and onshore oil and natural gas facilities such as platforms, pipelines, or processing facilities could displace, damage, or destroy archaeological resources.

6 RELATIONSHIP BETWEEN SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The short-term uses of man's environment in relation to the 2012-2017 Outer Continental Shelf (OCS) Leasing Program are the offshore and onshore activities needed to develop oil and gas resources to meet the energy needs of the United States. The Bureau of Ocean Energy Management (BOEM) makes every attempt to minimize the environmental effects from these uses. By adopting mitigating measures for OCS operations, BOEM attempts to minimize long-term impacts and maintain or enhance the long-term productivity of areas in which oil and gas have been exploited. With proper removal of offshore oil and gas facilities, or their disposal in areas designed to enhance recreational fishing, offshore areas will continue to maintain fish resources and provide habitat for marine mammals, birds, and reptiles long after oil and gas operations have ceased. The onshore effects of the OCS program and the proposed action will contribute to the continuing alteration of nearby coastal areas from natural environments to urbanized and industrialized environments.

Short-term use of the environment in the vicinity of OCS activities includes the exploration and development of OCS oil and gas resources during the period of activity needed for the completion of the proposed action. The overall life of the proposed action is estimated to be about 40-50 years, with about 10-15 years of oil and gas exploration and delineation activity and about 30-35 years of resource development and production activity. Many of the effects discussed in Chapter 4 are the result of short-term uses and are greatest during the exploration, development, and early production phases. These effects may be reduced by mitigation measures required by BOEM.

Extraction and consumption of offshore oil and natural gas would be a long-term depletion of nonrenewable resources. Economic, political, and social benefits would accrue from the availability of these natural resources. Most benefits would be short-term and would delay the increase in the dependency of the United States on oil imports. The production of offshore oil and natural gas from the proposed action would provide short-term energy sources and perhaps additional time for the development of long-term alternative energy sources or substitutes for these nonrenewable resources.

Onshore facility construction (e.g., pipelines, processing facilities, service bases, etc.) causes definite short- and long-term changes, with localized long-term effects on coastal habitats along onshore pipeline corridors. Some biological resources, such as nesting birds, may have difficulty repopulating altered habitats and could be permanently displaced from the local construction area. Short-term biological productivity would be reduced or lost in the immediate onshore areas where construction takes place; however, the long-term productivity in some of these areas could be mitigated with habitat reclamation.

After the completion of oil and gas production, the marine environment is generally expected to remain at or return to its normal long-term productivity levels. To date, there has been no discernible decrease in productivity in U.S. offshore areas where oil and gas have been produced for many years (MMS 2002, 2007).

In the Alaska region, habitat disturbance could cause local impacts to subsistence resources, which could threaten subsistence as a way of life. Road construction resulting from the proposed action would improve accessibility to primitive areas in the region. The wilderness values of the coast and along pipeline routes and associated access roads would decrease with increased human activity in these areas, particularly in areas that do not already have extensive oil and gas activities. Land use changes would be noticeable at onshore facility sites and along pipeline routes. Short-term changes include a shift in land use from subsistence-based activities to industrial activities during the life of the proposed action. Areas adjacent to onshore facilities and pipeline corridors would probably be subject to hunting regulations. Land use in some localized areas would change from conservation to resource development. Long-term effects on land use may result if the infrastructure or facilities continued to be used after the lifetime of the proposed action.

Increased population, minor gains in revenues, and the consequences of oil spills all contain the potential for disrupting coastal communities in the short term. In Alaska, an added incentive to shift from a subsistence-based economy to a cash-based economy, a reduction in subsistence resources, a decrease in subsistence activities, and other changes brought about by the proposed action could be factors in long-term consequences for Native social and cultural systems.

Archaeological and historic finds discovered during development would enhance long-term knowledge. Overall, finds may help to locate other sites, but destruction of artifacts or damage to sites would represent long-term losses.

REFERENCES

MMS (Minerals Management Service), 2002, *Outer Continental Shelf Oil & Gas Leasing Program: 2002-2007, Final Environmental Impact Statement*, OCS EIS/EA MMS 2002-006, Minerals Management Service, Herndon, Va., April.

MMS, 2007, *Outer Continental Shelf Oil and Gas Leasing Program: 2007-2012, Final Environmental Impact Statement, Volume I,* OCS EIS/EA, MMS 2007-003, April.

7 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

Section 102(2)(c)(ii) of the National Environmental Policy Act (NEPA) requires that an environmental impact statement (EIS) include information on any adverse environmental effects that cannot be avoided, should the proposed action be implemented. A commitment of a resource is considered *irreversible* when the primary or secondary impacts from its use limit the future options for its use. An *irretrievable* commitment refers to the use or consumption of a resource that is neither renewable nor recoverable for use by future generations.

7.1 MINERAL RESOURCES

The offshore oil and natural gas resources recovered as a result of the proposed action would be irretrievable once they are consumed.

7.2 BIOLOGICAL RESOURCES

Offshore and onshore oil and gas activities, such as aircraft, vessel, and vehicle traffic; facility construction; and platform removal, could permanently displace some fauna and flora species from favorable habitats to unfavorable habitats. Displacement and habitat loss may result in the reduction of some local populations and become irretrievable if alterations to the environment were permanently maintained. However, the degree of displacement and amount of irretrievable habitat loss should represent a transitory and negligible effect on the overall populations of species.

An irreversible and irretrievable commitment of biological resources may occur where wetlands are impacted by dredging, construction activities, or oil spills. Dredging and construction activities can destroy wetland vegetation, which results in soil erosion and wetland loss. This loss would be greatest in areas where oil and gas activities are currently not occurring.

7.3 LAND USE AND SOCIOECONOMIC RESOURCES

Land used for support of oil and gas development and processing would not revert to its predevelopment characteristics; however, the land may become favorable to other urban or industrial uses.

7.4 ARCHAEOLOGICAL RESOURCES

Irretrievable prehistoric archaeological sites and cultural materials may be lost through indiscriminate or accidental activity on known and unknown sites such as placement of a pipeline across a shipwreck. Loss of ground context in which artifacts are located is a very important factor in dating and relating an artifact to other artifacts. The archaeological protection requirements should mitigate some losses.

This page intentionally left blank.

8 CONSULTATION AND COORDINATION

8.1 PROCESS FOR THE PREPARATION OF THE 2012-2017 OCS OIL AND GAS LEASING PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT

8.1.1 Draft Proposed Program and Draft PEIS

Preparation and review of the draft programmatic environmental impact statement (PEIS) closely parallels that of the 2012-2017 Outer Continental Shelf (OCS) Oil and Gas Leasing Program (the Program) decision documents. Comments received on the program decision documents are also reviewed for consideration in the preparation of the PEIS.

In January 2009, the previous Administration published a Draft Proposed Program (DPP) and a Notice of Intent (NOI) to prepare a PEIS that requested comments from States, local governments, Native groups, tribes, the oil and gas industry, Federal agencies, and other interested individuals and groups and set out a schedule for scoping meetings in the areas of the DPP. In February 2009, the Secretary of the Interior extended the comment period on the DPP and postponed the scoping meetings to allow time to consider further public comment before determining which areas in the DPP should be scoped and analyzed for consideration in subsequent program proposals. A preliminary revised Program was proposed on March 31, 2010.

8.1.2 Scoping for the Draft PEIS

An NOI to prepare and scope the Program PEIS was published in the *Federal Register* (75 FR 16828) on April 2, 2010. That NOI invited the public to provide comments on the scope and content of the PEIS and identified as many as 14 locations where public scoping meetings could be held to obtain comments.

On June 30, 2010, Secretary of the Interior Salazar announced that the public scoping meetings would be postponed in response to the Deepwater Horizon incident. The additional time would be used to evaluate safety and environmental requirements of offshore drilling. On December 1, 2010, Secretary Salazar announced an updated oil and gas strategy for the OCS. The new strategy continued a moratorium for areas in the Eastern Gulf of Mexico (GOM) and eliminated the Mid-Atlantic and South Atlantic Planning Areas from consideration for potential sales and development through the 2017 planning horizon. The Western GOM, Central GOM, Cook Inlet, Chukchi Sea, and Beaufort Sea OCS Planning Areas would continue to be considered in the PEIS. Subsequently, on January 4, 2011, a Notice of Scoping Meetings for the proposed 2012-2017 OCS oil and gas leasing program PEIS was published in the *Federal Register* (76 FR 376) and a second scoping period was conducted from January 6, 2011, through March 31, 2011. During this scoping period, public scoping meetings were scheduled for 12 locations in the GOM, Alaska, and Washington, D.C. These meetings were held to garner significant issues and public concerns for inclusion in the PEIS. In addition, the Bureau of

Ocean Energy Management (BOEM) received comments through the mail and maintained a public website to accept electronic scoping comments.

BOEM established cooperating agency status with the U.S. Department of Commerce National Oceanic and Atmospheric Administration (NOAA), the State of Alaska, and the Alaska North Slope Borough (NSB). They reviewed preliminary sections of the PEIS.

8.1.3 Commenting on the Proposed Program and Draft PEIS

Comments will be requested during a 90-day period on the proposed Program and a 60-day period on the associated draft PEIS. Based on the consideration and analysis of comments, a Proposed Final Program and a Final PEIS will be prepared. The Proposed Final Program will be submitted to the President and to the Congress, along with an explanation from the U.S. Department of the Interior (USDOI) concerning the reasons for the decision.

8.2 DISTRIBUTION OF THE DRAFT PEIS

Copies of the draft PEIS will be distributed prior to publication in the *Federal Register* to Federal, State, and local agencies; to interested groups and individuals who have been involved in the preparation of the Program and the PEIS process; and to coastal libraries.

FEDERAL AGENCIES: Copies of the PEIS will be provided to the following Federal agencies:

U.S. Environmental Protection Agency (USEPA)
U.S. Department of Defense
U.S. Department of the Interior
U.S. Department of Homeland Security
U.S. Department of Justice
National Aeronautics and Space Administration
U.S. Geological Survey
U.S. Department of Commerce
U.S. Department of Energy
U.S. Department of Transportation
U.S. Department of State
Marine Mammal Commission
Federal Energy Regulatory Commission

CONGRESS: Copies of the draft PEIS will be provided to the following Congressional offices:

House of Representatives Committee on Resources
United States Senate Committee on Energy and Natural Resources

USEPA REGIONAL OFFICES:
Region 1, Boston, MA
Region 2, New York, NY
Region 3, Philadelphia, PA
Region 4, Atlanta, GA
Region 6, Dallas, TX

Region 9, San Francisco, CA
Region 10, Seattle, WA

FEDERAL AGENCIES (STATE OFFICES): Copies of the draft EIS were also distributed to Federal offices in various States, as shown below:

ALABAMA
- Readiness Support Center, U.S. Army Corps of Engineers (USACE)
- Mobile Bay National Estuary Program
- U.S. Coast Guard (USCG), Strike Team
- U.S. Fish & Wildlife Service (USFWS), Bon Secour National Wildlife Refuge (NWR), Gulf Shores

ALASKA
- National Marine Fisheries Service (NMFS), Alaska Regional Office, Juneau
- NMFS, Anchorage
- Marine Mammal Commission, Kotzebue
- USFWS, Juneau Ecological Services, Juneau
- USFWS, Region 7, Anchorage
- USFWS, Anchorage Field Office, Anchorage
- EPA, Alaska Operations Office, Anchorage
- U.S. Department of the Interior (DOI), Anchorage
- National Park Service (NPS), Anchorage
- Bureau of Indian Affairs, West Central Alaska Field Office, Anchorage
- USCG, Anchorage
- NOAA, North Pacific Fishery Management Council

CALIFORNIA
- USACE, Regulatory Branch
- Naval Air Weapons Station, Point Mugu
- NMFS, Habitat Conservation Division
- 11th USCG District, Marine Safety Office/Aids to Navigation
- NMFS, Southwest Region

COLORADO
- U.S. Bureau of Mines, Denver
- NPS, Denver

FLORIDA
- Apalachicola National Estuarine Research Reserve
- NMFS, Panama City Laboratory
- NMFS, Recreation Fisheries Development
- U.S. Navy, Pensacola
- National Oceanic and Atmospheric Administration (NOAA), Panama City
- U.S. Air Force, Pensacola
- USFWS, Cedar Keys and Lower Suwannee NWRs, Chiefland
- USFWS, St. Vincent NWR, Apalachicola
- USFWS, Panama City Field Office
- USFWS, J.N. ‘Ding’ Darling, Caloosahatchee, Island Bay, Matlacha Pass, Pine Island NWRs, Sanibel
- NOAA, Miami
- U.S. Air Force, Elgin Air Force Base, Elgin
- NPS, Homestead
- NPS, Key West
- EPA, Gulf Ecology Division, Sabine Island

GEORGIA
- USDOI, Office of Environmental Policy & Compliance
- NPS, Atlanta
- DOI
- USFWS, Atlanta

LOUISIANA
- USACE, Eastern Evaluation Section
- USCG, Marine Environmental Response & Safety Branch
- USACE, New Orleans District
- U.S. Department of Energy, Strategic Petroleum Reserve PMD
- USFWS, Cameron Prairie NWR, Bell City
- USFWS, Lacassine & Shell Keys NWR, Bell City
- USFWS, Lacombe
- USFWS, Bell City
- USFWS, Sabine NWR, Bell City
- NMFS, Baton Rouge
- U.S. Geological Survey (USGS), Baton Rouge
- U.S. Department of Energy, New Orleans
- USFWS, Lafayette
- BOEM, Bourg
- BOEM, Layfette
- BOEM, St. Charles

MISSISSIPPI
- USEPA Gulf of Mexico Program
- NMFS, Pascagoula
- USACE, Planning Division, Vicksburg, MS
- USFWS, Gulf Islands National Wildlife Refuge (NWR)

U.S. National Park Service, Gulf Islands National Seashore
NASA, Stennis Space Center
USFWS, Mississippi Sandhill Crane & Grand Bay NWRs, Gautier

OREGON
NOAA, Pacific Marine Environmental Laboratory, Newport

TEXAS
USFWS, Houston
U.S. Army Corps of Engineers, Galveston District (CESWG-PL-R)
U.S. Department of Commerce-NOAA/NMFS
USFWS, Corpus Christi
USFWS, Aransas & Matagorda Island NWR, Austwell
USFWS, Laguna Atascosa NWR, Los Fresnos
USFWS, McFaddin & Texas Point NWR, Sabine Pass
USFWS, San Bernard NWR, Brazoria
BOEM, Clute
USFWS, Moody & Anahuac NWRs, Anahuac
USCG, Marine Safety Office, Corpus Christi
NPS, Padre Island National Seashore
NOAA, Galveston Laboratory
NPS, Corpus Christi
U.S. Navy, Corpus Christi
NOAA, Flower Garden Banks National Marine Sanctuary

WASHINGTON
NOAA, Seattle
NMFS, Marine Mammal Laboratory, Seattle

TRIBES/TRIBAL ORGANIZATIONS: Copies of the draft EIS were provided to the following tribes and tribal organizations:

ALASKA
Inũpiat Community of the Arctic Slope
Cook Inlet Tribal Council, Anchorage
Alaska Area Native Health Service, Anchorage
Alaska Federation of Natives, Anchorage
Kenaitze Indian Tribe, Kenai
Koniag Incorporated, Anchorage
English Bay Native Corp, Anchorage
Aleut Corporation, Anchorage
Chugach Alaska Corporation, Anchorage
Calista Corporation, Anchorage
Bristol Bay Native Corporation, Anchorage
Native Village of Belkofski, King Cove
Agdaagux Tribe of King Cove, King Cove
Port Graham Corporation. Port Graham
King Salmon Village Council, King Salmon
Tyonek Native Corporation, Anchorage
Alaska Inter-Tribal Council, Anchorage
Native Village of Kanatak, Anchorage
Chignik Lake Village Council, Chignik Lake
Native Village of Ekuk, Dillingham
Emmonak Native Corporation, Emmonak
Chuloonawick Native Village, Chuloonawick
Native Village of False Pass, False Pass
Nelson Lagoon Tribal Council, Nelson Lagoon
Native Village of Chignik, Chignik
Newtok Corporation, Newtok
Orutsararmuit Native Council, Bethel
Qenritalek Coast Corporation, Kongiganak
Newtok Traditional Council, Newtok
Native Village of Akutan, Akutan
Cook Inlet Regional Corporation, Anchorage
Northwest Arctic Borough Planning Department
Alaska Eskimo Whaling Commission, Barrow
Nanwalek Traditional Council, Nanwalek
Nanwalek IRA Council, Nanwalek
Alaska Intertribal Council
Chenega IRA Council, Chenega Bay
Ivanoff Bay Tribal Council, Anchorage
Saguyak Incorporated, Clark's Point
Paimiut Corporation, Hooper Bay
Karluk IRA Council, Karluk
Alaska Native Harbor Seal Commission, Anchorage
Native Village of Port Heiden, Port Heiden
Kanatak Tribal Council, Wasilla
Ukpeagvik Inupiat Corporation, Barrow
Arctic Slope Native Association, Barrow
Native Village of Barrow Inupiat Traditional Government, Barrow
Arctic Slope Regional Corporation, Barrow
Kawerak Incorporated, Nome
Native Village of Barrow, Barrow
Council Native Corporation, Nome
White Mountain Native Corporation, White Mountain
Knik Tribe, Wasilla
Solomon Native Corporation, Nome
Valdez Native Tribe, Valdez
Qawalangin Tribe of Unalaska, Unalaska
Kotzebue IRA, Kotzebue
Unalakleet Native Corporation, Unalakleet

Elim Native Corporation, Elim
Native Village of South Naknek, South Naknek
Swan Lake Corporation, Nuama Iqua
Brevig Mission Native Corporation, Brevig Mission
Eskimo Walrus Commission, Nome
Bering Straits Native Corporation, Nome
Maniilaq Association, Kotzebue
Nana Regional Corporation, Kotzebue
Kikiktagruk Inupiat Corporation, Kotzebue
Native Village of Kivalina, Kivalina
Koyuk Native Corporation, Koyuk
Native Village of Point Lay, Point Lay
Native Village of Kaktovik, Kaktovik
Afognak Native Corporation, Kodiak
Central Council of The Tlingit & Haida Indian Tribes of Alaska, Juneau
Kaktovik Inupiat Corporation, Kaktovik
Chinik Eskimo Community, Golovin
Sitnasauk Native Corporation, Nome
Inalik Native Corporation, Diomede
Sivuqaq Incorporated, Gambell
Kawerak Incorporated, Nome
Native Village of Nuiqsut, Nuiqsut
Chickaloon Village Traditional Council, Chickaloon
King Island Native Corporation, Nome
Ninilchik Traditional Council, Ninilchik
St Michael Native Corporation, St. Michael
Qanirtuuq Corporation, Quinhagak
Native Village of Kwinhagak, Quinhagak
Bering Straits Native Corporation, Unalakeet
Platinum Traditional Village Council, Platinum
Pilot Point Tribal Council, Pilot Point
Native Village of Perryville, Perryville
Ouzinkie Native Corp, Ouzinkie
Shishmaref Native Corporation, Shishmaref
Ouzinkie Tribal Media Center, Ouzinkie
Shaktoolik Native Corporation, Shaktoolik
Old Harbor Native Corporation, Old Harbor
Native Village of Shaktoolik, Shaktoolik
Nunakauiak Yupik Corporation, Toksook Bay
Naknek Native Village Council, Naknek
Nima Corporation, Mekoryuk
Larsen Bay Tribal Council, Larsen Bay
Native Village of Kwigillingok, Kwigillingok
Kotlik Yupik Corporation, Kotlik
Kongnikilnomuit Yuita Corporation, Kotlik
Native Village of Kotlik, Kotlik
Kodiak Area Native Association, Kodiak
Teller Native Corporation, Teller
Ouzinkie Tribal Council, Ouzinkie
Quetekcak Native Tribe, Seward
Qagan Tayagungin Tribe, Sand Point
Unga Corporation, Sand Point
Unga Tribal Council, Sand Point
Native Village of Point Hope, Point Hope
Pauloff Harbor Tribe, Sand Point
Village of Wales, Wales
Shumagin Corporation, Sand Point
Seldovia Native Association Inc., Seldovia
Wales Native Corporation, Wales
Savoonga Native Corporation, Savoonga
Seldovia Village Tribe, Seldovia

STATE AGENCIES: Copies of the draft EIS were provided to the governors and clearinghouses of the following States:

GOVERNORS

The Honorable Robert Bentley, Governor of Alabama
The Honorable Sean Parnell, Governor of Alabama
The Honorable Edmund G. Brown, Governor of California
The Honorable Dannel P. Malloy, Governor of Connecticut
The Honorable Jack Markell, Governor of Delaware
The Honorable Rick Scott, Governor of Florida
The Honorable Nathan Deal, Governor of Georgia
The Honorable Bobby Jindal, Governor of Louisiana
The Honorable Paul LePage, Governor of Maine
The Honorable Martin O’Malley, Governor of Maryland
The Honorable Deval Patrick, Governor of Massachusetts
The Honorable Haley Barbour, Governor of Mississippi
The Honorable John Lynch, Governor of New Hampshire
The Honorable Chris Christie, Governor of New Jersey
The Honorable Andrew M. Cuomo, Governor of New York
The Honorable Bev Perdue, Governor of North Carolina
The Honorable John Kitzhaber, Governor of Oregon
The Honorable Tom Corbett, Governor of Pennsylvania

The Honorable Lincoln D. Chafee, Governor of Rhode Island
The Honorable Nikki Haley, Governor of South Carolina
The Honorable Robert F. McDonnell, Governor of Virginia
The Honorable Chris Gregoire, Governor of Washington

ALABAMA

Alabama Geological Survey, Tuscaloosa
Alabama House District 99, Montgomery
Alabama Department of Conservation & Natural Resources, Montgomery
Alabama State Docks
Chair, Natural Resources Committee, Alabama State Legislature
Coastal Section, Fairhope
Alabama State Lands Division, Montgomery
Alabama Department of Environmental Management, Montgomery
Alabama Highway Department
Alabama Historical Commission
State Oil & Gas Board of Alabama
Alabama Public Service Commission
Chair, Oil and Gas Committee, Alabama State Legislature
City of Dauphin Island
City of Mobile
Mobile Area Chamber of Commerce
Port of Mobile Al
Perdido Key Chamber of Commerce
Florida Chamber of Commerce

ALASKA

Department of Wildlife Management, North Slope Borough (NSB)
Alaska Department of Natural Resources (DNR), Anchorage
Alaska DNR, Juneau
Alaska DNR, Fairbanks
Alaska DNR, Bering Straits Coastal Resource Service Area (BSCRSA), Teller
Alaska Oil and Gas Conservation Commission, Anchorage
Alaska Department of Environmental Conservation, Juneau
Alaska Department of Fish and Game, Juneau
Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement, and Development, Douglas
Alaska Department of Transportation & Public Facilities, Juneau
Alaska Department of Commerce, Community, and Economic Development, Juneau
Alaska Department of Labor
Manokotak Village
North Slope Borough
Northwest Arctic Borough
Lake and Peninsula Borough
Village of Salamatoff
City of Anchorage
City of North Pole
Village of Clarks Point
City of Emmonak
Aleutians East Borough
Egegik Village
Village of Goodnews Bay
Chignik Lagoon
Chugachmiut, Forestry and Fire Management
City of Chignik
City & Borough of Yakutat
Village of Tyonek
Village of Sheldon Point
City of Nuiqsut
Kenai Peninsula Borough
Nightmute
City of White Mountain
City of Kenai
City of Tenakee Springs
City of Stebbins
City of Wales
City of Wainwright
Village of Wainwright
City of Teller
Aleutians East Borough
City of Savoonga
City of Point Hope
Lake and Peninsula Borough
City of Seward
City of Selawik
City of Seldovia
City of St George Island
City of Emmonak
Nunam Iqua
City of Sand Point
City of Goodnews Bay
City of Dillingham
City of Cold Bay
City of Soldotna
City of Angoon
Aleutians East Borough
City of St Michael
City of Pilot Point
Metlakatla Indian Community
Matanuska-Susitna Borough
City of St Paul

City of Haines
City of Ouzinkie
City of Kachemak
City of Kaktovik
City of Kotzebue
City of Kivalina
City of Kotlik
City of Port Lions
City of Chefornak
City of Unalakleet
City of Nome
City of Old Harbor
City & Borough of Yakutat
City of Larsen Bay
City of Barrow
City of Chignik
Kenai Chamber of Commerce
U.S. Senate, State of Alaska
U.S. Senate, State of Alaska
U.S. House of Representatives, State of Alaska

CALIFORNIA
California State Lands Commission
Joint Oil/Fisheries Liaison Office
California Energy Commission, Forecasting & Planning
National Marine Sanctuary, Monterey
California Coastal Commission, Energy & Ocean Resources Unit
Office of Oil Spill Prevention and Response
California Department of Conservation
Resources Agency of California
Department of Land Conservation & Development
Department of Fish & Game
California Coastal Commission
Attorney General, State of California
Port of Hueneme
Santa Barbara County Department of Planning & Development
San Luis Obispo County Air Pollution Control District
San Luis Obispo Council of Governments
Santa Barbara County Association of Governments
Santa Barbara

DELAWARE
Delaware Department of Natural Resources and Environmental Control, Dover

FLORIDA
Department of Community Affairs, Tallahassee
Department of Agriculture and Consumer Services, Tallahassee
Florida Department of Environmental Protection, Tallahassee
Dept. of Environment, Coastal and Aquatic Managed Areas, Tallahassee
Department of Transportation, Tallahassee
Department of State, Tallahassee
Department of Mining and Minerals Regulation, Tallahassee
Florida Fish and Wildlife Conservation, Tallahassee
Tampa Port Authority International Headquarters, Tampa
Florida Chamber of Commerce, Tallahassee
Florida Office of the Attorney General, Tallahassee
Florida Coastal Management Program
Growth Management Administrator
Department of State, Division of Historic Resources, Tallahassee
Florida Energy Office
Florida Sea Grant College, University of Florida, Gainsville
Northwest Department of Environmental Protection District Office, Pensacola
Office of Tourism, Trade and Economic Development
Department of Environmental Protection, Marine Research Institute
Chair, Natural Resources Committee, Florida House of Representatives
Chair, Natural Resources and Conservation, Florida Senate
Santa Rosa County
Walton County
Okaloosa County
Lee County
Citrus County
City of Fort Walton Beach
Franklin County
City of Pensacola
City of Destin
Florida Regional Councils Association
Hillsborough County
Gulf County Planning & Building Department
Panama City
City of Wilton Manors
Pasco County Government Center
Hernando County Planning Department
Bay County
Escambia County
District Representative, Pensacola
Sarasota County Coastal Resources
Sarasota County Government
Escumbia County
Gulf County

Perdido Key Chamber of Commerce
City of Naples
City of Gulf Breeze
Monroe County Industrial
Levy County
USFWS, Panama City Field Office
GOM Fishery Management Council

LOUISIANA

Louisiana Geological Survey, Baton Rouge
Louisiana Department of Environmental Quality, Baton Rouge
Louisiana Department of Transportation & Development, Baton Rouge
Louisiana Department of Wildlife & Fisheries, Baton Rouge
Louisiana Department of Culture/Recreation/Tourism, Baton Rouge
Louisiana Department of Natural Resources, Baton Rouge
State of Louisiana, Representative, House District 44, Lafayette
Abbeville Harbor and Terminal District, Baton Rouge
Louisiana Department of Natural Resources, Office of Coastal Management
Economic Development and Tourism Office
Chair, Natural Resources Committee, Louisiana Legislature
Chair, Natural Resources Committee, Louisiana House of Representatives
State of Louisiana, Representative, House District 84, Lafayette
Saint Bernard Planning Commission
Jefferson Parish
Mayor, City of Grand Isle
Jefferson Parish Port District
City of Lafayette
Greater Lafourche Port Commission
Grand Isle Port Commission
West Cameron Port Commission
Morgan City
City of New Orleans
Terrebonne Parish
City of Lake Charles
Twin Parish Port Commission
Lafource Parish
Plaquemines Parish Port, Harbor and Terminal District
Greater Baton Rouge Port Commission
Port of Iberia
St. Bernard Port, Harbor and Terminal District
Calcasieu Regulatory Planning Commission
St. Charles Parish
South Lafourche Levee District
City of Grand Isle
Houma-Terrebonne Chamber of Commerce
Greater Baton Rouge Port Commission
Louisiana Artificial Reef Program, Louisiana Department of Wildlife & Fisheries

MISSISSIPPI

Mississippi Department of Natural Resources, Jackson
Mississippi Department of Archives and History, Jackson
Mississippi Department of Wildlife Conservation, Jackson
Mississippi Department of Environmental Quality, Jackson
Mississippi State Port Authority
Chair, Oil, Gas, and Other Minerals Commission, Mississippi Legislature
Jackson County
City of Pascagoula
Greenville Port Commission
City of Bay Saint Louis
City of Gulfport
Southern Mississippi Planning and Development District
Mississippi Sea Grant Advisory Service, Biloxi
Mississippi Department of Marine Resources

NORTH CAROLINA

North Carolina Department of Environment and Natural Resources
North Carolina General Assembly

TEXAS

Texas Department of Water Resources
Texas General Land Office, Corpus Christi
Texas Commission on Natural Resources, Dallas
Texas Natural Resource Conservation Commission
Texas Parks & Wildlife Department, Habitat Assessment Branch
Texas Historical Commission, Texas Antiquities Committee, Austin
Texas Legislation Council, Capital Station
Texas Commission on Environmental Quality, Austin
Railroad Commission of Texas, Austin
Tracs Coordinator, Austin
Chair, Senate Natural Resources Committee, Austin
Chair, Natural Resources Committee, Texas Legislature, Austin
Texas Attorney General, Austin
Port of Beaumont

Port of Brownsville
City of Corpus Christi
Port of Corpus Christi Authority
Port of Galveston
City of Houston
City of Lake Jackson
Port of Houston
Port of Isabel, San Benito Navigation District
Port of Port Arthur
Port of Port Aransas Municipal Harbor
Lake Charles Harbor and Terminal District
Port Mansfield/Willacy County Navigation District

VIRGINIA
Commonwealth of Virginia, Department of Environmental Quality, Richmond
Virginia Department of Historic Resources
Virginia Department of Game and Fisheries
Virginia Department of Conservation and Recreation
Virginia Department of Natural Resources
Virginia Institute of Marine Science

WASHINGTON
Mr. Duane Phinney, Washington Department of Fisheries

LIBRARIES: Copies of the draft EIS were provided to the following libraries:

ALABAMA
Auburn University at Montgomery
Dauphin Island Sea Lab Library
Gulf Shores Public Library
Mobile Public Library
Montgomery Public Library
Thomas B. Norton Public Library
University of Alabama
University of Alabama Libraries, Tuscalossa
Documents Division Library, University of Southern Alabama
Alabama Public Library Service
Juliette Hampton Morgan Memorial Library

ALASKA
Kaveolook School Library, Kaktovik
Ilisaavik Library, Shishmaref
Kwigilingok Public Library
Koyuk City Library
King Cove Community/School Library
Golovin Community Library
Metlakatla Jr/Sr High School Library
Kuskokwim Consortium Library, Bethel
Tuzzy Consortium Library, Barrow
Kettleson Memorial Library, Sitka
Palmer Public Library
Pelican Public Library
Kasaan City Library
Juneau Public Library
Library, Information Services, Anchorage
Kegoyah Kozga Public Library, Nome
Kasilof Public Library
Kake City Community/School Library
Irene Ingle Public Library, Wrangell
Hydaburg School Library
Hooper Bay Public Library
Haines Borough Public Library
Tenakee Springs Public Library
University of Alaska, Fairbanks Institute of Arctic Biology
Kodiak College, Kodiak
Halibut Cove Public Library
Kenai Community Library
University of Alaska Southeast Library, Juneau
Noel Wien Library, Fairbanks
Kenai Peninsula College, Homer
Kenai Peninsula College, Soldotna
University of Alaska, Anchorage
North Slope Borough School, Barrow
Kiana Elementary School Library
Alaska State Library, Juneau
Tikigaq Library, Point Hope
Thorne Bay Community Library
Stebbins Community Library
Savoonga Public Library
Soldotna Public Library
Seward Community Library
Seldovia Public Library
Quinhagak Public Library
Petersburg Public Library
Katie Tokienna Memorial Library, Wales
Sand Point School Library
Pribolof Island School District Library, St. Paul Island
Ticasuk Library, Unalakleet
Ninilchik Community Library
Ouzinkie Community School Library
Alakanuk Public Library
A Holmes Johnson Memorial Library, Kodiak
Chenega Bay Community School Library
Gambell Community Library
Perryville Community School
Prince William Sound Community College, Cordova

Anchor Point Public Library
Alaska Fish and Game Library, Douglas
Larsen Bay Community School Library
Karluk Community School Library
Akhiok Community School Library
Skagway Public Library
Buckland Public Library
Cordova Public Library
Davis Menadelook Memorial High School Library, Diomede
Valdez Consortium Library
Tatitlek Community School Library
Kachemak Bay Campus Library, Homer
Dillingham Public Library
Craig Public Library
Nanwalek Elem/high School Library
Amakigchick & Chaputnguak School Library, Chefornak
University of Alaska, Fairbanks Wildlife Library
Homer Public Library
Esther Greenwald Library, Hoonah
Brevig Mission Community Library
Old Harbor Library
Northwest College Learning Resource Center, Nome
Trapper School Community Library, Nuiqsut
Elmer E Rasmuson Library, Fairbanks
Alaska Pacific University, Academic Support Center Library, Anchorage
BP Exploration (Alaska) Inc., Records Management, Anchorage
University of Alaska IMS, Seward Marine Center Library
Z J Loussac Public Library, Anchorage
Chiniak Public Library
Alaska Resources Library & Information Services Acquisitions, Anchorage
State of Alaska Dec Library, Juneau
Library Geophysical Institute, Fairbanks
Jessie Wakefield Memorial Library, Port Lions
Ernest Nylin Memorial Library

CALIFORNIA

University of California, Davis Shields Library, Davis
Humboldt State University Library, Arcata
University of California, Ethnic Studies Library, Berkley
Point Reyes Bird Observatory Library, Stinson Beach
California Academy of Sciences Library, San Francisco
Robert E. Kennedy Library, San Luis Obispo
California State Library, Sacramento
Cambria Library
Carpinteria Public Library
Corte Madera Library
Eureka Humboldt Co. Library
Goleta Public Library
Healdsburg Library
Salinas Public Library
Library-Business & Economics Department, Los Angeles
Long Beach Library
Mendocino County Library, Ft. Bragg
Mendocino County Library, Ukiah
Mill Valley Public Library
Monterey Public Library
Morro Bay Library
Novato Branch Library
Pacific Grove Library
Pacifica Public Library
Peninsula Conservation Foundation Library, Palo Alto
Petaluma Regional Library
Point Reyes Library
Redwood City Library
Sacramento Public Library
San Diego County Library
San Francisco Public Library
San Luis Obispo College District Library
Santa Barbara Museum of Natural History Library
Santa Barbara Public Library
Santa Cruz Public Library
Santa Monica Public Library
Santa Rosa Sonoma County Library
Sebastopol Public Library
Stinson Library, Stinson Beach
University of California, Santa Barbara
Channel Islands National Park Library, Ventura
Ventura College Library
Ventura Library SVC Agency
Santa Barbara Museum of Natural History Library

COLORADO

Information Center Ensr, Fort Collins
Science Library, University of Colorado, Boulder
Colorado State University Library
Colorado School of Mines

FLORIDA

Bay County Public Library, Panama City
Florida A&M University, Coleman Memorial Library, Tallahassee
Florida State University, Strozier Library, Tallahassee
Fort Walton Beach Public Library
Marathon Public Library

Port Charlotte Public Library
Northwest Regional Library System, Panama City
Selby Public Library, Sarasota
St. Petersburg Public Library
University of Florida Libraries, Gainesville
Tampa-Hillsborough County Library System
West Florida Regional Library, Pensacola
S.E. Wimberly Library
Pensacola State College Library
University of Miami Library
Collier County Public Library
Ann Marbut Environmental Library
Monroe County Public Library
Leon County Public Library
Ft. Meyers/Lee County Library
University of Florida, Levin College of Law
U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Miami

LOUISIANA
Calcasieu Parish Library, Lake Charles
Cameron Parish Library
Grand Isle Branch Library
Iberville Parish Library, Plaquemines
Jefferson Parish Lobby Library, Metairie
Lafayette Public Library
Lafitte Branch Library
LaFourche Parish Library, Thibodaux
Leon County Public Library, Baton Rouge
Loyola University Library, New Orleans
Lumcon Library, Chauvin
McNeese State University, Lake Charles
New Orleans Public Library, New Orleans
Nichols State University Library, Thibodaux
Plaquemines Parish Library, Buras
St. Bernard Parish Library, Chalmette
St. Charles Parish Library, Luling
St. John the Baptist Parish Library, LaPlace
St. Mary Parish Library, Franklin
St. Tammany Parish Library, Covington
Slidell Branch Library, Slidell
Terrebonne Parish Library, Houma
Tulane University, Howard Tilton Memorial Library, New Orleans
University of New Orleans Library
University of South West Louisiana, Dupre Library, Lafayette
Vermilion Parish Library, Abbeville
Jefferson Parish Regional Branch
Jefferson Parish West Bank Outreach
Middleton Library, Baton Rouge
Louisiana Tech University Library, Ruston
State Library of Louisiana, Baton Rouge
Louisiana State Library, Baton Rouge
Frazar Memorial Library, Lake Charles
West Regional Library, Luling
Martha Sowell Utley Memorial Library, Thibodaux

MISSISSIPPI
Gulf Coast Research Laboratory, Gunter Library, Ocean Springs
Hancock County Library System, Bay St. Louis
Harrison County Library, Gulfport
Jackson George Regional Library System, Pascagoula
H.T. Sampson Library, Jackson
Eudora Welty Library, Jackson
Southern Mississippi Planning and Development District

NEW HAMPSHIRE
US Army CRREL (Cold Regions Research & Engineering Lab) Library, Hanover
Dartmouth College Library, Hanover

OHIO
Ohio State University Libraries Monographs Department, Columbus

OKLAHOMA
University of Tulsa Library, Tulsa

OREGON
Oregon State Library, Salem
Oregon State University Library/Hatfield Marine Science Center, Newport
Oregon Institute of Marine Biology, Charleston

TEXAS
Margaret and Herman Brown Library, Abilene
Alma M. Carpenter Public Library, Sourlake
Aransas Pass Public Library
Austin Public Library
Bay City Public Library
Brazoria County Library, Freeport
Calhoun County Library, Port Lavaca
Chambers County Library System, Anahuac
Comfort Public Library
Corpus Christi Central Library
Corpus Christi Library Documents, Texas A&M University, Corpus Christi
Dallas Public Library
East Texas State University Library, Commerce
Evans Library, Texas A&M University, College Station
Fondren Library Government Publication Division, Houston
Houston Public Library

Jackson County Library, Edna
Lamar University, Lamar Station
Laratama Library, Corpus Christi
LBJ School of Public Affairs, Library University of Texas, Austin
Liberty Municipal Library
Orange Public Library
Port Arthur Public Library
Port Isabel Public Library
Reber Memorial Library, Raymondville
Refugio County Public Library
R.J. Kleberg Public Library, Kingsville
Rosenberg Library, Galveston
Sam Houston Regional Library & Research Center, Liberty
Stephen F. Austin State University, Steen Library, Nacogdoches
Texas Southmost College Library, Brownsville
Texas State Library, Austin
Texas Tech University Library, Lubbock
University of Houston Library
University of Texas at Arlington Library
University of Texas Library, Austin
University of Texas, Arnulfo Oliveria Memorial Library, Brownsville
University of Texas at Dallas Library, Richardson
University of Texas at El Paso Library
University of Texas at San Antonio Library
Victoria Public Library
Amoco Production Company Library, Houston
Fugro Inc. Corporate Library, Houston
Bay City Public Library, Bay City
Austin State University, Ralph W. Steen Library, Nacogdoches
University of Texas Libraries, Austin
Robert .J. Kleberg Public Library, Kingsville

VIRGINIA
National Technical Information Service, Springfield
U.S. Geological Survey Library, Reston

WASHINGTON
USEPA Region 10 Library, Seattle
NMFS Marine Mammal Lab Library, Seattle
Seattle Public Library
NMFS NW & Alaska Fisheries Center Library, Seattle
Parametrix Inc. Library, Bellevue

WASHINGTON, DC
USDOI Natural Resources Library
American Petroleum Institute Library

FOREIGN COUNTRIES
University of Alberta, Cameron Library, Edmonton Alberta
Pacific National Defense, Defense Research Library, Victoria British Columbia
Bibliotheque Institut, Maurice-Lamontagne, Montjoli, Quebec
Mackimmie Library, University of Calgary, Calgary, Alberta
Joint Secretariat, Inuvikon NT Canada
M. McLaren Library, McGill University, Montreal, Quebec
Danish Polar Centre, Copenhagen, Denmark
Scott Polar Research Institute Library, Cambridge, England
University of Oulu Biology Library, Linnanmaa, Finland
University of Oulu Geoscience Library, Yliopisto, Finland
Marine Research Institute Library, Reykjavik, Iceland
Lulea University Library, Lulea, Sweden
Swedish Institute of Space Physics Library, Kiruna, Sweden

OTHER AGENCIES, ORGANIZATIONS, AND INDIVIDUALS: Copies were also distributed to the following agencies and individuals:

REGIONAL PLANNING COUNCIL
South Alabama Regional Planning Commission
Apalachee Regional Planning Council
East Central Florida Regional Planning Council
North Central Florida Regional Planning Council
Northeast Florida Regional Planning Council
South Florida Regional Planning Council
Southwest Florida Regional Planning Council
Tampa Bay Regional Planning Council
Treasure Coast Regional Planning Council
West Florida Regional Planning Council
Withlacoochee Florida Regional Planning Council
Regional Planning Commission, New Orleans
Southern Mississippi Planning and Development District
Southeast Texas Regional Planning Commission
Golden Crescent Regional Planning Commission, Victoria

PRIVATE ORGANIZATIONS/ENVIRONMENTAL GROUPS:

ALABAMA
- Perdido Watershed Alliance, Lillian
- Portersuille Revival Group, Coden
- Mobile Baykeeper, Mobile
- Mobile Bay National Estuary Program, Mobile
- Alabama Petroleum Council, Montgomery
- Alabama Wildlife Federation, Millbrook
- General Insulation, Theodore
- WildLaw
- Audubon Society-Mobile Bay
- Alabama Wildlife Society
- University of Alabama
- Alabama Nature Conservancy, Birmingham
- Total Minatome Corporation, Birmingham
- Midstream Fuel Service, Mobile
- Horizon Shipbuilding, Inc., Coden
- Adem, Mobile
- Nbc 15 – WPMI, Mobile
- University of South Alabama, Dauphin Island Sea Laboratory
- University of Alabama

ALASKA
- Alaska Marine Conservation Council, Anchorage
- Point Hope Whaling Captains Association, Anchorage
- Alaska Operations, LGL Alaska Research Associates, Inc., Anchorage
- Northern Alaska Environmental Center, Anchorage
- Cascadia Wildlands Project, Anchorage
- Petro Star Inc, Anchorage
- Cook Inlet Region Inc, Anchorage
- Alaska Public Interest Research Group, Anchorage
- Conocophillips Alaska Inc, Anchorage
- Bio Economic Research and Analysis, Anchorage
- Alaska Public Radio Network, Anchorage
- Resource Development Council, Anchorage
- Earthjustice, Anchorage
- Oceana, Juneau
- Trustees for Alaska, Anchorage
- The Nature Conservancy, Anchorage
- Sierra Club Alaska Field Office, Anchorage
- Southwest Alaska Municipal Conference, Anchorage
- Anadarko Petroleum Corp, Anchorage
- Petro Marine Services, Anchorage
- Shell Exploration and Production Company, Anchorage
- Alaska Oil and Gas Association, Anchorage
- Western Geco, Anchorage
- National Biological Survey, Anchorage
- National Wildlife Federation, Anchorage
- National Audubon Society, Anchorage
- Bering Sea Fishermen's Association, Anchorage
- Alaska Support Industry Alliance, Anchorage
- The Wilderness Society, Anchorage
- Alaska Fisheries Development Foundation, Anchorage
- The Alaska Sea Otter and Steller Sea Lion Commission, Old Harbor
- Barrow Whaling Captains Association, Barrow
- Northwest Setnetters, Kodiak
- Cook Inlet Regional Citizens Advisory Council (RCAC), Kodiak
- Alaska Clean Seas, Prudhoe Bay
- Cook Inlet Spill Prevention & Response Co, Nikiski
- Alaska Eskimo Whaling Commission, Barrow
- Kwik Incorporated, Kwigillingok
- Alaska Survival, Talkeetna
- Bering Straits Coastal Resources Service Area, Unalakleet
- Yak-Tat-Kwaan, Yakutat
- Alaska Marine Conservation Council
- Whittier Small Boat Harbor, Whittier
- Northern Alaska Environmental Center, Fairbanks
- NGTA Incorporated, Nightmute
- Cook Inlet RCAC, Seldovia
- Cook Inlet RCAC, Soldotna
- Choggiung Ltd, Dillingham
- Alaska Nanuuq Commission, Anchorage
- LGL Alaska Research Associates Inc, Anchorage
- Chevron USA Inc, Anchorage
- Bp Exploration (Alaska) Inc, Anchorage
- Chignik River Ltd, Chignik Lake
- Cook Inlet RCAC, Kenai
- Sea Lion Corporation, Hooper Bay
- Tesoro Alaska Petroleum Company, Kenai
- Earthjustice, Juneau
- Peninsula Clarion, Kenai
- Kachemak Bay Institute, Homer
- Kugkaktlik Limited
- Alaska Coastal Community Alliance
- Cook Inlet Keeper
- Center for Alaska Coastal Studies
- Kachemak Bay Conservation Society
- Tikigaq Corp
- Alaska Trollers Association
- Alaska Miners Association
- Kodiak Daily Mirror, Kodiak
- KDLG Public Radio, Dillingham
- KBBI Public Radio, Homer

Homer News, Homer
Alaska Newspapers Inc, Anchorage
Arctic Sounder, Anchorage

CALIFORNIA
Surfrider Foundation, San Clemente
Turtle Island Restoration Network, Forest Knolls
Center for Biological Diversity, San Francisco
Natural Resources Defense Council, San Francisco
Testa Environmental Corporation, Mokelvmne Hill
ECOSLO Board of Trustees
League of Women Voters of San Luis Obispo
League of Women Voters
Get Oil Out, Inc. & GOO Education & Legal Fund
California Sport Fishing Association
Environmental Coalition, Ventura
Ventura County Commercial Fishermen's Association
Environmental Defense
Citizens Planning Association
Continental Shelf Associates, Inc.
Sierra Club
Central Coast Hook & Line, Fishermen's Association
Get Oil Out, Inc.
LA Commercial Fisherman's Association
Western States Petroleum Association
Environmental Defense Center
Trans-Pacific Seafood
Sierra Club Marine Committee
Southern California Trawler's Association
American Cetacean Society, San Pedro
Area Energy LLC, Bakersfield
Chevron Energy Research & Technology Company, Richmond
PacSEIS, Inc., Bakersfield

COLORADO
Armstrong Oil and Gas Inc., Denver
Aspen Exploration Corp., Denver
Forest Oil Corporation, Denver

FLORIDA
Manasota-88, Nokomis
Organized Fishermen of Florida, Cocoa
Gulf Coast Environmental Defense, Gulf Breeze
Escambia Co. Marine Resources, Gulf Breeze
Santa Rosa Sound Coalition, Gulf Breeze
Save the Manatee Club, Maitland
Harbor Branch Oceanographic Institute, Gainesville
Chuck's Dive World, Ft. Walton Beach
The Nature Conservancy
Apalachicola National Estuarine Research Reserve, Eastpoint
Florida Audubon Society, Miami
Izaak Walton League of America, Inc., Key Largo
Gulf and S. Atlantic Fisheries, Development Foundation
Florida Chapter Sierra Club
Gulf Coast Environmental Defense
1000 Friends of Florida
Center for Ecotoxicology
Florida Institute of Oceanography
Florida Public Interest Research
Southeastern Fisheries Association
Florida Wildlife Federation
Florida Fish & Wildlife Conservation Commission
Florida Conservation Association
Perdido Key Association
Citizens Association of Bonita Beach
Florida Petroleum Council
AAC/XPP
Florida Defenders of the Environment
Magnum Steel Services Corp., Tampa
Florida Natural Areas Inventory
Roffers Ocean Fishing Forecast Service, West Melbourne
League of Woman Voters, Pensacola
Earthjustice
Santa Rosa Sound Coalition
GOM Fishery Management Council
Florida Marine Research Institute
Gulf and South Atlantic Fisheries Development Foundation, Tampa
Pensacola Archaeological Society
FNGA, FPGA and AGDF, Tallahassee
Florida Petroleum Council, Tallahassee
James Madison Institute, Tallahassee
Development Foundation, Gulf and South Atlantic Fisheries
West Florida and Power 93, Tampa
Florida Natural Areas Inventory, Tallahassee
Apalachicola Riverkeeper, Apalachicola
Field Conserv Service Inc., Altamonte Springs
The Ocean Conservancy, St. Petersburg
Mote Marine Laboratory, Sarasota
Marine Science Center, St. Petersburg
Environmental Resources, Marathon
R. B. Falcon Drilling, Pensacola
Alton Strategic Environmental Group, New Port Richey
URS, Tallahassee
Ecology and Environment, Inc., Tallahassee
Han & Associates, Inc., Key Biscayne
SAIC, Shalimar
Lampl Herbert Consultants, Tallahassee

Csa International, Stuart
Florida Power and Light
NWF Daily News, Pensacola
St. Petersburg Times, St. Petersburg
Venice Herald Tribune, Venice
Florida State University, Tallahassee
Florida Sea Grant College, University of Florida, Gainsville
University of Miami, Miami
Pensacola Junior College, Pensacola
Florida Institute of Oceanography, St. Petersburg
Florida Institute of Technology, Melbourne
Bay County Audubon Society, Gulf Coast Environmental Defense
Executive Director, Southeastern Fisheries Association
Director, Florida Natural Areas Inventory

GEORGIA
Greenpeace
Associated Press, Atlanta

ILLINOIS
Chicago Zoological Society, Brookfield
Northwestern University, Environmental Policy and Culture Program, Evanston
Southern Illinois University, Edwardsville

INDIANA
Purdue University, Fort Wayne

KANSAS
Koch Exploration, Wichita
Gordon Energy Solutions, LLC, Overland

LOUISIANA
South Central Industrial Association, Houma
Sierra Club, Delta Chapter, New Orleans
Clean Gulf Associates, New Orleans
Lynder Oil Company, Gretna
Global Industries, Ltd., Carlyss
Audubon Louisiana Nature Center, New Orleans
Gulf Coast Fisherman’s Coalition, New Orleans
Coalition to Restore Coastal Louisiana
Gulf Restoration Network, New Orleans
Stone Energy Corporation, Lafayette
Sierra Club, Lafayette
Concerned Shrimpers of America, Marrero
Ocean Conservancy, New Orleans
L &M Botruc Rental, Inc, Galliano
Offshore Operators Committee, Metairie
LA 1 Coalition, Inc., Thibodaux
National Estuary Program, Thibodaux
Louisiana Wildlife Federation, Inc.
Restore or Retreat, Thibodaux
Louisiana Wildlife Federation, Inc. State Office – Louisiana State University
Mid-Continent Oil & Gas Association, Baton Rouge
Louisiana Oil and Gas Association, Baton Rouge
C-K Associates, LLC, Baton Rouge
The Nature Conservancy, Baton Rouge
LSU Sea Grant College, Program Center for Wetland Resources
Sierra Club Legal Defense Fund
Louisiana Land & Exploration Company
Louisiana State University, Center for Wetland Resources, Baton Rouge
Louisiana Gulf Coast Conservation Association
Chet Morrison Contractors, Houma
Coastal Environments, Inc., Baton Rouge
Applied Technology Research Corporation, Baton Rouge
T. Baker Smith, Inc., Houma
Petroleum Helicopters, Harahan
Bepco, L.P., Metairie
Project Consulting Services, Metairie
Century Exploration N.O., Inc., Metairie
The Daspit Companies, Poydras
John E. Chance & Associates, Inc.
Shell E&P Company, New Orleans
Deleon & Associates, LLC, Lafayette
Raintree Resources, Inc., Lake Charles
The Sji, LLC, Larose
Acadian Integrated Solutions, Maurice
Ensco75, Robeline
Louisiana Offshore Oil Port, Inc.
Flash Gas and Oil Southwest, Inc., Mandeville
Offshore Process Services, Mandeville
Larose Intercoastal Lands Inc., Larose
Waring & Assoc, New Orleans
Energy Partners, Ltd., New Orleans
Freeport-Mcmoran, Inc., New Orleans
Shell Offshore Inc., New Orleans
Walk, Haydel & Associates, New Orleans
Taylor Energy Co., New Orleans
Strategic Management Services, New Orleans
Aries Marine Corporation, Lafayette
Amoco Production Company
Seot, Inc., Lafayette
Phoenix International, Inc., Morgan City
Petroleum Information Corporation, New Orleans
Chevron USA
Asco USA, LLC, Lafayette
Adams and Reese, New Orleans
C.H. Fenstermaker & Associates, Lafayette
B-J Services Co., Lafayette
Ecosystem Management, Lafayette

Marathon Oil Co., Lafayette
ChevronTexaco, Kaplan
Cochrance Technology, Lafayette
Oil and Gas Property Management, Lafayette
John Chance Land Surveys, Inc., Lafayette
Vastar Resources, Lafayette
Baker Energy, Kaplan
Columbia Gulf Transmission, Kaplan
Times Picayune, New Orleans
The Times-Picayune, Lafayette
University of Southwestern Louisiana, Lafayette
University of Louisiana at Lafayette, Lafayette
Nicholls State University, Thibodaux
University of New Orleans, New Orleans
Lumcon, Chuavin
Tulane University, New Orleans

MARYLAND
Izaak Walton League of America, Inc., Gaithersburg
Reefkeeper International, Middletown

MASSACHUSETTS
Conservation Law Foundation, Boston
IOMA, N. Falmouth
Horizon Marine, Inc., Marion

MISSISSIPPI
Gulf States Marine Fisheries Commission, Ocean Springs
Mississippi-Alabama Sea Grant Consortium, Ocean Springs
Mississippi Development Authority, Jackson
Mississippi Nature Conservancy
Mississippi Wildlife Federation, Ridgeland
Gulf Coast Research Laboratory
Mississippi Mineral Resources Institute
University of Southern Mississippi, Hattiesburg
Mississippi State University
University of Mississippi

NORTH CAROLINA
Surfrider Outer Banks Chapter, Kill Devil Hills
Science Applications International Corp., Raleigh
University of North Carolina, Morehead City

NEBRASKA
Northern Natural Gas Company, Omaha

NEW JERSEY
N.J. Marine Sciences Consortium, Fort Hancock
Environment New Jersey, Trenton
Exxonmobil Biomedical Sciences, Inc, Annandale

NEW MEXICO
Acoustic Ecology Institute, Santa Fe

NEW YORK
Natural Resources Defense Council, New York
Waterkeeper Alliance, New York
Occidental Oil and Gas, Middlesex

NORTH DAKOTA
Dakota State University, Fargo

OKLAHOMA
Industrial Vehicles International Inc, Tulsa
American Association of Petroleum Geologists, Tulsa
University of Tulsa, Tulsa

RHODE ISLAND
University of Rhode Island, Narragansett

SOUTH CAROLINA
South Carolina Wildlife and Marine Resources
University of South Carolina, Conway

TEXAS
Texas Nature Conservancy, Corpus Christi
Walter Oil & Gas Corporation, Houston
Anadarko Petroleum Corporation, Houston
Seneca Resources Corporation, Houston
EOG Resources, Inc., Corpus Christi
Amerada Hess Corporation, Houston
Coastal Conservation Association, Houston
LGL-Ecological Research Associates, Inc, Bryan
Exxonmobil Corporation
Box Energy Corporation, Dallas
James K. Dodson Company, Grapevine
International Association of Geophysical Contractors, Houston
Hunt Oil Co., Dallas
Consumer Energy Alliance, Houston
Patton Boggs LLP, Dallas
Texas City Terminal Railway Company, Texas City
British Petroleum, Houston
Offshore Energy Center, Houston
Texas Conservation Foundation
Texas Water Conversation Association, Austin
Sierra Club-Lone Star Chapter, Austin
Texas Shrimp Association
Center Point Energy, Tivoli
Texas A&M University, Sea Grant Program
Coastal Coordination Council, Austin
Coastal Conservation Association
Shell Oil Co., Houston

Tatham Offshore, Inc., Houston
LCT Inc., Houston
Offshore Data Services, Inc., Houston
Mosbacher Energy Co., Houston
Green Canyon Pipeline Co., Houston
El Paso Production, Houston
Athens Group, Inc., Austin
PPI Technology Services, Houston
Brigham Oil and Gas, L.P., Austin
BP Amoco, Houston
Chevron U.S.A. Inc., Houston
Union Pacific Resources Company, Houston
Columbia Gas Development Corp., Houston
Geo-Marine, Inc., Plano
Clayton W. Williams, Jr., Inc., Midland
Drilling Rig Masters, Magnolia
ConocoPhillips Company, Houston
Enterprise Products Operating LP, Sabine Pass
PPG Industries, Inc., Laporte
Seacor Marine
Texas Geophysical Company, Inc., New Waverly
BW Offshore, Houston
J. Connor Consultants, Houston
Murphy Exploration & Production, Houston
Theom and Associates, Katy
Shell Exploration & Production Company, Houston
Veritas, Houston
W & T Offshore, Inc., Houston
BP America Inc., Houston
Exxonmobil Upstream Research Company, Houston
Shell Global Solutions (U.S.) Inc., Houston
Newfield Exploration Company, Houston
Halliburton, Houston
Shell Energy Resources Company, Houston
Exxonmobil Exploration Co., Houston
Agip Petroleum Company, Inc., Houston
Cairn Energy USA, Inc., Houston
W & T Offshore, Inc., Houston
Houston Exploration Company, Houston
American Association of Petroleum Geologists, Houston
Devon Energy Corp., Houston
Petrobas America, Inc., Houston
Chevrontexaco Upstream, Houston
Transco Exploration & Production Co., Houston
Pennzoil Exploration, Houston
Wil Rig (U.S.A.), Houston
B. T. Operating Company, Houston
JK Enterprises
Wayman W. Buchanan, Inc., San Antonio
Statoil U.S.A. E&P Inc., Houston
Baker Atlas, Spring
Propane Market Strategy Newsletter, Houston
Offshore Magazine, Houston
Gulf of Mexico Newsletter, Houston
Rice University, Houston
University of Houston, Houston
Audubon Society-Austin, Southwest Region
Texas A&M University, Department of Oceanography
University of Texas, Bureau of Economic Geology
University of Houston at Clear Lake, Houston
Texas A&M University at Galveston, Galveston
University of Texas at El Paso, El Pas
University of North Texas, Denton
University of Texas at Arlington, Arlington
Abilene Christian University, Abilene
University of Texas at San Antonio, San Antonio
University of Texas at Austin, Austin
University of Texas Law School, Austin
East Texas State University, Commerce
Lamar University, Beaumont

UTAH

Utah State University, Logan

VIRGINIA

Mangi Environmental Group, Inc.
60 Plus Association, Alexandria
Southern Environmental Law Center, Charlottesville
Chesapeake Climate Action Network, Richmond
Applied Statistical Associates, Inc., Oakton
International Window Film Association, Martinsville

WASHINGTON, DC

Coastal States Organization, Washington D.C.
Washington Post

WISCONSIN

University of Wisconsin, Stevens Point

This page intentionally left blank.

9 LIST OF PREPARERS

Name	Education/Expertise	Contribution
Bureau of Ocean Energy Management		
Tamara Arzt	J.D./M.PA., NEPA, Environmental Law and Policy; 12 years of experience working on a variety of national, State, and local environmental policy and legal issues.	NEPA compliance reviewer
Gene Augustine	M.S., Biology, aquatic ecology concentration; B.S. Biology, environmental biology; 34 years of impact assessment and natural resource planning and management, including 30 years of experience in Alaska ecosystems.	NEPA coordinator for the Alaska region and technical review
Melissa Batum	M.S., Geology; 14 years of experience in the field of geology.	Reviewer; physical environmental, geological hazards
Gregory Boland	M.S., Biological Oceanography; 37 years of experience in offshore environmental research, primarily benthic biology including coral reef and deep-sea ecology.	Reviewer; benthic habitat
Perry Boudreaux	M.S., Marine and Environmental Biology; 6 years of experience in wetland impact analysis and environmental assessment.	NEPA coordinator for the Gulf of Mexico region
Jerry Brian	M.S., Applied Economics and Management with a focus on environmental and resource economics; 9 years of experience in socioeconomic research and environmental analysis.	Reviewer; socioeconomics
Megan Butterworth	M.S., Marine Science; B.S., Marine Science; B.S., Biology; 4 years experience in biological oceanography and marine science.	Reviewer; human health impacts; marine mammals, reptiles, invertebrates, fish, EFH, Areas of Special Concern, water quality
Chris Campbell	M.A., Anthropology Cultural Resources; 40 years of experience in Alaskan anthropological research and field work; 33 years of NEPA experience.	Reviewer; socioeconomic, sociocultural, subsistence, environmental justice, archaeology
Bob Cameron	M.S., Meteorology; 30+ years experience in meteorology and climate issues.	Reviewer; climate change
Sidney F. Chaky	M.A., Sociology; 19 years experience.	Reviewer; land use and infrastructure, scenario

Name	Education/Expertise	Contribution
Douglas Choromanski	B.S., Geology; 30 years experience in site clearance shallow hazards surveys.	Reviewer; site clearance surveys
Catherine Coon	M.S., Fishery Biology; 20 years of fisheries, habitat ecology, and spatial statistics of Alaska marine resources.	Reviewer; EFH, fish, lower trophics
James Craig	Ph.D., Geology; 29 years experience in Alaska geology, E&D scenarios, costs, and fair market value evaluations.	Reviewer; provided exploration & development scenarios and schedules, inputs for both the MAG_PLAN and OECM models
Deborah Cranswick	32 years with OCS Program; 20 years NEPA; 9 years AK Region; 7 years EAS chief	NEPA compliance and OCS program reviewer
Christopher Crews	B.S., Wildlife Biology, minor Natural Resources; B.S. Biological Sciences; 6 years analytical experience (NEPA), 4 years landscape/grazing management	Reviewer; terrestrial mammals, pinnipeds
Jennifer Culbertson	Ph.D., Biology; 11 years of experience in coastal biology/chemistry and applied ecology	Reviewer; marine and coastal habitats; water quality; ecoregions
Jeffrey Denton	M.S., Wildlife Management; 38 years experience in wildlife and wildlife habitat management, research, and environmental assessment.	Reviewer of biological resources
Nancy Deschu	B.A., Zoology/M.S., Civil Engineering (water resources).	Reviewer; water quality, fish, EFH
Norman Froomer	Ph.D., Geography and Environmental Engineering; 35 years of experience in coastal research and environmental assessment.	Project manager; purpose and need, alternatives, scenarios, marine spatial planning
Jeffrey Gleason	Ph.D., Zoology (avian ecology); 7 years of experience in analysis.	Reviewer; birds
Donald (Tre) W. Glenn, III	Ph.D., Environmental Engineering; 10 years of experience in impact analysis.	Reviewer; reptiles and marine mammals
Kelly Hammerle	MPA, Environmental Policy emphasis; 7 years of experience in environmental assessment.	Project coordinator, NEPA compliance reviewer

Name	Education/Expertise	Contribution
Larry Hartzog	M.S., Fisheries Limnology; 34 years experience as environmental scientist preparing environmental impact analysis, endangered species coordination/ consultation and mitigation planning.	Reviewer; coastal and marine habitats and fish
Dirk Herkhof	M.S., Meteorology; 36 years experience in air quality impact analysis, meteorological and air quality studies, and NEPA.	Reviewer; air quality and climate; air emissions estimates
Tim Holder	Master of Urban Planning; 12 years experience in urban planning, 19 years working for MMS in Alaska, 2 years for MMS in the GOM as a socioeconomic specialist, and 2 years in MMS/BOEMRE HQ as Arctic Liaison.	Coordinating with Alaska cooperating agencies; reviewer; sociocultural
Dan Holiday	Ph.D., Physical Sciences and Biological Oceanography; 8 years experience in environmental modeling of primary productivity, and the biology and ecology of oceanographic and estuarine trophic systems.	Reviewer; lower trophics, vegetation and wetlands, oceanography, climate, and cumulative effects
Mark Jensen	M.S. Economics; 10 years experience in economic analysis, research, and document preparation.	Reviewer; sociocultural, tourism/recreation, commercial/recreational fishing, Areas of Special Concern
Walter Johnson	Ph.D., Marine Science, Physical Oceanography; 30 years of experience in coastal oceanography and numerical ocean modeling; 22 years of oil spill modeling.	Reviewer; oil spill-related information
Brian Jordan	Ph.D., Natural Resource Science and Management; M.S., Forestry with specialization in wood science; B.A. Anthropology with a minor in classical studies; 18 years of experience in underwater archaeology, submerged cultural resource management, historic preservation, and marine policy.	Reviewer; sociocultural
Arie R. Kaller	Ph.D., Oceanography and Coastal Sciences; 11 years of experience in coastal vegetation and nekton research, and 2 years of NEPA document preparation.	Reviewer; coastal and marine habitats, EFH, and fish
Jill Lewandowski	M.S. Environmental Science and Policy; Ph.D. in progress; 15 years experience in protected species assessment.	Reviewer; marine mammals, sea turtles, and acoustic environment

Name	Education/Expertise	Contribution
James Lima	Ph.D., Political Science; Socioeconomic Specialist; 25 years experience in marine-related social science research, ocean and coastal management, and environmental assessment.	Reviewer; socioeconomic
Matthew Lux	B.S., Geography.	Reviewer; GIS data/maps
Robert Martinson	M.S., Zoology; B.S., Biological Science; 32 years NEPA and environmental compliance experience with particular emphasis on wetlands and aquatic and coastal ecology.	Reviewer and comment resolution for purpose and need; alternatives
Tershara Matthews	Ph.D. candidate, Coastal Sciences; 16 years of experience and research in coastal research.	Reviewer
Lori Monroe	J.D.; 26 years of legal experience, including preparing and reviewing legal documents, both environmental and non-environmental in nature.	Reviewer; legal review
Dave Moran	M.S., Zoology; 27 years professional experience in applied environmental science.	Reviewer; invertebrates and lower trophic levels
Constance Murphy	B.S., Soil Science; 16 years in environmental science, consulting, assessment, and remediation; 3 years in editing.	Coordinator for printing and production
Michelle K. Nannen	M.S., Marine Environmental Science; 10 years of experience in benthic and fisheries ecological studies and environmental assessment.	Reviewer; marine benthic habitats and marine pelagic habitats
S.E. O'Reilly	Ph.D., Environmental Geochemistry; 9 years experience in mineralogy/ (bio)geochemistry as related to water quality.	Reviewer; water quality
Robert Peterson	M.S., Geology; 32 years offshore oil and gas experience; Chief Resource and Economic Analysis Section, AKOCS.	Reviewer; isonomic impacts
Richard Prentki	Ph.D., Chemical Oceanography; 30 years in Agency as OSRA Coordinator and COR.	Reviewer; geohazards

Name	Education/Expertise	Contribution
John Primo	Ph.D., MA Ecological and Applied Anthropology; marine, aquatic and coastal social science; experience with community and regional profiling (i.e., fishing communities, lakeside communities); experienced researcher; research portfolio and project management background.	Reviewer; sociocultural systems, environmental justice, and archaeological and historic resources
Virginia Raps	M.S., Aeronautical Science; B.S., Mathematics and Meteorology; 16 years of NEPA planning experience focusing on air quality impact analysis; 17 years experience National Weather Service and Naval Weather Service surface and upper air analysis.	Reviewer; meteorology, climate change, and air quality impacts
Rick Raymond	M.S., Environmental Sciences; 23 years fish and wildlife analysis, wetlands, NEPA and environmental assessment.	Reviewer; avian sections for Alaska
Michael Routhier	J.D., M.S.E.L.; 3 years experience in environmental planning and regulatory compliance.	NEPA reviewer
Mark Schroeder	M.S., Wildlife Biology; 25 years of government experience.	Reviewer
Lois Simenson	M.S., Environmental Science; 13 years of experience in coastal research and environmental assessment.	Coastal Zone Management Coordinator, BOEM Alaska
James Sinclair	M.S., Biological Sciences; 17 years of experience with coastal and offshore organisms and ecosystems research.	Reviewer; ecoregional settings
David Sire	B.S. Forest management; 23 years of experience in preparing and reviewing NEPA compliance documents.	NEPA compliance reviewer
Kimberly Skrupky	B.S., Environmental Science, Wildlife Conservation; 13 years experience in environmental policy and marine biology.	Writer/editor for marine mammals, sea turtles, and acoustic environment
Caryn Smith	M.S., Oceanography; 23 years of experience oil spill risk analysis and environmental assessment.	Reviewer; Alaska OCS region oceanography and sea ice, oil spill analysis
Bill Swears	M.A., English; 20 years experience in reading, writing, and editing Federal technical documents and regulations.	Accuracy checking; language consistency: purpose and need, alternatives

Name	Education/Expertise	Contribution
Lisa Treichel	M.S., Technology Management, Environmental and Waste Management Option/B.S., Forestry and Wildlife; 24 years environmental experience.	NEPA compliance reviewer
Poojan Tripathi	M.S., Plant and Soil Science; 7 years of experience as an interdisciplinary environmental science with expertise hydrology, water quality, wetlands, and NEPA.	Reviewer; water quality, purpose and need, alternatives
Sally Valdes	Ph.D., aquatic ecology; 25 years of science/science policy experience.	Reviewer; biological resources, commercial fisheries
Jeffrey Walker	B.S., Geological Engineering; 35 years experience managing oil and gas projects on the Alaska OCS.	Reviewer
Sharon Warren	Program Analysis Officer; 10+ years experience in review of environmental analyses related to land management and oil and gas activities in Alaska.	Reviewer
Kate Wedemeyer	M.S., Fisheries; M.S., Natural Resource Management; 24+ years in Alaskan fish and habitat management and related environmental assessments.	Reviewer; fisheries
Geoffrey Wikel	M.S., Marine Science; MPP; 11 years experience in coastal geomorphology and oceanography.	Project facilitator and reviewer
James Woehr	Ph.D., Ecology, avian ecologist; 30+ years in avian research and management.	Reviewer; birds
Eric Wolvovsky	M.S., Geographic Information Systems; B.S., Meteorology; 1.5 years of air quality experience	Reviewer; air quality
Argonne National Laboratory		
Timothy Allison	M.S., Mineral and Energy Resource Economics; M.A., Geography; 20 years of experience in regional analysis and economic impact analysis.	Population, employment and income; environmental justice; tourism and recreation; commercial and recreational fisheries
Bruce Biwer	Ph.D., Chemistry; 20 years of experience in environmental assessment.	Document manager
Brian Cantwell	B.S., Forestry; 28 years of experience in mapping and geographic information systems.	Technical lead for maps and spatial analysis

Name	Education/Expertise	Contribution
Adrianne Carr	Ph.D., Geological and Environmental Sciences; 5 years of experience in hydrological studies and impact analysis.	Water quality
Young-Soo Chang	Ph.D., Chemical Engineering; 24 years of experience in air quality and noise impact analysis.	Meteorology and air quality; acoustic environment
Vic Comello	M.S., Physics; 34 years of experience in technical writing and editing.	Lead technical editor
Deborah Elcock	M.B.A.; 30 years of experience in energy and environmental assessment.	Public scoping
John Gasper	M.S., M.P.H.; Environmental Health Science; 37 years of experience in energy and environmental research and assessment.	Project management, public scoping
Linda Graf	Desktop publishing specialist; 40 years of experience in creating, revising, formatting, and printing documents.	Document assembly and production
Fontaine Grant	B.A., 20 years of experience in program management.	Public scoping
Mark Grippo	Ph.D., Biology; 5 years of experience in aquatic resource studies and impact analysis.	Marine benthic and pelagic habitats; essential fish habitat; invertebrates and lower trophic levels; areas of special concern; commercial and recreational fisheries
John Hayse	Ph.D., Zoology; 24 years of experience in marine and freshwater ecology research; 24 years of experience in environmental assessment.	Fish resources and essential fish habitat; seafloor habitats; areas of special concern; fisheries
Ihor Hlohowskyj	Ph.D., Zoology; 31 years of experience in ecological research; 27 years in environmental assessment.	Argonne project manager; purpose and need; marine and coastal ecoregions; exploration and development scenarios; accidental oil spill scenarios; marine and coastal birds
Elizabeth Hocking	J.D.; 25 years of experience in environmental and regulatory analysis.	Public scoping
Leslie Kirchler	Ph.D., Urban, Technological, and Environmental Planning; Ph.D., Landscape Architecture; 8 years of experience in land use planning and environmental assessment.	Land use and infrastructure

Name	Education/Expertise	Contribution
Louis Martino	M.S., Environmental Toxicology; 35 years of experience in environmental remediation and assessment.	Public scoping
Robert N. McWhorter	B.S., MFR (Forest Resources); 25 years of experience in environmental assessment; 15 years of experience in public outreach.	Scoping meeting support
Ellen Moret	M.P.P., Public Policy; B.A., Environmental Studies; 7 years of experience in environmental assessment.	Public scoping comments
Michele Nelson	Graphic designer; 32 years of experience in graphical design and technical illustration.	Graphics
Ben O'Connor	Ph.D., Civil Engineering; 5 years of experience in hydrological studies and impact analysis.	Climate change; oceanography
Daniel O'Rourke	M.S., Industrial Archaeology; B.A. History and Anthropology; 17 years of experience in archaeology.	Archaeological and historic resources
Jana Padovano	B.A., Communications and Marketing; 20 years of experience in administrative support	Project administrative support lead; public scoping meeting support
Terri Patton	M.S., Geology; 22 years of experience in environmental research and assessment.	Geologic hazards; cumulative impacts
Pamela Richmond	M.S., Computer Information Systems; 16 years of experience in Web site development and related technology.	Public web site development
Lorenza Salinas	Desktop publishing specialist; 28 years of experience in creating, revising, formatting, and printing documents.	Document assembly and production
Kerri Schroeder	Desktop publishing specialist; 30 years of experience in creating, revising, formatting, and printing documents.	Document assembly and production
Albert E. Smith	Ph.D., Physics; 37 years of experience in policy analysis, air and noise impact assessment, and regulatory analysis.	Air quality impacts; acoustic impacts
Carolyn M. Steele	B.A., English; B.A., Rhetoric; 5 years of experience in technical writing and editing.	Editor

Name	Education/Expertise	Contribution
Robert Sullivan	M.L.A., Landscape Architecture; 24 years of experience in visual impact assessment and simulation.	Infrastructure and land use; public web site development
Robert Van Lonkhuyzen	B.A., Biology; 21 years of experience in ecological research and environmental assessment.	Coastal and estuarine habitats
Bruce Verhaaren	Ph.D., Archaeology; 21 years of experience in archaeological analysis; 17 years of experience in environmental assessments and records management.	Sociocultural systems; records management
William Vinikour	M.S., Biology with environmental emphasis; 34 years of experience in ecological research and environmental assessment.	Mammals
Leroy Walston, Jr.	M.S., Biology; 6 years of experience in ecological research and environmental assessment.	Reptiles
Emily Zvolanek	B.A., Environmental Science; 3 years of experience in GIS mapping.	GIS mapping

This page intentionally left blank.

APPENDIX A

GLOSSARY

This page intentionally left blank.

APPENDIX A

GLOSSARY

anadromous fish – fish that migrate up river from the sea to breed in fresh water.

anthropogenic – coming from human sources, relating to the effect of man on nature.

aphotic zone – zone where the levels of light entering through the surface are not sufficient for photosynthesis or for animal response.

archaeological interest – capable of providing scientific or humanistic understanding of past human behavior, cultural adaptation, and related topics through the application of scientific or scholarly techniques, such as controlled observation, contextual measurement, controlled collection, analysis, interpretation, and explanation.

archaeological resource – any material remains of human life or activities that are at least 50 years of age and that are of archaeological interest.

aromatic – applied to a class of organic compounds containing benzene rings or benzenoid structures.

attainment area – an area that is classified by the U.S. Environmental Protection Agency (USEPA) as meeting the primary or secondary ambient air quality standards for a particular air pollutant based on monitored data.

barrel – equal to 42 U.S. gallons or 158.99 liters.

benthic – bottom dwelling, associated with (in or on) the seafloor.

benthos – organisms that dwell in or on the seafloor, the organisms living in or associated with the benthic (or bottom) environment.

biological opinion – an appraisal from either the U.S. Fish and Wildlife Service (USFWS) or the National Marine Fisheries Service (NMFS) evaluating the impact of a proposed Federal action, if it is likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of critical habitat, as required by Section 7 of the Endangered Species Act.

bivalves – general term for two-shelled mollusks (clams, oysters, scallops, mussels).

carrying capacity – the maximum number or weight of individuals that can exist in a given habitat; an appraisal from either USFWS or NMFS evaluating the impact of a proposed activity on endangered and threatened species.

cetacean – any of an order (Cetacea) of aquatic mostly marine mammals including the whales, dolphins, porpoises, and related forms with a large head, fusiform nearly hairless body, paddle-shaped forelimbs, vestigial concealed hind limbs, and horizontal flukes (tails).

chemosynthetic – organisms that obtain their energy from the oxidation of various inorganic compounds rather than from light (photosynthesis).

coastal wetlands – forested and nonforested habitats, mangroves, and all marsh islands that are exposed to coastal waters. Included in forested wetlands are hardwood hammocks, cypress-tupelogum swamps, and fluvial vegetation/bottomland hardwoods. Nonforested wetlands include fresh, brackish, and salt marshes. These areas directly contribute to the high biological productivity of coastal water by input of detritus and nutrients, by providing nursery and feeding areas for shellfish and finfish, by serving as habitat for many birds and other animals, and by providing waterfowl hunting and fur trapping.

coastal zone – the coastal waters (including the lands therein and thereunder) and the adjacent shore lands (including the waters therein and thereunder) strongly influenced by each other and in proximity to the shorelines of the several coastal States; and including islands, transitional and intertidal areas, salt marshes, wetlands, and beaches. The zone extends seaward to the outer limit of the United States territorial sea. The zone extends inland from the shorelines only the extent necessary to control shore lands, the uses of which have a direct and significant impact on the coastal waters. Excluded from the coastal zone are lands the use of which are by law subject to the discretion of or which are held in trust by the Federal Government, its officers, or agents. (The State land and water area officially designated by the State as “coastal zone” in its State coastal zone program as approved by the U.S. Department of Commerce under the Coastal Zone Management Act [CZMA].)

coastal zone consistency review – State review of direct Federal activities or private individual activities requiring Federal licenses or permits, and outer continental shelf (OCS) plans pursuant to the CZMA to determine if the activity is consistent with the enforceable policies of the State’s federally approved Coastal Zone Management (CZM) program.

continental shelf – a broad, gently sloping, shallow feature extending from the shore to the continental slope, generally considered to exist to the depth of 200 m (656 ft); that part of the continental margin between the continental shelf and the continental rise (or oceanic trench).

continental slope – a relatively steep, narrow feature paralleling the continental shelf; the region in which the steepest descent to the ocean bottom occurs.

contingency plan – a plan for possible offshore emergencies prepared and submitted by the oil or gas operator as part of the plan of development and production, and which may be required for part of the plan of exploration.

critical habitat – a designated area that is essential to the conservation of an endangered or threatened species that may require special management considerations or protection.

crude oil – petroleum in its natural state as it emerges from a well, or after it passes through a gas-oil separator but before refining or distillation.

crustaceans – any aquatic invertebrate with jointed legs, such as crabs, shrimp, lobster, barnacles, amphipods, isopods, etc.; primarily an aquatic group.

deferral – action taken by the Secretary of the Interior at the time of the area identification to remove certain areas/blocks from a lease offering.

delineation well – an exploratory well drilled to define the areal extent of a field. Also referred to as an "expendable well."

development – activities that take place following discovery of minerals in paying quantities, including geophysical activity, drilling, platform construction, and operation of all onshore support facilities, and that are for the purpose of ultimately producing the minerals discovered.

development and production plan (DPP) – a plan describing the specific work to be performed on an offshore lease, including all development and production activities that the lessee proposes to undertake during the time period covered by the plan and all actions to be undertaken up to and including the commencement of sustained production. The plan also includes descriptions of facilities and operations to be used, well locations, current geological and geophysical information, environmental safeguards, safety standards and features, time schedules, and other relevant information. All lease operators are required to formulate and obtain approval of such plans by the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) before development and production activities may begin; requirements for submittal of DPP are wholly identified in 30 CFR 250.34.

development well – a well drilled into a known producing formation in a previously discovered field, to be distinguished from a wildcat, exploratory, or offset well.

dilution – the reduction in the concentration of dissolved or suspended substances by mixing with water.

discharge – something that is emitted; flow rate of a fluid at a given instant expressed as volume per unit of time.

dispersion – a distribution of finely divided particles in a medium.

drillship – a self-propelled, self-contained vessel equipped with a derrick amidships for drilling wells in deep water.

drilling mud – a special mixture of clay, water, or refined oil, and chemical additives pumped downhole through the drill pipe and drill bit. The mud cools the rapidly rotating bit, lubricates the drill pipe as it turns in the wellbore, carries rock cuttings to the surface, serves to keep the hole from crumbling or collapsing, and provides the weight or hydrostatic head to prevent extraneous fluids from entering the wellbore and to control downhole pressures that may be encountered (drilling fluid).

effluent – the liquid waste of sewage and industrial processing.

emission offset – emission reductions obtained from facilities, either onshore or offshore, other than the facility or facilities covered by the proposed exploration plan or development and production plan. The emission reductions achieved must be sufficient so that there will be no net increase in emissions for the area.

endangered and threatened species (endangered species) – any species that is in danger of extinction throughout all or a significant portion of its range and has been officially listed by the appropriate Federal or State agency; a species is determined to be endangered (or threatened) because of any of the following factors: (1) the present or threatened destruction, modification, or curtailment of its habitat or range; (2) over utilization for commercial, sporting, scientific, or educational purposes; (3) disease or predation; (4) the inadequacy of existing regulatory mechanisms; or (5) other natural or man-made factors affecting its continued existence.

environmental assessment – a concise public document required by the National Environmental Policy Act of 1969 (NEPA). In the document, a Federal agency proposing (or reviewing) an action provides evidence and analysis for determining whether it must prepare an environmental impact statement (EIS) or whether it finds there is no significant impact (i.e., Finding of No Significant Impact [FONSI]).

environmental effect – a measurable alteration or change in environmental conditions.

environmental impact statement (EIS) – a statement required by the NEPA or similar State law in relation to any major action significantly affecting the environment; a NEPA document.

essential habitat – specific areas crucial to the conservation of a species that may necessitate special considerations.

essential fish habitat (EFH) – those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. This includes areas that are currently or historically used by fish, or that have substrate such as sediment, hard bottom, bottom structures, or associated biological communities required to support a sustainable fishery.

estuary – semi-enclosed coastal body of water that has a free connection with the open sea and within which seawater is measurably diluted with freshwater.

Exclusive Economic Zone (EEZ) – the maritime region adjacent to the territorial sea, extending 200 nautical miles from the baseline of the territorial sea, in which the United States has exclusive rights and jurisdiction over living and nonliving natural resources.

exploration – the process of searching for minerals. Exploration activities include: (1) geophysical surveys where magnetic, gravity, seismic, or other systems are used to detect or infer the presence of such minerals; and (2) any drilling, except development drilling, whether on or off known geological structures. Exploration also includes the drilling of a well in which a discovery of oil or natural gas in paying quantities is made, and the drilling, after such a discovery, of any additional well that is needed to delineate a reservoir and to enable the lessee to determine whether to proceed with development and production.

exploration plan (EP) – a plan submitted by a lessee (30 CFR 250.33) that identifies all the potential hydrocarbon accumulations and wells that the lessee proposes to drill to evaluate the accumulations within the lease or unit area covered by the plan. All lease operators are required to obtain approval of such a plan by a BOEMRE Regional Supervisor before exploration activities may commence.

exploratory well – a well drilled in unproven or semi-proven territory for the purpose of ascertaining the presence underground of a commercially producible deposit of petroleum or natural gas.

fault – a fracture in the earth's crust accompanied by a displacement of one side of the fracture with respect to the other.

fauna – the animals of a particular region or time.

fixed or bottom founded – permanently or temporarily attached to the seafloor.

flyway – an established air route of migratory birds.

formation – a bed or deposit sufficiently homogeneous to be distinctive as a unit. Each different formation is given a name, frequently as a result of the study of the formation outcrop at the surface and sometimes based on fossils found in the formation.

fugitive emissions – emission into the atmosphere that could not reasonably pass through a stack, chimney, vent or other functionally equivalent opening.

geochemical – of or relating to the science dealing with the chemical composition of and the actual or possible chemical changes in the crust of the earth.

geologic hazard – a feature or condition that, if unmitigated, may seriously jeopardize offshore oil and gas exploration and development activities. Mitigation may necessitate special engineering procedures or relocation of a well.

geophysical – of or relating to the physics of the earth, especially the measurement and interpretation of geophysical properties of the rocks in an area.

geophysical data – facts, statistics, or samples that have not been analyzed or processed, pertaining to gravity, magnetic, seismic, or other surveys/systems.

geophysical survey – the exploration of an area during which geophysical properties and relationships unique to the area are measured by one or more geophysical methods.

habitat – a specific type of place that is occupied by an organism, a population, or a community; a specific type of place defined by its physical or biological environment that is occupied by an organism, a population, or a community.

harassment – an intentional or negligent act or omission that creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns that include, but are not limited to, feeding or sheltering.

haulout area – specific locations where pinnipeds come ashore and concentrate in numbers to rest, breed, and/or bear young.

herbivores – animals whose diet consists of plant material.

hydrocarbon – any of a large class of organic compounds containing primarily carbon and hydrogen; comprising paraffins, olefins, members of the acetylene series, alicyclic hydrocarbons, and aromatic hydrocarbons; and occurring, in many cases, in petroleum, natural gas, coal, and bitumens.

hypothermia – subnormal temperature of the body, usually due to excessive heat loss.

hypoxia – depressed levels of dissolved oxygen in water, usually resulting in decreased metabolism.

incidental take – take of a threatened or endangered fish or wildlife species that results from, but is not the purpose of, carrying out an otherwise lawful activity conducted by a Federal agency or applicant (see take).

indirect effects – effects caused by activities that are stimulated by an action but not directly related to it.

industry infrastructure – the facilities associated with oil and gas development (e.g., refineries, gas processing plants, etc.).

information to lessees – information included in the Notice of Sale to alert lessees and operators of special concerns in or near a sale area of regulatory provisions enforceable by Federal or State agencies.

jack-up rig – a barge-like floating platform with legs at each corner that can be lowered to the sea bottom to raise the platform above the water; a drilling platform with retractable legs that can be lowered to the sea bottom to raise the platform above the water.

landfall – the site at which a marine pipeline comes to shore.

lay barge – a shallow-draft, barge-like vessel used in the construction and laying of underwater pipelines.

lighter – a barge or small tanker used to move cargo from a large ship to port; also, to transport by lighter.

macroinvertebrate – animals such as worms, clams, or crabs that are large enough to be seen without the aid of a microscope.

mariculture – the breeding or growth of marine animals and plants to increase their stocks.

marine sanctuary – area protected under the Marine Protection, Research, and Sanctuaries Act of 1972.

marshes – persistent, emergent nonforested wetlands characterized by vegetation consisting predominantly of cordgrasses, rushes, and cattails.

microcrustacean – any relatively small crustacean (may range from microscopic to slightly over one centimeter in size) including organisms such as beach hoppers (amphipods), copepods, ostracods, isopods, and mysids.

military warning area – an area established by the U.S. Department of Defense within which the public is warned that military activities take place.

minerals – as used in this document, minerals include oil, gas, sulfur, and associated resources, and all other minerals authorized by an Act of Congress to be produced from public lands, as defined in Section 103 of the Federal Land Policy and Management Act of 1976.

mollusks – animal phylum characterized by soft body parts including clams, mussels, snails, squid, and octopus.

mud – the liquid circulated through the wellbore during rotary drilling operations. In addition to its function of bringing cuttings to the surface, drilling mud cools and lubricates the bit and drill stem, protects against blowouts by holding back subsurface pressures, and deposits a mud cake on the wall of the borehole to prevent loss of fluids to the formations; also called drilling mud or drilling fluid; also a sediment designation composed of silt and clay-sized particles.

mysids – small shrimp-like organisms, also known as opossum shrimp due to their method of egg incubation.

natural gas – hydrocarbons that are in a gaseous phase under atmospheric conditions of temperature and pressure.

nearshore waters – offshore open waters that extend from the shoreline out to the limit of the territorial seas (12 nautical miles).

nonattainment area – an area that is shown by monitoring data or air quality modeling calculations to exceed primary or secondary ambient air quality standards established by the USEPA.

offloading – another name for unloading; offloading refers more specifically to liquid cargo, crude oil, and refined products.

oil spill contingency plan – a plan submitted by the lease or unit operator along with or prior to a submission of a plan of exploration or a development/production plan that details provisions for fully defined specific actions to be taken following discovery and notification of an oil spill occurrence.

operational discharge – a release of oil that is part of the routine operation of a function.

operator – the person or company engaged in the business of drilling for, producing, or processing oil, gas, or other minerals and recognized by BOEMRE as the official contact and responsible for the lease activities or operations.

organic matter – material derived from living plant or animal organisms.

outer continental shelf (OCS) – all submerged lands that comprise the continental margin adjacent to the United States and seaward of State offshore lands.

petroleum – an oily, flammable, bituminous liquid that occurs in many places in the upper strata of the earth, either in seepages or in reservoirs; essentially a complex mixture of hydrocarbons of different types with small amounts of other substances; any of various substances (as natural gas or shale oil) similar in composition to petroleum.

phytoplankton – plant (photosynthetic) plankton; microscopic, freefloating, photosynthetic organisms that drift passively in the water.

pinniped – any of a suborder (Pinnipedia) of aquatic carnivorous mammals (e.g., seals, sea lions, sea otters, walruses) with all four limbs modified into flippers.

plankton – passively floating or weakly motile aquatic plants and animals.

planning area – a subdivision of an offshore area used as the initial basis for considering blocks to be offered for lease in the U.S. Department of the Interior’s areawide offshore oil and gas leasing program.

platform – a steel, concrete, or gravel structure from which offshore development wells are drilled.

postlease – any activity on a block or blocks after the issuance of a lease on said block or blocks.

potential impact (effect) – the range of alterations or changes to environmental conditions that could be caused by an action.

primary production – production of carbon by a plant through photosynthesis over a given period of time; oil and gas production that occurs from the reservoir energy inherent in the formation.

produced water – total water produced from the oil and gas extraction process; the water may be discharged after treatment or reinjected; production water or production brine.

production – activities that take place after the successful completion, by any means, of the removal of minerals, including such removal, field operations, transfer of minerals to shore, operation monitoring, maintenance, and workover drilling.

production well – a well that is drilled for the purpose of producing oil or gas reserves; it is sometimes termed a development well.

prospect – an untested geologic feature having the potential for trapping and accumulating hydrocarbons.

recoverable reserves – portion of the identified oil or gas resources that can be economically extracted under current technological constraints.

recoverable resource estimate – an assessment of oil and gas resources that takes into account the fact that physical and technological constraints dictate that only a portion of resources or reserves can be brought to the surface.

refining – fractional distillation, usually followed by other processing (e.g., cracking).

reserves – portion of the identified oil or gas resource that can be economically extracted.

reservoir – a subsurface, porous, permeable rock body in which hydrocarbons have accumulated.

resources – concentrations of naturally occurring solid, liquid, or gaseous materials in or on the earth's crust some part of which is currently or potentially extractable. These include both identified and undiscovered resources.

rig – a structure used for drilling an oil or gas well.

right-of-way – a legal right of passage, an easement; the specific area or route for which permission has been granted to place a pipeline, (and) ancillary facilities, and for normal maintenance thereafter.

rookery – the nesting or breeding grounds of gregarious (i.e., social) birds or mammals; also a colony of such birds or mammals.

sale area – the geographical area of the OCS being offered for lease for the exploration, development, and production of mineral resources.

scoping – the process prior to EIS preparation to determine the range and significance of issues to be addressed in the EIS for each proposed major Federal action.

seagrass beds – more or less continuous mats of submerged, rooted marine flowering vascular plants occurring in shallow tropical and temperate waters. Seagrass beds provide habitat, including breeding and feeding grounds, for adults and/or juveniles of many of the economically important shellfish and finfish.

sediment – material that has been transported and deposited by water, wind, glacier, precipitation, or gravity; a mass of deposited material.

seeps (hydrocarbon) – gas or oil that reaches the surface along bedding planes, fractures, unconformities, or fault planes through connected porous rocks.

seismic – pertaining to, characteristic of, or produced by earthquakes or earth vibration; having to do with elastic waves in the earth; also geophysical when applied to surveys.

semisubmersible – a floating offshore drilling structure that has hulls submerged in the water but not resting on the seafloor.

shunting – a method used in offshore oil and gas drilling activities where expended drill cuttings and fluids are discharged near the ocean seafloor rather than at the surface, as in the case of normal offshore drilling operations.

significant archaeological resource – those archaeological resources that meet the criteria of significance for eligibility to the *National Register of Historic Places* as defined in 36 CFR 60.4 or its successor.

stipulations – specific measures imposed upon a lessee that apply to a lease. Stipulations are attached as a provision of a lease; they may apply to some or all tracts in a sale. For example, a stipulation might limit drilling to a certain time period of the year or certain areas.

subsistence uses – the customary and traditional uses by rural residents of wild, renewable resources for direct personal or family consumption as food, shelter, fuel, clothing, tools, or transportation; for making and selling of handcraft articles out of nonedible byproducts of fish and wildlife resources taken for personal or family consumption; for barter, or sharing for personal or family consumption; and for customary trade.

supply boat – a vessel that ferries food, water, fuel, and drilling supplies and equipment to a rig and returns to land with refuse that cannot be disposed of at sea.

take – to harass, harm, pursue, hunt, shoot, wound, kill, capture, or collect a threatened or endangered fish or wildlife species, or attempt to engage in any such conduct. (Harm includes habitat modification that impairs behavioral patterns, and harass includes actions that create the likelihood of injury to an extent that normal behavior patterns are disrupted.)

threatened species – any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range, and which has been officially listed by the appropriate Federal agency. Criteria for determination of threatened status can be found under “endangered species.”

trawl – a large, tapered fishing net of flattened, conical shape that is typically towed along the sea bottom.

trophic – trophic levels refer to the hierarchy of organisms from photosynthetic plants to carnivores, such as man; feeding trophic levels refer to the hierarchy of organisms from photosynthetic plants to carnivores in which organisms at one level are fed upon by those at the next higher level (e.g., phytoplankton eaten by zooplankton eaten by fish).

turbidity – reduced water clarity resulting from the presence of suspended matter.

vascular plants – plants containing food and water conducting structures; higher plants that reproduce by seeds.

volatile organic compound (VOC) – any reactive organic compound that is emitted to the atmosphere as a vapor. The definition does not include methane.

vulnerability – the likelihood of being damaged by external influences. Vulnerability implies sensitivity of a system plus the risk of a damaging influence occurring.

weathering – the aging of oil due to its exposure to the atmosphere and environment causing marked alterations in its physical and chemical makeup.

wetlands – areas periodically inundated or saturated by surface or groundwater and predominantly supporting vegetation typically adapted for life in saturated soil conditions.

zooplankton – animal plankton, mostly dependent on phytoplankton for its food source; small, free-floating animals, may be passive drifters or motile, dependent on phytoplankton as a food source.

APPENDIX B

ASSUMED MITIGATION MEASURES

This page intentionally left blank.

APPENDIX B

ASSUMED MITIGATION MEASURES

All Bureau of Ocean Energy Management (BOEM) sale proposals include rules and regulations prescribing environmental controls to be imposed on lease operators. Lease stipulations, outer continental shelf (OCS) regulations, and other measures provide a regulatory base for implementing environmental protection on leases issued as a result of a sale. The BOEM Environmental Studies Program and the analyses and monitoring of activities in a sale area provide information used in formulating the agency's regulatory control over the activities that occur during the life of the leases.

The Bureau of Safety and Environmental Enforcement (BSEE) has broad permitting and monitoring authority to ensure safe operations and environmental protection. Use of the best available and safest technologies during exploration, development, and production, as well as the adopted stipulations, are just a few of the measures designed to prevent environmental damage. The BSEE also monitors operations after drilling has begun and carries out periodic inspections of facilities (in certain instances, in conjunction with other Federal agencies such as the U.S. Environmental Protection Agency) to ensure safe and clean operations over the life of the leases.

The analyses in the environmental impact statement assume the implementation of all mitigation measures required by statute or regulation. In addition, the impact analysis assumes that sale-specific stipulations that were commonly adopted in past lease sales are in effect. The following is a brief description of the sale-specific stipulations or other mitigations assumed in the analysis of potential effects of the proposed action. Because over 100 individual mitigations can be applied to exploration and development activities in the Gulf of Mexico region, only lease stipulations are described individually. Both the lease stipulations and other protective environmental measures issued through Information to Lessees (ITL) in Alaska are described.

B.1 GULF OF MEXICO REGION

B.1.1 Lease Stipulations

B.1.1.1 Topographic Features

This stipulation designates a "No Activity Zone" around several underwater topographic features commonly called "banks" whose crests may contain biological communities including corals. The No Activity Zone is designed to protect the biota of these features from adverse effects of routine offshore oil and gas activities by preventing the emplacement of platforms, or the anchoring of service vessels or mobile drilling units, directly on the banks and requiring that drilling discharges be shunted in such a manner that they do not settle on the biota.

B.1.1.2 Live Bottom (Pinnacle Trend)

This stipulation is intended to protect the pinnacle trend area and the associated hard-bottom communities from damage from oil and gas activities. If the required live bottom survey report determines that the live bottom may be adversely impacted by the proposed activity, certain measures, such as relocation or monitoring, may be required.

B.1.1.3 Live Bottom (Low Relief)

This stipulation is intended to protect hard-bottom communities not associated with bathymetric features on the sea bottom. Biological communities such as seagrass beds, sponges, and corals may occur on smooth topography. If the required live bottom survey report determines that the live bottom may be adversely impacted by the proposed activity, certain measures, such as relocation or monitoring, may be required.

B.1.1.4 Oil-Spill Response (Eastern Gulf of Mexico)

This stipulation is intended to minimize the risk of oil spills reaching Florida State waters by requiring the staging of state-of-the-art mechanical oil-spill response equipment within specified timeframes and by requiring that oil dispersant chemicals and equipment be maintained in a state of readiness.

B.1.1.5 Military Areas

This stipulation has three sections: hold harmless, electromagnetic emissions, and operational. The hold harmless section serves to protect the U.S. Government from liability in the event of an accident involving a lessee and military activities. The electromagnetic emissions section requires the lessee and its agents to reduce and curtail the use of equipment emitting electromagnetic energy in certain areas. This reduces the impact of offshore oil and gas activities on military communications and missile testing. The operational section requires prior notification of the military when offshore oil and gas activities are scheduled within a military use area to assist in scheduling activities and to prevent potential conflicts.

A second stipulation requires the evacuation, upon the receipt of a directive from the BSEE Regional Director, of all personnel from all structures on the lease and the shutting in and securing of all wells and other equipment, including pipelines, on the lease.

Two additional stipulations are applied to leases in the Eastern Gulf of Mexico Planning Area only. In cooperation with the U.S. Air Force, “drilling windows” are established for 6-month periods during which exploratory operations or workover operations may be conducted on leases. This time-sharing arrangement allows military operations to proceed in areas containing leases without being disrupted by oil and gas activities, and without undue disturbance to the exploratory activity and workover operations.

An additional stipulation has been included for the Western Gulf of Mexico Planning Area only. The Naval Mine Warfare Stipulation is intended to eliminate potential impacts from multiple-use conflicts in the Western Planning Area, Mustang Island Area East Addition, Blocks 732, 733, and 734. The U.S. Department of the Navy has identified these blocks as needed for testing equipment and for training mine warfare personnel.

B.1.2 Other Mitigations Categories

B.1.2.1 Air Quality

This category includes eight mitigations that apply to offshore exploration, development, and pipeline activities.

B.1.2.2 Archaeology

There are 18 mitigations describing procedures for conducting archaeological surveys before bottom-disturbing activities can occur on a lease; the procedures operators must follow these to avoid impacts on potential prehistoric and shipwreck sites.

B.1.2.3 Artificial Reefs

Five mitigations exist to avoid impacts on artificial reef sites and permit areas.

B.1.2.4 Chemosynthetic Communities

There are five mitigations to avoid impacts on chemosynthetic communities in deepwater areas of the Gulf of Mexico.

B.1.2.5 Coastal Zone Management

Five mitigations describe the conditions of approval in each of the Gulf Coast States.

B.1.2.6 Topographic Features, Live Bottoms, and the Flower Garden Banks

There are 13 mitigations to protect the health and stability of these benthic features.

B.1.2.7 Miscellaneous Mitigations

These apply to space-use conflicts, oil spill preparedness, remote operating vehicle surveys in deep water, essential fish habitat, hydrogen sulfide, and other issues.

B.2 ALASKA REGION

B.2.1 Lease Stipulations

B.2.1.1 Orientation Program

This stipulation is designed to provide an increased understanding of, and appreciation for, local community values, customs, and lifestyles of Alaska Native communities. The required orientation program must be designed in sufficient detail to inform individuals working on OCS projects of specific types of environmental, social, and cultural concerns in the area. The orientation program must provide information to industry employees on protected species, biological resources used for commercial and subsistence purposes, archaeological resources of the area and appropriate ways to protect them, and reducing industrial noise and disturbance effects on marine mammals and marine and coastal birds. The program must also include information about avoiding conflicts with subsistence activities.

B.2.1.2 Protection of Biological Resources

This stipulation provides for identifying and protecting previously unknown important or unique biological populations or habitats that may occur in a lease area. If previously unknown sensitive biological resources are identified during the conduct of lease activities under an approved Plan of Exploration or Development and Production Plan, the lessee will be required to modify operations, if necessary, to minimize adverse impacts on those biological populations or habitats.

B.2.1.3 Protection of Fisheries (Cook Inlet Planning Area)

This stipulation is designed to minimize spatial conflicts between OCS activities and commercial, sport, and subsistence fishing activities. Lease-related uses will be restricted, if determined necessary by the BOEM Alaska Regional Supervisor for Field Operations, to prevent unreasonable conflicts with fishing operations. The stipulation requires the lessee to review planned exploration and development activities (including plans for seismic surveys, drilling rig transportation, or other vessel traffic) with potentially affected fishing organizations, subsistence communities, and port authorities to prevent unreasonable fishing gear conflicts.

B.2.1.4 Transportation of Hydrocarbons

This stipulation informs lessees that (1) BOEM reserves the right to require the placement of pipelines in certain designated management areas, (2) pipelines must be designed and constructed to withstand the hazardous conditions that may be encountered in the sale area, and (3) pipeline construction and associated activities must comply with regulations. This stipulation requires the use of pipelines if (1) pipeline rights-of-way can be determined and obtained; (2) laying such pipelines is technologically feasible and environmentally preferable; and (3) in the opinion of the lessor, pipelines can be laid without net social loss, taking into account any incremental costs of pipelines over alternative methods of transportation and any incremental benefits in the form of increased environmental protection or reduced multiple-use conflicts.

B.2.1.5 Industry Site-Specific Monitoring Program for Marine Mammal Subsistence Resources (Arctic Planning Areas)

This stipulation requires industry to conduct a site-specific monitoring program to determine when marine mammals are present in the vicinity of exploration operations, including ancillary seismic surveys, during periods of subsistence use. The monitoring program and review process required for Marine Mammal Protection Act authorization will satisfy the requirements of this stipulation. The monitoring plan must provide for reports on marine mammal sightings and the extent of observed behavioral effects because of lease activities. It also provides a formal mechanism for the oil and gas industry to coordinate logistics activities with the BOEM Bowhead Whale Aerial Survey Program. The stipulation provides for an opportunity for recognized co-management organizations to review and comment on the proposed monitoring plan before BOEM approval. The stipulation requires the lessee to fund an independent peer review of the proposed monitoring plan and the draft reports on the results of the monitoring program. No monitoring program will be required if the BOEM Alaska Regional Supervisor for Field Operations, in consultation with the appropriate agencies and co-management organizations, determines that a monitoring program is not necessary based on the size, timing, duration, and scope of the proposed operations.

B.2.1.6 Conflict Avoidance Mechanisms to Protect Subsistence Whaling and Other Marine Mammal Subsistence Activities (Arctic Planning Areas)

This stipulation is designed to reduce disturbance effects on Alaska Native subsistence practices from OCS oil and gas industry activities by requiring industry to make reasonable efforts to conduct all aspects of their operations in a manner that recognizes Alaska Native subsistence requirements and avoids conflict with local subsistence harvest activities. The stipulation applies to both on-lease operations and to support activities, such as vessel and aircraft traffic. The stipulation also requires industry to consult with directly affected subsistence communities, the North Slope Borough, and the recognized co-management organizations to discuss possible siting and timing conflicts and to assure that exploration, development, and production activities do not result in unreasonable conflicts with subsistence whaling and other subsistence harvests. The stipulation also provides a mechanism to address unresolved conflicts between the oil and gas industry and subsistence activities.

B.2.1.7 Measures to Minimize Effects on Spectacled and Steller's Eiders During Exploration Activities (Arctic Planning Areas)

This stipulation is designed to minimize the likelihood that spectacled or Steller's eiders will strike drilling structures or vessels. The stipulation requires specific lighting protocols for structures and vessels, a plan for recording and reporting bird strikes, and avoidance of specified blocks by OCS-related vessels.

B.3 INFORMATION TO LESSEE

Several ITLs have been developed to notify lessees and operators about environmental, social, and cultural concerns.

Past ITLs have provided lessees information or advisories on the following:

- Community participation in operations planning;
- Bird and marine mammal protection laws;
- Endangered, threatened, and candidate species and designated critical habitat under the Endangered Species Act;
- Consideration in Oil Spill Response Plans of river deltas of the Beaufort Sea coastal plain that have been identified by the U.S. Fish and Wildlife Service as special habitats for bird nesting, fish overwintering, or for other species' use;
- Possible prohibition of shore-based facilities in river deltas that have been identified as special habitats;
- Potential effects of seismic surveys on marine mammals and subsistence activities;
- Requirements on the availability of bowhead whales for subsistence whaling;
- The BOEM bowhead whale aerial monitoring program;
- The possibility that BOEM may limit or modify operations if they could result in significant effects on the availability of bowhead whales for subsistence use;

- Requirements for protection of polar bears and to limit potential encounters and interactions between lease operations and polar bears;

- Requirements for archaeological and shallow geologic hazards reports in support of exploration and development plans;

- Navigational safety;

- Requirements for air quality permits;

- Designated Class I air quality areas;

- Requirements for National Pollutant Discharge Elimination System permits for discharge of produced water, drilling fluids, and cuttings;

- Sensitive areas to be considered when developing oil-spill contingency plans;

- Requirements for BSEE approval of Oil Spill Reponses Plans;

- Requirements for establishing and maintaining oil-spill financial responsibility;

- BOEM encouragement of the use of existing pads and islands wherever feasible;

- The importance of the area around Cross Island for Nuiqsut subsistence whaling activities;

- Requirements for mitigation of unreasonable conflicts with subsistence activities; and

- BOEM encouragement of industry to establish of a Good Neighbor Policy to provide an immediate compensation system to minimize disruption to subsistence activities and provide resources to relocate subsistence hunters to alternate hunting areas or provide temporary food supplies in the event an accidental oil spill adversely affects the harvest of marine subsistence resources.

This page intentionally left blank.

APPENDIX C

FEDERAL LAWS AND EXECUTIVE ORDERS

This page intentionally left blank.

APPENDIX C

FEDERAL LAWS AND EXECUTIVE ORDERS

C.1 FEDERAL LAWS

C.1.1 The Outer Continental Shelf Lands Act (OCSLA)

The Outer Continental Shelf Lands Act of 1953 (OCSLA) authorized the Secretary of the Interior to grant mineral leases and to prescribe regulations governing oil and gas activities on Outer Continental Shelf (OCS) lands. The OCSLA defines the OCS as:

> . . . *all submerged lands lying seaward and outside of the areas lands beneath navigable waters as defined in section 2 of the Submerged Lands Act and of which the subsoil and seabed appertain to the United States and are subject to its jurisdiction and control.*

The pertinent provision of the Submerged Lands Act defines "navigable waters" as:

> . . . *all lands permanently or periodically covered by tidal waters up to but not above the line of mean high tide and seaward to a line three geographical miles distant from the coast line of each such State and to the boundary line of each such State where in any case such boundary as it existed at the time such State became a member of the Union, or as heretofore approved by Congress, extends seaward (or into the Gulf of Mexico) beyond three geographical miles* . . . .

Under the OCSLA, the U.S. Department of the Interior (USDOI) is required to:

- Manage the orderly leasing, exploration, development, and production of oil and gas resources on the Federal OCS;
- Ensure the protection of the human, marine, and coastal environments;
- Ensure that the public receives a fair and equitable return for these resources; and
- Ensure that free-market competition is maintained.

Within the USDOI, the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) is charged with the responsibility of managing and regulating the development of OCS oil and gas resources in accordance with the provisions of the OCSLA. The BOEMRE operating regulations are presented in Chapter 30, Code of Federal Regulations (CFR), Part 250.

C.1.2 The National Environment Policy Act (NEPA)

The National Environmental Policy Act of 1969 (NEPA) is the foundation of environmental policymaking in the United States. The NEPA process is intended to help public officials make decisions based on an understanding of environmental consequences and take actions that protect, restore, and enhance the environment. The NEPA established two primary mechanisms for this purpose:

- The Council on Environmental Quality (CEQ) was established to advise Agencies on the environmental decision making process and to oversee and coordinate the development of Federal environmental policy.

- Agencies must include an environmental review process early in the planning for proposed actions.

The CEQ issued regulations in 1978 implementing NEPA. The regulations include procedures to be used by Federal Agencies for the environmental review process. These regulations provide for the use of the NEPA process to identify and assess reasonable alternatives to proposed actions that avoid or minimize adverse effects of these actions upon the quality of the human environment. Scoping is used to identify the scope and significance of important environmental issues associated with a proposed Federal action through coordination with Federal, State, and local agencies; the general public; and any interested individual or organization prior to the development of an impact statement. The process also identifies and eliminates from further detailed study issues that are not significant or that have been covered by prior environmental review.

The NEPA requires all Federal Agencies to use a systematic, interdisciplinary approach to protect the human environment. Such an approach ensures the integrated use of natural and social sciences in any planning and decision making that may have an impact on the environment. The NEPA also requires the preparation of a detailed environmental impact statement (EIS) on any major Federal action that may have a significant impact on the environment. The EIS must address any adverse environmental effects that cannot be avoided or mitigated, alternatives to the proposed action, the relationship between short-term resources and long-term productivity, and irreversible and irretrievable commitments of resources. Environmental assessments (EAs) are prepared to determine whether significant impacts may occur. If an EA finds that significant impacts may occur, NEPA requires preparation of an EIS. The briefest form of NEPA review is the categorical exclusion review (CER). The purpose of a CER is to verify that neither an EA nor an EIS is needed prior to making a decision on the activity being considered for approval.

C.1.3 The Energy Policy Act of 2005

This law, enacted in 2005, gives the BOEMRE new responsibilities over Federal offshore renewable energy and related uses of the OCS. Section 388 of the Act gives the Secretary of the Interior the authority to grant leases, easements, or rights-of-way for renewable energy-related uses on the Federal OCS, and to monitor and regulate the facilities used for energy production and energy support services.

C.1.4 The Alaska National Interest Lands Conservation Act (ANILCA)

In 1980, the Alaska National Interest Lands Conservation Act (ANILCA) created over 40 million ha (100 million ac) of new national parks, refuges, monuments, conservation areas, recreation areas, forests, and wild and scenic rivers in the State of Alaska for the preservation of "nationally significant" natural resources. To address special issues and needs arising from the new land designations, ANILCA contains numerous provisions and special rules for managing Alaska's public lands and nationally important resource development potential. ANILCA requires Federal land managers to balance the national interest in Alaska's scenic and wildlife resources with recognition of Alaska's economy and infrastructure, and its distinctive rural way of life. Title VIII of ANILCA requires that subsistence uses by "rural" Alaska residents be given a priority over all other (sport and commercial) uses of fish and game on Federal public lands in Alaska. As a compromise, Congress allowed the State to continue managing fish and game uses on Federal public lands, but only on the condition that the State of Alaska adopt a statute that made the new Title VIII "rural" subsistence priority applicable on State, as well as on Federal lands. If the State ever fell out of compliance with Title VIII, Congress required the Secretary of the Interior to reassume management of fish and game on the Federal public lands. Section 810 of ANILCA creates special steps a Federal agency must take before it decides to "withdraw, reserve, lease, or otherwise permit the use, occupancy, or disposition of public land."

Specifically, the Federal agency must first evaluate three factors: the effect of its action on subsistence uses and needs; the availability of other lands for the purposes sought to be achieved; and alternatives that would "reduce or eliminate the use, occupancy, or disposition of public lands needed for subsistence purposes." If the Federal agency concludes that its action "would significantly restrict subsistence uses," it must notify the appropriate State agency, regional council, and local committee. It then must hold a hearing in the vicinity of the area involved, and must make the following findings:

- Such significant restriction of subsistence uses is necessary and consistent with sound management principles for the utilization of public lands.

- The proposed activity will involve the minimal amount of public lands necessary to accomplish the purpose of such use, occupancy, or other disposition.

- Reasonable steps will be taken to minimize adverse impacts upon subsistence uses and resources resulting from such actions (16 USC 3120(a)(3)).

In *People of the Village of Gambell vs. Clark*, 746 F.2d 572 (9th Cir. 1984) (Gambell I), the court ruled that the "lands and waters" of the OCS were "public lands" for the purpose of this section. The court later ruled that the provisions of Section 810 should not be applied in a staged manner, despite the staged decision making approach set out in the OCS Lands Act and relied upon by the Supreme Court in *Secretary of the Interior vs. California* (*People of the Village of Gambell vs. Hodel*, Civ. No. 85-3877 (9th Cir. Oct. 25, 1985)). As a result of these rulings, the USDOI prepares an analysis under section 810 of ANILCA for OCS lease sales and plans of exploration and development/production for activities offshore Alaska. The provisions of ANILCA do not apply to the 5-Year Leasing Program because the USDOI does not make any of the above-described decisions.

C.1.5 The Clean Air Act (CAA)

The Clean Air Act (CAA), as amended, delineates jurisdiction of air quality between the U.S. Environmental Protection Agency (USEPA) and the BOEMRE. For OCS operations in the Gulf of Mexico, those west of 87.5°W longitude are subject to BOEMRE air quality regulations; operations east of 87.5°W longitude are subject to USEPA air quality regulations.

Under the CAA, the Secretary of the Interior is required to consult with the USEPA Administrator "to assure coordination of air pollution control regulations for OCS emissions and emissions in adjacent onshore areas." The MMS established 30 CFR 250.302, 250.303, and 250.304 to comply with the CAA. The regulated pollutants include carbon monoxide, particulates, sulfur dioxide, nitrogen oxides, and volatile organic compounds (as a precursor to ozone). In areas where hydrogen sulfide may be present, operations are regulated by 30 CFR 250.417. The MMS regulations allow for the collection of information about potential sources of pollution for the purpose of determining whether the projected emissions of air pollutants from a facility could result in ambient onshore air pollutant concentrations above maximum levels provided in the regulations. These regulations also stipulate appropriate emissions controls deemed necessary to prevent accidents and air quality deterioration.

C.1.6 The Federal Water Pollution Control Act (FWPCA) and Clean Water Act (CWA)

The Federal Water Pollution Control Act (FWPCA) establishes water pollution control activities to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. The Clean Water Act of 1977 (CWA) amended the FWPCA. Title III of the CWA requires the USEPA to establish national effluent limitation standards for existing point sources of wastewater discharges that reflect the application of the best practical control technology currently available. These standards apply to existing OCS exploratory drillships, semisubmersible vessels, and jackup rigs used in exploration activities. The CWA also requires the USEPA to establish regulations for effluent limitations for categories and classes of point sources that require the application of "best available control technology economically achievable."

Section 311 of the CWA, as amended, prohibits the discharge of oil or hazardous substances into the navigable waters of the United States that may affect natural resources, except under limited circumstances, and establishes civil penalty liability and enforcement procedures to be administered by the U.S. Coast Guard (USCG). The CWA Title IV establishes requirements for Federal permits and licenses to conduct an activity (including construction or operation of facilities) that may result in any discharges into navigable waters. Section 402 of the CWA gives the USEPA the authority to issue National Pollutant Discharge Elimination System (NPDES) permits for the discharge of pollutants. The NPDES permits apply to all sources of wastewater discharges from exploratory vessels and production platforms operating on the OCS.

C.1.7 The Coastal Zone Management Act (CZMA) and the Coastal Zone Reauthorization Amendments of 1990

Congress passed the Coastal Zone Management Act (CZMA) and created the Coastal Zone Management Program to improve the management of our Nation's coastal areas. The program, a voluntary partnership between the Federal Government and the coastal States and territories, is administered at the Federal level by the National Oceanic and Atmospheric Administration (NOAA) within the U.S. Department of Commerce (USDOC). The program's goal is to reduce potential conflicts between environmental and economic interests in the coastal area through the use of federally approved coastal management programs (CMPs).

The CZMA allows a coastal State or territory, with a federally approved CMP, to review Federal activities for Federal consistency. Federal consistency is the CZMA requirement that all Federal actions that are reasonably likely to affect any land or water use or natural resource of the coastal zone be consistent with the enforceable policies of a State's/territory's CMP. Section 307 of the CZMA contains the Federal consistency provisions that impose certain requirements on Federal agencies to comply with enforceable policies detailed in the federally approved CMPs:

- Section 307(c)(1) requires that any direct Federal agency activities affecting any land or water use or natural resources of the coastal zone be consistent, to the maximum extent practicable, with enforceable policies of the State's CMP. This section applies to OCS lease sales.

- Section 307(c)(3)(A) requires that any Federal licenses/permit affecting any land or water use or natural resources of the coastal zone be consistent with enforceable policies of the State's CMP. This section applies to geological and geophysical permits. In addition, this section prohibits the Federal agency from issuing the license/permit until the affected State(s) has concurred with or presumed to concur with the applicant's consistency certification or until the Secretary of Commerce has overridden the State's consistency objection to the licensed/permitted activity.

- Section 307(c)(3)(B) requires that activities affecting any land or water use or natural resources of the coastal zone, described in detail in OCS exploration or development and production plans, be consistent with enforceable policies of the State's CMP. The MMS is prohibited from approving an OCS plan until the affected State(s) has concurred with, or is presumed to concur with, the applicant's consistency certification or until the Secretary of Commerce has overridden the State's consistency objection.

C.1.8 The Endangered Species Act (ESA)

The Endangered Species Act of 1973 (ESA) establishes policy to protect and conserve threatened and endangered species and the ecosystems upon which they depend. The ESA is administered by the USDOI, U.S. Fish and Wildlife Service (USFWS), and the USDOC, National Marine Fisheries Service (NMFS). Section 7 of the ESA mandates that all Federal agencies consult with the USFWS or NMFS to ensure that any agency action is not likely to do the following:

- Jeopardize the continued existence of any endangered or threatened species, and/or

- Destroy or adversely modify an endangered or threatened species' critical habitat.

The ESA requires Federal agencies to formally consult when there is reason to believe that a listed (or proposed to be listed) species may be affected by a proposed action. Formal endangered species consultations provide a threshold examination and a biological opinion on the likelihood that the proposed activity will or will not jeopardize the continued existence of the resource, and on the effect of the proposed activity on the endangered species. The biological opinion may include recommendations for modification of the proposed activity. The USFWS or NMFS notifies the Federal agency in writing when insufficient information is available to conclude that the proposed activity is not likely to jeopardize the species or its habitat. In such cases, the Federal agency must obtain additional information, and, if recommended by the USFWS or NMFS, conduct appropriate biological surveys or studies to determine how the proposed activity may affect the endangered species or its critical habitat. After such additional information is received, USFWS or NMFS would conclude the consultation process by issuing a formal biological opinion.

For OCS activities in the Western and Central Gulf of Mexico Planning Areas, the BOEMRE consults with the USFWS and/or NMFS at the multisale stage. This consultation covers OCS activities from lease sale through the exploration, development, production, and decommission stages. For other OCS areas, the BOEMRE consults with USFWS and/or NMFS at the lease sale stage; however, this consultation only covers leasing and exploration activities. A separate consultation is conducted for development, production, and decommissioning stages.

C.1.9 The Magnuson-Stevens Fishery Conservation and Management Act (FCMA)

The Magnuson-Stevens Fishery Conservation and Management Act of 1976 (FCMA) established and delineated an area from the States' seaward boundary to approximately 200 nautical miles out as a fisheries conservation zone for the United States and its possessions.

The FCMA created eight regional fishery management councils (FMCs) and mandated a continuing planning program for marine fisheries management by the FMCs. In addition, the FCMA requires the FMC to prepare a fishery management plan (FMP), based upon the best available scientific and economic data, for each commercial species (or related group of species) of fish in need of conservation and management within each respective region.

When the Sustainable Fisheries Act of 1996 reauthorized the FCMA, Congress required the NMFS to designate and conserve essential fish habitat (EFH) for those species managed under an existing FMP. By designating EFH, Congress hoped to minimize any adverse effects on habitat caused by fishing or nonfishing activities and to identify other actions to encourage the conservation and enhancement of such habitat. The phrase "essential fish habitat" encompasses "those waters and substrate necessary to fishes for spawning, breeding, feeding, or growth to maturity." As a result of this change, Federal agencies must consult with the NMFS on those activities that may have direct (e.g., physical disruption) or indirect (e.g., loss of prey species) effects on EFH. For OCS activities in the Western and Central Gulf of Mexico Planning Areas, the BOEMRE consults with the NMFS at the multisale stage. This consultation covers OCS activities from lease sale through the exploration, development, production, and decommission stages. For other OCS areas, the BOEMRE consults with the NMFS at each OCS project stage individually (e.g., the lease sale, exploration plan, and development and production plan).

C.1.10 The Marine Mammal Protection Act (MMPA)

The Marine Mammal Protection Act (MMPA) was enacted in 1972 to ensure that marine mammals are maintained at, or in some cases restored to, healthy population levels. Jurisdiction over marine mammals under the MMPA is split between two Federal Agencies, the USFWS and NMFS. The USFWS has jurisdiction over sea otters, polar bears, manatees, dugongs, and walrus, while the NMFS has jurisdiction over all other marine mammals.

The MMPA established a moratorium on the taking or importing of marine mammals except during certain activities that are regulated and permitted. Such activities include scientific research, public display, commercial and educational photography, import and export of marine mammal parts, commercial fishing authorizations, and take incidental to non-fishing commercial activities. Taking is defined as "to harass, hunt, capture, or kill or attempt to harass, hunt, capture, or kill any marine mammal." Harass is defined as any act of pursuit, torment, or annoyance that has the potential to do the following:

- Injure a marine mammal or marine mammal stock in the wild, or

- Disturb a marine mammal or marine mammal stock in the wild by disrupting behavioral patterns (e.g., breathing, nursing, breeding).

Upon request, the Secretary (of either the USDOI or the USDOC, depending on jurisdiction) can authorize the unintentional taking of small numbers of marine mammals incidental to activities other than commercial fishing (e.g., offshore oil and gas exploration and development) for a period of 1–5 yr, depending on the level of anticipated take. To authorize the taking, the Secretary must find that the total of the taking during the 5-yr period (or less) would have a negligible impact on the affected species. In addition, the Secretary shall withdraw or suspend permission to take marine mammals incidental to oil and gas production, and other activities when the following take place:

- The applicable regulations concerning the methods of taking, monitoring, or reporting are not being complied with; or

- The taking is having, or may be having, more than a negligible impact on the affected species or stock.

The BOEMRE coordinates with the USFWS and NMFS to ensure that MMS and offshore operators comply with the MMPA, and to identify mitigation and monitoring requirements for permits or approvals for activities like seismic surveys and platform removals.

C.1.11 The International Convention of the Prevention of Pollution from Ships (MARPOL) and Marine Plastic Pollution Research and Control Act (MPPRCA)

In 1978, the International Convention of the Prevention of Pollution from Ships (MARPOL) was updated to include five annexes on ocean dumping. By signing onto MARPOL, countries agree to enforce Annexes I and II (oil and noxious liquid substances) of the treaty. Annexes III (hazardous substances), IV (sewage), and V (plastics) are optional. The United States is signatory to two of the optional MARPOL Annexes, III and V. Annex V is of particular importance to the maritime community (e.g., shippers, oil platform personnel, fishers, recreational boaters) because it prohibits the disposal of plastic at sea and regulates the disposal of other types of garbage at sea. The USCG is the enforcement agency for MARPOL Annex V within the U.S. Exclusive Economic Zone (EEZ) (within 322 km [200 mi] of the U.S. shoreline).

The Marine Plastic Pollution Research and Control Act (MPPRCA) is the Federal law implementing MARPOL Annex V in all U.S. waters. Under the MPPRCA, it is illegal to throw plastic trash off any vessel within the EEZ. It is also illegal to throw any other garbage (e.g., orange peels, paper plates, glass jars, and monofilament fishing line) overboard while navigating in inland waters or within 5 km (3 mi) offshore. The greater the distance from shore, the fewer restrictions apply to nonplastic garbage. However, dumping plastics overboard in any waters anywhere is illegal at anytime. Fixed and floating platforms, drilling rigs, manned production platforms, and support vessels operating under a Federal oil and gas lease are required to develop waste management plans and to post placards reflecting discharge limitations and restrictions. Garbage must be brought ashore and properly disposed of in a trash can, dumpster, or recycling container. Docks and marinas are required to provide facilities to handle normal amounts of garbage from their paying customers. Violations of MARPOL or MPPRCA may result in a fine of up to $50,000 for each incident. If criminal intent can be proven, an individual may be fined up to $250,000 and/or imprisoned up to 6 yr. If an organization is responsible, it may be fined up to $500,000 and/or be subject to 6 yr of imprisonment.

C.1.12 The Marine Protection, Research, and Sanctuaries Act (MPRSA)

The Marine Protection, Research, and Sanctuaries Act of 1972 (MPRSA) regulates the ocean dumping of waste, provides for a research program on ocean dumping, and provides for the designation and regulation of marine sanctuaries. Also known as the Ocean Dumping Act, it regulates the ocean dumping of all material beyond the territorial limit (5 km [3 mi] from shore) and prevents or strictly limits dumping material that "would adversely affect human health, welfare, or amenities, or the marine environment, ecological systems, or economic potentialities." Material includes, but is not limited to, dredged material; solid waste; incinerator residue; garbage; sewage; sewage sludge; munitions; chemical and biological warfare agents; radioactive materials; chemicals; biological and laboratory waste; wrecked or discarded equipment; rocks; sand; excavation debris; and industrial, municipal, agricultural, and other waste. The term does not include sewage from vessels or oil, unless the oil is transported via a vessel or aircraft for the purpose of dumping. Disposal by means of a pipe, regardless of how far at sea the discharge occurs, is regulated by the CWA through the NPDES permit process.

Title III of the MPRSA, later called the National Marine Sanctuaries Act, charged the Secretary of the Department of Commerce to identify, designate, and manage marine sites based on conservational, ecological, recreational, historical, aesthetic, scientific, or educational value within significant national ocean and Great Lake waters. The NOAA administers the National Marine Sanctuary Program. Twelve national marine sanctuaries, representing a wide variety of ocean environments, have been designated.

C.1.13 The Merchant Marine Act of 1920 (Jones Act)

The Merchant Marine Act of 1920 (Jones Act) regulates coastal shipping between U.S. ports and inland waterways. The Jones Act provides that "no merchandise shall be transported by water, or by land and water . . . between points in the United States . . . in any other vessel than a vessel built in and documented under the laws of the United States and owned by persons who are citizens of the United States . . . ." Therefore, the Jones Act requires that all goods shipped between different ports in the United States or its territories must be:

- Carried on vessels built and documented (flagged) in the United States,
- Crewed by U.S. citizens or legal aliens licensed by the USCG, and
- Owned and operated by U.S. citizens.

The rationale behind the Jones Act and earlier sabotage laws was that the United States needed a merchant marine fleet to ensure that its domestic waterborne commerce remains under Government jurisdiction for regulatory, safety, and national defense considerations. The same general principles of safety regulations are applied to other modes of transportation in the United States. While other modes of transportation can operate foreign-built equipment, these units must comply with U.S. standards. However, many foreign-built ships do not meet the standards required of U.S.-built ships and, thus, are excluded from domestic shipping.

The U.S. Customs Service has determined that facilities fixed or attached to the OCS used for the purpose of oil exploration are considered points within the United States. The OCS oil facilities are considered U.S. sovereign territory and fall under the requirements of the Jones Act; so all shipping to and from these facilities related to OCS oil exploration can only be conducted by vessels meeting the requirements of the Jones Act. Shuttle tankering of oil that is produced at OCS facilities can only be legally provided by U.S.-registered vessels and aircraft that are properly endorsed for coastwise trade under the laws of the United States.

C.1.14 The National Fishing Enhancement Act

The National Fishing Enhancement Act of 1984, also known as the Artificial Reef Act, established broad artificial-reef development standards and a national policy to encourage the development of artificial reefs that will enhance fishery resources and commercial and recreational fishing. The national plan identifies oil and gas structures as acceptable material of opportunity for artificial-reef development. The BOEMRE adopted a rigs-to-reefs policy in 1985 in response to this Act and to broaden interest in the use of petroleum platforms as artificial reefs.

C.1.15 The National Historic Preservation Act (NHPA)

The National Historic Preservation Act of 1966 (NHPA) requires the head of any Federal agency possessing licensing authority or having direct or indirect jurisdiction over a proposed Federal or federally assisted activity to consider the proposed activity's effect on any district, site, building, structure, or object that is included in or eligible for inclusion in the *National Register of Historic Places*. The historic properties (i.e., archaeological resources) on the OCS include historic shipwrecks, sunken aircraft, lighthouses, and prehistoric archaeological sites that have become inundated due to the 120-m (394-ft) rise in global sea level since the height of the last ice age (ca. 19,000 yr ago).

Because the OCS is not federally owned land and the Federal Government has not claimed direct ownership of historic properties on the OCS, the BOEMRE only has the authority to ensure that any agency-funded and permitted actions do not adversely affect significant historic properties. Beyond avoidance of adverse impacts, BOEMRE does not possess the legal authority to manage the historic properties on the OCS. The BOEMRE has conducted archaeological baseline studies of the OCS to determine where known historic properties may be located and to outline areas where presently unknown historic properties may be located. These baseline studies are used to identify "archaeologically sensitive" areas that may contain significant historic properties.

Prior to approving any OCS exploration or development activities within an archaeologically sensitive area, BOEMRE requires the lessee to conduct a marine remote sensing survey and to prepare an archaeological report. If the marine remote sensing survey indicates any evidence of a potential historic property, the lessee must do one of the following:

- Move the site of the proposed lease operations a sufficient distance to avoid the potential historic property, or

- Conduct further investigations to determine the nature and significance of the potential historic property.

If further investigation determines that there is a significant historic property within the area of proposed OCS operations, NHPA consultation procedures are followed.

C.1.16 The Oil Pollution Act (OPA 90)

The Oil Pollution Act (OPA 90) establishes a single uniform Federal system of liability and compensation for damages caused by oil spills in U.S. navigable waters. The OPA 90 requires removal of spilled oil and establishes a national system of planning for and responding to oil-spill incidents. In addition, OPA 90 includes provisions to do the following:

- Improve oil-spill prevention, preparedness, and response capability;

- Establish limitations on liability for damages resulting from oil pollution;

- Promote funding for natural resource damage assessment;

- Implement a fund for the payment of compensation for such damages; and

- Establish an oil pollution research and development program.

The USCG is responsible for enforcing vessel compliance with the OPA 90. The Secretary of the Interior is given authority over offshore facilities and associated pipelines (except deepwater ports) for all Federal and State waters, including responsibility for spill prevention, oil-spill contingency plans, oil-spill containment and cleanup equipment, financial responsibility certification, and civil penalties. The Secretary of the Interior delegated this authority to BOEMRE.

The BOEMRE regulations governing oil-spill financial responsibility (OSFR) for offshore facilities and related requirements for certain crude oil wells, production platforms, and pipelines located in the OCS and certain State waters became effective in October 1998. The regulations implement the OPA requirement for responsible parties to demonstrate they can pay for cleanup and damages caused by facility oil spills. Responsible parties can be required to demonstrate as much as $150 million in OSFR if BOEMRE determines that it is justified by the risks from potential oil spills from the covered offshore facilities. The minimum amount of OSFR that must be demonstrated is $35 million for covered offshore facilities located in the OCS, and $10 million for covered offshore facilities located in State waters. The regulation exempts persons responsible for facilities having a potential worst-case, oil-spill discharge of 1,000 bbl or less, unless the risks posed by a facility justify a lower threshold.

C.1.17 The Outer Continental Shelf Deep Water Royalty Relief Act

The Outer Continental Shelf Deep Water Royalty Relief Act of 1995 authorizes the Secretary of the Interior to offer OCS blocks for lease with suspension of royalties for a volume, value, or period of production. Deepwater royalty relief applies to blocks offered for lease in the western and central Gulf of Mexico in water depths exceeding 200 m (656 ft) through November 28, 2000. The MMS has developed procedures for suspension of royalty payment on production from eligible leases.

C.1.18 The Ports and Waterways Safety Act

The Ports and Waterways Safety Act authorizes the USCG to designate safety fairways, fairway anchorages, and traffic separation schemes to provide unobstructed approaches through oil fields for vessels using ports. The USCG regulations provide listings of these designated areas along with special conditions related to oil and gas production. In general, no fixed structures such as platforms are allowed in fairways. Temporary underwater obstacles such as anchors and attendant cables or chains attached to floating or semisubmersible drilling rigs may be placed in a fairway under certain conditions. Fixed structures may be placed in anchorages, but the number of structures is limited.

C.1.19 The Resource Conservation and Recovery Act (RCRA)

The Resource Conservation and Recovery Act (RCRA) provides a framework for the safe disposal and management of hazardous and solid wastes. Most oil-field wastes have been exempted from coverage under RCRA hazardous waste regulations. Any hazardous wastes generated on the OCS that are not exempt must be transported to shore for disposal at a hazardous waste facility.

C.2 EXECUTIVE ORDERS (EO)

C.2.1 Executive Order 12898: Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations (February 1994)

In the memorandum to heads of departments and agencies that accompanied the Executive Order (EO), the President specifically recognized the importance of procedures under the NEPA for identifying and addressing environmental justice concerns. The memorandum states that “each Federal agency shall analyze the environmental effects, including human health, economic and social effects, of Federal actions, including effects on minority communities and low-income communities, when such analysis is required by [NEPA].” In August 1994, the Secretary of the Interior directed its bureaus to include environmental justice (EJ) in NEPA documentation, and in February 1998, the CEQ issued guidance to assist Federal Agencies in addressing EJ.

The issue of disproportionate, OCS-related impacts on minority and low-income populations is addressed in all OCS regions when such analysis is required by the NEPA. This issue is a primary focus in Alaska OCS Region environmental assessments where Native Alaskan subsistence hunting, fishing, and gathering activities occur in coastal areas.

Executive Order No. 12898 provides the following:

Section 1-1. IMPLEMENTATION.

1-101. *Agency Responsibilities*. To the greatest extent practicable and permitted by law, and consistent with the principles set forth in the report on the National Performance Review, each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States and its territories and possessions, the District of Columbia, the Commonwealth of Puerto Rico, and the Commonwealth of the Marianas Islands.

1-102. *Creation of an Interagency Working Group on Environmental Justice*.

(a) Within 3 months of the date of this order, the Administrator of the Environmental Protection Agency ("Administrator") or the Administrator's designee shall convene an interagency Federal Working Group on Environmental Justice ("Working Group"). The Working Group shall comprise the heads of the following executive agencies and offices, or their designees: (a) Department of Defense; (b) Department of Health and Human Services; (c) Department of Housing and Urban Development; (d) Department of Labor; (e) Department of Agriculture; (f) Department of Transportation; (g) Department of Justice; (h) Department of the Interior; (i) Department of Commerce; (j) Department of Energy; (k) Environmental Protection Agency; (l) Office of Management and Budget; (m) Office of Science and Technology Policy; (n) Office of the Deputy Assistant to the President for Environmental Policy; (o) Office of the Assistant to the President for Domestic Policy; (p) National Economic Council; (q) Council of Economic Advisers; and (r) such other Government officials as the President may designate. The Working Group shall report to the President through the Deputy Assistant to the President for Environmental Policy and the Assistant to the President for Domestic Policy.

(b) The Working Group shall:

(1) provide guidance to Federal agencies on criteria for identifying disproportionately high and adverse human health or environmental effects on minority populations and low-income populations;

(2) coordinate with, provide guidance to, and serve as a clearinghouse for, each Federal agency as it develops an environmental justice strategy as required by section 1-103 of this order, in order to ensure that the administration,

interpretation and enforcement of programs, activities and policies are undertaken in a consistent manner;

(3) assist in coordinating research by, and stimulating cooperation among, the Environmental Protection Agency, the Department of Health and Human Services, the Department of Housing and Urban Development, and other agencies conducting research or other activities in accordance with section 3-3 of this order;

(4) assist in coordinating data collection, required by this order;

(5) examine existing data and studies on environmental justice;

(6) hold public meetings as required in section 5-502(d) of this order; and

(7) develop interagency model projects on environmental justice that evidence cooperation among Federal agencies.

1-103. *Development of Agency Strategies*.

(a) Except as provided in section 6-605 of this order, each Federal agency shall develop an agency-wide environmental justice strategy, as set forth in subsections (b)–(e) of this section that identifies and addresses disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations. The environmental justice strategy shall list programs, policies, planning and public participation processes, enforcement, and/or rulemakings related to human health or the environment that should be revised to, at a minimum: (1) promote enforcement of all health and environmental statutes in areas with minority populations and low-income populations; (2) ensure greater public participation; (3) improve research and data collection relating to the health of and environment of minority populations and low-income populations; and (4) identify differential patterns of consumption of natural resources among minority populations and low-income populations. In addition, the environmental justice strategy shall include, where appropriate, a timetable for undertaking identified revisions and consideration of economic and social implications of the revisions.

(b) Within 4 months of the date of this order, each Federal agency shall identify an internal administrative process for developing its environmental justice strategy, and shall inform this Working Group of the process.

(c) Within 6 months of the date of this order, each Federal agency shall provide the Working Group with an outline of its proposed environmental justice strategy.

(d) Within 10 months of the date of this order, each Federal agency shall provide the Working Group with its proposed environmental justice strategy.

(e) Within 12 months of the date of this order, each Federal agency shall finalize its environmental justice strategy and provide a copy and written description of its strategy to the Working Group. During the 12 month period from the date of this order, each Federal agency, as part of its environmental justice strategy, shall identify several specific projects that can be promptly undertaken to address particular concerns identified during the development of the proposed environmental justice strategy, and a schedule for implementing those projects.

(f) Within 24 months of the date of this order, each Federal agency shall report to the Working Group on its progress in implementing its agency-wide environmental justice strategy.

(g) Federal agencies shall provide additional periodic reports to the Working Group as requested by the Working Group.

1-104. *Reports to the President*. Within 14 months of the date of this order, the Working Group shall submit to the President, through the Office of the Deputy Assistant to the President for Environmental Policy and the Office of the Assistant to the President for Domestic Policy, a report that describes the implementation of this order, and includes the final environmental justice strategies described in section 1-103(e) of this order.

Sec. 2-2. FEDERAL AGENCY RESPONSIBILITIES FOR FEDERAL PROGRAMS.

Each Federal agency shall conduct its programs, policies, and activities that substantially affect human health or the environment, in a manner that ensures that such programs, policies, and activities do not have the effect of excluding persons (including populations) from participation in, denying persons (including populations) the benefits of, or subjecting persons (including populations) to discrimination under, such programs, policies, and activities, because of their race, color, or national origin.

Sec. 3-3. RESEARCH, DATA COLLECTION, AND ANALYSIS.

3-301. *Human Health and Environmental Research and Analysis*.

(a) Environmental human health research, whenever practicable and appropriate, shall include diverse segments of the population in epidemiological and clinical studies, including segments at high risk from environmental hazards, such as minority populations, low-income populations and workers who may be exposed to substantial environmental hazards.

(b) Environmental human health analyses, whenever practicable and appropriate, shall identify multiple and cumulative exposures.

(c) Federal agencies shall provide minority populations and low-income populations the opportunity to comment on the development and design of research strategies undertaken pursuant to this order.

3-302. *Human Health and Environmental Data Collection and Analysis*. To the extent permitted by existing law, including the Privacy Act, as amended (5 U.S.C. § 552a):

(a) Each Federal agency, whenever practicable and appropriate, shall collect, maintain, and analyze information assessing and comparing environmental and human health risks borne by populations identified by race, national origin, or income. To the extent practical and appropriate, Federal agencies shall use this information to determine whether their programs, policies, and activities have disproportionately high and adverse human health or environmental effects on minority populations and low-income populations;

(b) In connection with the development and implementation of agency strategies in section 1-103 of this order, each Federal agency, whenever practicable and appropriate, shall collect, maintain and analyze information on the race, national origin, income level, and other readily accessible and appropriate information for areas surrounding facilities or sites expected to have a substantial environmental, human health, or economic effect on the surrounding populations, when such facilities or sites become the subject of a substantial Federal environmental administrative of judicial action. Such information shall be made available to the public unless prohibited by law; and

(c) Each Federal agency, whenever practicable and appropriate, shall collect, maintain, and analyze information on the race, national origin, income level, and other readily accessible and appropriate information for areas surrounding Federal facilities that are: (1) subject to the reporting requirements under the Emergency Planning and Community Right-to-Know Act, 42 U.S.C. section 11001-11050 as mandated in Executive Order No. 12856; and (2) expected to have a substantial environmental, human health, or economic effect on surrounding populations. Such information shall be made available to the public, unless prohibited by law.

(d) In carrying out the responsibilities in this section, each Federal agency, whenever practicable and appropriate, shall share information and eliminate unnecessary duplication of efforts through the use of existing data systems and cooperative agreements among Federal agencies and with State, local, and tribal governments.

Sec. 4-4. SUBSISTENCE CONSUMPTION OF FISH AND WILDLIFE.

4-401. *Consumption Patterns*. In order to assist in identifying the need for ensuring protection of populations with differential patterns of subsistence consumption of fish and wildlife, Federal agencies, whenever practicable and appropriate, shall collect, maintain, and analyze information on the consumption patterns of populations who principally rely on fish and/or wildlife for subsistence. Federal agencies shall communicate to the public the risks of those consumption patterns.

4-402. *Guidance*. Federal agencies, whenever practicable and appropriate, shall work in a coordinated manner to publish guidance reflecting the latest scientific information available concerning methods for evaluating the human health risks associated with the consumption of pollutant-bearing fish or wildlife. Agencies shall consider such guidance in developing their policies and rules.

Sec. 5-5. PUBLIC PARTICIPATION AND ACCESS TO INFORMATION.

(a) The public may submit recommendations to Federal agencies relating to the incorporation of environmental justice principles into Federal agency programs or policies. Each Federal agency shall convey such recommendations to the Working Group.

(b) Each Federal agency may, whenever practicable and appropriate, translate crucial public documents, notices, and hearings relating to human health or the environment for limited English speaking populations.

(c) Each Federal agency shall work to ensure that public documents, notices, and hearings relating to human health or the environment are concise, understandable, and readily accessible to the public.

(d) The Working Group shall hold public meetings, as appropriate, for the purpose of fact-finding, receiving public comments, and conducting inquiries concerning environmental justice. The Working Group shall prepare for public review a summary of the comments and recommendations discussed at the public meetings.

Sec. 6-6. GENERAL PROVISIONS.

6-601. *Responsibility for Agency Implementation*. The head of each Federal agency shall be responsible for ensuring compliance with this order. Each Federal agency shall conduct internal reviews and take such other steps as may be necessary to monitor compliance with this order.

6-602. *Executive Order No. 12250*. This Executive order is intended to supplement but not supersede Executive Order No. 12250, which requires consistent and effective implementation of various laws prohibiting discriminatory practices in programs receiving Federal financial assistance. Nothing herein shall limit the effect or mandate of Executive Order No. 12250.

6-603. *Executive Order No. 12875*. This Executive order is not intended to limit the effect or mandate of Executive Order No. 12875.

6-604. *Scope*. For purposes of this order, Federal agency means any agency on the Working Group, and such other agencies as may be designated by the President, that conducts any Federal program or activity that substantially affects human health or the environment. Independent agencies are requested to comply with the provisions of this order.

6-605. *Petitions for Exemptions*. The head of a Federal agency may petition the President for an exemption from the requirements of this order on the grounds that all or some of the petitioning agency's programs or activities should not be subject to the requirements of this order.

6-606. *Native American Programs*. Each Federal agency responsibility set forth under this order shall apply equally to Native American programs. In addition, the Department of the Interior, in coordination with the Working Group, and, after consultation with tribal leaders, shall coordinate steps to be taken pursuant to this order that address Federally-recognized Indian Tribes.

6-607. *Costs*. Unless otherwise provided by law, Federal agencies shall assume the financial costs of complying with this order.

6-608. *General*. Federal agencies shall implement this order consistent with, and to the extent permitted by, existing law.

6-609. *Judicial Review*. This order is intended only to improve the internal management of the executive branch and is not intended to, nor does it create any right, benefit, or trust responsibility, substantive or procedural, enforceable at law or equity by a party against the United States, its agencies, its officers, or any person. This order shall not be construed to create any right to judicial review involving the compliance or noncompliance of the United States, its agencies, its officers, or any other person with this order.

C.2.2 Executive Order 13007: Indian Sacred Sites (May 1996)

The Indian Sacred Sites EO directs Federal land managing Agencies to accommodate access to, and ceremonial use of, Indian sacred sites by Indian religious practitioners, and to avoid adversely affecting the physical integrity of such sacred sites. It is BOMRE's policy to consider the potential effects of all aspects of plans, projects, programs, and activities on Indian sacred sites, and to consult, to the greatest extent practicable and to the extent permitted by law, with tribal governments before taking actions that may affect Indian sacred sites located on Federal lands.

C.2.3 Executive Order 13089: Coral Reef Protection (June 1998)

This EO directs the U.S. Coral Reef Task Force, co-chaired by the Secretaries of Interior and Commerce, to develop and implement a comprehensive program of research and mapping to inventory, monitor, and "identify the major causes and consequences of degradation of coral reef ecosystems." In addition, the EO directs Federal agencies to protect coral reef ecosystems and, to the extent permitted by law, prohibits them from authorizing funding or carrying out any actions that will degrade these ecosystems. Relatedly, the USDOI works with domestic and international partners through the Coral Reef Initiative. This initiative focuses efforts to protect and monitor coral reefs around the world by building and sustaining partnerships, programs, and institutional capacities at the local, national, regional, and international levels.

C.2.4 Executive Order 12114: Environmental Effects Abroad (January 1979)

This EO requires that Federal officials be informed of environmental considerations, and take those considerations into account when making decisions on major Federal actions that could have environmental impacts anywhere beyond the borders of the United States, including Antarctica. Such Federal actions include the following:

- All major Federal actions significantly affecting the environment outside the jurisdiction of any nation (the oceans or Antarctica). This would apply to proposals that result in actions within the United States, which because of ocean currents, winds, stream flow, or other natural processes, may affect parts of the oceans not claimed by any nation (high seas). Included in this category would be an OCS project that, because of ocean currents, could result in effluents or spilled oil reaching fishing grounds or areas not claimed by another nation.

- All major Federal actions significantly affecting the environment of a foreign nation not involved in the action. This would apply to proposals that result in actions within U.S. territory or within the EEZ that, because of ocean currents, winds, stream flow, or other natural processes, may affect parts of another nation, or seas or oceans within the jurisdiction of other nations. This category would include an OCS project located up-current from the Mexican coastline that could affect Mexico's territory in the event of an oil spill. Also in this category are all major Federal actions in which a foreign nation is a participant and that would normally be covered by the EIS addressing the U.S. part of the proposal. An example would be an OCS right-of-way pipeline bringing Canadian energy resources to the northeast United States.

- All major Federal actions providing a foreign nation with a product, or involving a project that produces an emission or effluent prohibited or regulated by U.S. Federal law because of its effects on the environment or the creation of a serious public health risk.

Federal actions causing significant impacts on environments outside the United States are to be addressed in the following:

- EISs (generic), program (5-Year OCS Leasing Program) EISs, and project-specific (OCS lease sale) EISs;

- Documents prepared for decision makers containing reviews of environmental issues involved in Federal actions, or summaries of environmental analyses (e.g., OCS lease sale decision documents, Records of Decision); and

- Environmental studies or research prepared by the United States and one or more foreign nations, or by an international body in which the United States is a member or participant.

The United States, Canada, and Mexico are negotiating a Transboundary Environmental Impact Assessments (TEIA) Agreement through the North Atlantic Free Trade Agreement (NAFTA) Commission on Environmental Cooperation (CEC). The CEC deals with a wide range of environmental and natural resource protection issues common to Canada, the United States, and Mexico. Developing a TEIA process is one of the requirements of the 199l North American Agreement on Environmental Cooperation. Under this agreement, a transboundary environmental impact is any impact on the environment within the area under the jurisdiction of Canada, the United States, or Mexico caused by a proposed project, the physical origin of which is situated wholly or in part within the area under the jurisdiction of one of the three countries. For example, a proposed project on the United States OCS that, because of ocean currents, winds, or proximity to the Mexican coastline, could affect Mexican waters (fishing industry, fish resources, etc.) or the Mexican coastline (oil spill contacts, etc.) would be a project considered to have the potential to cause transboundary environmental impacts. The agreement recognizes that there is a significant bilateral nature to many transboundary issues and calls upon the three countries to develop an agreement to do the following:

- Assess the environmental impacts of proposed projects in any of the three countries party to the agreement (NAFTA) that would be likely to cause significant adverse transboundary impacts within the jurisdiction of any of the other parties;

- Develop a system of notification, consultation, and sharing of relevant information between countries with respect to such projects; and

- Give consideration to mitigating measures to address the potential adverse effects of such projects.

Negotiations are currently underway between the three parties to the agreement, but the final language has yet to be worked out. Because the requirements of the assessment portion of the agreement are somewhat similar to the requirements imposed by EO 12114 (i.e., impacts on foreign territory must be addressed in NEPA documents), the BOEMRE requires that EISs prepared on major Federal OCS actions contain an assessment of potential significant impacts on foreign territory.

C.2.5 Executive Order 13158: Marine Protected Areas (MPAs) (May 2000)

The EO defines an MPA as “any area of the marine environment that has been reserved by Federal, State, territorial, tribal, or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein.” The EO directs Federal agencies to work closely with State, local, and nongovernmental partners to create a comprehensive system of MPAs “representing diverse U.S. marine ecosystems, and the Nation’s natural and cultural resources." Ultimately, the MPA system will include new sites, as well as enhancements to the conservation of existing sites. Five principal components of the EO are the following:

- **National MPA List:** The USDOC and the USDOI will develop and maintain a national list of MPAs in U.S. waters. Candidate sites for the list are drawn from existing programs for Federal, tribal, State and local protected areas. When completed, the list and the companion data on each site will serve several purposes, such as ensuring that agencies "avoid harm" to MPAs, providing a foundation for the analysis of gaps in the existing system of protections, and helping improve the effectiveness of existing MPAs.

- **The MPA Web Site:** The USDOC and USDOI will develop and maintain a publicly accessible Web site to provide information on MPAs and Federal agency reports required by the EO. In addition, the Web site will be used to publish and maintain the National MPA List and other useful information, such as maps of MPAs; a virtual library of MPA reference materials, including links to other web sites; information on the MPA Advisory Committee; activities of the national MPA Center; MPA program summaries; and background materials such as MPA definitions, benefits, management challenges, and management tools.

- **The MPA Federal Advisory Committee:** Created to provide expert advice on, and recommendations for, a national system of MPAs, this advisory committee will include nonfederal representatives from science, resource management, environmental organizations, and industry.

- **The Mandate to Avoid Harmful Federal Actions:** This mandate directs Federal Agencies to avoid harm to MPAs or their resources through activities that they undertake, fund, or approve.

- **The Marine Protected Areas Center:** The EO directs NOAA to create a Marine Protected Areas Center (MPA Center). In cooperation with the USDOI and working closely with other organizations, the MPA Center will coordinate the effort to implement the EO and will do the following:
  - develop the framework for a national system of MPAs;
  - coordinate the development of information, tools, and strategies;
  - provide guidance that will encourage efforts to enhance and expand the protection of existing MPAs and to establish or recommend new ones;
  - coordinate the MPA Web site;
  - partner with Federal and nonfederal organizations to conduct research, analysis, and exploration;
  - help maintain the National MPA List; and
  - support the MPA Advisory Committee.

C.2.6 Executive Order 13112: Invasive Species (February 1999)

The EO defines an "invasive species" as a species that is nonnative (or alien) to the ecosystem under consideration and whose introduction causes or is likely to cause, economic or environmental harm or harm to human health. This EO requires all Federal agencies to do as follows:

- Identify any actions affecting the status of invasive species;
- Prevent invasive species introduction;
- Detect and respond to and control populations of invasive species in a cost-effective and environmentally sound manner;
- Monitor invasive species populations accurately and reliably;
- Provide for restoration of native species and habitat conditions in invaded ecosystems;
- Conduct research on invasive species and develop technologies to prevent introduction and provide for environmentally sound control of invasive species;
- Promote public education on invasive species and the means to address them; and
- Refrain from authorizing, funding, or carrying out actions that are likely to cause or promote invasive species introduction or spread, unless the agency has determined that the benefits of such actions clearly outweigh the potential harm caused by invasive species and that all feasible and prudent measures to minimize risk of harm will be taken.

In addition, the EO established the National Invasive Species Council (Council), co-chaired by the Secretaries of Agriculture, Commerce and the Interior, and comprised of the Secretaries of State, Treasury, Defense, and Transportation, and the Administrator of the USEPA. The Council does the following:

- Provides national leadership on invasive species;
- Sees that Federal efforts are coordinated and effective;
- Promotes action at local, State, tribal and ecosystem levels;
- Identifies recommendations for international cooperation;
- Facilitates a coordinated network to document and monitor invasive species;

- Develops a web-based information network;
- Provides guidance on invasive species for Federal Agencies to use in implementing the NEPA; and
- Prepares an Invasive Species Management Plan to serve as the blueprint for Federal action to prevent introduction; provide control; and minimize economic, environmental, and human health impacts of invasive species.

The BOEMRE requires that EISs prepared on major Federal OCS actions (e.g., 5-Year OCS Leasing Program and OCS lease sales) contain an assessment of the proposed action's contribution to the invasive species problem.

This page intentionally left blank.

The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the sound use of our land and water resources, protecting our fish, wildlife and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island communities.

The Bureau of Ocean Energy Management

The Bureau of Ocean Energy Management (BOEM) works to manage the exploration and development of the nation's offshore resources in a way that appropriately balances economic development, energy independence, and environmental protection through oil and gas leases, renewable energy development and environmental reviews and studies.