Environmental Impact Analysis
Revision 2

Exploration Plan, Chukchi Sea, Alaska
Burger Prospect: Posey Area Blocks 6714, 6762, 6764, 6812, 6912, 6915
Chukchi Sea Lease Sale 193

Revision 1 (May 2011)

Revision 2 (March 2015)

Submitted to:

U.S. Department of the Interior

Bureau of Ocean Energy Management

Alaska OCS Region

Submitted by:

Shell Gulf of Mexico Inc.

3601 C Street, Suite 1000

Anchorage, AK 99503

Table of Contents

List of Tables

List of Figures

List of Attachments

ACRONYMS & ABBREVIATIONS

~	approximately
°	degrees
°C	degrees Celsius
°F	degrees Fahrenheit
µ	micro
µg	micrograms
µg/g	micrograms per gram
µm	micrometer
µPa	micro-Pascal
2D	two-dimensional
3D	three-dimensional
4MP	Marine Mammal Monitoring and Mitigation Plan
AAAQS	Alaska Ambient Air Quality Standards
AAC	Alaska Administrative Code
ac	acre(s)
ACIA	Arctic Climate Impact Assessment
ACMA	Alaska Coastal Management Act
ACMP	Alaska Coastal Management Program
ACRT	Auxiliary Contract Response Teams
ACS	Alaska Clean Seas
A.D.	anno domini
ADCA	Alaska Division of Community Advocacy
ADCCED	Alaska Department of Commerce, Community and Economic Development
ADEC	Alaska Department of Environmental Conservation
ADF&G	Alaska Department of Fish & Game
ADIOS2	Automated Data Inquiry for Oil Spills
ADNR	Alaska Department of Natural Resources
AES-RTS	ASRC Energy Services – Regulatory & Technical Services
AEWC	Alaska Eskimo Whaling Commission
AGL	above ground level
AHRS	Alaska Heritage Resource Survey
AIS	Automatic Identification System
ALT	Aircraft altitude
AMAP	Arctic Monitoring and Assessment Program
ANCSA	Alaska Native Claim Settlement Act
ANTHC	Alaska Native Tribal Health Consortium
ANWR	Arctic National Wildlife Refuge
AO	Arctic Oscillation
APD	Application for Permit to Drill
APDES	Alaska Pollutant Discharge Elimination System
Approved EP	Shell's Approved Outer Continental Shelf Lease Exploration Plan, Chukchi Sea, Alaska (Shell 2009a)
AQCR	Air Quality Control Region
AQRP	Air Quality Regulatory Program
AS	Alaska Statute
ASAMM	Aerial Surveys of Arctic Marine Mammals

ASL	above sea level
ASRC	Arctic Slope Regional Corporation
ATV	all-terrain vehicle
Avg	average
AWAC	acoustic wave and current meter
BACT	best available control technology
Barrow Airport	Barrow Wiley Post Will Rogers Memorial Airport
bbl	barrel(s) (petroleum)
BCB	Bering-Chukchi-Beaufort
BLM	U.S. Department of the Interior, Bureau of Land Management
BO	Biological Opinion
BOD	biological oxygen demand
BOEM	Bureau of Ocean Energy Management
BOEMRE	Bureau of Ocean Energy Management, Regulation, and Enforcement
BOP	blowout preventer
bopd	barrel(s) of oil per day
BP	before present
BSEE	Bureau of Safety and Environmental Enforcement
Burger # 1 well	OCS-&-1413 (legacy Burger #1 well)
BWASP	Bowhead Whale Aerial Survey Project
CAA	Clean Air Act
CAB	chemical and benthos
C	calibrated
Can-Aic	Canning River to Aichilik River
CDFO	Canadian Department of Fisheries and Oceans
CDPF	catalytic diesel particulate filter
CESQG	Conditionally Exempt Small Quantity Generator
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CHA	Critical Habitat Area
CI	confidence interval
CIP	Capital Improvement Projects
CLO	Community Liaison Officer
cm	centimeter(s)
cm^3	cubic centimeter(s)
cm/s	centimeter(s) per second
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
COCP	Critical Operations and Curtailment Plan
COD	chemical oxygen demand
Col-Can	Colville River to Canning River
Com Center	Communications and Call Center
COMIDA	Chukchi Sea Offshore Monitoring in the Drilling Area
COPD	chronic obstructive pulmonary disease
COTPZ	Captain of the Port Zone
CPQ	Coastal Project Questionnaire

CPUE	catch per unit effort
CSESP	Chukchi Sea Environmental Studies Program
CSIS	Community subsistence information system
CTD	conductivity, temperature, and depth
Cu	copper
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
dB	decibel
DCOM	Division of Coastal and Ocean Management
DCRA	Department of Community and Regional Affairs
DDT	Dichloro-diphenyl-trichloroethanes
DEW	Distant Early Warning
DIMP	Drilling Ice Management Plan
Discoverer	drillship M/V *Noble Discoverer*
DNV	Det Norske Veritas
DOI	Department of Interior
DOT&PF	Department of Transportation & Public Facilities
DP	dynamic positioning
DPS	distinct population segment
DWH	Deepwater Horizon
E	east
EA	Environmental Assessment
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EHA	essential fish habitat
EIA	Environmental Impact Analysis for Shell's Revised Outer Continental Shelf Lease Exploration Plan, Chukchi Sea, Alaska (Shell 2011b)
EIS	Environmental Impact Statement
EMP	Environmental Monitoring Program
EP	Exploration Plan
EP Revision 1	Shell's Approved Revised Outer Continental Shelf Lease Exploration Plan, Chukchi Sea, Alaska (Shell 2011a)
EP Revision 2	Revised Outer Continental Shelf Lease Exploration Plan, Chukchi Sea, Alaska (Shell 2014a)
EPA	U.S. Environmental Protection Agency
ERA	Environmental Resource Area
ERL	Effects Range Low
ESA	Endangered Species Act
EWL	Electric wire line
F	Fall
FAA	Federal Aviation Administration
FDD	freezing degree days
Fe	iron
FMP	Fishery Management Plan
FONSI	Finding of No Significant Impact
FR	Federal Register
FSEIS	Final Supplemental Environmental Impact Statement

ft	feet/foot
ft^2	square feet/foot
ft^3	cubic feet/foot
FTP	Fuel Transfer Plan
Fugro	Fugro-McClelland Marine Geosciences, Inc.
g	gram(s)
G&G	Geological and Geophysical
gal	gallon(s)
GHG	greenhouse gas
GLS	Grouped Land Segments
GOM	Gulf of Mexico
GP	General Permit
gpd	gallons per day
H_2S	hydrogen sulfide
ha	hectare(s)
HAPs	hazardous air pollutants
HIV	human immunodeficiency virus
hp	horsepower
hr	hour(s)
HSSE	Health, Safety, Security, and Environmental
HSWUA	Hanna Shoal Walrus Use Area
Hz	hertz
ICAS	Inupiat Community of Arctic Slope
Icy-Nal	Icy Cape to Nalimiut Point
Ikp-Col	Ikpikpuk River to Colville River
IHA	Incidental Harassment Authorization
IMO	International Maritime Organization
in.	inch(es)
$in.^3$	cubic inch(es)
ind	individual
Initial Chukchi Sea EP	Shell's Chukchi Sea Exploration Plan that was Approved by MMS on 7 December 2009 (Shell 2009)
IRA	Indian Reorganization Act
ITRs	incidental take regulations
IUCN	International Union for the Conservation of Nature
IWC	International Whaling Commission
KCL	potassium chloride
KDR	kitchen/dining/recreation
kg	kilogram(s)
kHz	kilohertz
KIC	Kikiktagruk Inupiat Corporation
km	kilometer(s)
km^2	square kilometer(s)
kts	knots
kW-hr	kilowatt per hour
LA	launch area(s)
lb	pound(s)

LBCHU	Ledyard Bay Critical Habitat Unit
lb/hr	pounds of pollutant per hour
LC_{50}s	lethal concentration 50
LD	lateral distance
LOA	Letter of Authorization
LS	Land Segment
LWD	logging while drilling
m	meter(s)
m^2	square meter(s)
m^3	cubic meter(s)
MAI	Maximum Allowable Increases
MARPOL	International Convention for the Prevention of Pollution from Ships
MAWP	maximum allowable working pressure
max	maximum
mg	milligram(s)
mg/g	millograms/gram
mg/L	milligrams per Liter
mi	statute mile(s)
mi^2	square mile(s) (statute)
min	minute(s)/ minimum
ml	milliliter(s)
MLC	mudline cellar
mm	millimeter(s)
	million metric tons
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service
mmt	million metric ton
Mn	manganese
MODU	mobile offshore drilling unit
MONM	Marine Operations Noise Model
mph	miles per hour
MSA	Magnuson-Stevens Fishery Conservation Act
MSD	marine sanitation device
MSW	municipal solid waste
MT	metric ton(s)
M/V	Motor Vessel
MYI	multiyear ice
N	North
N/A	not available
NA	not applicable
NAAQS	National Ambient Air Quality Standards
NaC1	sodium chloride
NAD	North American Datum
NAD 83	North American Datum 1983
Nal-Ikp	Nalimiut Point to Ikpikpuk River
NAO	North Atlantic Oscillation
NARL	Naval Arctic Research Laboratory

National Register	National Register of Historic Places
NATO	North Atlantic Treaty Organization
ND	no data collected/available
NE	northeast
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
Ni	nickel
NMFS	National Marine Fisheries Service
NMHC	Non-methane hydrocarbon
nmi	nautical mile(s)
NMML	National Marine Mammal Laboratory
NO_2	nitrogen dioxide
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NOx	nitrogen oxide
NO_y	Totally reactive nitrogen
NPDES	National Pollutant Discharge Elimination System
NPFMC	North Pacific Fishery Management Council
NPR-A	National Petroleum Reserve – Alaska
NRC	National Research Council
NS	no survey
NSB	North Slope Borough
NSSRT	North Slope Spill Response Team
NTL	Notice to Lessees
NWAB	Northwest Arctic Borough
NWP	nationwide permit
NWR	National Wildlife Refuge
O_3	ozone
OBH	Ocean bottom hydrophones
OCS	Outer Continental Shelf
OCSLA	Outer Continental Shelf Lands Act
OHA	Office of History and Archaeology
OOC	Offshore Operators Committee
OPA	Oil Pollution Act of 1990
OPE	ozone production efficiency
OPMP	Office of Project Management and Permitting
org C	organic carbon
OSHA	Occupational Safety and Health Administration
OSR	oil spill response
OSRA	oil spill risk analysis
OSR barge	oil spill response barge
OSRO	Oil Spill Response Organization
OSRP	Oil Spill Response Plan
OSRV	oil spill response vessel
OST	oil storage tanker
OSV	offshore supply vessel
OWS	oily water separator

OxyCat	oxidation catalysts
P&A	plugged and abandoned
PAEL	preapproved emission limit
PAH	polycyclic aromatic hydrocarbons
Pb	lead
PCB	polychlorinated biphenyls
PDO	Pacific Decadal Oscillation
pk-pk	peak-to-peak
P.L.	Public Law
PM_{10}	particulate matter
PM_{10}	particulate matter < 10 micrometers
$PM_{2.5}$	particulate matter < 2.5 micrometers
POB	persons on board
POC	Plan of Cooperation
Polar Pioneer	Mobile Offshore Drilling Unit (MODU) Transocean *Polar Pioneer*
POP	persistent organic pollutant
ppb	parts per billion
ppm	parts per million
PPOR	potential place of refuge
PRB	Potential Biological Removal
PRPA	Paleontological Resources Preservation Act
PSD	Prevention of Significant Deterioration
psi	pounds per square inch
PSO	Protected Species Observer
psu	practical salinity units
PTS	Permanent Threshold Shift
PWS	Prince William Sound
RIPS	Rotor Ice Prevention System
RKB	rotor kelly bushing
rms	root mean square
ROV	remotely operated vehicle
RS/FO	Regional Supervisor/Field Operations
S	south/summer
SA	Subsistence Advisor/ Sensitive Area
SAPP	sodium acid pyrophosphate
SAR	Search and Rescue
SCR	Selective Catalytic Reduction
sd	standard deviation
S	south
SE	southeast
sec	second(s)
SEIS	Supplemental Environmental Impact Statement
SEL	sound exposure level
Shell	Shell Gulf of Mexico Inc./ Shell Oil Company
SHPO	State Historic Preservation Office
SILs	Significant Impact Levels
SIPs	state implementation plans

SIWAC	Shell Ice and Weather Advisory Center
SO_2	sulfur dioxide
SOA	State of Alaska
SO_x	sulfur oxide
SW	southwest
SWEPI	Shell Western E&P Inc.
T&E	Threatened and/or endangered (listed under the ESA)
TBD	to be determined
TCP	Traditional Cultural Property
TD	Total Depth
TDS	total dissolved solids, also Treatment/Disposal Storage
Temp	temperature
TK	Traditional Knowledge
TLUI	Traditional Land Use Inventory
TOC	total organic carbon
TPH	total petroleum hydrocarbons
tpy	tons of pollutant per year
TSS	Total Suspended Solids
TTS	Temporary Threshold Shift
TVD	Total vertical depth
UIC	Ukpeagvik Inupiat Corporation
ULSD	Ultra Low Sulfur Diesel
UN	United Nations
U.S.	United States
USACE	U.S. Army Corps of Engineers
USAF	U.S. Air Force
USC	United States Code
USCG	U.S. Coast Guard
USCGC	U.S. Coast Guard Cutter
USFWS	U.S. Fish and Wildlife Service
UTM	Universal Transverse Mercator
V	Vanadium
VGP	Vessel General Permit (EPA NPDES)
VLOS	very large oil spill
VOC	volatile organic compounds
VOSS	vessel of opportunity skimming system
VRTs	Village Response Teams
VSI	vertical seismic imaging
VSP	vertical seismic profile
v/v	volume/volume
W	west
WBM	Water Based Mud
WCD	Worst Case Discharge
WHOI	Woods Hole Oceanographic Institution
WRF	Weather Research and Forecasting
yd	yard(s)
yd^3	cubic yard(s)

Y-K	Yukon-Kuskokwim
yr	year
Zn	zinc
ZVSP	zero-offset vertical seismic profile

PREFACE

This Environmental Impact Analysis (EIA) accompanies Shell Gulf of Mexico Inc.'s (Shell's) Revised Outer Continental Shelf Lease Exploration Plan, Chukchi Sea, Alaska, Burger Prospect, Posey Area Blocks 6714, 6762, 6764, 6812, 6912, and 6915 (Shell 2014a), referred to as EP Revision 2.[1] This EIA is prepared pursuant to the requirements of the Outer Continental Shelf Lands Act (OCSLA), 43 United States Code (USC) §§ 1331-1356, and the regulations of the Bureau of Ocean Energy Management (BOEM), including 30 Code of Federal Regulations (CFR) 550.212(o) and 550.227. Per regulations at 30 CFR 550.285, a revised Exploration Plan (EP), including the EIA, need only include information related to, or affected by, the proposed changes in the exploration drilling program. However, for clarity and improved understanding, Shell is submitting a complete EIA that provides an entire description and analysis of the proposed exploration drilling program.

This EIA is a project- and site-specific analysis of Shell's planned activities under EP Revision 2. It provides a complete description of all of the activities that Shell plans to perform. It identifies and describes the resources and conditions of the project area and assesses the potential environmental impacts on those resources and conditions of the planned activities. It further identifies and describes the mitigation measures Shell will implement in connection with the planned activities. The EIA presents data, analysis, and conclusions to assist BOEM in complying with the National Environmental Policy Act (NEPA), and other relevant federal laws including the Endangered Species Act (ESA) and the Marine Mammal Protection Act (MMPA), as the agency considers EP Revision 2 for approval.

Shell's plan, as detailed in its EP Revision 2, is to use two drilling units, the Motor Vessel (*M/V) Noble Discoverer (Discoverer)* and the semi-submersible Mobile Offshore Drilling Unit (MODU) *Transocean Polar Pioneer (Polar Pioneer)*, to conduct exploration drilling activities at six well locations on six leases (one well per lease) offshore in the Chukchi Sea, Alaska, beginning in the next exploration drilling season. The drill sites are over 64 statute miles (mi) (103 kilometers [km]) offshore in Arctic waters that are inaccessible for eight months or more of the year due to pack ice. Shell's proposed exploration drilling activities will take place on Federal Outer Continental Shelf (OCS) leases in the Chukchi Sea, an area of approximately 230,000 square miles (mi^2) (595,000 square kilometers [km^2]). The drill sites are remote from any infrastructure. Shell plans to conduct exploration drilling activities during the open water season in summer and early fall, beginning on or about 1 July, until on or about 31 October, in the initial and subsequent drilling seasons. [2]

Shell's Arctic Experience

Shell, through its parent and affiliate corporations, has substantial experience exploring for oil and gas in Arctic environments, including the Beaufort and Chukchi Seas. Beginning almost 50 years ago, various

---

[1] Shell's Initial Chukchi Sea Exploration Plan was submitted in 2009 and approved by the Minerals Management Service (MMS) in 2009 ("Initial Chukchi Sea EP"). In May 2011, Shell submitted a revised Chukchi Sea Exploration Plan, which was approved by the BOEM in December 2011. For purposes of this submittal, Shell refers to the 2011 approved EP as "EP Revision 1." In its March 2015 Revised Chukchi Sea Exploration Plan ("EP Revision 2"), Shell proposes limited changes to EP Revision 1. Those changes are discussed here and analyzed throughout this revised EIA.

[2] Shell may, depending on seasonal ice conditions, marine mammal distributions, and planned subsistence harvest in the area of interest, request permission from the US Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) to transit through certain areas prior to 1 July 1. These areas have been defined in the USFWS' Chukchi Sea incidental take regulations (50 CFR 18.112 & 18.118(a)(2)(iv)) and as part of NMFS's Proposed Issuance of Incidental Harassment Authorization (IHA) for Shell's Chukchi Sea exploratory drilling activities (80 Fed. Reg. 11726, 11772, March 4, 2015).

Shell Oil Company (Shell) subsidiaries operated continuously in Alaska until 1998. Shell was one of the most prominent explorers in all of the frontier offshore basins of Alaska, as well as being an operator and major producer in Cook Inlet. During the 1980s, Shell either operated or was a partner in nine exploration wells drilled offshore in the Beaufort Sea. During the late-1980s through the early-1990s, Shell also drilled four exploration wells in the Chukchi Sea and participated in a fifth exploration well.

In 2012, under Shell's approved EPs in the Beaufort and Chukchi Seas, Shell drilled a top hole with the *Discoverer* at the Burger A drill site in the Chukchi Sea and another top hole with the *Kulluk* at the Sivulliq Prospect in the Beaufort Sea. Shell's Burger A well was drilled to a measured depth of 1,505 feet (ft) rotary kelly bushing (RKB) and was temporarily abandoned according to the Bureau of Safety and Environmental Enforcement (BSEE) regulations at 30 CFR 250.1721-.1723. In support of its 2012 exploration drilling, Shell deployed numerous assets, rotated thousands of employees to the Arctic, and demonstrated its ability to respond quickly and effectively to changing ice conditions in the Arctic. This activity marked industry's return to offshore drilling in the Alaskan Arctic after more than a decade. Shell's 2012 exploration drilling operations in the Arctic were conducted safely, and with no serious injuries or environmental impact(s).

Project Description and Changes from Approved EP Revision 1

Shell's EP Revision 2 proposes exploration drilling activities over several seasons, on the same six lease blocks and same locations within the Burger Prospect (i.e., Burger A, F, J, R, S, and V) included in Shell's EP Revision 1. There is a long history of safe and environmentally responsible exploration drilling activity in the Chukchi Sea. Five wells were drilled in the Chukchi Sea between 1989 and 1991, and Shell safely drilled a top hole at the Burger A drill site in 2012 (Figure 1.2-1). These historic wells include the Burger OCS-Y-1413 #1 well drilled within the same prospect as Shell's planned wells.

Changes to Drilling Units

Under EP Revision 2, Shell plans to drill all six exploration wells using the *Discoverer* and/or the *Polar Pioneer*. Only the *Discoverer* was in EP Revision 1. The *Discoverer* is ice-strengthened for operating in Arctic OCS waters. The *Discoverer* includes state-of-the-art drilling and well control equipment, as well as accommodations for a crew of up to 124 persons. Under EP Revision 2, Shell proposes to also use the *Polar Pioneer* for its exploration drilling activities. The *Polar Pioneer* is a non-self-propelled semi-submersible drilling unit capable of drilling in harsh environments, and also includes state-of-the-art drilling and well control equipment, as well as accommodations for a crew of up to 114 persons. Each drilling unit will serve as its own primary relief well drilling unit and as the secondary relief well drilling unit for the other drilling unit.

Shell modeled and analyzed the impacts that are uniquely associated with a two drilling unit exploration drilling program as opposed to its approved exploration drilling program, EP Revision 1, that uses a single drilling unit. Some types of impacts are associated with a single well and the total impact for the exploration drilling program is simply the sum of the impacts from all the wells in the program with no synergistic effects between wells due to separation in time and space. Other types of impacts could possibly be synergistic if the impacting activities were conducted simultaneously or in such proximity that their effects overlap. Identified components of the exploration drilling program that could possibly have synergistic effects include: air emissions, vessel traffic, sound generation by drilling activities, drilling waste discharges, vessel discharges, and aircraft traffic. The potential impacts associated with these aspects of the drilling program are discussed in Section 4.0 of the EIA.

Changes to Vessels and Travel Routes

The drilling units will be supported by additional vessels for ice management, anchor handling, resupply, and crew transport, as well as oil spill response (OSR) support vessels and barges staged near the drilling units, with a full complement of crew and OSR equipment. Additional vessels will implement Shell's

Marine Mammal Monitoring and Mitigation Plan (4MP) and support scientific research efforts. All support vessels will be equipped for operating in Arctic waters.

One change between the approved EP Revision 1 and EP Revision 2 is the use of additional support vessels and OSR equipment for Shell's exploration drilling program in the Chukchi Sea. Table P-1 provides a comparison of the changes from EP Revision 1 to EP Revision 2. These adjustments have been made in direct response to Shell's experiences during the 2012 season, the planned use of a second drilling unit, and discharge monitoring requirements under the new National Pollutant Discharge Elimination System (NPDES) exploration facilities General Permit (GP). Additional vessels will be used occasionally to support exploration drilling activities in the Chukchi Sea (e.g., ice management, anchor handling, offshore supply, alternate Mudline Cellar (MLC) Remotely Operated Vehicle (ROV) System vessel and OSR augmentation) and are therefore included in EP Revision 2 and analyzed in this EIA. The expected frequency of offshore supply vessels (OSVs) to the drilling units has been increased from 17 round trips/season to 30 round trips/season.

There have also been changes in the designated locations of some of the vessels and the frequency of their use. Further information regarding the location and specifications of these vessels and aircraft is provided in Sections 2.1 and 2.2 of this EIA.

Changes to Aircraft and Flights

Under EP Revision 2 Shell plans to utilize an additional helicopter for crew changes, and increase the frequency of crew change flights from 12 round trips / week to 40 round trips / week. An additional fixed wing aircraft is provided for in EP Revision 2 as the platform for conducting ice reconnaissance flights.

Table P-1 Comparison of the Exploration Drilling Program Under Shell's Approved EP Revision 1 and EP Revision 2

Parameter	Approved EP Revision 1	EP Revision 2
Drilling Units	*Discoverer*	*Discoverer* and *Polar Pioneer*
MLC Construction	*Discoverer*	*Discoverer*, *Polar Pioneer, MLC ROV system*
Support Vessels	Drilling Support Vessels: • Ice Management vessel (x1) • Anchor handler (x1) • OSVs (x2) • Shallow water landing craft (x1) OSR Support Vessels: • OSR vessel (x1) • OSR tug and barge (x1) • Oil storage tanker (OST) for recovered liquids (x1) • Oil spill containment system tug (x1) and barge (x1) • Oil spill containment system Anchor handler (x1)	Drilling Support Vessels: • Ice Management Vessels (x2) • Anchor Handlers (x3) • Supply Tugs (x2) and barges (x2) • OSVs (x3) • Support Tugs (x2) • Science vessels (x2) • Shallow water vessels (x2) • MLC ROV System vessel (x1) OSR Support Vessels: • OSRV (x1) • OSR tug and barge (x1) • OSTs (x2) • Containment system tugs (x2) and barge (x1) • OSR tug (x1) and barge for nearshore response (x1)

Table P-1 Comparison of the Exploration Drilling Program Under Shell's Approved EP Revision 1 and EP Revision 2

Parameter	Approved EP Revision 1	EP Revision 2
Aircraft	• S-92 or AW139 for crew change • S-61, S92 or EC225 for Search and Rescue (SAR) • Fixed wing aircraft for protected species observer (PSO) flights • Fixed-wing aircraft – crew change from Wainwright to regional jet service in Barrow	• S-92 Helicopters (or similar) for crew change (x3) • S-92 Helicopter (or similar) for SAR • Fixed wing aircraft for PSO and ice monitoring flights (x2) • Fixed-wing– crew change from Wainwright to regional jet service in Barrow
Aircraft Flights	• Helicopter Crew Change Flights - Approximately 12 round trips/week for crew change/resupply • Fixed wing aircraft for PSO • Fixed wing aircraft crew change between Barrow & Wainwright up to 4 times per week	• Helicopter Crew Change Flights - Approximately 40 round trips/week for crew changes/resupply • Fixed wing aircraft for PSO and ice monitoring flights daily • Fixed wing aircraft crew change between Barrow and Wainwright once every 3 weeks
Drilling Unit Discharges	Discharges as listed in Section 6 of EP Revision 1	Revised discharges volumes/rates in Section 6.0 of EP Revision 2
Drilling Unit Authorizations	Burger drill sites were authorized under NPDES exploration facilities General Permit (GP) AKG-28-0000	Notices of Intent (NOI) to discharge certain wastes at the Burger drill sites will be filed under the new NPDES exploration facilities GP AKG-28-8100
Drilling Fluid Components	List of approved components are in Table 6.c-1 of EP Revision 1	Additional drilling components have been added and are in Tables 6.c-1 and 6.c-2 of EP Revision 2
Shorebase	Barrow – 75 person man camp	• Barrow – lease 40 person man camp; add a kitchen unit to the 75 person man camp; add hangar space for an additional helicopter • Wainwright – additional existing yard space will be leased for response equipment storage
Secondary Relief Well Unit for the *Discoverer*	*Kulluk*	*Polar Pioneer* will serve as secondary relief well unit for *Discoverer*, and *Discoverer* will serve as secondary relief well unit for *Polar Pioneer*
Air Emissions Authorization	Air emissions approved by EPA under authorization R10OCS/PSD-AK-09-01	Jurisdiction for regulating air emissions for projects on the OCS in areas off the coast of the North Slope Borough (NSB) in Alaska was changed from the U.S. Environmental Protection Agency (EPA) to BOEM (Consolidated Appropriations Act)
Containment System Location	Centrally located in the Chukchi Sea or Beaufort Sea	Located in or near Goodhope Bay within Kotzebue Sound
Hydrogen Sulfide (H_2S) Classification	Requested 'H_2S Unknown' classification	Requests 'H_2S Absent' classification; H_2S Contingency Plan removed

Changes to Drilling Protocols

Each drill site has been surveyed by Shell and determined not to contain any shallow hazards or archeological or historical resources that would be impacted by Shell's proposed drilling activities. Shell plans to pre-set anchors at one or more drill site(s) in advance of the drilling units arriving. Once a drilling unit is mobilized to a drill site and securely anchored to the seafloor, exploration drilling operations will commence.

Changes in EP Revision 2 include the option to utilize a MLC ROV System to construct the MLCs, in addition to the current MLC construction technique using the MLC bit. This option would increase the amount of time the drilling units are available for drilling the wells.

It is anticipated that the work included in EP Revision 2 will take place over multiple drilling seasons. Depending on a variety of factors in a given drilling season, including ice, weather conditions, the length of the open water season, and operational conditions, Shell may drill an approved well to Total Depth (TD) or limit operations on such well to constructing MLCs and/or upper hole segments (*i.e*., partial well or top hole). Any well where drilling is suspended would be secured in compliance with BSEE regulations and with the approval of the Regional Supervisor/Field Operations (RS/FO), whether permanently abandoned (30 CFR 250.1710-1717) or temporarily abandoned (30 CFR 250.1721-1723). All wells will be permanently plugged and abandoned in accordance with BSEE requirements upon lease termination. No oil or gas will be produced from the exploration wells, and no pipelines or other permanent facilities will be built.

EP Revision 2 also includes changes to drilling fluid components and blowout preventer (BOP) fluids, and drilling waste and wastewater volume estimates. Specifically, Shell is adding a number of drilling fluid components to the drilling fluids plan, increasing its estimates of drilling waste volumes, and modifying the discharge method for drilling wastes from the MLC and upper well sections (top hole). These changes are a direct result of lessons learned from Shell's 2012 operations. Shell plans to use only water-based drilling fluids and all fluids will meet EPA criteria under the NPDES exploration facilities GP. Details on drilling fluids and wastes are discussed below in Section 2.7.

Changes to Support Facilities

Shell plans to expand its existing man-camp facilities in Barrow by leasing a nearby construction camp with accommodations for 40 persons, expanding the passenger processing facilities at the Barrow Airport, and potentially booking blocks of hotel rooms. Shell may also utilize a larger (up to 55-person) man camp in Wainwright, and utilize additional storage yard at an existing pad. These changes are being implemented to accommodate crews from the additional support vessels, and minimize any impact that crew-changes might have in Barrow. Crew change personnel may require shelter on occasions when flights in and out of Barrow are restricted by weather and flying conditions. Additional information on the construction of these facilities and their maintenance (*e.g*., electricity, water, sewage) is provided in Section 2.5.

Permits and Authorizations

All operations will comply with applicable federal, state and local laws, regulations, and lease and permit requirements. Shell will have trained personnel and monitoring programs in place to ensure such compliance. In addition, BOEM and other federal regulatory agencies will maintain continuing oversight of all of Shell's exploration drilling activities, and BOEM and BSEE retain the specific authority to require additional mitigation, as appropriate, to respond to actual conditions encountered.

The following are among the permits and authorizations governing Shell's activities, which collectively impose mandatory requirements to ensure safety, protect the environment, avoid interference with subsistence resources and activities, and mitigate any potential adverse impacts. The current status of each permit is also noted.

- **Applications for Permit to Drill (APDs) from BSEE for each proposed well**. Burger drill sites A, J, and V received authorizations in 2012 to drill to the base of the 20-inch casing. APDs for these drill sites require revision and approval by BSEE following BOEM approval of EP Revision 2 to allow for drilling to TD and use of the *Polar Pioneer*.APDs for Burger drill sites F, R and S also must be approved by BSEE following BOEM approval of EP Revision 2
- **NPDES exploration facilities GP under the Clean Water Act (CWA) from the EPA, imposing strict limits on the permissible discharges to the Chukchi Sea.** Shell submitted submit NOIs for a NPDES exploration facilities GP AKG-28-8100 to EPA for discharge at Burger drill sites on 23 January 2015; authorizations will be secured prior to the start of exploration drilling. BOEM was copied on these submittals.
- **MMPA authorization from the NMFS for non-lethal, incidental harassment of whales and seals.** Shell requested its authorization from NMFS on 18 September 2014 and a Notice of Proposed Incidental Harassment Authorization (IHA) was published in the Federal Register on March 4, 2015; authorizations will be secured prior to the start of exploration drilling. BOEM will be copied on these authorizations.
- **MMPA authorization for non-lethal, incidental and intentional harassment of polar bears and walruses from USFWS.** Shell requested MMPA authorization for non-lethal incidental and intentional harassment of polar bears and Pacific walrus from USFWS on 17 September 2014; Authorizations will be secured prior to the start of exploration drilling. BOEM will be copied on these authorizations.
- **Nationwide Permit (NWP) No. 8 under the Rivers and Harbors Act from the U.S. Army Corps of Engineers (USACE), regulating the location and installation of the *Discoverer* and the *Polar Pioneer* on the seafloor.** Requests for these permits for Burger A, F, J, R., S, and V drill sites were submitted on 30 September 2014 and approved on 11 February 2015. The approvals are valid through 18 March 2017.
- **Oil Spill Response Plan (OSRP) approval from BSEE was received for Shell's Chukchi Sea Regional OSRP on 17 February 2012. Shell submitted modifications to that OSRP on 18 December 2013, and those changes were approved by BSEE on 23 June 2014.** Shell will request additional administrative changes to the OSRP to address the use of a second drilling unit in the prospect and minor changes to OSR assets.

Mandatory and Voluntary Mitigation Measures

Shell must implement mandatory mitigation measures and safety programs. Shell will also employ voluntary mitigation measures that have been developed over several years of Arctic exploration activities in consultation with Alaska Native stakeholders, which voluntary measures have been proven effective in minimizing impacts to the environment, subsistence resources, and Alaska Native subsistence activities. Shell's measures were effective in the 2012 season to protect this important resource, and therefore remain fundamentally the same as they were in the 2012 season.

Shell has made some adjustments to its mitigation measures as a result of new legal requirements. Changes in Shell's mandatory mitigation measures for EP Revision 2 include:

Bird Strike Avoidance and Lighting Plan: The process and procedures in this Plan were successfully implemented during the Chukchi Sea exploration drilling program in 2012 and will be continued for EP Revision 2, with one minor change. Shell will not be able to continue with the use of the ClearSky lighting technology as a mitigation measure. These lights are no longer commercially available. In compliance with the Chukchi Sea 193 Lease Sale Stipulation No. 7, (EP Revision 2, Section 11) lighting on the drilling units will be shaded to reduce the possibility of a bird collision. Due to this minor change, a revised Bird Strike Avoidance and Lighting Plan is provided in Appendix E to EP Revision 2.

Polar Bear and Pacific Walrus Authorizations for Incidental and Intentional Harassment

Shell will apply for MMPA authorization for incidental and intentional harassment of polar bears and Pacific walruses. Those requests for authorization detail mitigation measures required for avoidance of impacts to species or subsistence activities. Mitigation measures from prior MMPA authorizations and others will be incorporated into the mitigation plan for exploration drilling (EP Revision 2, Section 12). These include the following:

- Except in an emergency, vessels will not approach within 0.5 mi (0.8 km) of walruses or polar bears when observed on ice.
- Except in an emergency, vessels will not approach within 1.0 mi (1.6 km) of groups of walruses or 0.5 mi (0.8 km) of polar bears when observed on land.
- Except in an emergency, aircraft will not operate at an altitude lower than 1,500 ft (457 meters [m]) within 0.5 mi (0.8 km) of polar bears when observed on land or ice.
- Helicopters will not operate at an altitude lower than 3,000 ft (914 m) within 1 mi (1.6 km) of walrus groups observed on land, and fixed-wing aircraft will not, except in an emergency, operate at an altitude lower than 1,500 ft (457 m) within 0.5 mi (805 m) of walrus groups observed on ice, or within 1 mi (1,610 m) of walrus groups observed on land.
- If aircraft must be operated below 1,500 ft (457 m) because of weather, the operator will avoid areas of known walrus and polar bear concentrations and will take precautions to avoid flying directly over or within flying within 0.5 mi (805 m) of these areas.

Shell's EP Revision 1 also adopted a number of voluntary mitigation measures, such as a Communications Plan to coordinate activities with subsistence users, employment of local Subsistence Advisors (SAs), and voluntary limitations on aircraft and vessel routes and travel. Shell plans minor changes to the voluntary mitigation measures it undertook in the 2012 open water season. The few proposed changes are the result of lessons learned in the 2012 open water season. These planned changes are indicated below:

- **Shell will not recycle drilling fluids from one drill site to the next.** Spent drilling fluids will be discharged after each well is drilled to TD because of space restrictions on the drilling units and the need for multiple drilling fluid types.
- **Drilling mud (fluid) may be cooled.** This measure was removed as no permafrost has been observed in the five historical wells, recognized in the modern shallow hazards surveys, or encountered in the Burger A well during exploration drilling in 2012.
- **Shell's blowout prevention program will involve changing the BOP pressure test frequency from once every 7 days to once every 14 days.** This change is consistent with 30 CFR 250.447(b), which requires a BOP system test before 14 days have elapsed since the last pressure test.
- **The containment system tugs and barge, OSR tug and barge, and two supply barges and tugs will be located in or near Goodhope Bay, Kotzebue Sound.** Positioning the containment system tugs and barge in or near Goodhope Bay, Kotzebue Sound yields a response time to a well control incident at the Burger Prospect that is consistent with the time for the previously stated location for the containment system tug and barge in EP Revision 1.
- **Certain engines on the *Discoverer* will be Tier-rated.** This improvement will reduce carbon monoxide (CO), volatile organic compounds (VOCs), and hazardous air pollutants (HAPs).

- **Shell has developed an "Adaptive Approach to Ice Management in Areas Occupied by Pacific Walruses", which details a process and procedures for engagement with USFWS biologists during ice management where the potential exists for the presence of Pacific walruses.** The process and procedures were implemented during Shell's Chukchi Sea exploration drilling in 2012 and will be adopted for EP Revision 2 (Appendix J). This document was submitted to the USFWS following promulgation of the current Chukchi Sea ITRs for polar bears and Pacific walruses. This adaptive approach will further mitigate the effects of ice management on Pacific walruses through well-defined ice management procedures when in the presence of Pacific walruses in conjunction with regular contact with USFWS personnel.

Science in the Chukchi Sea

BOEM and its predecessor agency MMS, have also conducted or funded numerous baseline studies of the Arctic OCS, and BOEM is planning more. Among recent publications, these baseline studies include:

- Dunton, K.H., J. Grebmeier, L. Cooper, J. Trefry. 2012. The COMIDA-CAB project: an overview of the biological and chemical characteristics of the northern Chukchi Sea benthos. Pp 6-19 in K.H. Dunton (editor). Chukchi Sea Offshore Monitoring in Drilling Area (COMIDA): Chemical and Benthos (CAB). Final Report. OCS Study BOEM 2012-012 USDOI Bureau of Ocean Energy Management, Anchorage, AK.
- Quakenbush, L.T., R.J. Small, and J.J. Citta. 2013. Satellite tracking of bowhead whales: movements and analysis from 2006 to 2012. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Alaska Outer Continental Shelf Region, Anchorage, AK. OCS Study BOEM 2013-01110. 60 pp + app.
- Givens, G.H., S.L. Edmondson, J.C. George, R. Suydam, R.A. Charif, A. Rahaman, D. Hawthorne, B. Tudor, R.A. DeLong, and C.W. Clark. 2013. Estimate of 2011 Abundance of the Bering-Chukchi-Beaufort Seas bowhead whale population. SC/65a/BRG01 International Whaling Commission.
- MAR, Inc., SL Ross Environmental Research Ltd., DF Dickens Associates Ltd. 2008. Empirical Weathering Properties of Oil in Ice and Snow. OCS Study MMS 2008-033. U.S. Department of the Interior Minerals Management Service, Alaska Outer Continental Shelf Region.
- Bercha Group. 2008. Alternative Oil Spill Occurrence Estimators and Their Variability for the Alaskan OCS- Fault Tree Method: Update of GOM OCS Statistics to 2006. OCS Study MMS 2008-025. U.S. Department of the Interior Minerals Management Service, Alaska Outer Continental Shelf Region, Anchorage. October 2008.

Shell successfully conducted an exploration drilling season in the Chukchi Sea in 2012 during which an extensive 4MP was implemented. The results of the program are detailed in:

- LGL Alaska Research Associates, Inc., JASCO Applied Sciences, Inc., and Greeneridge Sciences, Inc. 2013. Joint Monitoring Program in the Chukchi and Beaufort Seas, 2012. LGL Alaska Draft Report P1272-2 for Shell Offshore, Inc. ION Geophysical, Inc., and Other Industry Contributors, National Marine Fisheries Service, and U.S. Fish and Wildlife Service. 320 p. plus Appendices.

The BOEM website lists dozens of studies completed to date, as well as planned studies for the future http://www.boem.gov/studies/. In addition, Shell has performed its own studies in preparation for this project, including coastal environmental sensitivity surveys, water and sediment quality surveys, acoustical monitoring and air quality monitoring.

A multi-faceted baseline study within four large study areas in the northeastern Chukchi Sea, including a 30 nautical mile (nmi) x 30 nmi Burger Study Area encompassing all the blocks in Shell's Burger

Prospect, has been conducted each year in 2008-2014 and the resulting reports were utilized in the preparation of this EIA. Those reports are listed below:

- Aerts, L.A.M., C.L. Christman, C.A. Schudel, W. Hetrick, and D. Snyder. 2014. Marine mammal distribution and abundance in the northeastern Chukchi Sea from shipboard surveys during summer and early fall, 2008–2013. Final report prepared by LAMA Ecological, Anchorage, AK for ConocoPhillips Company, Shell Exploration & Production Company, and Statoil USA E&P, Inc., Anchorage, AK. 71 pp.
- Aerts, L.A.M., W. Hetrick, S. Sitkiewicz, C.S. Schudel, D. Snyder, and R. Gumtow. 2013. Marine mammal distribution and abundance in the northeastern Chukchi Sea during summer and early fall 2008-2012. Prepared by Lama Ecological for ConocoPhillips Company, Shell Exploration and Production Company, and Statoil USA E&P, Inc., Anchorage, AK. 69 pp.
- Aerts, L.A.M., A. Kirk, C. Schudel, B. Watts, P. Sesier, A. McFarland, and K. Lomac-Macnair. 2012. Marine mammal distribution and abundance in the northeast Chukchi Sea, July-October 2008-2011. Draft Report. Prepared for ConocoPhillips Company, Shell Exploration and Production Company, and Statoil USA E&P, Inc. by Lama Ecological, OASIS-ERM, ABR Inc., and Fairweather Science. 69 pp.
- Aerts, L.A.M., A. Kirk, C. Schudel, K. Lomac-Macnair, A. McFarland, B. Sesier, and C. Watts. 2011. Marine mammal distribution and abundance in the northeast Chukchi Sea, July-October 2008-2010. Final Report. prepared for ConocoPhillips Company, Shell Exploration and Production Company, and Statoil USA E&P, Inc. by Lama Ecological, OASIS Environmental Inc. and Fairweather Science, Anchorage, AK.
- Brueggeman, J. 2010. Marine Mammal Surveys at the Klondike and Burger Survey Areas in the Chukchi Sea during the 2009 Open Water Season. Prepared for ConocoPhillips Company and Shell Exploration & Production Company. Prepared by Canyon Creek Consulting, LLC.
- Brueggeman, J. 2009. Marine Mammal Surveys at the Klondike and Burger Survey Areas in the Chukchi Sea during the 2008 Open Water Season. Prepared for ConocoPhillips Company and Shell Exploration & Production Company. Prepared by Canyon Creek Consulting, LLC.
- Blanchard, A.L. and A.L. Knowlton. 2014. Chukchi Sea Environmental Studies Program: Benthic Ecology of the Northeastern Chukchi Sea, 2008-2013. Final Report. Prepared For ConocoPhillips Company, Shell Exploration & Production Company, and Statoil USA E&P, Inc. by University of Alaska, Fairbanks, AK
- Blanchard, A.L., and A.L. Knowlton. 2013. Chukchi Sea Environmental Studies Program: Benthic Ecology of the Northeastern Chukchi Sea, 2008-2012. Prepared for ConocoPhillips Alaska, Inc. and Shell Exploration & Production Company, by University of Alaska, Fairbanks, AK.
- Blanchard, A.L., and A.L. Knowlton. 2013. Chukchi Sea Environmental Studies Program: Benthic Ecology of the Northeastern Chukchi Sea, 2008-2011. Prepared for ConocoPhillips Alaska, Inc. and Shell Exploration & Production Company, by University of Alaska, Fairbanks, AK.
- Blanchard, A.L., C. Parris, and A.L. Knowlton. 2011. Benthic ecology of the Northeastern Chukchi Sea. Chukchi Sea Environmental Studies Program 2008-2010. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil USA E&P, Inc. by University of Alaska, Fairbanks, AK.
- Blanchard, A.L., C. Parris, and H. Nichols. 2010b. Benthic ecology of the Burger and Klondike survey areas: 2009 environmental studies program in the northeastern Chukchi Sea. Prepared for

ConocoPhillips Alaska, Inc. and Shell Exploration & Production Company, by University of Alaska, Fairbanks, AK.

- Blanchard, A.L., H. Nichols, and C. Parris. 2010a. Benthic ecology of the Burger and Klondike survey areas: 2008 environmental studies program in the northeastern Chukchi Sea. Prepared for ConocoPhillips Alaska, Inc. and Shell Exploration & Production Company, by University of Alaska, Fairbanks, AK.
- Gall A. and B. Day. 2014. Distribution and abundance of seabirds in the northeastern Chukchi Sea, 2008 - 2013. Prepared for ConocoPhillips Company, Shell Exploration & Production Company, and Statoil USA E&P, Inc., Anchorage AK by ABR, Inc. Environmental Services, Fairbanks, AK.
- Gall A. and B. Day. 2013. Distribution and abundance of seabirds in the northeastern Chukchi Sea, 2008 - 2012. Draft Report prepared for ConocoPhillips Company, Shell Exploration & Production Company, and Statoil USA E&P, Inc., Anchorage AK by ABR, Inc. Environmental Services, Fairbanks, AK.
- Gall A. and B. Day. 2012. Distribution and abundance of seabirds in the northeastern Chukchi Sea, 2008 - 2011. Draft Report prepared for ConocoPhillips Company, Shell Exploration & Production Company, and Statoil USA E&P, Inc., Anchorage AK by ABR, Inc. Environmental Services, Fairbanks, AK. 42 pp. + app.
- Gall A. and B. Day. 2011. Distribution and abundance of seabirds in the northeastern Chukchi Sea, 2008 - 2010. Prepared for ConocoPhillips Company, Shell Exploration & Production Company, and Statoil USA E&P, Inc., Anchorage AK by ABR, Inc. Environmental Services, Fairbanks, AK. 74 pp.
- Gall A. and B. Day. 2010. Distribution and abundance of seabirds in the northeastern Chukchi Sea, 2008 and 2009. Prepared for ConocoPhillips Company, Shell Exploration & Production Company, and Statoil USA E&P, Inc., Anchorage AK by ABR, Inc. Environmental Services, Fairbanks, AK. 68 pp.
- Gall, A. and B. Day. 2009. Distribution and abundance of seabirds in the northeastern Chukchi Sea, 2008. Prepared for ConocoPhillips Company, Shell Exploration & Production Company, and Statoil USA E&P, Inc., Anchorage AK by ABR, Inc. Environmental Services, Fairbanks, AK. 55 pp.
- Hopcroft, R., J. Questel, J. Lamb, C. Clarke-Hopcroft. 2014. Oceanographic assessment of the planktonic communities in the northeastern Chukchi Sea: report for survey year 2013. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil E&P USA, Anchorage, AK by the Institute of Marine Science, University of Alaska, Fairbanks and School of Oceanography, University of Washington, Seattle.
- Hopcroft, R. P. Hariharan, J. Questel, J. Lamb, E. Lessard, M. Foy, and C. Clarke-Hopcroft. 2013b. Oceanographic assessment of the planktonic communities in the northeastern Chukchi Sea: report for survey year 2012. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil E&P USA, Anchorage, AK by the Institute of Marine Science, University of Alaska, Fairbanks and School of Oceanography, University of Washington, Seattle.
- Hopcroft, R., J. Questel, P. Hariharan, C. Stark, and C. Clarke-Hopcroft. 2012. Oceanographic assessment of the planktonic communities in northeastern Chukchi Sea: report for survey year 2011. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil E&P USA, Anchorage, AK by the Institute of Marine Science, University of Alaska, Fairbanks.

- Hopcroft, R., J. Questel, and C. Clarke-Hopcroft. 2011. Oceanographic assessment of the planktonic communities in the northeastern Chukchi Sea: report for survey year 2010. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil E&P USA, Anchorage, AK by the Institute of Marine Science, University of Alaska, Fairbanks.
- Hopcroft, R., J. Questel, and C. Clarke-Hopcroft. 2010. Oceanographic assessment of the planktonic communities in the Klondike and Burger survey areas of the Chukchi Sea: report for survey year 2009.
- Hopcroft, R., J. Questel, and C. Clarke-Hopcroft. 2009. Oceanographic assessment of the planktonic communities in the Klondike and Burger survey areas of the Chukchi Sea: report for survey year 2008.
- Mathis, J.T. and N.M. Monacci. 2014. Seasonal Observations of Carbonate Chemistry and Ocean Acidification in the Northeastern Chukchi Sea in 2013. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil E&P USA. Prepared by Ocean acidification Research Center. School of Fisheries and Ocean Sciences. University of Alaska Fairbanks. Fairbanks, AK.
- Mathis, J.T. 2013. Seasonal Observations of Carbonate Chemistry and Ocean Acidification in 2012. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil E&P USA. Prepared by Ocean acidification Research Center. School of Fisheries and Ocean Sciences. University of Alaska Fairbanks. Fairbanks, AK.
- Mathis, J.T. 2012. Seasonal Observations of Carbonate Chemistry and Ocean Acidification in 2011. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil E&P USA. Prepared by Ocean acidification Research Center. School of Fisheries and Ocean Sciences. University of Alaska Fairbanks. Fairbanks, AK.
- Mathis, J.T. 2011. Seasonal Observations of Carbonate Chemistry and Ocean Acidification in 2010. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil E&P USA. Prepared by Ocean acidification Research Center. School of Fisheries and Ocean Sciences. University of Alaska Fairbanks. Fairbanks, AK.
- Weingartner, R., S. Danielson, L. Dobbins, R. Potter. 2014. Physical Oceanographic Measurements in the Northeastern Chukchi Sea: 2013. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil E&P USA. Prepared by Institute of Marine Science, University of Alaska. Fairbanks, AK.
- Weingartner, R., S. Danielson, L. Dobbins, R. Potter. 2013. Physical Oceanographic Measurements in the Northeastern Chukchi Sea: 2012. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil E&P USA. Prepared by Institute of Marine Science, University of Alaska. Fairbanks, AK.
- Weingartner, R., S. Danielson, L. Dobbins, R. Potter. 2012. Physical Oceanographic Measurements in the Northeastern Chukchi Sea: 2011. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil E&P USA. Prepared by Institute of Marine Science, University of Alaska. Fairbanks, AK.
- Weingartner, R., S. Danielson, L. Dobbins, R. Potter. 2011. Physical Oceanographic Measurements in the Northeastern Chukchi Sea: 2008-2010. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil E&P USA. Prepared by Institute of Marine Science, University of Alaska. Fairbanks, AK.
- Weingartner, R. and S. Danielson. 2010. Physical Oceanographic Measurements in the Northeastern Chukchi Sea: 2008 and 2009. Prepared for ConocoPhillips Alaska, Inc. and Shell

Exploration & Production Company. Prepared by Institute of Marine Science, University of Alaska. Fairbanks, AK.

- Weingartner, R.S. 2009. Physical Oceanographic Measurements in the Northeastern Chukchi Sea. Prepared for ConocoPhillips Alaska, Inc. and Shell Exploration & Production Company. Prepared by Institute of Marine Science, University of Alaska. Fairbanks, AK.
- Goodman, S.E., J.A. June, K.L. Antonelis, A.L. Antonelis. 2013. Acoustic Survey of Fishes in the Chukchi Sea Environmental Studies Program in 2012. Prepared for Olgoonik Fairweather, LLC. Prepared by Natural Resources Consultants, Inc. Seattle, WA.
- Goodman, S.E., J.A. June, K.L. Antonelis. 2012. 2011 Fish and Invertebrate Trawl Surveys in the Chukchi Sea Environmental Studies Program. Prepared for Olgoonik Fairweather, LLC. Prepared by Natural Resources Consultants, Inc. Seattle, WA.Priest, J.T., S.T. Crawford, R.M. Meyer, S.W. Raborn, and B.J. Gallaway. 2011a. Fish community observation for three locations in the Chukchi Sea, 2010. Annual report prepared by LGL Alaska Research Associates, Inc., Anchorage, Alaska for Olgoonik-Fairweather. 95 p.
- Norcross, B.L., B.A. Holladay, L. E. Edenfield. 2011. 2009 Environmental Studies Program in the Northeast Chukchi Sea: Fisheries Ecology of the Burger and Klondike Survey Areas. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil USA E&P, Inc. Prepared by Institute of Marine Science. School of Fisheries and Ocean Sciences. University of Alaska Fairbanks.

These studies provide many volumes of data on the Arctic OCS. The studies, collectively, analyze everything from potential impacts on the natural environment to the socioeconomic effects of exploration activities on humans. The studies also include numerous technical studies ranging from the likely trajectory of spilled oil in the ocean to the effects of drilling sound energy on threatened and/or endangered (T&E) species. The studies also provide information for agency decision making on whether to lease, where to and where not to lease, lease stipulations and mitigation measures, operational requirements, and permit restrictions. This comprehensive body of work, which in part forms the basis for the evaluation presented herein, will allow BOEM and other regulatory agencies to evaluate EP Revision 2 and ensure that all oil and gas exploration activities are performed in an environmentally sound manner, with minimal impacts to the environment.

Previous Environmental Analyses

National Oceanic and Atmospheric Administration (NOAA), USFWS, and BOEM (and its predecessors, Bureau of Ocean Energy Management Regulation and Enforcement [BOEMRE] and MMS), have performed numerous environmental studies of the Arctic OCS over the last 40 years. In recent years, these environmental studies have included the following:

- BOEM. 2015. Alaska Outer Continental Shelf. Chukchi Sea Planning Area. Oil and Gas Lease Sale 193 in the Chukchi Sea, Alaska. Final Second Supplemental Environmental Impact Statement. OCS EIS/EA BOEM 2014-669. U.S. Department of Interior, Bureau of Ocean Energy Management, Alaska OCS Region, Office of Environment, Anchorage, AK.
- NOAA. 2013b. Effects of oil and gas activities in the Arctic Ocean: Supplemental Draft Environmental Impact Statement. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources.
- NMFS. 2013b. Endangered Species Act Section 7(a)(2) Biological Opinion: Oil and Gas Leasing and Exploration Activities in the U.S. Beaufort and Chukchi Seas, Alaska (April 2, 2013).

- USFWS. 2013a. Final Environmental Assessment: Final rule to authorize the incidental take of small numbers of Pacific walruses (*Odobenus rosmarus divergens*) and polar bears (*Ursus maritimus*) during oil and gas industry exploration activities in the Chukchi Sea. U.S. Fish and Wildlife Service, Anchorage, AK. 182 p.
- BOEM 2013. Alaska Outer Continental Shelf Shell Gulf of Mexico, Inc. (Shell) 2013 Ancillary Activities Survey; Chukchi Sea, Environmental Assessment. OCS EIS/EA 2013-01161, U.S. Department of Interior, Bureau of Ocean Energy Management, Alaska OCS Region, Office of Environment, Anchorage, AK.
- NMFS. 2012b. Final Environmental Assessment for the Issuance of Incidental Harassment Authorizations for the Take of Marine Mammals by Harassment Incidental to Conducting Exploratory Drilling Programs in the U.S. Beaufort and Chukchi Seas. National Oceanic and Atmospheric Administration. National Marine Fisheries Service. May 2012.
- BOEMRE. 2011a. Chukchi Sea Planning Area: Statoil USA E&P Inc. 2011 ancillary activities, Chukchi Sea, Alaska: Environmental Assessment. OCS EIS/EA BOEMRE 2011-036. USDOI, Bureau of Ocean Energy Management, Regulation and Enforcement, Alaska OCS Region, Anchorage, AK. 62 p. + app.
- BOEM. 2011a. Chukchi Sea Planning Area, Shell Gulf of Mexico, Inc., Shell revised Chukchi Sea exploration plan Burger Prospect: Posey Area Blocks 6714, 6762, 6764, 6812, 6912, 6915, Chukchi Lease Sale 193, Environmental Assessment. OCS EIS/EA BOEM 2011-061, Bureau of Ocean Energy Management, Alaska OCS Region, Anchorage, AK. 153 p. + app.
- BOEMRE. 2011b. Chukchi Sea Planning Area: oil and gas lease sale 193 in the Chukchi Sea. Final Supplemental Environmental Impact Statement. OCS EIS/EA BOEMRE 2011-041. USDOI, Bureau of Ocean Energy Management, Regulation and Enforcement, Alaska OCS Region, Anchorage, AK.
- MMS. 2009. Shell Gulf of Mexico, Inc. 2010 exploration drilling program Burger, Crackerjack, and SW Shoebill Prospects, Chukchi Sea, Alaska, Chukchi Sea OCS Leases OCS-Y-2280, OCS-Y-2267, OCS-Y-2321, OCS-Y-2111, and OCS Y-2142. Office of Leasing and Environment, USDOI Minerals Management Service, Alaska OCS Region, Anchorage, AK. December 2009. 113 pp. + app.
- MMS. 2008a. 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, Alaska OCS Region, Minerals Management Service, Alaska OCS Region, Anchorage, Alaska.
- MMS. 2007b. Chukchi Sea planning area-oil and gas lease sale 193 and seismic surveying activities in the Chukchi Sea. Final Environmental Impact Statement. Vol. I-III. OCS EIS/EA MMS 2007-026. USDOI Minerals Management Service, Alaska OCS Region, Anchorage, AK.
- MMS. 2007a. Environmental assessment Shell Offshore Inc. Beaufort Sea exploration plan Beaufort Sea OCS-Y-1743, 1805, 1807, 1808, 1809,1817, 1828, 1834, 1841, 1842, 1845, and 1849. Minerals Management Service, Alaska OCS Region, Anchorage, AK. 87 pp.
- MMS. 2007c. Seismic surveys in the Beaufort and Chukchi Seas, Alaska. Draft Programmatic Environmental Impact Statement. OCS EIS/EA MMS 2007-001. Minerals Management Service, Alaska OCS Region, Anchorage, Alaska.
- MMS. 2006c. Environmental assessment: proposed lease sale 202 Beaufort Sea Planning Area. OCS EIS/EA MMS 2006-001, USDOI Minerals Management Service Alaska OCS Region, Anchorage.155 pp. + app.

- MMS. 2004. Environmental assessment proposed oil and gas lease sale 195 Beaufort Sea planning area. OCS EIS/EA MMS 2004-028, USDOI Minerals Management Service, Alaska OCS Region, Anchorage, Alaska.
- MMS. 2003a. Beaufort Sea planning area, oil and gas lease sales 186, 195, 202, Final Environmental Impact Statement. OCS EIS/EA MMS 2003-001 UDOI Minerals Management Service, Alaska OCS Region, Anchorage, AK.
- MMS. 1991. Alaska outer continental shelf Chukchi Sea oil & gas lease sale 126, Final Environmental Impact Statement. US Department of the Interior, Minerals Management Service, Alaska OCS Region, OCS EIS/EA MMS 90-0095.
- MMS. 1987a. Alaska outer continental shelf Chukchi Sea oil & gas lease sale 109 – Final Environmental Impact Statement (OCS EIS/EA MMS 87-0110). USD0I, Minerals Management Service, Alaska OCS Region, Anchorage, AK.

Many of the NEPA analyses at the lease sale stage have explicitly considered a future level of seismic, exploration, and development activity that well exceeds that anticipated under EP Revision 2. Specifically, the following prior NEPA analyses have considered an expanded exploration scenario that includes multiple drilling units operating simultaneously in the Chukchi and/or Beaufort Seas:

- BOEM. 2015. Alaska Outer Continental Shelf. Chukchi Sea Planning Area. Oil and Gas Lease Sale 193 in the Chukchi Sea, Alaska. Final Second Supplemental Environmental Impact Statement. OCS EIS/EA BOEM 2014-669. U.S. Department of Interior, Bureau of Ocean Energy Management, Alaska OCS Region, Office of Environment, Anchorage, AK.
- NMFS. 2013b. Endangered Species Act Section 7(a)(2) Biological Opinion: Oil and Gas Leasing and Exploration Activities in the U.S. Beaufort and Chukchi Seas, Alaska (April 2, 2013).
- NOAA. 2013b. Effects of oil and gas activities in the Arctic Ocean: Supplemental Draft Environmental Impact Statement. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources (Analyzing three levels of exploratory drilling activity: (1) one exploratory drilling program per sea per year (Level 1), (2) up to two exploratory drilling programs per sea per year (Level 2), and (3) up to four exploratory drilling programs per sea per year (Level 3), all of which were accompanied with significant simultaneous survey activity).
- MMS. 2008a. 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, Alaska OCS Region, Minerals Management Service, Alaska OCS Region, Anchorage, Alaska. (Analyzing two exploration drilling units operating in the Beaufort Sea at the same time, and one exploration drilling unit operating in the Chukchi Sea).
- MMS. 2003a. Beaufort Sea planning area, oil and gas lease sales 186,195, 202, Final Environmental Impact Statement. OCS EIS/EA MMS 2003-001 UDOI Minerals Management Service, Alaska OCS Region, Anchorage, AK. (Analyzing two exploration drilling units operating simultaneously in the Beaufort Sea).
- MMS. 1998. Beaufort Sea planning area oil and gas lease sale 170 Final Environmental Impact Statement. OCS EIS/EA, MMS 98-0007. USDOI MMS Alaska OCS Region. Anchorage, Alaska. (Analyzing two exploration drilling units operating simultaneously in the Beaufort Sea).
- MMS 1996. Alaska outer continental shelf Beaufort Sea Planning Area, oil and gas lease sale 144. Final Environmental Impact Statement. OCS EIS/EA MMS 96-0012. U.S. Department of Interior, Minerals Management Service, Alaska OCS Region (Analyzing two exploration drilling

units operating simultaneously in the Beaufort Sea in the base case and four exploration drilling units operating simultaneously in the "high" case).

- MMS. 1991. Alaska outer continental shelf Chukchi Sea oil & gas lease sale 126, Final Environmental Impact Statement. US Department of the Interior, Minerals Management Service, Alaska OCS Region, OCS EIS/EA MMS 90-0095.

(Analyzing up to two exploration drilling units operating simultaneously in the "low" case, up to five exploration drilling units operating simultaneously in the "base" case, and up to six exploration drilling units operating simultaneously in the "high" case). Among other important findings, detailed studies by BOEM, and its predecessors BOEMRE and MMS, have repeatedly confirmed that exploration drilling activities (such as those addressed in Shell's approved EP Revision 1 and this EP Revision 2):

- Have only negligible to minor and fleeting impacts on the environment, including wildlife;
- Do not threaten the continued existence of any T&E species;
- Do not cause significant or unreasonable interference with any subsistence species, particularly bowhead whales, or Alaska Native subsistence activities when appropriate mitigation measures are followed; and
- Pose a statistically insignificant risk of a large, catastrophic oil spill (blowout).

This EIA, which supports EP Revision 2, comes to the same findings as BOEM, namely, the exploration drilling activities proposed at the Burger Prospect in the Chukchi Sea:

- Have negligible to minor direct or indirect environmental impacts, and impacts which do occur are expected to be ameliorated soon after drilling ceases and would be expected to be un-measurable the following year;
- Have negligible or minor and short term effects on biological resources, as most effects on marine mammals, marine birds, and marine fish are limited to temporary disturbance or displacement;
- Do not threaten the continued existence of any T&E species or adversely modify or destroy any designated critical habitat;
- Will not cause significant or unreasonable interference with any subsistence species, particularly bowhead whales, or Alaska Native subsistence activities;
- Will have brief minor impacts on water quality; and
- Pose a statistically insignificant risk of a large, catastrophic oil spill (blowout).

Direct and Indirect Environmental Impacts from EP Revision 2 and Changes from Approved EP Revision 1

This EIA analyzes the exploration drilling activity under EP Revision 2. Given changes in the program and changes in some of the regulatory schemes, new modeling was required to estimate impacts. In particular, the analysis of air emissions, drilling waste discharges, vessel traffic, aircraft traffic, sound generation, and shorebases have changed from EP Revision 1. Important changes to Shell's modeling and assumptions, which in turn affected the direct and indirect environmental impacts analysis on various biological, physical, and other resources are summarized.

This EIA, which supports EP Revision 2, comes to essentially the same findings as BOEM's review of EP Revision 1.

Cumulative Impacts from EP Revision 2 and Changes from Approved EP Revision 1

In this EIA, Shell also considers cumulative impacts from other reasonably foreseeable future activities over the next three years. Section 5.0 discusses Shell's determination, grounded in government guidance and NEPA case law on the appropriate temporal time frame for the Cumulative Impacts analysis as to which future activities are reasonably foreseeable and which are speculative and appropriately excluded from the Cumulative Impacts analysis. Activities defined as reasonably foreseeable and considered *for the first time* in this cumulative impacts analysis (not considered in the prior EIA) include: NOAA anticipated hydrographic surveys in the Chukchi Sea in 2013-2018 (based on an IHA application) and potential shallow hazards, ice gouge and strudel scour surveys, geotechnical surveys, and environmental surveys of various types in the Chukchi Sea during the open water season over the next three years. The EPA issued an Arctic NPDES GP for geotechnical activities in the Beaufort and Chukchi Seas in January 2015. This permit authorizes discharges from geotechnical facilities operating during $\geq$1 seasons within OCS waters. Activities defined as speculative (therefore not reasonably foreseeable) and not considered in the Cumulative Impacts analysis included: large scale three-dimensional (3D) or two-dimensional (2D) seismic surveys in the Chukchi Sea by Shell or others during the same time frame, shallow hazards surveys in the Chukchi Sea by other operators during the same time frame, and exploration drilling by other oil and gas leaseholders in the Chukchi Sea.

1.0 INTRODUCTION

Shell received approval for its Initial Chukchi Sea EP, (Shell 2009) from the MMS on 7 December 2009. Shell was not able to drill in 2010 or 2011.

Shell then received approval from the BOEM for its EP Revision 1 (Shell 2011a) on 15 December 2011. Per BOEM's requirements at 30 CFR 550.212(o), Shell's EP Revision 1 was accompanied by an EIA (Shell 2011b). Shell conducted one season of exploration drilling under EP Revision 1 during the 2012 open water season during which a partial well was drilled at the Burger A drill site.

Shell is now preparing for continued operations, and proposes to modify its approved EP Revision 1 to facilitate the efficient completion of the program. Shell submitted a draft of EP Revision 2 (Shell, 2014a) on 28 August 2014. Shell is now seeking approval, via Shell's Final EP Revision 2, to make these revisions, which would be implemented beginning in Shell's next open water season.

This EIA addresses the potential environmental impacts associated with EP Revision 2. Per regulations at 30 CFR 550.285, a revised EP, including the EIA, need only include information related to, or affected by, the proposed changes in the exploration drilling program. However, for clarity and to facilitate review of this document, Shell is submitting a complete EIA to provide an entire description and analysis of the proposed exploration drilling program. Shell's analysis indicates that, in light of the proposed differences between EP Revisions 1 and 2, there are few differences in the potential effects associated with the activities in the initial Chukchi Sea EP, EP Revision 1, and EP Revision 2.

This document is organized as follows:

- Preface summarizes EP Revision 2 including the mitigation measures
- Section 1.0 summarizes historic work and regulatory framework and baseline studies
- Section 2.0 summarizes planned exploration and drilling activities
- Section 3.0 summarizes important changes in environmental conditions and resources
- Section 4.0 provides an analysis of the direct and indirect environmental impacts
- Section 5.0 provides and analysis of the cumulative impacts
- Section 6.0 provides an analysis of the probability and potential impacts of a very large oil spill
- Section 7.0 discusses Shell's adherence to lease stipulations
- Section 8.0 summarizes Shell's consultation efforts for the revisions to the exploration drilling program
- Section 9.0 provides a list of references cited in the EIA

Comparison of Shell's Initial Approved Chukchi Sea EP, Shell's Approved EP Revision 1, and EP Revision 2

In the Initial Chukchi Sea EP, Shell identified seven blocks (Posey Area Blocks 6713, 6714, 6763, 6764, 6912 and Karo Area Blocks 6864 and 7007) of interest in three prospects (Burger, Southwest Shoebill, and Crackerjack), that contained five potential drill sites (Burger C, F, J, Southwest Shoebill C, and Crackerjack C). The Initial EP consisted of an exploration drilling program, which was to be conducted during the 2010 exploration drilling season, and included plans to drill three of the above-referenced five proposed drill sites using the *Discoverer*. The initial EP included an extensive EIA. BOEM subsequently prepared an Environmental Assessment (EA) of the proposed exploration drilling program and distributed the EA for public comment. After rigorous agency review, which included evaluation and verification of information provided in the EIA, BOEM concluded the exploration drilling program would have no significant environmental impacts, and issued a Finding of No Significant Impact (FONSI) on the initial Chukchi Sea EP on 7 December 2009. The initial Chukchi Sea EP was also found to be consistent with the Alaska Coastal Management Program (ACMP) and the enforceable policies of the affected coastal districts on 2 March 2010.

Shell's EP Revision 1 was limited to a single prospect (Burger Prospect) with six identified EP Blocks (Posey Area Blocks 6714, 6762, 6764, 6812, 6912, and 6915). Six drill sites were identified (Burger A, F, J, R, S, and V). BOEM again prepared an EA, distributed the EA for public comment, issued a FONSI and approved EP Revision 1 on 15 December 2011. Shell subsequently submitted minor revisions to Section 7 of the EP, which adjusted the estimated volumes of air pollutant emissions that would be emitted by the exploration drilling program; these revisions were approved by BOEM on 30 August 2012.

EP Revision 2 is still limited to the Burger Prospect with the same six EP Blocks. The primary difference is that EP Revision 2 adds another drilling unit, the *Polar Pioneer*. Other differences include changes in the number of support vessels and vessel travel corridors, addition of MLC ROV system, changes in the number of aircraft and aircraft travel routes, changes to drilling fluids and BOP fluids, and changes in the estimates of drilling waste discharge volumes. Some vessels, including the containment system tugs and barge and the near shore OSR tug and barge, will be moored in or near Goodhope Bay in Kotzebue Sound. Additional changes include revised estimates of the area of ensonification by vessel and drilling based sound measurements recorded in 2012, changes to air permitting and emissions, changes in the secondary relief well drilling unit, revisions to shorebases, and changes in mitigation measures. There are few salient differences between the approved EP Revision 1 and EP Revision 2, as indicated in Table 1.0-1. Additional minor differences are described in the following sections.

Table 1.0-1 Exploration Drilling Programs: Approved EP, Approved EP Revision 1, and EP Revision 2

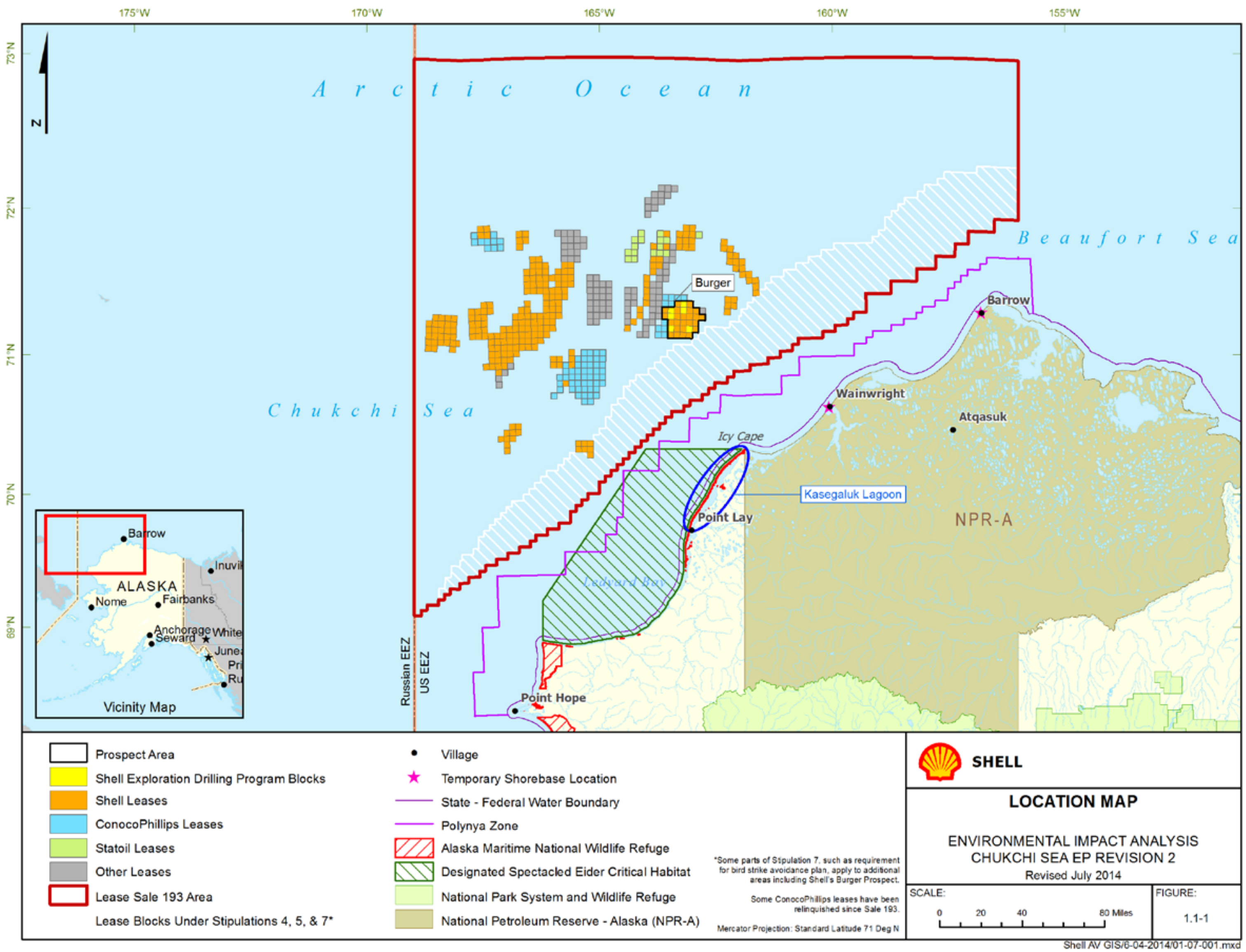
Parameter	Initial Approved EP	Approved EP Revision 1	EP Revision 2
Wells	Five wells with Three on the Burger Prospect	Six wells on the Burger Prospect	Six wells on the Burger prospect
Drilling unit	Drillship *Discoverer*	Drillship *Discoverer*	Drillship *Discoverer* Semisubmersible *Polar Pioneer*
Secondary Relief Well Drilling Unit	*Kulluk*	*Kulluk*	*Discoverer* *Polar Pioneer*
MLC Construction	*Discoverer*	*Discoverer*	*Discoverer* *Polar Pioneer* *MLC ROV System*
Prospects	Burger, Southwest Shoebill, Crackerjack	Burger	Burger
Potential Drill Sites	Five - Burger C, F, J, SW Shoebill C, Crackerjack C	Six - Burger A, F, J, R, S, V	no change
Shorebase	Wainwright – marine, Barrow - air support	Wainwright – marine (and possible/ secondary air support), Barrow - air support	Wainwright – expanded marine (and possible/ secondary air support), Barrow - air support (some facilities expansion)
Vertical Seismic Profile	None	One planned at TD in each well	No change, One planned at TD in each well
Drilling Waste	Water-based fluids & cuttings discharged; recycled when practicable	Water based fluids & cuttings discharged; recycled when practicable	Water based fluids & cuttings discharged (changes in fluid components and discharge volumes)
Support Vessels	Anchor handler (x1) Ice management vessel (x1) OSV (x1) Shallow water landing craft (x1)	Anchor handlers (x2) Ice management vessel (x1) OSVs (x2) Shallow water landing craft (x1)	Anchor handlers (x3) Ice management vessels (x2) Larger offshore supply vessels (x3) Shallow water vessels (x2) Science vessels (x2) Support tugs (x2) Supply tugs (x2) and barge (x2) MLC ROV system vessel (OSV)
OSRV	OSRV (x1) OSR tug and barge (x1) Oil storage tanker (OST) (x1)	OSRV (x1) OSR tug and barge (x1) OST (x1) Capping stack and Containment system (tug and barge) (x1)	OSRV (x1) OSR tug and barge (x1) OST (x2) Capping stack and Containment system tugs (x2) and barge (x1) Nearshore OSR tug and barge (x1)
Aircraft	2 helicopters (1 crew change and 1 SAR)	2 helicopters (1 crew change and 1 SAR) 1 fixed-wing for PSO flights 1 fixed-wing for crew changes	4 helicopters (3 crew change and 1 SAR) 1 fixed-wing for PSO flights 1 fixed-wing for ice reconnaissance 1 fixed-wing for crew changes
Helicopter Flight Frequency	Approximately 7 round trips/week (crew change)	Approximately 12 round trips/week (crew change)	Approximately 40 round trips/week (crew change)
Regulatory Update	30 CFR 250 Subpart B EPA Air Jurisdiction	30 CFR 250 Subpart B Notice to Lessees (NTL) and Operators NTL-2010-06 EPA Air Jurisdiction NPDES exploration facilities GP AKG-28-0000	30 CFR 550 Subpart B NTL-2015-N01 BOEM Air Jurisdiction (changes in air emissions) NPDES exploration facilities GP AKG-28-8100

1.1 Current Shell Lease Holdings and Historical Chukchi Lease Sales

BOEM held OCS Oil and Gas Lease Sale 193 in 2008 during which Shell was awarded 275 leases (blocks) through a competitive bidding process. The locations of these lease blocks are depicted on Figure 1.1-1 along with the locations of leases obtained by other oil and gas companies during the same sale. Shell has included six of these lease blocks (Figure 1.1-1) located within the Burger Prospect in the EP Revision 2 (which are the same as those identified in EP Revision 1).

BOEM previously held two lease sales in the Chukchi Sea Planning Area of the OCS. Lease Sale 109 was held in 1988 and resulted in issuance of 350 leases. Lease Sale 126 was held in 1991 and resulted in issuance of 28 leases. Additionally, two early Beaufort Sea lease sales (Lease Sale 97 and Lease Sale 124) resulted in the issuance of leases in portions of what is now the Chukchi Sea Planning Area. All leases associated with these historic lease sales have expired. Exploration that occurred as a result of these historic lease sales is discussed in Sections 1.2 and 1.3.

Figure 1.1-1 Location Map



1.2 Historic Exploration Drilling in the Chukchi Sea

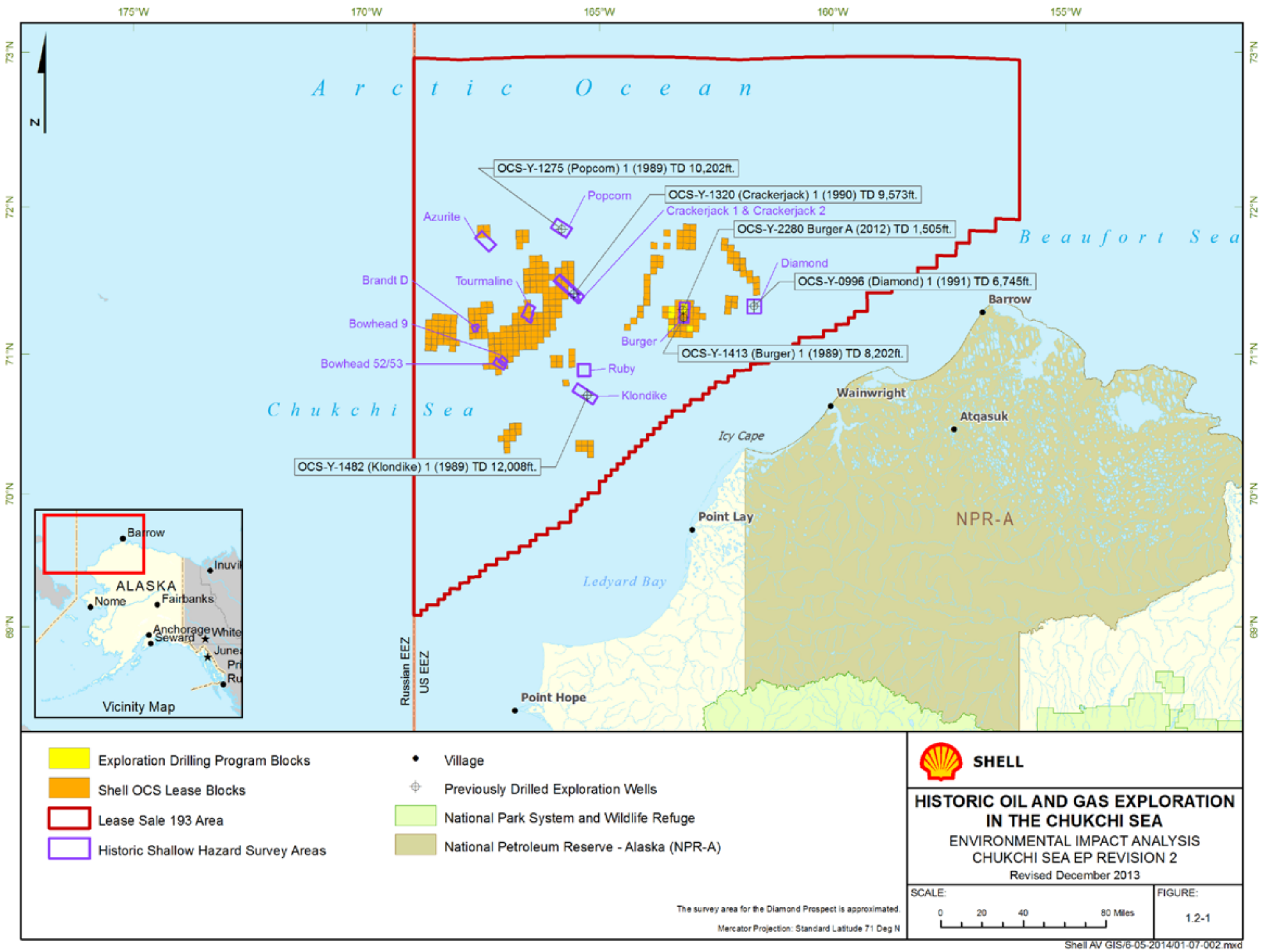
Exploration drilling has been conducted in the past in the Chukchi Sea. Operators have drilled five exploration wells in the United States (U.S.) waters of the Chukchi Sea to date (Figure 1.2-1). Shell Western E&P Inc. (SWEPI) was the operator of four of these five wells and participated in the fifth well drilled by Chevron. All these historic wells were drilled with a drilling unit that is similar to the *Discoverer* which will be used by Shell to drill some of the wells identified in EP Revision 2. The Burger A well was spud in 2012 and was temporarily abandoned at the end of the 2012 season. Detailed information about each well, including well name, year the well was drilled, operator, drilling unit, location, and water depth, is presented in Table 1.2-1.

Table 1.2-1 Historic Exploration Wells Drilled in the Chukchi Sea Planning Area

Well	Drilling Started	P&A	Operator	Drilling Unit	Area	Block	Water Depth
Diamond	1991	1991	Chevron USA Inc.	Drillship *Explorer III*	Hanna Shoal	6704	152 ft (46.3 m)
Popcorn	1989	1990	Shell Western E&P Inc.	Drillship *Explorer III*	Karo	6118	143 ft (43.6 m)
Crackerjack	1990	1991	Shell Western E&P Inc.	Drillship *Explorer III*	Karo	6669	137 ft (41.8 m)
Burger	1989	1990	Shell Western E&P Inc.	Drillship *Explorer III*	Posey	6814	149 ft (45.4 m)
Klondike	1989	1989	Shell Western E&P Inc.	Drillship *Explorer III*	Colbert	6323	141 ft (43.0 m)
Burger A	2012	--	Shell Gulf of Mexico Inc.	Drillship *Discoverer*	Posey	6764	144 ft (43.9 m)

P&A= Plugged and Abandoned

Figure 1.2-1 Historic Oil and Gas Exploration in the Chukchi Sea



1.3 Historic Shallow Hazards Surveys

Shallow hazards surveys have been conducted in the past at 10 historic prospects (Azurite, Brandt, Bowhead, Tourmaline, Crackerjack, Popcorn, Diamond, Burger, Klondike, and Ruby) in the Chukchi Sea Planning Area. The locations of these historic surveys in relation to Shell's planned drill sites, are depicted on Figure 1.2-1. The historic Burger survey, conducted by Fugro-McClelland Marine Geosciences, Inc. (Fugro 1989a; Fugro 1990a) for Shell, covers portions of some blocks in Shell's current Burger Prospect. Information from these shallow hazards surveys is used throughout this EIA, as is other information collected in conjunction with these historic prospects.

1.4 Shell's Shallow Hazards Surveys

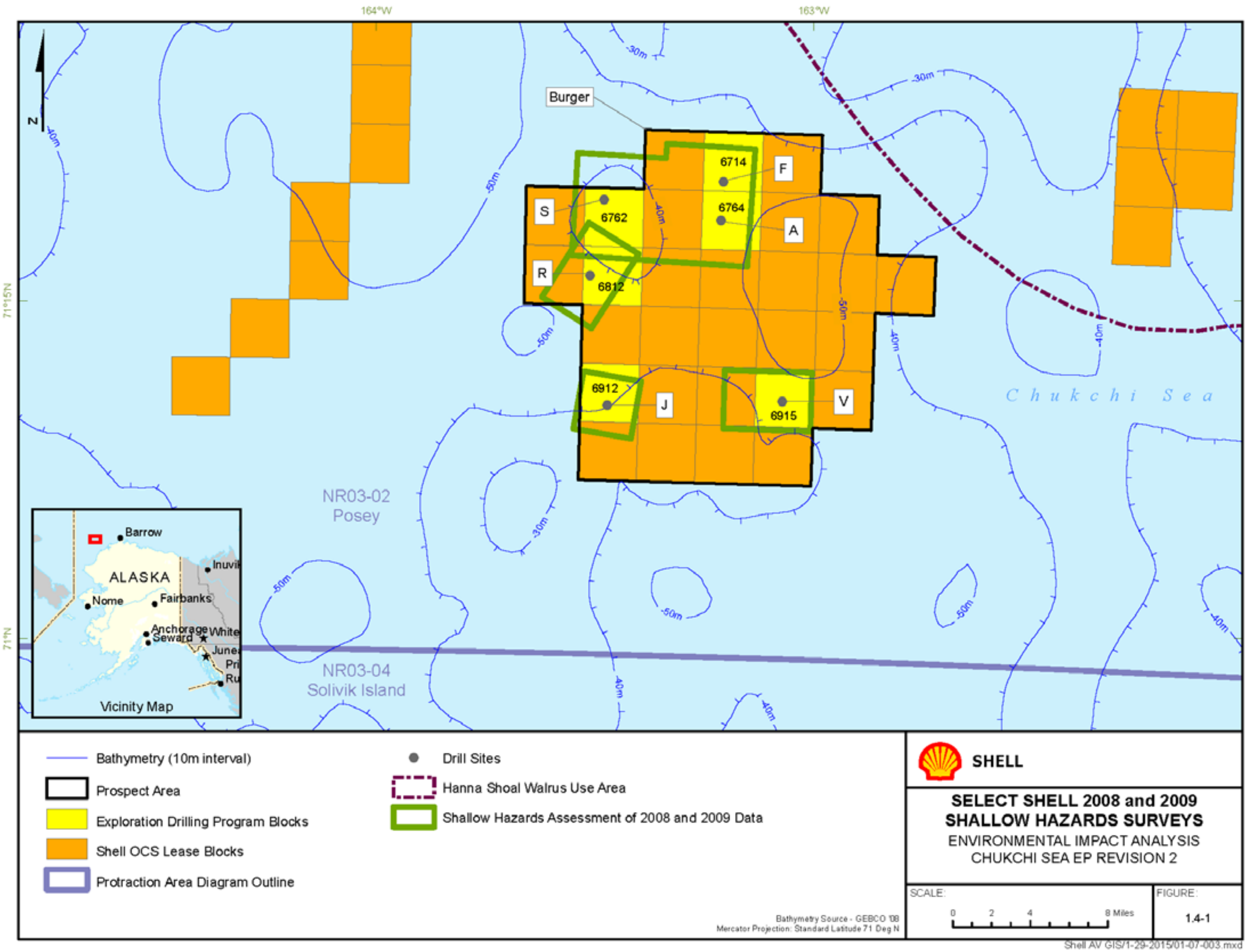
Shell has conducted shallow hazards surveys at each of the six planned drill sites. Surveys were conducted at one of the drill sites in 2008 and at the other five drill sites in 2009. The surveys were conducted in a manner that meets or exceeds requirements set forth by BOEM in NTL 05-A01 and NTL 05-A03. Shallow hazards survey reports and assessments for these drill sites were submitted to BOEM under separate cover in April 2009 (Geoscience Earth & Marine Services, Inc. (GEMS) 2009), December 2010 (Fugro GeoConsulting, Inc. 2010a,b,c,d,e,f), and April 2011 (Fugro GeoConsulting, Inc. 2011a,b). Information from these reports is used throughout this EIA.

Exploration drilling cannot be conducted at a drill site until the results of shallow hazards surveys have been submitted to BOEM and BOEM concurs with Shell's interpretation. The location of these submitted Shell shallow hazards surveys are indicated in Figure 1.4-1.

The submitted reports are as follows:

- Fugro GeoConsulting, Inc. 2010a. Shallow hazards and archaeological assessment Burger Site Survey 1 OCS Lease Sale 193 area Chukchi Sea, Alaska. Report No. 27.2009-2327 prepared by Fugro GeoConsulting, Inc., Houston, TX for Shell Gulf of Mexico Inc., Houston, TX.
- Fugro GeoConsulting, Inc. 2010b. Drill site clearance letter proposed Burger A drill site Block 6764 OCS-Y-2280 Posey Area, Chukchi Sea, Alaska. Report No. 27.2010-2375-1 prepared by Fugro GeoConsulting, Inc., Houston, TX for Shell Gulf of Mexico Inc., Houston, TX.
- Fugro GeoConsulting, Inc. 2010c. Drill site clearance letter proposed Burger F drill site Block 6714 OCS-Y-2267 Posey Area, Chukchi Sea, Alaska. Report No. 27.2010-2375-3 prepared by Fugro GeoConsulting, Inc., Houston, TX for Shell Gulf of Mexico Inc., Houston, TX.
- Fugro GeoConsulting, Inc. 2010d. Drill site clearance letter proposed Burger S drill site Block 6762 OCS-Y-2278 Posey Area, Chukchi Sea, Alaska. Report No. 27.2010-2375-4 prepared by Fugro GeoConsulting, Inc., Houston, TX for Shell Gulf of Mexico Inc., Houston, TX.
- Fugro GeoConsulting, Inc. 2010e. Shallow hazards and archaeological assessment Burger Site Survey 3 OCS Lease Sale 193 area Chukchi Sea, Alaska. Report No. 27.2010-2342 prepared by Fugro GeoConsulting, Inc., Houston, TX for Shell Gulf of Mexico Inc., Houston, TX.
- Fugro GeoConsulting, Inc. 2010f. Drill site clearance letter proposed Burger V drill site Block 6915 OCS-Y-2324 Posey Area, Chukchi Sea, Alaska. Report No. 27.2010-2375-6 prepared by Fugro GeoConsulting, Inc., Houston, TX for Shell Gulf of Mexico Inc., Houston, TX.
- Fugro GeoConsulting, Inc. 2011a. Shallow hazards and archaeological assessment Burger Site Survey 4 OCS Lease Sale 193 area Chukchi Sea, Alaska. Report No. 27.2010-2343 v.1&2 prepared by Fugro GeoConsulting, Inc., Houston, TX for Shell Gulf of Mexico Inc., Houston, TX.
- Fugro GeoConsulting, Inc. 2011b. Drill site clearance letter proposed Burger R drill site Block 6812 OCS-Y-2294 Posey Area, Chukchi Sea, Alaska. Report No. 27.2010-2375-7 prepared by Fugro GeoConsulting, Inc., Houston, TX for Shell Gulf of Mexico Inc., Houston, TX.
- GEMS 2009. Shallow Hazards and Archeological Assessment, Burger J Drill Site Posey Block NR03-02 6912, Chukchi Sea, Alaska. Prepared by Geoscience Earth & Marine Services, Inc., Houston, Texas to Shell Gulf of Mexico Inc., Houston, Texas.

Figure 1.4-1 Shells 2008 and 2009 Shallow Hazards Surveys



1.5 Regulatory Framework

1.5.1 Outer Continental Shelf Lands Act

The OCSLA established federal jurisdiction over the OCS and granted authority to the Secretary of the Interior to manage OCS resources. The Secretary has delegated the authority to promulgate regulations, conduct leasing, and issue permits in the OCS to BOEM and BSEE. Section 18 of the OCSLA also directs BOEM to periodically revise its oil and gas leasing programs, which BOEM does on a five-year basis. These five-year leasing plans are national in scope and provide a schedule for all lease sales within the five-year period. These programs are developed through a comprehensive NEPA process that includes resource analyses, public input, and environmental analyses. Chukchi Sea Lease Sale 193 was initially scheduled as part of BOEM's 2002-2007 leasing program (MMS 2002c) but was delayed, and eventually conducted under BOEM's Outer Continental Shelf Oil & Gas Five Year Leasing Program: 2007-2012 (MMS 2007e).

BOEM has issued regulations pertaining to oil and gas exploration and development in 30 CFR 550. Exploration drilling activities must comply with BOEM's regulations, as well as applicable lease stipulations, and any conditions applied to BOEM's approval of the required EP. Shell's compliance with the Lease Sale 193 lease stipulations is discussed in Section 11.0 of EP Revision 2 and Section 7.0 of this document. BOEM also issues NTLs for specific OCS regions and activities, and requires several interagency and government-to-government consultations to demonstrate compliance with applicable federal laws. Shell must also submit and obtain approval of an APD from BSEE (under 30 CFR 250.410-.418) for each drill site, after approval of the EP from BOEM, and before conducting the exploration drilling program. APDs contain detailed information about well design, equipment and procedures to be used in drilling operations to allow BSEE to ensure that drilling operations are safe and protect the environment.

1.5.2 National Environmental Policy Act

NEPA mandates federal agencies conduct an environmental review of their actions or projects that require federal funding, federal authorizations or permits, or the involvement of federal lands. NEPA is a coordinated review process that includes resource impact analyses. NEPA reviews are conducted at various levels of detail and scope depending on the nature of the proposed action. Routine activities with well-known environmental effects may qualify for a Categorical Exclusion from further NEPA analysis, while other activities trigger an EA or the most rigorous level of review of an Environmental Impact Statement (EIS).

BOEM prepares EISs for their five-year leasing plans, and prepared one for both the 2002-2007 leasing plan (MMS 2002d) and the 2007-2012 plan (MMS 2007d), both of which contained Lease Sale 193. These NEPA reviews are conducted by BOEM headquarters.

Following issuance of a five year plan, more detailed NEPA documents are prepared by BOEM regional offices for their respective lease sales. BOEM's Alaska OCS Region prepared a detailed EIS (MMS 2007b) specifically for Lease Sale 193, which included analyses of anticipated levels of exploration drilling by multiple operators before holding the sale in 2008. BOEM also prepared a Supplemental EIS (SEIS) for Lease Sale 193 in 2011 in response to litigation and a 21 July 2010 U.S. District Court Ruling for the District of Alaska decision remanding the initial EIS back to the agency. The Final SEIS (FSEIS) addressed the issues identified by the district court in the remand order: (1) the potential impacts associated with potential natural gas development resulting from the lease sale, and (2) statements made in the previous EIS regarding incomplete or unavailable information. The FSEIS also updated the analysis with new information concerning resources in the planning area and the regulatory environment, and in response to public comments on a draft of the SEIS provided an analysis of the potential effects associated with a hypothetical very large oil spill (VLOS).

The FSEIS was subject to a subsequent legal challenge by the same Plaintiffs. The district court upheld BOEM's NEPA supplemental analysis but, on appeal, the U.S. Court of Appeals for the Ninth Circuit held that one aspect of the FSEIS was "arbitrary and capricious": the agency's reliance on a one billion barrel estimate of total economically recoverable oil. The FSEIS was remanded back to BOEM, and the agency prepared a Final Second SEIS to correct the deficiencies identified by the Ninth Circuit. A draft Second SEIS was published and public comments were collected. The agency issued the Final Second SEIS in February 2015. . The environmental analysis presented in this EIA tiers off of, and incorporates by reference, many of the analyses presented in these four EISs already prepared by BOEM, and then uses the information to provide a site-specific and project-specific analysis of the potential effects associated with Shell's planned exploration drilling program. Because the deficiency of the Sale 193 FSEIS currently on remand to BOEM is based exclusively on the hypothetical production scenario, any required changes in the Sale 193 EIS are not likely to be relevant to the environmental impacts associated with the exploration activities in Shell's EP Revision 2. Under its NEPA-implementing rules, BOEM will prepare a NEPA document specifically evaluating the effects of Shell's planned exploration drilling program as presented in EP Revision 2.

1.5.3 Marine Mammal Protection Act

The MMPA established a federal responsibility to conserve and protect marine mammals. Under the MMPA, NMFS is responsible for the management and protection of many of the marine mammals occurring near the Burger Prospect including: the bowhead whale, gray whale, fin whale, humpback whale, minke whale, harbor porpoise, beluga whale, bearded seal, ringed seal, and spotted seal. The animals occurring near the Burger Prospect that the USFWS has jurisdiction over include the polar bear and Pacific walrus. The MMPA prohibits anyone from taking marine mammals in U.S. waters without NMFS and/or USFWS authorization and defines the term "take" as harassing, hunting, capturing, killing, or collecting, or attempting to harass, capture, kill, or collect marine mammals. Harassment is statutorily defined as "any act of pursuit, torment, or annoyance." This is further categorized and defined as Level A Harassment – which has the potential to injure a marine mammal stock or species - and Level B Harassment – which has the potential to disturb a marine mammal stock or species by causing disruption of behavioral patterns.

Sounds transmitted into water, vessels, and aircraft traffic associated with the planned exploration drilling program possibly could result in incidental disturbance of marine mammals. MMPA authorizations are required by NMFS and USFWS to authorize incidental disturbances that represent "takes" of marine mammals. Shell has applied for, and must receive, such authorizations for the planned exploration drilling activities.

1.5.4 Endangered Species Act

The ESA of 1973 provides a process by which animal or plant populations that are in jeopardy of extinction throughout all or a significant portion of their range can be listed as T&E to protect the species and its critical habitat. A threatened species is an animal or plant species that is likely to become endangered within the foreseeable future throughout all or a significant portion of its range. Critical habitat must, to the maximum extent prudent and determinable, be designated for a species concurrently with listing it as a T&E species; however, some species such as the bowhead whale have been listed for years and to date have no designated critical habitat.

Under the ESA, the taking of a listed species is prohibited without an MMPA authorization issued by the agency that has jurisdiction over the species. To take is defined as: to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. This may include significant habitat modification or degradation if it kills or injures wildlife by significantly impairing essential behavioral patterns including breeding, feeding, or sheltering.

Section 7 of the ESA mandates consultation by federal agencies to ensure that their activities are not likely to jeopardize the continued existence of listed species or adversely modify designated critical habitats. Section 7 consultation is triggered when a federal action agency, e.g., BOEM, proposes to authorize, fund, or carry out any action and such action may affect a listed species or its designated critical habitat. Under this section of the ESA, BOEM must consult with USFWS and NMFS before issuing approval of Shell's EP Revision 2. BOEM previously consulted with NMFS and USFWS regarding potential effects on T&E species from the exploration drilling that could occur as a result of leasing activities in the Chukchi Sea. NMFS (2006, 2008) published a Biological Opinion (BO) concluding that the exploration activities resulting from the lease sale would not likely jeopardize the continued existence of the fin whale, humpback whale, and bowhead whale. The USFWS (2007) similarly provided a BO for the planned Lease Sale 193 in the Chukchi Sea, finding that the resulting exploration activities would not likely jeopardize the continued existence of the Steller's or spectacled eiders. The USFWS (2008c) also issued a BO on incidental take regulations, and concluded that the levels of oil and gas exploration expected to be conducted in the Chukchi Sea in 2007-2012 would not likely jeopardize the continued existence of polar bears. (In a Ninth Circuit court ruling on 6 January 2013, all critical habitat previously designated for the polar bear by the USFWS was vacated and remanded back to the agency.)

BOEM conducted consultations for the SEIS for Sale 193, which resulted in a NMFS 2013 BO and a USFWS 2012 BO. The NMFS 2013c BO concluded that the oil and gas leasing and exploration activities in the BOEM FSEIS would not likely jeopardize the continued existence of bowhead whale, fin whale, humpback whale, North Pacific right whale found only in the Bearing Sea, the Arctic subspecies of ringed seal, the Beringia DPS bearded seal, and the Steller sea lion. In light of the updated scenario analyzed in its Final Second SEIS, BOEM has reinitiated Section 7 consultation with both NMFS and USFWS. The USFWS recently determined that the Pacific walrus (76 Federal Register [FR] 7634-7679 [10 February 2011]) warranted listing, but that listing was precluded by higher priorities. The Pacific walrus is currently considered a candidate species. During the process of developing and promulgating ITRs (50 CFR Part 18) under the MMPA in June 2013 for the Chukchi Sea, the USFWS delineated an area of heavy use by walruses that they termed the Hanna Shoal Walrus Use Area (HSWUA). The limits of the HSWUA were based on walrus utilization distributions determined from walruses tagged with satellite telemetry. USFWS overlaid the 50% utilization distributions in (Jay et al. 2012) for both foraging and occupancy in the Hanna Shoal area, as defined bathymetrically by (Smith 2011), for the months of June through September. At its greatest extent, the HSWUA encompasses approximately 9,500 mi^2 (24,600 km^2). USFWS issued a BO on the Chukchi Sea ITRs (USFWS 2013b). The USFWS determined in the BO that promulgating ITRs would not likely jeopardize the continued existence of the polar bear or Pacific walrus (USFWS 2013b).

NMFS listed the Arctic subspecies of ringed seal (77 FR 76705-76738 December 28, 2012) and the Beringia distinct population of bearded seal (77 FR 76739-76768 December 28, 2012), both found in the northeastern Chukchi Sea, as threatened under the ESA. In July 2014 the threatened listing for the bearded seal was vacated and remanded to NMFS.

1.5.5 Coastal Zone Management Act

The federal Coastal Zone Management Act (CZMA) of 1972, 16 USC 1451 et seq. (Section 307), authorized the state to review most federal activities and federally permitted activities within or affecting resources within the state's coastal zone. The review authority applied to exploration drilling activities of an area leased under the OCSLA that could affect resources within a state's coastal zone.

The ACMP implemented the CZMA and required OCS plans and projects in Alaska's coastal zone, including potential shorebases, to be reviewed for consistency with statewide standards; however, the SOA did not pass legislation required to extend the ACMP and the ACMP no longer applies.

1.5.6 Clean Air Act

The Clean Air Act (43 USC. § 7401, et seq.) as revised in 1990, governs air pollutant emissions and requires the EPA, the Department of Interior (DOI) and the states to carry out programs to assure attainment of the National Ambient Air Quality Standards (NAAQS). The Clean Air Act established two types of standards. Primary standards set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against visibility impairment, damage to animals, crops, vegetation, and buildings.

On 23 December 2011, an amendment to the Clean Air Act, Section 328, transferred authority for the control of oil and gas-related emissions on the Arctic OCS to the DOI through the Consolidated Appropriations Act, 2012 (Public Law 112-74). The emission sources on a drilling unit operating in the OCS off the northern coast of Alaska require an air quality permit authorization from BOEM through an approved EP. BOEM regulations regarding the control of air emissions are found at 30 CFR Part 550.302-304.

1.5.7 Clean Water Act (CWA)

Section 402 of the CWA established the NPDES to be administered by the EPA. The CWA and accompanying regulations made it unlawful to discharge any pollutant from a point source into navigable waters, including the OCS, without an NPDES permit.

The EPA (2012a) issued a five year NPDES exploration facilities GP for Authorization to Discharge under the NPDES for Oil and Gas Exploration Facilities on the OCS in the Chukchi Sea (NPDES exploration facilities GP, permit number AKG-28-8100) in November 2012. This permit authorizes certain discharges from oil and gas exploration facilities located in the Chukchi Sea and imposes various effluent limitations, monitoring requirements, and conditions. Permitted discharges related to exploration drilling include drilling fluids and cuttings, deck drainage, treated sanitary waste, domestic waste, desalination unit wastes, BOP fluid, boiler blowdown, fire control system test water, non-contact cooling water, uncontaminated ballast water, bilge water, excess cement slurry, mud, cuttings and cement at the seafloor, and test fluids (EPA 2012a). Section 403(c) of the CWA requires that NPDES GPs for such ocean discharges be issued in compliance with the EPA's Ocean Discharge Criteria for preventing unreasonable degradation of ocean waters. The NPDES exploration facilities GP was subjected to an Ocean Discharge Criteria Evaluation (EPA 2012b) and found to comply with the 10 statutory discharge criteria.

A NOI must be submitted to the EPA in order for discharges to be covered under the Chukchi Sea NPDES exploration facilities GP. Separate NOIs are filed for each drill site in which exploration drilling could occur. Shell is submitting NOIs for the drill sites in the EP Revision 2 for the *Discoverer* and the *Polar Pioneer*.

Since 2008, the EPA has required commercial vessels (previously excluded from NPDES permit requirements) to obtain authorization for discharges within state waters, and has issued a Vessel General Permit (VGP) for Discharges Incidental to the Normal Operation of Vessels. Shell will ensure that the support vessels associated with the proposed exploration drilling program will obtain authorization under the VGP.

1.5.8 Oil Pollution Act of 1990

The Oil Pollution Act of 1990 (OPA) establishes a program governing removal of spilled oil and planning for and responding to oil spills. Under OPA, Shell has prepared the Chukchi Sea Regional Exploration OSRP as a fundamental component of the planned exploration drilling program. Shell prepared a Chukchi Sea Regional Exploration Program OSRP as a fundamental component of the planned exploration drilling program when it submitted EP Revision 1. BSEE approved that Chukchi Sea OSRP on 17 February 2012. Shell submitted a modification to its Chukchi Sea OSRP on 18 December 2013 to BSEE; BSEE approved that submission on 23 June 2014. Further revisions to the approved OSRP, reflecting changes in the OSR assets are being submitted to BSEE and must be approved before the exploration drilling program begins.

Shell's Chukchi Sea Exploration program OSRP is a regional OSRP that demonstrates Shell's capabilities to prevent entirely or rapidly and effectively respond to and manage, oil spills that may result from exploration drilling operations. Despite the extremely low likelihood of a large oil spill event occurring during exploration, Shell has designed its response program based upon a regional capability of responding to a range of spill volumes that increase from small operational spills up to and including a Worst Case Discharge (WCD) from an exploration well blowout.

The OSRP includes information regarding Shell's regional oil spill organization and dedicated response assets, potential spill risks, and local environmental sensitivities. The plan also details Shell's spill prevention programs, including personnel training and the procedures and management practices to prevent discharges. The plan's response information addresses personnel and equipment mobilization from various locations, equipment operating characteristics, and the availability of additional response resources both on and off site.

1.5.9 National Historic Preservation Act and Other Cultural Resource Regulations

Cultural resource management and protection regulations focus on cultural resources from the past or those that people have used or valued continually for the last 50 years or longer. These regulations include federal and state laws and policies, and NSB ordinances (Table 1.5.9-1).

Table 1.5.9-1 Agencies and Governments Managing and Protecting Historic Resources

Agency or Government	Scope	Dataset	Primary Associated Applicable Laws and Policies
U.S. Federal Government	federal, state, regional, and local	National Register of Historic Places	Abandoned Shipwreck Act Antiquities Act of 1906 Archaeological and Historic Preservation Act Archaeological Resource Protection Act CZMA National Historic Preservation Act (NHPA) NEPA
Office of History and Archaeology (OHA), Alaska Department of Natural Resources (ADNR)	state, local	Alaska Heritage Resource Survey (AHRS)	Alaska Historic Preservation Act (Alaska Statute (AS) 41.35) Alaska Administrative Code (AAC) (11 AAC 16)
NSB	borough	Traditional Land Use Inventory (TLUI)	NSB Comprehensive Plan North Slope Code of Ordinances

The National Register of Historic Places (National Register) recognizes properties of exceptional historical importance. The importance may be local, regional, or national. Historic preservationists evaluate a property's historical importance using four key criteria:

- Criterion A – Property illustrates important historical event(s) or broad pattern(s).
- Criterion B – Property demonstrates an association with person/people who was/were significant in the past.
- Criterion C – Property embodies distinctive characteristics of a type, period, or method of construction, style, or high artistic value.
- Criterion D – Property yields or has potential to yield important information about prehistory or history.

The OHA in Anchorage maintains data on historic and archaeological properties in the state. The AHRS database, a collection of archaeological and historic properties reports, and the NHPA compliance related letters comprise these data. The NSB maintains its own database entitled the TLUI of cultural resources. The TLUI includes information on archaeological and historic sites, as well as places people continue to use for traditional activities. Public agencies usually maintain their own cultural resource databases that serve their management needs.

Section 106 of the NHPA requires that BOEM consult with the State Historic Preservation Office (SHPO), local governments, local tribes, and other interested parties before approving an EP (36 CFR 800).

1.6 Baseline Studies

Multi-faceted baseline studies have been conducted within a 30 x 30 nmi study area (56 x 56 km) encompassing all the blocks in Shell's Burger Prospect annually since 2008 to gather additional data regarding resources in and around the prospect and have continued to date. The following reports are currently available and were used in this EIA:

- Aerts, L.A.M., C.L. Christman, C.A. Schudel, W. Hetrick, and D. Snyder. 2014. Marine mammal distribution and abundance in the northeastern Chukchi Sea from shipboard surveys during summer and early fall, 2008–2013. Final report prepared by LAMA Ecological, Anchorage, AK for ConocoPhillips Company, Shell Exploration & Production Company, and Statoil USA E&P, Inc., Anchorage, AK. 71 pp.
- Aerts, L.A.M., W. Hetrick, S. Sitkiewicz, C.S. Schudel, D. Snyder, and R. Gumtow. 2013. Marine mammal distribution and abundance in the northeastern Chukchi Sea during summer and early fall 2008-2012. Prepared by Lama Ecological for ConocoPhillips Company, Shell Exploration and Production Company, and Statoil USA E&P, Inc., Anchorage, AK. 69 pp.
- Aerts, L.A.M., A. Kirk, C. Schudel, B. Watts, P. Sesier, A. McFarland, and K. Lomac-Macnair. 2012. Marine mammal distribution and abundance in the northeast Chukchi Sea, July-October 2008-2011. Draft Report. Prepared for ConocoPhillips Company, Shell Exploration and Production Company, and Statoil USA E&P, Inc. by Lama Ecological, OASIS-ERM, ABR Inc., and Fairweather Science. 69 pp.
- Aerts, L.A.M., A. Kirk, C. Schudel, K. Lomac-Macnair, A. McFarland, B. Sesier, and C. Watts. 2011. Marine mammal distribution and abundance in the northeast Chukchi Sea, July-October 2008-2010. Final Report. prepared for ConocoPhillips Company, Shell Exploration and Production Company, and Statoil USA E&P, Inc. by Lama Ecological, OASIS Environmental Inc. and Fairweather Science, Anchorage, AK.

- Brueggeman, J. 2010. Marine Mammal Surveys at the Klondike and Burger Survey Areas in the Chukchi Sea during the 2009 Open Water Season. Prepared for ConocoPhillips Company and Shell Exploration & Production Company. Prepared by Canyon Creek Consulting, LLC.
- Brueggeman, J. 2009. Marine Mammal Surveys at the Klondike and Burger Survey Areas in the Chukchi Sea during the 2008 Open Water Season. Prepared for ConocoPhillips Company and Shell Exploration & Production Company. Prepared by Canyon Creek Consulting, LLC. Blanchard, A.L. and A.L. Knowlton. 2014. Chukchi Sea Environmental Studies Program: Benthic Ecology of the Northeastern Chukchi Sea, 2008-2013. Final Report. Prepared For ConocoPhillips Company, Shell Exploration & Production Company, and Statoil USA E&P, Inc. by University of Alaska, Fairbanks, AK
- Blanchard, A.L., and A.L. Knowlton. 2014. Chukchi Sea Environmental Studies Program: Benthic Ecology of the Northeastern Chukchi Sea, 2008-2013. Prepared for ConocoPhillips Alaska, Inc. and Shell Exploration & Production Company, by University of Alaska, Fairbanks, AK.
- Blanchard, A.L., and A.L. Knowlton. 2013. Chukchi Sea Environmental Studies Program: Benthic Ecology of the Northeastern Chukchi Sea, 2008-2012. Prepared for ConocoPhillips Alaska, Inc. and Shell Exploration & Production Company, by University of Alaska, Fairbanks, AK.
- Blanchard, A.L., and A.L. Knowlton. 2013. Chukchi Sea Environmental Studies Program: Benthic Ecology of the Northeastern Chukchi Sea, 2008-2011. Prepared for ConocoPhillips Alaska, Inc. and Shell Exploration & Production Company, by University of Alaska, Fairbanks, AK.
- Blanchard, A.L., C. Parris, and A.L. Knowlton. 2011. Benthic ecology of the Northeastern Chukchi Sea. Chukchi Sea Environmental Studies Program 2008-2010. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil USA E&P, Inc. by University of Alaska, Fairbanks, AK.
- Blanchard, A.L., C. Parris, and H. Nichols. 2010b. Benthic ecology of the Burger and Klondike survey areas: 2009 environmental studies program in the northeastern Chukchi Sea. Prepared for ConocoPhillips Alaska, Inc. and Shell Exploration & Production Company, by University of Alaska, Fairbanks, AK.
- Blanchard, A.L., H. Nichols, and C. Parris. 2010a. Benthic ecology of the Burger and Klondike survey areas: 2008 environmental studies program in the northeastern Chukchi Sea. Prepared for ConocoPhillips Alaska, Inc. and Shell Exploration & Production Company, by University of Alaska, Fairbanks, AK.
- Gall A. and B. Day. 2014. Distribution and abundance of seabirds in the northeastern Chukchi Sea, 2008 - 2013. Prepared for ConocoPhillips Company, Shell Exploration & Production Company, and Statoil USA E&P, Inc., Anchorage AK by ABR, Inc. Environmental Services, Fairbanks, AK.
- Gall A. and B. Day. 2013. Distribution and abundance of seabirds in the northeastern Chukchi Sea, 2008 - 2012. Draft Report prepared for ConocoPhillips Company, Shell Exploration & Production Company, and Statoil USA E&P, Inc., Anchorage AK by ABR, Inc. Environmental Services, Fairbanks, AK.
- Gall A. and B. Day. 2012. Distribution and abundance of seabirds in the northeastern Chukchi Sea, 2008 - 2011. Draft Report prepared for ConocoPhillips Company, Shell Exploration & Production Company, and Statoil USA E&P, Inc., Anchorage AK by ABR, Inc. Environmental Services, Fairbanks, AK. 42 pp. + app.

- Gall A. and B. Day. 2011. Distribution and abundance of seabirds in the northeastern Chukchi Sea, 2008 - 2010. Prepared for ConocoPhillips Company, Shell Exploration & Production Company, and Statoil USA E&P, Inc., Anchorage AK by ABR, Inc. Environmental Services, Fairbanks, AK. 74 pp.
- Gall A. and B. Day. 2010. Distribution and abundance of seabirds in the northeastern Chukchi Sea, 2008 and 2009. Prepared for ConocoPhillips Company, Shell Exploration & Production Company, and Statoil USA E&P, Inc., Anchorage AK by ABR, Inc. Environmental Services, Fairbanks, AK. 68 pp.
- Gall, A. and B. Day. 2009. Distribution and abundance of seabirds in the northeastern Chukchi Sea, 2008. Prepared for ConocoPhillips Company, Shell Exploration & Production Company, and Statoil USA E&P, Inc., Anchorage AK by ABR, Inc. Environmental Services, Fairbanks, AK. 55 pp.
- Hopcroft, R., J. Questel, J. Lamb, C. Clarke-Hopcroft. 2014. Oceanographic assessment of the planktonic communities in the northeastern Chukchi Sea: report for survey year 2013. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil E&P USA, Anchorage, AK by the Institute of Marine Science, University of Alaska, Fairbanks and School of Oceanography, University of Washington, Seattle.
- Hopcroft, R. P. Hariharan, J. Questel, J. Lamb, E. Lessard, M. Foy, and C. Clarke-Hopcroft 2013b. Oceanographic assessment of the planktonic communities in the northeastern Chukchi Sea: report for survey year 2012. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil E&P USA, Anchorage, AK by the Institute of Marine Science, University of Alaska, Fairbanks and School of Oceanography, University of Washington, Seattle.
- Hopcroft, R., J. Questel, P. Hariharan, C. Stark, and C. Clarke-Hopcroft 2012. Oceanographic assessment of the planktonic communities in northeastern Chukchi Sea: report for survey year 2011. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil E&P USA, Anchorage, AK by the Institute of Marine Science, University of Alaska, Fairbanks.
- Hopcroft, R., J. Questel, and C. Clarke-Hopcroft 2011. Oceanographic assessment of the planktonic communities in the northeastern Chukchi Sea: report for survey year 2010. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil E&P USA, Anchorage, AK by the Institute of Marine Science, University of Alaska, Fairbanks.
- Hopcroft, R., J. Questel, and C. Clarke-Hopcroft 2010. Oceanographic assessment of the planktonic communities in the Klondike and Burger survey areas of the Chukchi Sea: report for survey year 2009.
- Hopcroft, R., J. Questel, and C. Clarke-Hopcroft 2009. Oceanographic assessment of the planktonic communities in the Klondike and Burger survey areas of the Chukchi Sea: report for survey year 2008.
- Mathis, J.T. and N.M. Monacci. 2014. Seasonal Observations of Carbonate Chemistry and Ocean Acidification in the Northeastern Chukchi Sea in 2013. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil E&P USA. Prepared by Ocean acidification Research Center. School of Fisheries and Ocean Sciences. University of Alaska Fairbanks. Fairbanks, AK.
- Mathis, J.T. 2013. Seasonal Observations of Carbonate Chemistry and Ocean Acidification in 2012. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and

Statoil E&P USA. Prepared by Ocean acidification Research Center. School of Fisheries and Ocean Sciences. University of Alaska Fairbanks. Fairbanks, AK.

- Mathis, J.T. 2012. Seasonal Observations of Carbonate Chemistry and Ocean Acidification in 2011. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil E&P USA. Prepared by Ocean acidification Research Center. School of Fisheries and Ocean Sciences. University of Alaska Fairbanks. Fairbanks, AK.
- Mathis, J.T. 2011. Seasonal Observations of Carbonate Chemistry and Ocean Acidification in 2010. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil E&P USA. Prepared by Ocean acidification Research Center. School of Fisheries and Ocean Sciences. University of Alaska Fairbanks. Fairbanks, AK.
- Weingartner, R. S. Danielson, L. Dobbins, R. Potter. 2014. Physical Oceanographic Measurements in the Northeastern Chukchi Sea: 2013. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil E&P USA. Prepared by Institute of Marine Science, University of Alaska. Fairbanks, AK.
- Weingartner, R. S. Danielson, L. Dobbins, R. Potter. 2014. Physical Oceanographic Measurements in the Northeastern Chukchi Sea: 2013. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil E&P USA. Prepared by Institute of Marine Science, University of Alaska. Fairbanks, AK.
- Weingartner, R. S. Danielson, L. Dobbins, R. Potter. 2013. Physical Oceanographic Measurements in the Northeastern Chukchi Sea: 2012. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil E&P USA. Prepared by Institute of Marine Science, University of Alaska. Fairbanks, AK.
- Weingartner, R. S. Danielson, L. Dobbins, R. Potter. 2012. Physical Oceanographic Measurements in the Northeastern Chukchi Sea: 2011. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil E&P USA. Prepared by Institute of Marine Science, University of Alaska. Fairbanks, AK.
- Weingartner, R. S. Danielson, L. Dobbins, R. Potter. 2011. Physical Oceanographic Measurements in the Northeastern Chukchi Sea: 2008-2010. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil E&P USA. Prepared by Institute of Marine Science, University of Alaska. Fairbanks, AK.
- Weingartner, R. S. Danielson. Physical Oceanographic Measurements in the Northeastern Chukchi Sea: 2008 and 2009. Prepared for ConocoPhillips Alaska, Inc. and Shell Exploration & Production Company. Prepared by Institute of Marine Science, University of Alaska. Fairbanks, AK.
- Weingartner, R. S. 2009. Physical Oceanographic Measurements in the Northeastern Chukchi Sea. Prepared for ConocoPhillips Alaska, Inc. and Shell Exploration & Production Company. Prepared by Institute of Marine Science, University of Alaska. Fairbanks, AK.
- Goodman, S.E., J.A. June, K.L. Antonelis, A.L. Antonelis. 2013. Acoustic Survey of Fishes in the Chukchi Sea Environmental Studies Program in 2012. Prepared for Olgoonik Fairweather, LLC. Prepared by Natural Resources Consultants, Inc. Seattle, WA.
- Goodman, S.E., J.A. June, K.L. Antonelis. 2012. 2011 Fish and Invertebrate Trawl Surveys in the Chukchi Sea Environmental Studies Program. Prepared for Olgoonik Fairweather, LLC. Prepared by Natural Resources Consultants, Inc. Seattle, WA.Priest, J.T., S.T. Crawford, R.M. Meyer, S.W. Raborn, and B.J. Gallaway. 2011a. Fish community observation for three locations in the

Chukchi Sea, 2010. Annual report prepared by LGL Alaska Research Associates, Inc., Anchorage, Alaska for Olgoonik-Fairweather. 95 p.

- Priest, J. T., S. T. Crawford, R. M. Meyer, S. W. Raborn, and B. J. Gallaway. 2011. Fish community observation for three locations in the Chukchi Sea, 2010. Annual report prepared by LGL Alaska Research Associates, Inc., Anchorage, Alaska for Olgoonik-Fairweather. 95 p.

- Norcross, B.L., B.A. Holladay, L. E. Edenfield. 2011. 2009 Environmental Studies Program in the Northeast Chukchi Sea: Fisheries Ecology of the Burger and Klondike Survey Areas. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil USA E&P, Inc. Prepared by Institute of Marine Science. School of Fisheries and Ocean Sciences. University of Alaska Fairbanks.

Shell has also collected a large amount of information regarding marine mammals in the northeastern Chukchi Sea, including the area of Shell's Burger Prospect, through its marine mammal monitoring program associated with seismic surveys. Data collected over the last four years is summarized in the comprehensive reports. Shell has provided BOEM with all of these reports. They are as follows:

- Joint monitoring program in the Chukchi and Beaufort Seas, July-November 2006. LGL Alaska Report P891-2, Report from LGL Alaska Research Associates, Inc., LGL Ltd., Greeneridge Sciences, Inc., Bioacoustics Research Program, Cornell University, and Bio-Wave Inc. for Shell Offshore, Inc., ConocoPhillips Alaska, Inc., and GX Technology, and National Marine Fisheries Service, U.S. Fish and Wildlife Service. 316 p. plus Appendices (Funk, et al. 2007).
- Joint monitoring program in the Chukchi and Beaufort Seas, July-November 2007. LGL Alaska Report P1050-3, Report from LGL Alaska Research Associates, Inc., LGL, Ltd., Greeneridge Sciences, Inc., and JASCO Research, Ltd. and for Shell Offshore, Inc., ConocoPhillips Alaska, Inc., and National Marine Fisheries Service, U.S. Fish and Wildlife Service. 445 p. plus Appendices (Ireland, et al. 2008).
- Joint monitoring program in the Chukchi and Beaufort Seas, open-water seasons, 2006–2009. LGL Alaska Report P1050-2, Preliminary Draft Report from LGL Alaska Research Associates, Inc., LGL Ltd., Greeneridge Sciences, Inc., and JASCO Applied Sciences, for Shell Offshore, Inc. and Other Industry Contributors, and National Marine Fisheries Service, U.S. Fish and Wildlife Service. 462 p. plus Appendices (Funk, et al. 2011a).
- Joint Monitoring Program in the Chukchi and Beaufort Seas, 2012. LGL Alaska Final Report P1272-2 for Shell Offshore, Inc. ION Geophysical, Inc., and Other Industry Contributors, National Marine Fisheries Service, and U.S. Fish and Wildlife Service. 354 p. plus Appendices (LGL et al. 2014).

Additionally, Shell:

- Deployed meteorological buoys in the Chukchi Sea near the Burger Prospect in 2008-2014 that reported hourly measurements via satellite – this work is being continued in 2015.

- Deployed an acoustical wave and current meter (AWAC) in the Chukchi Sea near the Burger Prospect in 2008-2010, which was serviced and redeployed in 2011-2012.

Shell also established a meteorological and air quality monitoring station at Wainwright. Data have been collected and reported for November 2008 through December 2010 in the following reports, which indicate that measured concentrations of air pollutants are well below NAAQS.

- Wainwright near-term ambient air quality monitoring program first quarter data report November 2008 through January 2009 final. Unpublished report prepared by AECOM, Inc. for ConocoPhillips Alaska, Inc., Anchorage, Alaska (AECOM, Inc. 2009a).
- Wainwright near-term ambient air quality monitoring program second quarter data report February through April 2009 final. Document No. 01865-104-3220 prepared by AECOM, Inc. for ConocoPhillips Alaska, Inc., Anchorage, Alaska (AECOM, Inc. 2009b).
- Wainwright near-term ambient air quality monitoring program third quarter data report May through July 2009 final. Document No. 01865-104-3230 prepared by AECOM, Inc. for ConocoPhillips Alaska, Inc., Anchorage, Alaska (AECOM, Inc. 2009c).
- Wainwright near-term ambient air quality monitoring program fourth quarter data report August through October 2009 final revision 02. Unpublished report prepared by AECOM, Inc. for ConocoPhillips Alaska, Inc., Anchorage, Alaska (AECOM, Inc. 2009d).
- Wainwright permanent ambient air quality monitoring program fourth quarter data report September through December 2009 Final. Unpublished report prepared by AECOM, Inc. for ConocoPhillips Alaska, Inc., Anchorage, Alaska. (AECOM, Inc. 2009e)
- Wainwright near-term ambient air quality monitoring program annual data report November 2008 through November 2009 final. Unpublished report prepared by AECOM, Inc. for ConocoPhillips Alaska, Inc. Anchorage, Alaska (AECOM, Inc. 2010a).
- Wainwright permanent ambient air quality monitoring program first quarter data report January through March 2010 final. Unpublished report prepared by AECOM, Inc. for ConocoPhillips Alaska, Inc., Anchorage, Alaska (AECOM, Inc. 2010b).
- Wainwright permanent ambient air quality monitoring program second quarter data report April through June 2010 draft. Unpublished report prepared by AECOM, Inc. for ConocoPhillips Alaska, Inc., Anchorage, Alaska (AECOM, Inc. 2010c).
- Wainwright permanent ambient air quality monitoring program third quarter data report July through September 2010 draft. Unpublished report prepared by AECOM, Inc. for ConocoPhillips Alaska, Inc., Anchorage, Alaska (AECOM, Inc. 2010d).
- Wainwright permanent ambient air quality monitoring program fourth quarter data report October through December 2010 draft. Unpublished report prepared by AECOM, Inc. for ConocoPhillips Alaska, Inc., Anchorage, Alaska (AECOM, Inc. 2011a).
- Wainwright permanent ambient air quality monitoring program annual data report January 2010 through December 2010 final. Unpublished report prepared by AECOM, Inc. for ConocoPhillips Alaska, Inc., Anchorage, Alaska (AECOM, Inc. 2011b).
- 2011 Annual Data Report, Wainwright Ambient Air Quality and Meteorological Monitoring Program, Jan. 1 – Dec. 31, 2011. Unpublished report by SLR Consulting, Inc. for ConocoPhillips Alaska, Inc., Anchorage, Alaska, Feb. 2012 (SLR 2012a).
- 2012 Annual Data Report, Wainwright Ambient Air Quality and Meteorological Monitoring Program, Jan. 1 – Dec. 31, 2012. Unpublished report by SLR Consulting, Inc. for ConocoPhillips Alaska, Inc., Anchorage, Alaska, Feb. 2013 (SLR 2013a).

Meteorological and air quality data were also collected at Point Lay as detailed in the following reports:

- Point Lay Comprehensive Ambient Air and Meteorological Monitoring Program, Annual Data Summary for June 1, 2010 – May 31, 2011. Unpublished report by SLR Consulting, Inc. for Shell Offshore Inc., Anchorage, Alaska, Sep. 2011 (SLR 2011).
- 2012 Annual Data Report, Point Lay Comprehensive Ambient Air and Meteorological Monitoring Program, Jan. 1 – Dec. 31, 2012. Unpublished report by SLR Consulting, Inc. for Shell Gulf of Mexico Inc., Anchorage, Alaska, Feb. 2013 (SLR 2013b).
- 2013 Annual Data Report, Point Lay Comprehensive Ambient Air and Meteorological Monitoring Program, Jan. 1 – Dec. 31, 2013. Unpublished report by SLR Consulting, Inc. for Shell Gulf of Mexico Inc., Anchorage, Alaska, Feb. 2014 (SLR 2014).

Shell also conducted coastal environmental sensitivity surveys along the coastline of the northeastern Chukchi Sea (Sound Enterprises and Associates, LLC 2008) and collected data on subsistence harvests and uses in the Chukchi and Beaufort Seas (AES-RTS and UMIAQ). The Sound Enterprises and Associates, LLC (2008), ASRC Energy Services (2009, 2010) and UMIAQ (2011) reports were previously submitted to BOEM; the UMIAQ (2012, 2013, 2014) reports are attached as part of this submission.

- Chukchi Village Interview Program. Unpublished report prepared by Sound Enterprises and Associates, LLC, Bainbridge Island, WA for Shell Exploration and Production Company (Sound Enterprises and Associates, LLC. 2008).
- Subsistence Advisor Program summary North Slope, Alaska. Report dated April 2009 prepared by ASRC Energy Services for Shell Exploration and Production Company, Anchorage, Alaska (ASRC Energy Services. 2009).
- 2011 Subsistence Advisor Program, North Slope, Alaska. Report prepared by UMIAQ, Anchorage, Alaska for Shell Exploration and Production, Anchorage, Alaska (UMIAQ. 2012).
- 2012 Subsistence Advisor Program, North Slope, Alaska. Report prepared by UMIAQ, Anchorage, Alaska for Shell Exploration and Production, Anchorage, Alaska (UMIAQ. 2013).
- 2013 Subsistence Advisor Program North Slope, Alaska. Report prepared by UMIAQ, Anchorage, Alaska for Shell Exploration & Production Company, Anchorage, Alaska (UMIAQ. 2014).

2.0 PLANNED EXPLORATION DRILLING ACTIVITIES

Shell plans to drill six exploration wells over multiple drilling seasons. Shell will mobilize both of its drilling units, the *Discoverer* and the *Polar Pioneer* and support vessels through the Bering Strait on or about 1 July each drilling season, reaching the first Chukchi Sea drill site as early as 4 July as ice conditions permit. Exploration drilling activities will continue until on or about 31 October. Shell will demobilize the drilling units and support vessels out of the Chukchi Sea at the end of each drilling season. Additional exploration drilling program details are provided below.

2.1 The Prospect and Drill Sites

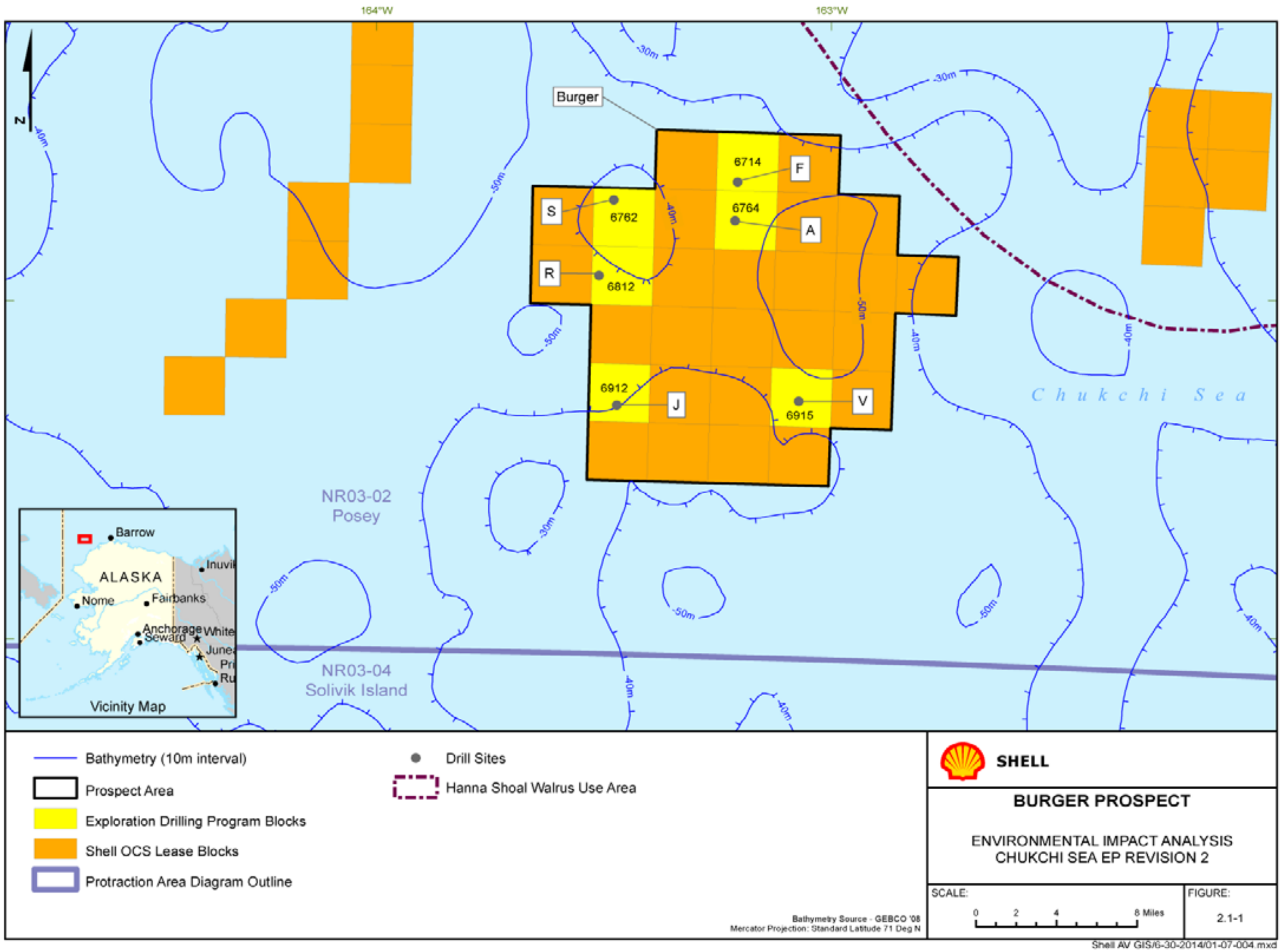
Shell has identified six proposed drill sites within its Chukchi Sea lease blocks, all within the Burger Prospect. These are the same drill sites identified by Shell in EP Revision 1 and analyzed in detail in Shell's May 2011 EIA that accompanies EP Revision 1. Coordinates of the six drill sites are listed in Table 2.1-1. Locations of the drill sites are depicted in Figure 2.1-1.

Table 2.1-1 Drill Sites in the Chukchi Sea Exploration Drilling Program

Prospect	Well	Area	Block	Lease Number	Coordinates (m) [1] X	Y	Latitude	Longitude
Burger	A	Posey	6764	OCS-Y-2280	563945.26	7912759.34	N71° 18' 30.92"	W163° 12' 43.17"
Burger	F	Posey	6714	OCS-Y-2267	564063.30	7915956.94	N71° 20' 13.96"	W163° 12' 21.75"
Burger	J	Posey	6912	OCS-Y-2321	555036.01	7897424.42	N71° 10' 24.03"	W163° 28' 18.52"
Burger	R	Posey	6812	OCS-Y-2294	553365.47	7907998.91	N71° 16' 06.57"	W163° 30' 39.44"
Burger	S	Posey	6762	OCS-Y-2278	554390.64	7914198.48	N71° 19' 25.79"	W163° 28' 40.84"
Burger	V	Posey	6915	OCS-Y-2324	569401.40	7898124.84	N71° 10' 33.39"	W163° 04' 21.23"

[1] Coordinate system is North American Datum 1983 (NAD 83) UTM Zone 3

Figure 2.1-1 Burger Prospect Drill Site Locations



2.2 Drilling Units, Support Vessels, and Aircraft

Drilling Units

All planned exploration wells will be drilled using either the *Discoverer* or the semi-submersible *Polar Pioneer*. The drilling units will be in the Lease Sale 193 area operating as primary drilling units. Provisions for a second relief well drilling unit will be in place, in the event that the primary drilling unit is disabled and not capable of drilling its own relief well. Both the *Discoverer* and *Polar Pioneer* will serve as their own primary relief well drilling unit. If either the *Discoverer* or the *Polar Pioneer* cannot be used to drill its own relief well, the other drilling unit would be used for that purpose. The drilling units will be in the Burger Prospect operating as primary drilling units, or one may be no further than Dutch Harbor when the other drilling unit is drilling hydrocarbon bearing zones. In either case, the other drilling unit could be mobilized to the location in the Burger Prospect, moored, and then drill a relief well and kill the flow within 38 days.

Photograph 2.2-1 *Polar Pioneer*

The *Polar Pioneer* (photo at left) is a non-selfpropelled, semi-submersible drilling unit capable of drilling in harsh environments. Its class notation is Det Norske Veritas (DNV) 1A1 column stabilized drilling unit. It is a largely self-contained drilling unit that offers full accommodations for a crew of up to 114 persons, with quarters, galley, and sanitation facilities. General specifications for the *Polar Pioneer* are provided below in Table 2.2-1.

Photograph 2.2-2 *Discoverer*

The *Discoverer* (photo to left) is an ice strengthened drillship and can mobilize under its own power. It is a largely self-contained drilling unit that offers full accommodations for a crew of up to 124 persons, with quarters, galley, and sanitation facilities. Specifications for the *Discoverer* are provided in Table 2.2-1.

Table 2.2-1 Specifications of the *Discoverer* and the *Polar Pioneer*

Specification	*Discoverer*	*Polar Pioneer*
Dimensions		
Hull Length	514 ft (156.7 m)	279 ft (85 m)
Hull Width	85 ft (26.0 m)	233 ft (71 m)
Height	274 ft (83.2 m)	319 ft (97.3m)
Derrick Height	175 ft (53.3 m)	170 ft (51.8 m)
Draft		
Transit Draft	26.9 ft (8.2 m)	30 ft (9.15 m)
Operating Draft at Loadline	26.9 ft (8.2 m)	75.4 ft (23 m)
Berths	124 berths	114 berths
Storage Capacity		
Potable Water	1,670 barrels (bbl) (266 cubic meters [m^3])	4,843 bbl (770 m^3)
Drill Water	5,798 bbl (922 m^3)	11,140 bbl (1,770 m^3)
Liquid Mud	2,400 bbl (382 m^3)	6,180 bbl (982 m^3)
Bulk Cement	6,400 cubic feet (ft^3) (180 m^3)	12,678 ft^3 (359 m^3)
Fuel	6,497 bbl (1,033 m^3)	11,290 bbl (1,794 m^3)
Propulsion Engines	(1) MAN Diesel B&W l, 6,480 horse power (hp)	N/A
Power Plant	(6) Caterpillar 3512, 1,476 hp	(5) Bergen KVG-18 3,890 hp
Mooring		
Anchors	9 - 15 metric (mt) ton Stevshark, 8 each	9 - 15 mt ton Stevshark 8 each
Anchor Lines	2.75 inch (in.) (7 centimeters [cm]) wire rope 2.5-in. (6 cm) chain	3.3 in (88 millimeters [mm]) K-4 chain
Anchor Line Length	(8 each) 2,750 ft (838 m) wire + 1,150 ft (351 m) chain (useable) per anchor	(8 each) 1,969-2,035 m chain per anchor
Transit Speed	8.0 knots	NA (non-selfpropelled)
Marine Sanitation Device	OMNIPUR Series 55	Piranha WRS-40

Operation Support Vessels and Oil Spill Response Vessels

The drilling units will be attended by operational support vessels consisting of ice management vessels, anchor handlers, OSVs, support tugs, resupply barges and tugs, and shallow water vessels. Up to two science vessels will be used to conduct discharge monitoring required by the new Chukchi Sea NPDES exploration facilities GP. OSR support vessels consisting of an OSRV, an offshore OSR tug and barge, a nearshore OSR tug and barge, a support tug, OSTs, and a containment system tug and barge. The drilling units, operational support vessels, and OSR support vessels are listed below:

- Drilling units: *Discoverer* and *Polar Pioneer*
- Ice management vessels (x2)
- Anchor handlers (x3)
- OSVs (x3)
- Science vessels (x2)
- MLC ROV System vessel
- Support tugs (x2)
- Shallow water vessels (x2)
- Supply tugs (x2) and barges (x2) (one tug of which may have temporary duties accompanying the *Discoverer* during transiting to and from a drill site)
- OSRV
- OSR tugs (x2) and barges (x2)
- OSTs (x2)
- Containment system tugs (x2) and barge (x1)

- SAR helicopter
- Crew change/resupply helicopters (x3)
- Fixed-wing aircraft for ice reconnaissance
- Fixed-wing aircraft for PSO flights
- Fixed-wing aircraft for crew change between Barrow and Wainwright

Some support vessels are not yet contracted; specifications for vessels of the sizes and types that may be contracted are presented in Tables 2.2-2 and 2.2-3. Vessels that are eventually contracted may differ from these but they will be similar. Fuel storage capacities and expected trip frequencies for these vessels are indicated in Table 2.2-4. Vessel and aircraft travel corridors are indicated in Figures 2.2-1 and 2.2-2. A generalized route is identified for vessels to effect crew changes between the prospect or offshore vessels and Barrow. This is a contingency for the possibility that sufficient crew change flights cannot be accommodated by helicopters because of weather, visibility, subsistence or other operational issues.

Some vessels will not be in the Lease Sale 193 Area for extended periods but may be used in the prospect on occasion. The resupply barges and tugs, the nearshore OSR tug and barge, the containment system tugs and shallow water vessels will be primarily located outside the Lease Sale 193 Area. A location for these vessels has been identified near Goodhope Bay in Kotzebue Sound in water depths of about 30 ft (9.1 m). Four mooring buoys may be established at the site. The site of these four, closely spaced, temporary mooring locations were selected in large part because the area has been selected and approved by the SOA as a potential place of refuge (PPOR) in addition to traditional knowledge received from nearby communities. Communities did not indicate issues (such as subsistence use conflicts) with Shell's mooring location.

One OST will be located in the prospect. Some of the OST storage capacity will be used to hold fuel for refueling the drilling units and support vessels; the remaining storage will be used for storage of recovered liquids in the event of a spill. The second OST will be located where it could be mobilized to relieve the first OST in the event of a spill. The OST in the prospect will possess enough storage capacity to store all recovered liquids for the initial response or until the second OST arrives to supplement the response. The total storage capacity between the two tankers available for the response is > 750,000 bbl, the WCD planning scenario under the OSRP.

Crew changes will occur throughout the season using the shallow water vessels transiting between Kotzebue and the vessel locations in Kotzebue Sound. Vessels will also be resupplied with food stores via shallow water vessel. Other vessels may be located with these vessels on occasion. Additional information on vessel locations is provided in Table 2.2-4. Vessels will comply with the waste management plan, including International Convention for the Prevention of Pollution from Ships (Marine Pollution or MARPOL) standards and requirements and the EPA NPDES vessel GP for any discharge of gray water or treated effluent.

Table 2.2-2 Specifications of Operations Support Vessels

Specification	Ice Management Vessels (x2)[1,2]	Anchor Handlers (x3)[1,3]	OSV (x3)[1,4]	Science Vessel (x2)[1,5]	Shallow Water Vessel (x2)[1,6]	Support Tugs (x2)[1,7]	Supply Tugs (x2) and Barges (x2)[1,8]		MLC ROV System Vessel[1,9]
							Tug	Barge	
Length	380 ft (116 m)	361 ft (110.1 m)	300 ft (91.5 m)	300 ft (91.5 m)	85 ft (25.9 m)	146 ft (44.5 m)	150 ft (45.7 m)	400 ft (122 m)	280 ft (85.3 m)
Width	85 ft (26 m)	80 ft (24.4 m)	64 ft (19.5 m)	64 ft (19.5 m)	20 ft (6.1 m)	46 ft (14 m)	40 ft (12.2 m)	99.5 ft (30.3m)	60 ft (18.3 m)
Draft	27 ft (8.4 m)	28 ft (8.5 m)	19.6 ft (5.9 m)	19.6 ft (5.9 m)	4.5 ft (1.4 m)	21 ft (6.4 m)	19.5 ft (5.9 m)	25 ft (7.6 m)	16.5 ft (5 m)
Accommodations	77	64	50	50	50	13	11	--	26
Maximum Speed	16 knots (30 km/hr)	15 knots (28 km/hr)	13 knots (24 km/hr)	13 knots (24 km/hr)	20 knots (37 km/hr)	16 knots (30 km/hr)	12 knots (22 km/hr)	--	13 knots (24 km/hr)
Available Fuel Storage	14,192 bbl (2,256 m^3)	11,318 bbl (1,799 m^3)	5,786 bbl (920 m^3)	5,786 bbl (920 m^3)	43 bbl (6.8 m^3)	5,030 bbl (799 m^3)	4,800 bbl (774 m^3)	--	6,233 bbl (991 m^3)

[1] Or similar vessel
[2] Based on the *Nordica*
[3] Based on the *Aiviq*
[4] Based on the *Harvey Champion*
[5] Based on the *Harvey Champion*
[6] Based on the *King C*
[7] Based on the tug *Ocean Wave*
[8] Based on the tug *Lauren Foss* and barge *Tuuq*
[9] Based on the *Harvey Spirit*

Table 2.2-3 Specifications of the Major Oil Spill Response Vessels

Specification	OSRV [1,2]	Offshore OSR [1,3]		Nearshore OSR[1,4]		OST [1,5]	OST [1,6]	Containment System [1,7]	
		Tug (x1)	Barge (x1)	Tug (x1)	Barge (x1)			Tugs (x2)	Barge (x1)
Length	301 ft (91.9 m)	136 ft (41.4 m)	333 ft (101.5 m)	90 ft (27.4 m)	205 ft (62.5 m)	748 ft (228 m)	813 ft (248 m)	150 ft (45.7 m)	316.5 ft (96.5 m)
Width	60 ft (18.3 m)	37 ft (11.2 m)	76 ft (23.1 m)	32 ft (9.8 m)	90 ft (27.4 m)	105 ft (32 m)	141 ft (48 m)	40 ft (12.2 m)	105 ft (32 m)
Draft	19 ft (5.8 m)	20 ft (6.0 m)	22 ft (6.7 m)	10 ft (3 m)	15 ft (4.6 m)	66 ft (20 m)	69 ft (21 m)	19.5 ft (5.9 m)	12.5 ft (3.8 m)
Accommodations	41	15	--	8	--	25	25	11	72
Maximum Speed	16 knots (30 km/hr)	12 knots (22 km/hr)	--	12 knots (22 km/hr)	--	15 knots (28 km/hr)	15 knots (28 km/hr)	10 knots (19 km/hr)	--
Available Fuel Storage	7,692 bbl (1,223 m^3)	3,690 bbl (586 m^3)	3,875 bbl (616 m^3)	1,286 bbl (204.5 m^3)	--	16,121 bbl (2,563m^3)	20,241 bbl (3,218 m^3)	4,800 bbl (763 m^3)	6,630 bbl (1,054 m^3)
Available Liquid Storage	12,245 bbl (1,947 m^3)	--	76,900 bbl (12,226 m^3)	--	17,000 bbl (5,183 m^3)	106,000 bbl8 (16,852 m^3)	670,000 bbl (106,518 m^3)	--	--
Workboats	(3) 34 ft work boats		--	-	(1) skim boat 47 ft (14 m) (3) work boats 34 ft (10 m) (4) mini-barges	--	--	--	--

[1] Or similar vessel
[2] Based on the *Nanuq*
[3] Based on the tug *Guardsman* and barge *Klamath*
[4] based on the tug *Point Oliktok* and barge *Endeavor*
[5] Based on a Panamax type tanker
[6] Based on an Aframax type tanker
[7] Based on the Corbin Foss (tug), Arctic Challenger (barge)
[8] Total available storage is 350,000 bbl; however, 244,000 bbl of ULSD or a fuel with equal or lower sulfur content (used to refuel the drilling units and support vessels) will take up storage space, leaving 106,000 bbl for recovered liquids. Storage space for recovered liquids will increase as fuel is dispensed for refueling.

Table 2.2-4 Expected Fuel Storage Capacity and Trip Information for Support Vessels

Vessel Type	Maximum Fuel Tank Storage Capacity (each vessel)	Trip Frequency or Duration/Location
Marine Support Vessels (or similar)		
Ice management vessels (x2)	14,192 bbl (2,256 m^3)	Will remain in the vicinity of the drilling units until their mission is finished
Anchor handlers (x3)	11,318 bbl (1,799 m^3)	Will remain in the vicinity of the drilling units until their mission is finished
OSVs (x3)	5,786 bbl (920 m^3)	Up to 30 round trips (combined for all OSVs) for resupply between drilling unit and Dutch Harbor/Kotzebue during each drilling season
Supply Tugs (x2) and barges (x2)	4,800 bbl (774 m^3)	Will generally remain in Kotzebue Sound for storage
Support Tugs (x2)	5,585 bbl (888 m^3)	Support for the *Polar Pioneer*
Science Vessel (x2)	5,786 bbl (920 m^3)	Will remain in the vicinity of the drilling units until their mission is finished
MLC ROV System vessel	6,233 bbl (991 m^3)	Located on the prospect establishing MLCs ahead of the drilling units
Shallow water vessels (x2)	43 bbl (6.8 m^3)	Occasional trips as needed in vicinity of Kotzebue
OSR Support Vessels (or similar)		
OSRV	7,692 bbl (1,223 m^3)	Will remain in the vicinity of the drilling units until its mission is finished
OSR tug (x1) and barge (x1) (offshore)	1,786 bbl (284 m^3)	Will remain in the vicinity of the drilling units until its mission is finished
OSR tug (x1) and barge (x1) (nearshore)	1,286 bbl (204.5 m^3)	Staged in Kotzebue Sound
OST (Panamax)	16,121 bbl (2,563 m^3)	Will remain in the vicinity of the drilling units until its mission is finished
OST (Aframax)	20,241 bbl (3,218 m^3)	Stationed outside the Chukchi Sea lease sale planning area
Containment system tugs (x2) and barge (x1)	6,630 bbl (1,054 m^3)	Staged in Kotzebue Sound
Aircraft (or similar)		
Saab 340 B, Beechcraft 1900, or Dash 8 fixed-wing or similar – transport from shorebase to regional jet service in Barrow	9 bbl (1.4 m^3)	1 trip every 3 weeks between Wainwright and Barrow or Anchorage
Gulfstream 690 Aero Commander (or similar)(x2)	9 bbl (1.4 m^3)	PSO overflights (aka offshore aerial wildlife monitoring photographic survey) and ice reconnaissance; both to occur daily when possible
Helicopter S-92 (or similar)(x3) for crew rotation & groceries/supply	18 bbl (2.9 m^3)	Approximately 40 trips/ week between Barrow and the Burger Prospect (approximately 3.0 hr/trip)
Helicopter S-92 (or similar) – SAR	18 bbl (2.9 m^3)	Stationed in Barrow – 40 hr/week for proficiency training & trips made in emergency

Figure 2.2-1 Marine Vessel Routes

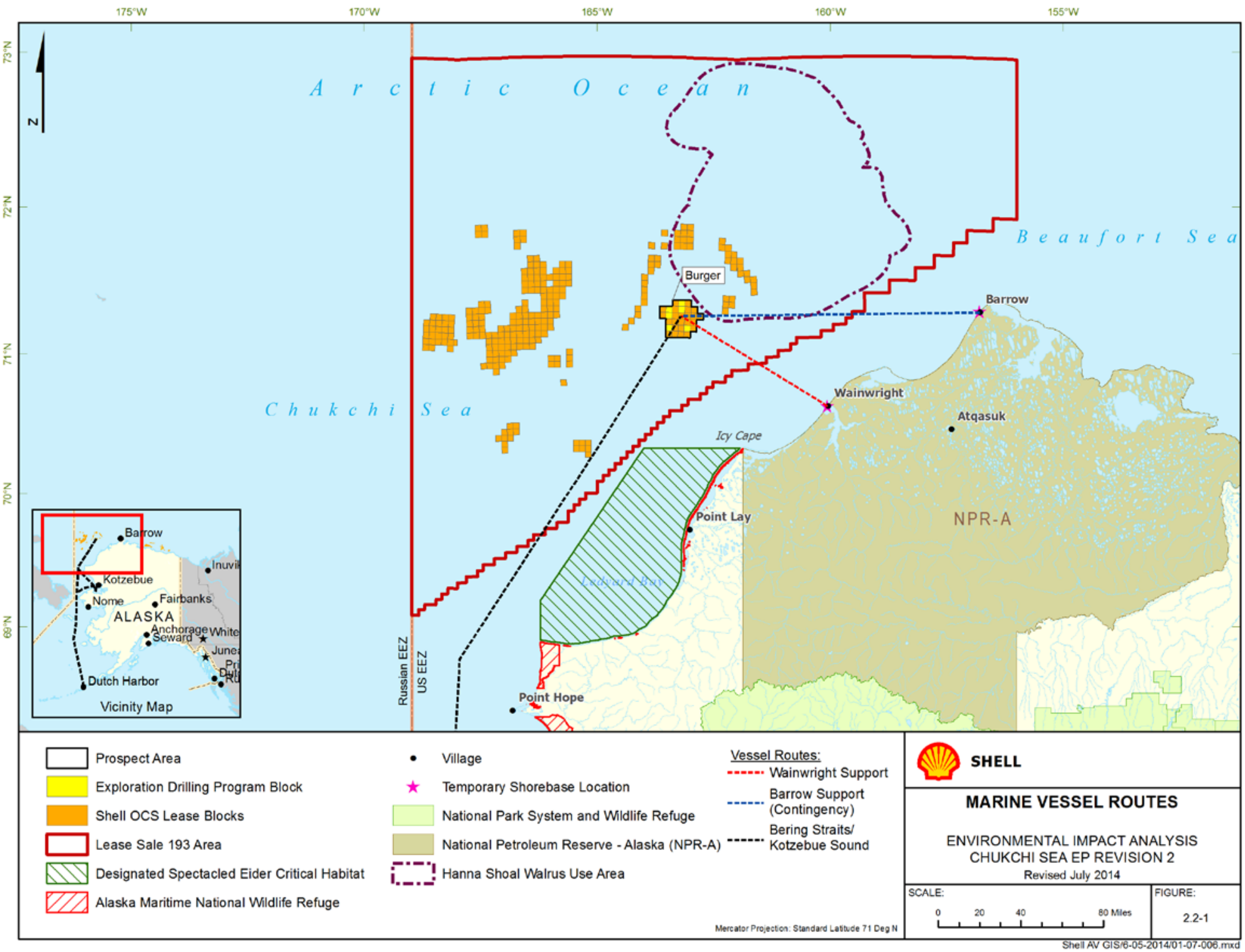
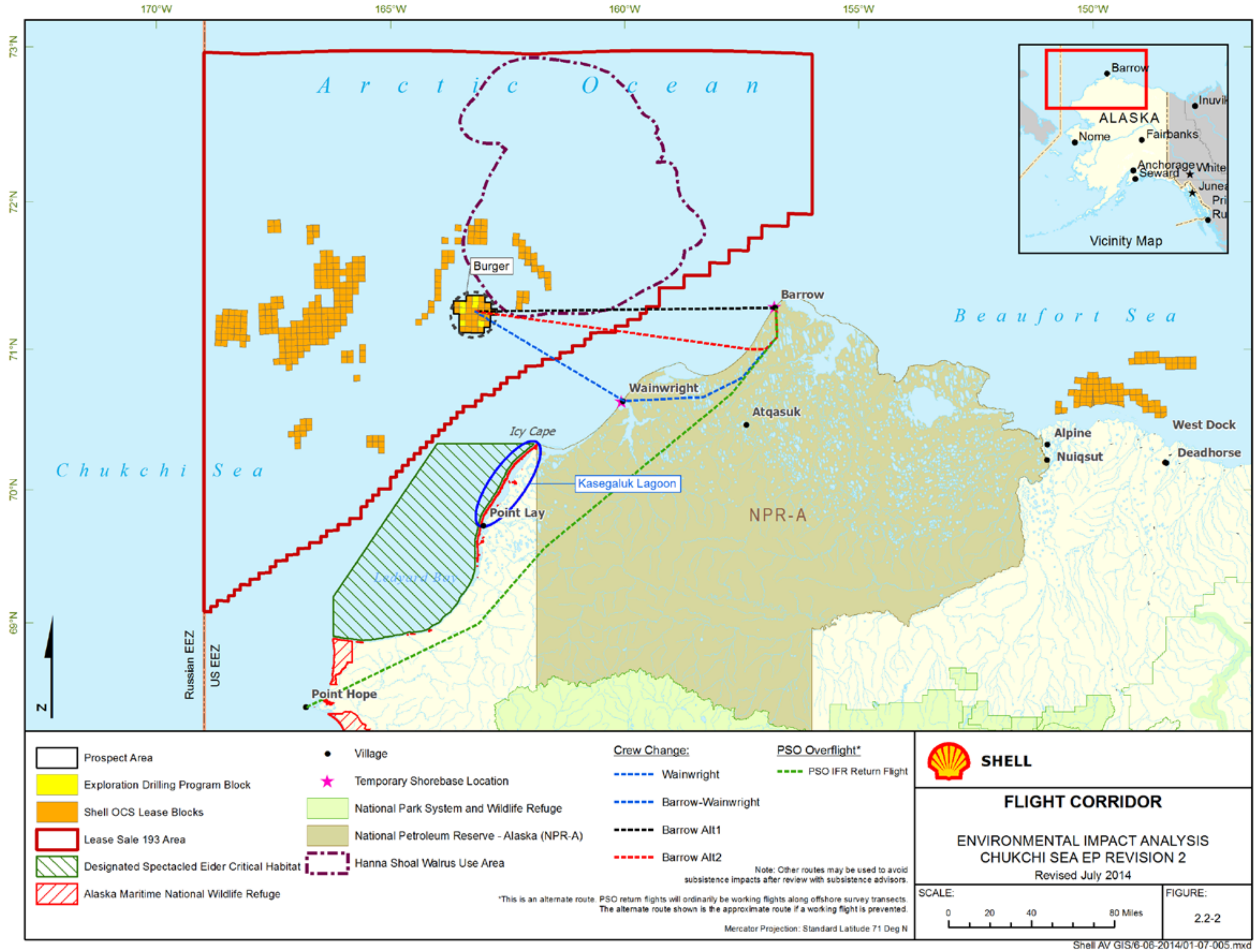


Figure 2.2-2 Flight Corridors



Photograph 2.2-3 Ice Management Vessel

Two primary ice management vessels will support the drilling units (photograph is the M/V *Nordica*). These vessels will enter and exit the Chukchi Sea with the drilling units or before and will generally remain in the vicinity of the drilling units during the drilling season. Ice management and ice reconnaissance is expected to occur at distances of 20 mi (32 km) and 30 mi (48 km) respectively. However, these vessels may have to expand beyond these ranges depending on the ice conditions.

Photograph 2.2-4 Anchor Handler

Three anchor handlers (photograph of *Aiviq*) will support the drilling units and the containment system tug and barge. These vessels will enter and exit the Chukchi Sea with the drilling units or before, and will generally remain in the vicinity of the drilling units during the drilling season. When not anchor handling, these vessels will be available to provide other general support if needed.

Photograph 2.2-5 OSV, MLC ROV System Vessel, Science Vessel

The planned exploration drilling operations will require three OSVs for resupply of the drilling units and support vessels. Drilling materials, food, fuel and other supplies will be picked up in Dutch Harbor (with possible minor resupply coming out of Kotzebue) and transported to the drilling units and support vessels.

Shell plans to use up to two science vessels to monitor discharges from the drilling units during drilling. The science vessel specifications are based on a large OSV (*Harvey Champion* [photograph] or similar) but may be a smaller vessel. This vessel will help sample drilling discharges that are defined in the EPA NPDES exploration facilities GP AKG-28-8100.

Photograph 2.2-6 Support Tug

Two support tugs will tow the *Polar Pioneer* to the Burger Prospect (photograph 2.2-6 of the *Ocean Wave*). After the *Polar Pioneer* is moored, the tugs will remain in the vicinity of the drilling units to help move them in the event that either drilling unit has to be moved off a drilling site due to ice or any other event.

Photograph 2.2-7 Supply Tug and Barge

Shell plans to use two tugs and supply barges (photograph is of the tug *Lauren Foss*) that may be based in Kotzebue Sound. The barges will house well material for the drilling vessels and for the containment system tug and barge, provide contingency accommodations for personnel in Kotzebue Sound, and carry mooring equipment for the containment system barge.

Shell also plans to use an OSV type vessel to support an MLC ROV system that may be used to construct some of the MLCs. If used, this vessel will be located at a drill site on the Burger Prospect. When not in use, the vessel will be outside of the Chukchi Sea lease sale planning area.

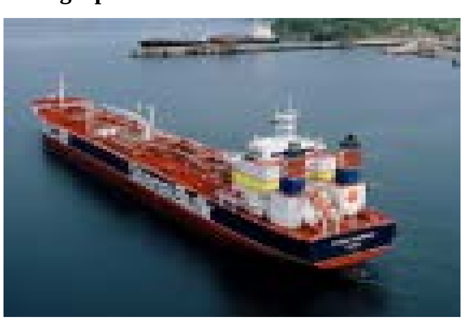
Photograph 2.2-8 Shallow Water Vessel

Shell plans to use two shallow water vessels, based in Kotzebue Sound (photograph of the *Diana G*, now known as the *King C*). These vessels will be used to transport supplies and crew between Kotzebue and the vessels moored in Kotzebue Sound. These vessels will have a shallow draft and be capable of entering shallow water.

Photograph 2.2-9 OSRV

An OSRV such as the *Nanuq* (or similar) will be staged in the vicinity of the drilling units when either is drilling in liquid hydrocarbon bearing zones. This will enable the OSRV to immediately respond to a spill and provide containment, recovery, and storage for the initial operational period following a spill event.

Photograph 2.2-10 Arctic OST



Shell plans to use up to two OSTs (Photograph2.2-10 of a Panamax tanker). As planned, one OST with specifications of a Panamax tanker will be staged in the vicinity of the Burger Prospect. This tanker will hold fuel for Shell's drilling units and support vessels in addition to storage space to store collected recovered liquids if there is a well control event. A second OST, with specifications of an Aframax tanker, will be stationed in the Chukchi Sea lease sale planning area. More information on the location of oil spill response assets is located in Shell's OSRP. The Aframax tanker will be sited such that it will be able to respond to a well control event before the Panamax tanker reaches its recovered liquid capacity.

Photograph 2.2-11 Offshore OSR Barge and Tug

An OSR tug and barge, (photograph is of the *Guardsman* tug and *Klamath* barge), will be staged in the Chukchi Sea. Together with the OSRV, it will have sufficient containment, recovery, and storage capacity for the initial operational period in the event of a spill.

Photograph 2.2-12 Nearshore OSR Tug and Barge

A tug and barge (*Endeavor* barge is pictured) will be used for nearshore OSR. It will carry a 47-ft (14-m) skimming vessel, three 34-ft (10-m) workboats, four mini-barges, and boom and duplex skimming units for nearshore recovery. This tug and barge will be moored in Kotzebue Sound.

Photograph 2.2-13 Arctic Containment System barge

Shell's oil spill containment system, housed on the Arctic Challenger barge, will be accompanied by two tugs, likely the Corbin Foss and a similar tug. The containment system tugs and barge will be moored in or near Goodhope Bay in Kotzebue Sound.

Aircraft

The exploration drilling program will be supported by:

- crew change/ resupply helicopters (x3)
- SAR helicopter
- fixed wing aircraft for crew change between Barrow and Wainwright
- fixed wing aircraft for PSO flights (aka offshore aerial wildlife monitoring photographic survey)
- fixed wing aircraft for ice reconnaissance flights

The three crew change helicopters will be operated from shorebase facilities at the Barrow Airport. These helicopters are expected to be Sikorsky S-92 helicopters (but may be similar aircraft) capable of transporting 10 to 12 persons, and will be used to transport crews between the onshore support base and the drilling units. The helicopters will also be used to haul small amounts of food, materials, subsurface samples, equipment between vessels and the shorebase. Generalized flight corridors over the onshore and near shore areas are indicated on Figure 2.2-2, but flight paths will be selected and/ or modified each day in coordination with the SAs. These flights are planned to be conducted at an altitude of > 1,500 ft (457 m).

Shell will have a fourth helicopter for SAR. The SAR helicopter is also expected to be a Sikorsky S-92, but may be a similar model. This aircraft will stay grounded at the Barrow shorebase location except during training drills, emergencies, and other non-routine events.

A fixed-wing aircraft, such as Saab 340-B 30-seat, Beechcraft 1900 19-seat, or DeHavilland Dash 8 30-seat, will be used to routinely transport crews, materials, and equipment between the shorebase and hub airports such as Barrow or Fairbanks. Fixed-wing aircraft, such as Aero-Commanders (or similar aircraft), will be used for overflights in support of Shell's 4MP, and to conduct ice reconnaissance overflights for operations in support of the Drilling Ice Management Plan (DIMP). Ice reconnaissance flights are planned to be conducted daily depending conditions and need; these flights will be conducted in the area within about 50 mi (80 km) of the drill sites, at an altitude of ≥ 3,000 ft (914 m).

Weather conditions experienced by Shell during the 2012 operations affected the ability to fly offshore for crew changes. Shell has improved the helicopter equipment by equipping crew change and SAR helicopters with Rotor Ice Protection Systems (RIPS) and utilizing improved offshore instrument flight rules. This will enable the helicopters to fly at or above 1,500 ft (457 m) during low-ceiling and/or icing conditions. This allows for crew change to occur on time and reduces the risk for worker fatigue offshore.

The types of aircraft that may be contracted are presented in Table 2.2-5. Some of these aircraft are not yet contracted; the aircraft that are eventually contracted may differ from these, but will be similar. The expected primary uses, fuel storage capacities, and frequency of trips for these aircraft are also indicated in Table 2.2-5.

Table 2.2-5 Fuel Storage Capacity and Trip Information for Support Aircraft

Aircraft Type [1] / Purpose	Maximum Fuel Tank Storage Capacity	Trip Frequency or Duration
Saab 340 B, Beechcraft 1900, Dash 8, or similar fixed-wing aircraft for transport from shorebase to regional jet service in Barrow	9 bbl ($1.4\ m^3$)	Approximately one trip every three weeks between Wainwright and Barrow
S-92 or similar helicopters for crew rotation & groceries/supply (x3)	18 bbl ($2.9\ m^3$)	Approximately 40 round trips/week between shorebase & prospect – approx. 3.0 hr/trip
S-92 or similar helicopter for SAR	18 bbl ($2.9\ m^3$)	Stationed in Barrow – 40 hr/month for proficiency training & trips made in emergency
Gulfstream 690 Aero-Commander or similar (x2)	9.1 bbl (m^3) (Aero-commander)	PSO overflights and ice reconnaissance; both to occur daily when possible

[1] Similar model of aircraft may be contracted for these purposes

2.3 Drilling Units Mobilization, Schedule, and Drill Site Preparation

Mobilization - Entry/Exit from the Chukchi Sea and Schedule

Each exploration drilling season the *Discoverer* drilling unit will be mobilized under its own power, and the *Polar Pioneer* drilling unit will be towed to Dutch Harbor, Alaska or directly to the Burger Prospect. The ice management and anchor handling vessels, and other support vessels will transit from their homeports, or other locations where they are working, to Dutch Harbor, at approximately the same time as the drilling units.

In accordance with 33 CFR 151, Subpart D, the drilling units and foreign support vessels will undergo one or more complete mid-ocean ballast water exchanges before entering U.S. waters or the Alaska Captain of the Port Zone (COTPZ) from another zone to prevent the unintentional introduction of non-native species into the Chukchi Sea. Prior to transiting to the Burger Prospect, the drilling units and support vessels will undergo loadout and refueling and will undergo BSEE, U.S. Coast Guard (USCG), and DNV inspections as well as inspection for U.S. Customs requirements, such as the purging of foreign food materials.

The schedule for exploration drilling activities in the Chukchi Sea will depend on ice conditions and other factors. Both drilling units and their supporting ice management vessels, anchor handlers, OSV, OST and OSR support vessels will transit into the Chukchi Sea on or about 1 July.[3] The 1 July date for entry north of Point Hope into the Chukchi Sea is in accordance with past MMPA authorization requirements that Shell not enter the Bering Strait prior to this date. The July entry is also responsive to concerns voiced by the local communities of Wainwright and Point Lay; these communities have requested that entry into the Chukchi Sea be delayed until after the walrus and beluga whale hunts. PSOs will be onboard transiting vessels while in the Bering and Chukchi Seas. Approximate travel routes for mobilization of the drilling units and support vessels from Dutch Harbor through the Bering Sea and Chukchi Sea to the Burger Prospect are indicated on Figure 2.2-1. The vessel route reflects Shell’s commitment to avoid transit of any part of the Ledyard Bay Critical Habitat Unit (LBCHU) by operational marine traffic. Exploration drilling is expected to commence no earlier than 4 July.

Exploration drilling activities will continue until on or about 31 October, depending on ice and weather conditions. The drilling unit(s) and associated vessels will then exit the Chukchi Sea along approximately the same route they used for entry. Shell may elect to also construct one or more MLCs or upper hole segments (partial holes) in the drilling season. Partial wells are those where a portion of the well construction is completed in one year, but not the entire well to the objective depth. This could be the result of approaching hazard(s) that force cessation of exploration drilling operations prematurely, or a lack of time before the end of the drilling season to complete lower portions of the well. After suspension per BSEE regulations, the part of the well that has been completed does not have to be re-drilled the following drilling season. This capability would allow the operator the ability to re-enter the well during favorable operating conditions in the following drilling seasons. This means evaluating the reservoir at the drill site during the subsequent drilling season(s) would take less time leaving the remainder of the drilling season available to drill at other approved drill sites. It is noted that this occurred in two of the three drilling seasons during the 1989-1991 exploration drilling campaign in the Chukchi Sea. Both wells were drilled to the objective depth and all required data collected in the following drilling season.

If a well cannot reach objective depth by the end of the exploration drilling season, drilling of that well will be finished in a subsequent year or the well will be permanently abandoned as per BSEE regulations prior to lease termination. Any exploration well on which exploration drilling operations are suspended at

[3] *See supra* note 2.

the end of the drilling season will be secured in compliance with BSEE regulations and with the approval of the RS/FO.

All wells will be plugged and permanently abandoned in accordance with BSEE regulations. The only exception to this plan involves the inability to return to the drill site following an emergency evacuation due to an approaching hazard such as ice. If a well cannot be permanently abandoned due to ice, it will be properly suspended per BSEE approval before the drilling unit evacuates. At the beginning of a subsequent drilling season, the drilling unit may return to the drill site to permanently abandon the unfinished well or continue exploration drilling/evaluation of the well.

Mooring of the Drilling Units

Each drilling unit will be positioned and moored over the drill site with its system of eight anchors with the support of the anchor handlers. Anchors for the *Discoverer* are typically pre-set before the drillship is moved into position; the *Polar Pioneer* carries its own anchors and is conventionally moored. Mooring analyses indicate that all planned anchor locations are within a 3,608-ft (1,100 m) radius of the drilling unit. Dimensions of the anchors are provided in Table 2.3-1.

The anchors are embedment-type anchors and therefore designed to penetrate the seafloor to the depth of the anchor and drag through the seafloor sediments for a distance two or three times the anchor length itself before becoming firmly set in the seafloor. Setting the anchors and subsequent anchor removal disturbs the seafloor and commonly leave a depression on the seafloor. The anchor chain will also be dragged along the seafloor creating a trough equal to the dragged chain length. The total disturbed area for each anchor placement is the sum of the area disturbed by the anchor plus the area disturbed by the chain. The dimensions of these disturbed areas vary with the size of the anchor, the length of the anchor chain and the consistency of the seafloor sediments. The expected dimensions of the area disturbed by a single anchor and the volume of sediments that might be displaced by each anchor are provided in Table 2.3-1. Expected or average dimensions of the area disturbed by anchors resulting from Shell's exploration drilling program are provided in Table 2.3-2, assuming that all eight anchors are set once per location.

Table 2.3-1 Dimensions of Drilling Unit Anchors and Potential Anchor Disturbed by a Single 33,000 lb (15,000 kg) Anchor[1]

	Estimated Disturbed Width on Seafloor	Estimated Seafloor Penetration	Estimated Disturbed Length on Seafloor[2]	Estimated Total Disturbed Seafloor Surface Area	Estimated Disturbed Seafloor Sediment Volume
Anchor	22.5 ft (6.9 m)	12.6 ft (3.8 m)	62.6 ft (19.1 m)	1,410 square feet (ft^2) (131 square meters [m^2])	17,747 ft^3 (503 m^3)
Line and Chain[3]	1 ft (0.3 m)	1 ft (0.3 m)	1,100 ft (335 m)	1,100 ft^2 (102 m^2)	1,100 ft^3 (31 m^3)
Totals:				2,510 ft^2 (233 m^2)	18,847 ft^3 (534 m^3)

[1] This is the anticipated maximum size of each anchor and was utilized in Section 4.0 impacts assessment
[2] Disturbed length is based on the anchor length of 20.9 ft (6.4 m) x 3.0
[3] Mooring analyses indicates grounded length of up to approximately 1,100 ft (335 m); estimated disturbed width of grounded length is 1 ft and estimated penetration into the seafloor is 1 ft

Table 2.3-2 Estimated Seafloor Area Disturbed by Mooring the Drilling Unit

Time Period	Anchors	Estimated Disturbed Seafloor Area	Estimated Disturbed Seafloor Sediment Volume
Per Well	8	20,080 ft^2 (1,866 m^2)	150,776 ft^3 (4,259 m^3)
Per Program[1]	64	160,640 ft^2 (14,928 m^2)	1,206,208 ft^3 (34,072 m^3)

[1] "Program" refers to six drill sites in EP Revision 2; includes contingency for re-setting 16 anchors, if necessary

Wet Storage of Anchors for the Containment System Barge

The containment system barge will be moored in Kotzebue Sound and would be mobilized to the Burger Prospect if needed; however, the anchors for the barge may be wet stored, or located for storage on the seafloor, in the Burger Prospect during the exploration drilling season. The anchor system consists of eight 7MT Stevshark Mk5 anchors and one 25.3 MT Stockless anchor. The anchors may be transported to the prospect and stored on the seafloor after the drilling units are moored, and may be removed at the end of the drilling season. The storage location will be at one of Shell's approved drill sites, where a shallow hazards survey and archaeological assessment has been conducted.

MLC Construction

An MLC will be constructed at each drill site. The MLCs will be constructed in the seafloor using either a large diameter bit (disk harrow) operated by hydraulic motors and suspended from the *Discoverer* or *Polar Pioneer* or with a tool on a ROV herein referred to as the MLC ROV system (described below). Approximate dimensions of the resulting MLCs are presented below in Table 2.3-3. The MLC constructed by the MLC ROV System is larger than that of a conventional bit because of the different technology involved.

Table 2.3-3 Dimensions of MLCs Planned for Chukchi Sea Drill Sites

Equipment	Location	Estimated Dimensions (ft)(Length x Height x Width)	Estimated Cuttings Volume in ft^3 (bbl)	Estimated Surface Area Disturbed ft^2 (m^2)	Assumptions
MLC ROV System	Ramp	150 x 20 (40/2) x 30	90,000 (16,028)	4,500 (418)	Assumes vertical sides. No additional washout included. Height is 0 ft at beginning of the ramp and 40 ft as it terminates at the MLC. Assumes ramp at 15° slope.
	MLC	30 x 40 x 30	36,000 (6,411)	900 (84)	Assumes vertical sides. No additional washout included.
	MLC Sides	30 x 20 (40/2) x 14.84 x 3	26,712 (4,758)	1,336 (124)	Assumes 3 sides each sloped at approximately 70 degrees.
		Estimated Totals:	**152,712 (27,197)**	**6,736 (626)**	
Equipment	**Location**	**Dimensions (Radius x Height (ft))**	**Estimated Cuttings Volume in ft^3 (bbl)**	**Estimated Surface Area Disturbed in ft^2 (m^2)**	**Assumptions**
MLC Bit	MLC	10.5 x 40	13,854 (2,469)	See assumption	Estimated surface area disturbed included in MLC washout calculation.
	MLC Washout	See assumption	6,927 (1,234)	1,075 (100)	Volume includes approximately 50% volumetric washout of MLC volume of 13,854 ft^3; assume surface radius widens to 18.5 due to washout.
		Estimated Totals:	**20,781 (3,703)**	**1,075 (100)**	

Note:
1 bbl = 5.615 ft^3
10.76 ft^2 = 1 m^2

The purpose of the MLC is to ensure that the top of any portion of the wellhead and BOP is located below the maximum ice keel gouge depth (30 CFR 250.451(h)). Shallow hazards surveys (GEMS 2009; Fugro GeoConsulting, Inc. 2010a,b,c,d,e,f; Fugro GeoConsulting, Inc. 2011a,b) conducted in the area of the planned exploration drill sites in the Burger area, indicate that the observed ice gouge occurrence ranges from infrequent to pervasive depending on the drill site, with a maximum observed depth of about 5.0 ft (1.5 m) below the seafloor.

The area of seafloor that would be directly disturbed by excavation of MLCs for one well and for the exploration drilling program, are provided below in Table 2.3-4, along with the total volumes of sediment that would be displaced. The sediments will be discharged on or near the surface of the seafloor at the drill site.

Table 2.3-4 Estimated Seafloor Area Disturbed Directly by MLC Construction

Time Period	Equipment	MLC's	Estimated Cuttings Volume		Estimated Seafloor Footprint	
			ft^3 (bbl)	m^3	ft^2	m^2
Per Well	MLC ROV System	1	152,712 (27,197)	4,327	6,736	626
	MLC Bit	1	20,781 (3,703)	589	1,075	100
Drilling Program	MLC ROV System	6	916,272 (163,182)	25,964	40,416	3,756
	MLC Bit	6	124,686 (22,218)	3,534	6,450	600

Note:
1 bbl = 5.615 ft^3
10.76 ft^2 = 1 m^2
35.29 ft^3 = 1 m^3

The MLC ROV System

The MLC ROV system provides a mechanical means to implement an MLC from an ROV rather than from a drilling unit. The MLC ROV system would use implements such as an excavator bucket, a rotating cutter, auger, drill, and rock hammer on the ROV sled. The intention of the use of the MLC ROV system is to ultimately remove MLC construction from the work stream of the drilling units in the future, to allow more time for drilling in lower well intervals. Use of an MLC ROV system would require an additional OSV type vessel from which the ROV would be transported, deployed and operated. Photographs of some systems that could be used as the MLC ROV system are provided below. The MLC ROV system is approximately 26 ft (8.0 m) long x 21 ft (6.3) m wide x 16 ft (5.0) m high.

Photograph MLC ROV Systems

Drilling

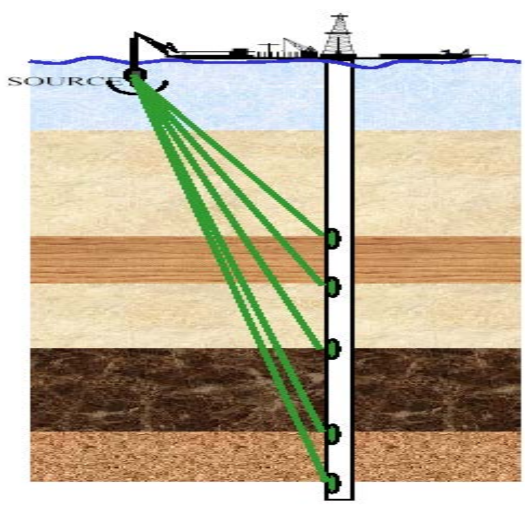
Standard rotary drilling technology and water-based drilling fluids will be used for exploration drilling. The geologic formations and fluids within each wellbore will be evaluated with down hole techniques, including mud LWD (logging while drilling), and EWL (electric wire line) logging. The EWL program will involve lowering sensors down the wellbore with a cable that will relay data back to surface instrumentation with data being recorded in a "log." The LWD and EWL tools may include both electric and radioactive logs. The wells will not be flow tested and no oil or gas will be produced. Once the exploration well is drilled to its final TD and logging (Zero-Offset Vertical Seismic Profile) ZVSP survey program is finished, it will be permanently plugged and abandoned in accordance with BSEE regulations (30 CFR 250.1712-1717).

2.4 Vertical Seismic Profiling

Shell plans to conduct a geophysical activity referred to as a vertical seismic profile (VSP) at each drill site. During VSP operations, an air gun array, which is typically much smaller than those used for routine seismic surveys, is deployed at a location near or adjacent to the drilling unit, while receivers are placed (temporarily anchored) in the wellbore. The sound source (air gun array) is fired, and the reflected sonic waves are recorded by receivers (geophones) located in the wellbore. The geophones, typically a string of them, are then raised up to the next interval in the wellbore and the process is repeated until the entire wellbore has been surveyed. The purpose of the VSP is to gather geophysical information at various depths in the well, which can then be used to tie-in or ground-truth geophysical information from the previously acquired 2D and 3D seismic surveys with geological data collected within the wellbore.

Shell would likely be conducting a particular form of VSP referred to as ZVSP surveys, in which the sound source is maintained at a constant location near the wellbore (Figure 2.4-1). Shell may use one of two typical sound sources: 1) a three-air gun array consisting of three 150-in^3 (2,458-cm^3) air guns, or 2) a two-air gun array consisting of two 250-in^3 (4,097-cm^3) air guns. The air guns can be activated in any combination and Shell would utilize the minimum volume required to obtain an acceptable signal. Specifications for the maximum volume of the array are provided in Table 2.4-1. Typical receivers would consist of a standard wireline four-level vertical seismic imaging (VSI) tool, which has four receivers 50 ft (15.2 m) apart.

Figure 2.4-1 Schematic of ZVSP Survey



Photograph 3-Air Gun Array in Sled

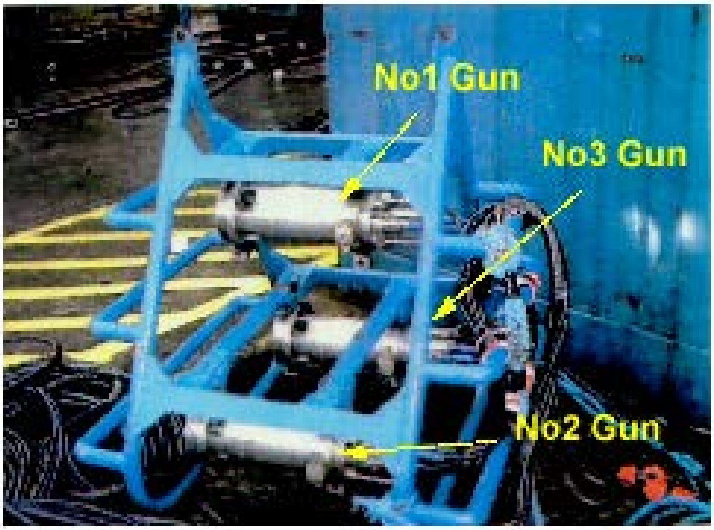


Table 2.4-1 Sound Source (Air Gun Array) Specifications for Planned ZVSP Surveys

Source Type	Number of Sources	Max. Total Chamber Size	Pressure	Source Depth	Zero-Peak Sound Pressure Level
Sleeve Array	(3) air guns (3) 150 in^3	450 in^3 7,374 cm^3	3,000 psi 207 bar	23 ft (7.0 m)	241 dB re1µPa @1m
Sleeve Array	(2) air guns (2) 250 in^3	500 in^3 8,194 cm^3	3,000 psi 207 bar	23 ft (7.0 m)	239 dB re1µPa @1m

µPa – micro Pascal
dB – decibel
psi- pounds per square inch

A ZVSP survey is typically conducted at each well after TD is reached but may be conducted at a shallower depth. For each well, the sound source (air gun array) would be deployed over the side of the *Discoverer* or *Polar Pioneer* with a crane. The sound source will be positioned 50 to 200 ft (15 to 61 m) from the wellhead (depending on crane location), at a depth of 23 ft (7 m) below the water surface. Receivers will be temporarily anchored in the wellbore at depth (Figure 2.4-1). The sound source will be pressured up to 3,000 psi, and activated 5 to 7 times at approximately 20-second intervals. The receivers will then be moved to the next interval of the wellbore and re-anchored, after which the air gun array will again be activated 5 to 7 times. This process will be repeated until the entire well bore has been surveyed in this manner. The interval between anchor points for the receiver array is usually 200 to 300 ft (61 to 91 m). A typical ZVSP operation takes about 10 to14 hours (hr) to complete depending on the depth of the well and the number of anchoring points.

2.5 Exploration Drilling Operations and Logistics)

Shorebase facilities and logistics such as crew rotation, refueling, and resupply are addressed below.

Air Support Shore Base Facilities at Barrow

Primary shorebase facilities for air support will be located in Barrow, and will consist of:

- An existing 75-man camp with Kitchen/Dining/Recreation (KDR) unit
- A planned 40-man camp
- An existing passenger processing facilities to be expanded
- Shell helicopter hangar
- Cape Smythe helicopter hangar
- Pilot office
- Rental housing for air crews
- Rental of blocks of hotel rooms

Primary shorebase facilities for air support will be located in Barrow at the state-owned and operated Barrow Wiley Post Will Rogers Memorial Airport (Barrow Airport). The Barrow Airport has a 6,500 x 150 ft (1,980 x 46 m) paved runway, hangar and service facilities, passenger terminal, and jet service. Shell will house the crew change and SAR helicopters at the Shell hangar and the Cape Smythe hangar at the Barrow Airport (Figure 2.5-1). Space is leased at the airport to serve as a pilot office (Figure 2.5-1). Helicopter crews will be housed at rental properties (approximately eight houses) in Barrow. Passenger processing facilities for processing offshore crews have been established at the airport (Figure 2.5-1), and will be expanded. The expansion would consist of four adjoining buildings totaling approximately 2,200 ft^2 (204 m^2). The expansion would adjoin the existing passenger facilities (Figure 2.5-2) and would be located on previously developed lands adjacent to the airport and controlled by Federal Aviation Association (FAA). The facilities will be constructed and operated by Ukpeaġvik Iñupiat Corporation (UIC) and leased to Shell. No State or Federal permits are required. The expansion will be permitted with the NSB.

Shell has a 75-man camp for housing offshore crew that cannot fly out the same day they arrive. These consist of skid-mounted modular buildings and are located on an existing pad located in the Naval Arctic Research Laboratory (NARL) area (Figure 2.5-3) approximately 4.0 mi (6.4 km) from the center of Barrow. The camp is supported by a KDR unit; capable of providing meals for up to 200 people. The KDR unit is approximately 166 ft long by 64 ft wide and is installed on a pad at the southwest corner of the existing accommodations (Figure 2.5-4). The 75-person camp and KDR unit have been permitted by UIC with the NSB with a Development Permit and a fill permit, and with the SOA Fire Marshal. In addition, UIC has obtained a Preapproved Emission Limit (PAEL) from the Alaska Department of Environmental Conservation (ADEC). The PAEL establishes an annual limit on diesel fuel usage for the 75-person camp and KDR unit which limits potential emissions below air quality permitting thresholds. No additional State or Federal authorizations were required.

Accommodations at the 75-man camp will be augmented by leasing an additional existing 40-man construction camp owned by UIC. UIC will re-locate the 40-man camp from its existing location in Barrow to a similar sand pad constructed by the U.S. Navy in the 1940’s as indicated in Figure 2.5-3. The existing pad is also located in the NARL area about 0.75 mi (1.2 km) from the 75-man camp. The modular accommodations owned by UIC are currently unused and reside in Barrow. They would be moved to the pad and installed on the pad through pad pilings. Permitting of these facilities is not Shell’s responsibility as the facilities are not Shell's. Shell will lease the facilities once installed at the new location. The KDR would service both man camps and overflow facilities. The shorebase is expected to be staffed by 6 to 7 local hires.

Black water (sewage) and gray water (showers, kitchen) from the two camps will be held in holding tanks at each site. Based on camp occupancy of 100 percent capacity, and average per capita waste generation factors provided by the local utility, Shell expects to generate about 23,000 gallons (gal) of combined black water and gray water wastes per day. These wastes will be picked up by the NSB with their routine service and treated in their waste water plant. These wastes generated by camps with temporary population of 115 persons, will not tax Barrow's municipal wastewater treatment system, which accommodates a population of over 4,000 people, and consists of a series of large water treatment lagoons.

Household trash from the camps will be stored in bear proof containers or areas. These household wastes will be transported to the NSB Landfill for disposal. Shell estimates, based on 2012 Barrow operations and accounting for the additional planned camp accommodations, that the two man camps may generate up to 600 yd^3. (153 m^3) of household trash per season, which represents less than 1.3 percent of the average annual volumes disposed of at the landfill.

Non-household waste generated at the camps will be stored in a 20-ft (6.1-m) shipping container set up as a waste accumulation area located behind the primary camp. The accumulation area will hold any hazardous, non-hazardous and liquid wastes. All of Shell's Barrow facilities are operated as a Conditionally Exempt Small Quantity Generators (CESQG) of Hazardous waste by the EPA, and therefore a permit is not required and hold times do not apply. These wastes will be transported out of the Arctic and disposed of at licensed facilities.

Marine and Air Support Shorebase Facilities at Wainwright

Primary shorebase facilities for marine support will be located in Wainwright, and will consist of:

- Existing accommodations for up to 55 persons at the Olgoonik Field Services Camp
- An existing secure 100 ft x 300 ft yard leased from Olgoonik Oilfield Services
- Additional existing 150 ft x 200 ft camp pad

Shorebase facilities for marine support will be established in Wainwright for the duration of the exploration drilling program. The marine support shorebase facilities in Wainwright will be used as a base for shuttling materials and crew changes between land and the drilling units, and the shorebase and OSR support vessels. Marine access may be accomplished by a relatively shallow draft vessel and OSR workboats. There currently are no docks in Wainwright and no new docks are planned for this exploration drilling program. There are two earthen boat ramps (at the lagoon and at the lagoon entrance) connected to the village by gravel roads that would be used for marine access and support by shallow draft vessels. The primary ramp would be the lagoon ramp, and the primary use of the ramp would be to support OSR training. Lifting and hoisting equipment would be installed near the ramp with a boom truck, fork lift, and smaller pieces of equipment.

Shell will reserve rooms for up to 55 persons at the existing Olgoonik Oilfield Services Camp in Wainwright (Figure 2.5-5). Shell's OSR group will be housed and fed at these facilities. Shell may utilize these rooms to accommodate certain contingencies such as Shell conducting crew changes through Wainwright, or conducting onshore environmental studies in the area. At this time, this would involve only the potential reservation of additional rooms. Construction of new facilities or expansion of existing facilities at Wainwright is not planned at this time.

With the exception of food waste from the camp kitchen, all wastes generated at the Wainwright camp will be containerized and transported out of the Arctic to approved disposal facilities. Food wastes from the kitchen will be disposed in the Wainwright landfill. This waste handling approach will minimize the impact to the community, including the landfill. Based on water usage information provided by the ADEC website, it is estimated that the response group will generate less than 200 gal of black water and gray water (combined) per day on average. This equates to approximately 2.0 percent of the estimated average generation rate for the entire village, based on a 2012 population of 575.

An existing secure yard approximately 100 ft x 300 ft owned by Olgoonik Corporation will be leased from Olgoonik Oilfield Services (owned by Olgoonik Corporation) for storage of OSR equipment and load staging for the marine vessels in Wainwright. An additional existing 150 ft x 200 ft yard space approximately will be leased from Olgoonik Oilfield Services for additional response equipment storage.

All wastes generated at the Wainwright OSR Yard will be containerized and transported out of the Arctic to an approved disposal facilities. These actions taken by Shell, with respect to waste handling, will minimize the impact to the community, including the landfill.

The airstrip in Wainwright will also be utilized for rotating OSR personnel in and out of Wainwright. The Wainwright airstrip is gravel, 4,494 x 90 ft (1,370 x 27 m), and maintained year round.

Crew Rotation

The offshore crews will work a schedule of 21 days of work (or longer) followed by 21 days off (or longer). They will be transported to the shorebase by helicopter at the end of each 21-day (or longer) shift Crew rotation will be staggered. Approximately 40 helicopter round-trips per week are anticipated between the marine shorebase facilities and the drill sites. Off-shift crewmembers will be transported by a fixed-wing aircraft from the shorebase facilities to Anchorage or Fairbanks, using commercial and chartered flights.

Refueling

Extra fuel for offshore exploration drilling operations will be brought into the Chukchi Sea on the OST. Refueling of the drilling units will be accomplished by lightering fuel between the OST and the drilling units with a support vessel. Refueling of each drilling unit may be required an estimated 3-5 times during each exploration drilling season. Refueling will be vessel-to-vessel in accordance with USCG regulations, BOEM Lease Stipulation 6, and Shell’s Fuel Transfer Plan (FTP). Although BOEM stipulation number 6 requires pre-booming of the vessels for fuel transfers of 100 bbl or more, Shell will pre-boom during all fuel transfers, per Shell’s FTP.

Resupply

Exploration drilling requires numerous types of supplies such as drill pipe, dry drilling fluid chemicals, bulk cement, casing, drill collars, drill bits, etc. The drilling units can hold most of the supplies required for one well plus some additional spare materials and supplies. Additional supplies will be brought to each drilling unit by the OSVs, as required. A total of about 30 round-trips between Dutch Harbor and the Burger Prospect with the OSVs will be required during an exploration drilling season. Some supplies may be brought to the shorebase via fixed-wing aircraft and transferred to the drilling units or offshore vessels via helicopter. The helicopter trips necessary to transport supplies are included in the estimate of approximately 40 total helicopter round-trips per week between the prospect and the shorebase. Resupply and crew transport for OSR support vessels will be accomplished primarily using the Nanuq (or similar) to transport the crews to the drilling units or other vessel with a heli-deck for helicopter transport to the shoreline. The locations of vessel routes to and from the shorebase are indicated in Figure 2.2-1.

Figure 2.5-1 Barrow Air Terminal Facilities Locations

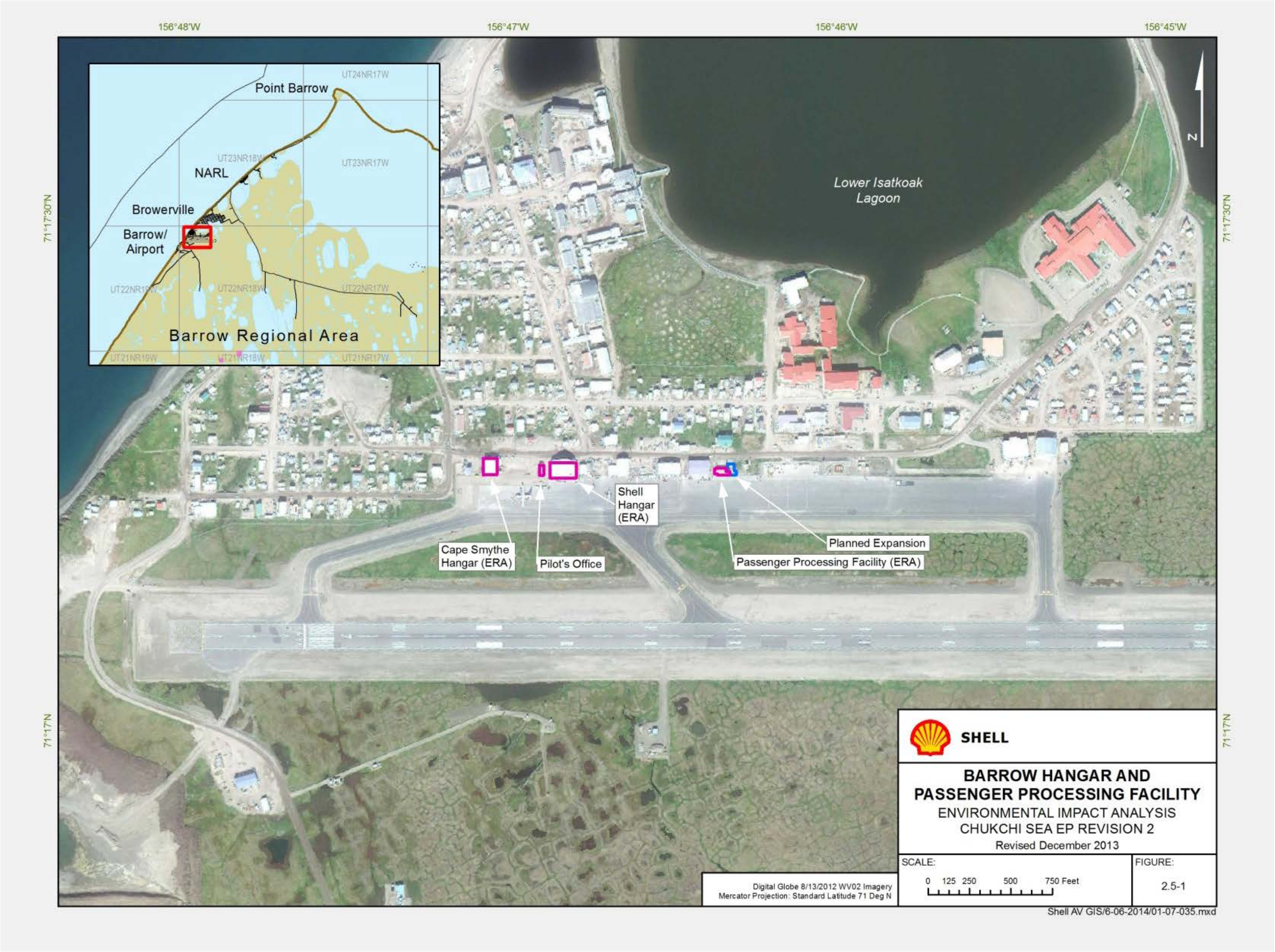


Figure 2.5-2 Barrow Passenger Processing Facilities Expansion Diagram

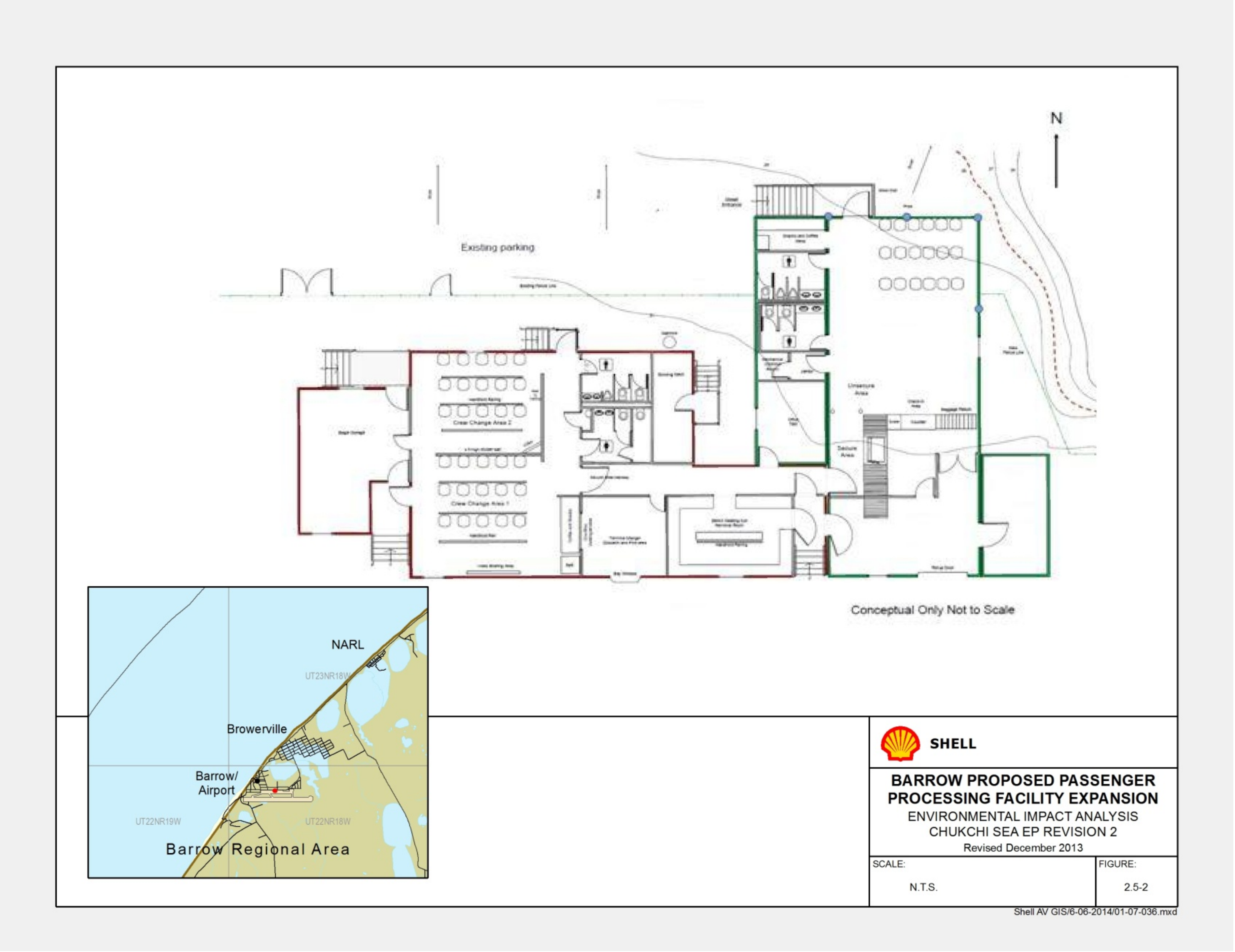


Figure 2.5-3 Barrow Man Camp Locations

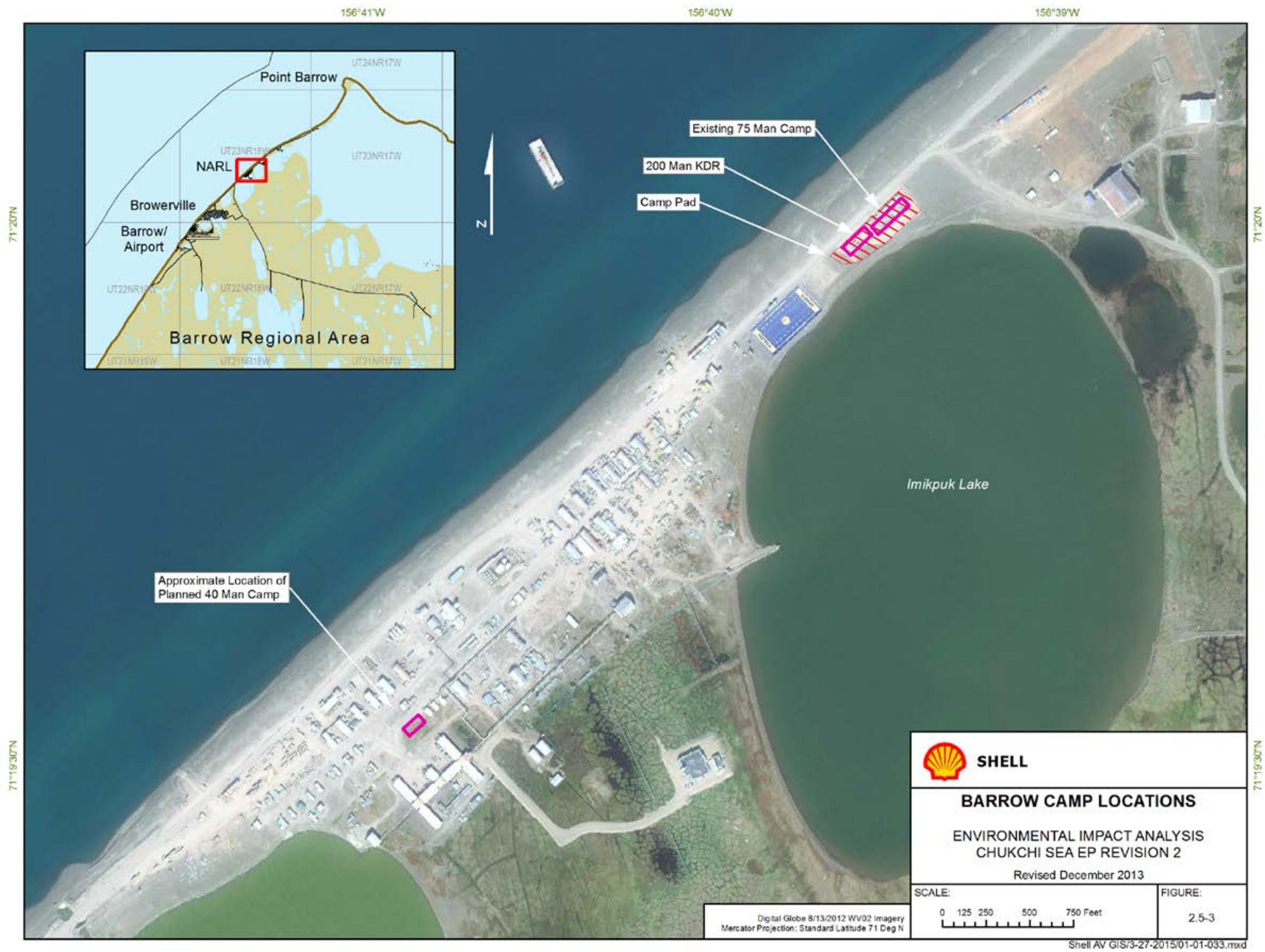


Figure 2.5-4 Layout and Planned Expansion of Shell's Existing 75-Person Man Camp

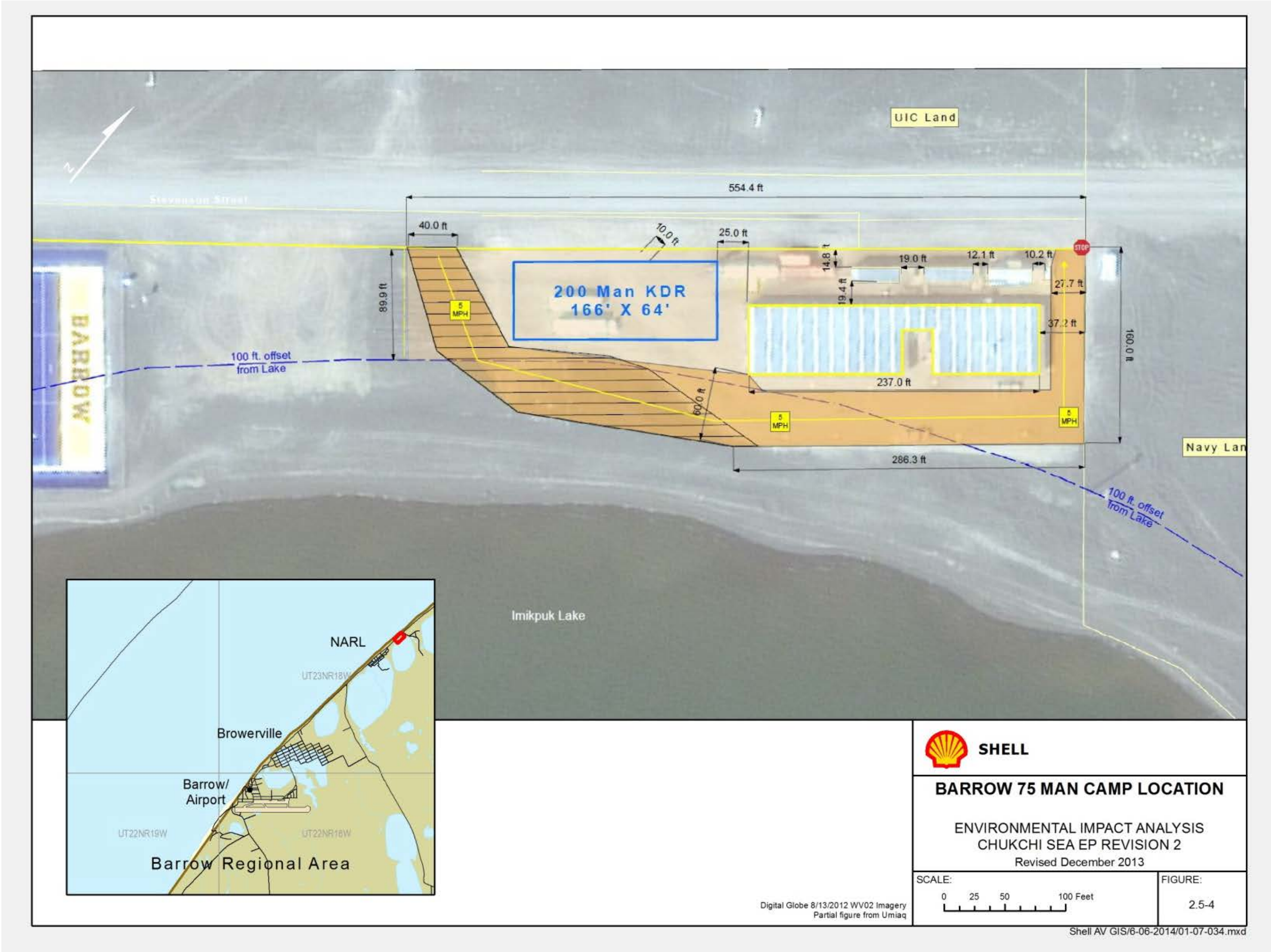
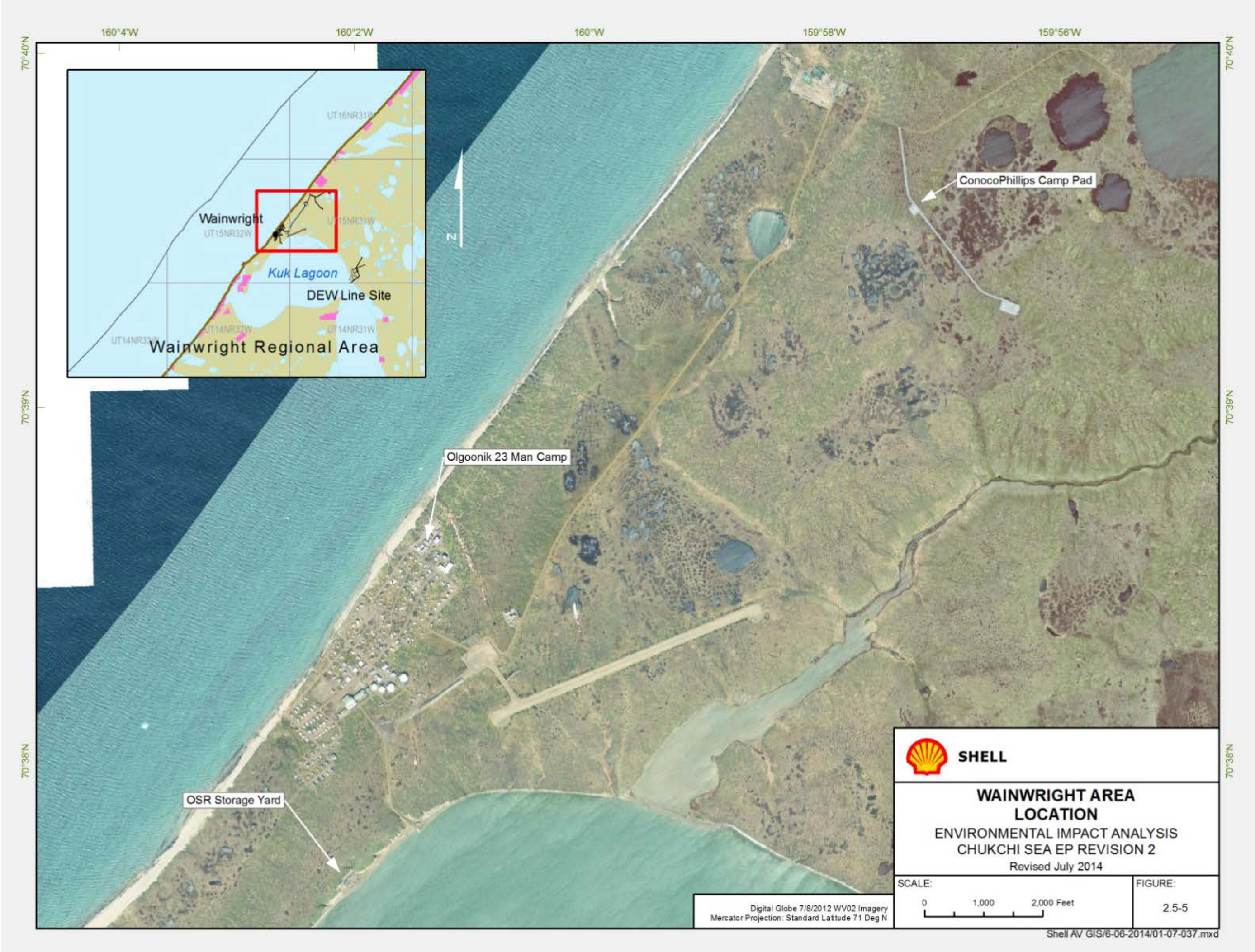


Figure 2.5-5 Wainwright Camp Location



The SAR helicopter will be stationed and serviced in existing facilities at the Barrow Airport. The crew change helicopters will also be stationed at the Barrow Airport. Offshore crewmembers will be transported to shore at Barrow or sometimes at Wainwright via the crew change helicopters. Crews will be transported from shore to Anchorage via a mix of commercial and chartered fixed wing aircraft

2.6 Drilling Fluids and BOP Fluids

Drilling fluids will generally consist of untreated saltwater with gel/polymer sweeps for the MLC (by conventional bit) and the conductor and structural casing sections (Table 2.6-1). After the marine riser and BOP are established, the lower intervals will be drilled using water based drilling fluids (Table 2.6-2). Three basic drilling fluids will be used: 1) gel polymer sweeps / weighted gel / polymer fluid for the upper well sections; 2) KLA-SHIELD inhibitive water based fluid for the lower well sections; and, 3) water based abandonment fluid for the end of well. Base fluid components, additives, and contingency additives for these base fluid types are indicated in Tables 2.6-1, 2.6-2, and 2.6-3. In addition to these components, potassium chloride (KCL) is considered a contingent fluid that could be added to the water based spacer fluids pumped ahead of the cement when cementing.

Table 2.6-1 Gel/Polymer Sweeps/Weighted Polymer Fluid Components

Generic Description	Product Name	Maximum Concentration
BASE FLUID		
Biopolymer	DUOVIS	5 lb/bbl
Bentonite	M-I GEL	35 lb/bbl
Bentonite extender	GELEX	0.05 lb/bbl
Polyanionic cellulose	Polypac Supreme UL	5 lb/bbl
ADDITIVES		
Crushed nut hulls	NUT PLUG	20 lb/bbl
CONTINGENCY PRODUCTS		
Barite	M-I WATE	160 lb/bbl
Defoamer	DEFOAM-X	0.3 lb/bbl
Dye	Sodium Fluoresceine Green Dye	0.5 gal/bbl in seawater
Caustic soda	stock product	8 lb/bbl
Citric acid	stock product	5 lb/bbl
Sodium acid pyrophosphate (SAPP)	stock product	To be determined
Soda ash	stock product	13 lb/bbl
Biocide	Busan 1060	0.4 lb/bbl
NaCl brine	Sodium chloride brine	100 lb/bbl
Hydrogen sulfide scavenger	SAFE-SCAV HS	0.1 lb/bbl
Surfactant	SCREENKLEEN	2% v/v
Lubricant	DRILLZONE	7% v/v

v/v=volume/volume

Table 2.6-2 Components of the KLA-SHIELD Inhibited Water Based Mud (WBM)

Generic Description	Product Name	Maximum Concentration
BASE FLUID		
Soda ash	stock product	12 lb/bbl
Acrylic polymer	IDCAP D	5 lb/bbl
Shale/clay inhibitor	EMI-2009	20 lb/bbl
Shale/clay inhibitor	KLA-STOP	20 lb/bbl
Biopolymer	DUOVIS	2 lb/bbl
Biopolymer	Flowzan	2 lb/bbl
Polyanionic cellulose	POLYPAC SUPREME UL	5 lb/bbl
Sodium hydroxide	Caustic Soda	8 lb/bbl
Barite	M-I WATE	160 lb/ bbl
Sodium chloride in brine	Salt/NaCl	100 lb/bbl
ADDITIVES		
Copolymeric shale stabilizer	POROSEAL	19 lb/bbl
Deflocculant	CF Desco®II	4 lb/ bbl
Sodium bicarbonate	stock product	10 lb/bbl
Citric acid	stock product	4 lb/bbl
Liquid defoamer	DEFOAM-X	0.3 lb/bbl
Liquid defoamer	DF-9065	0.3 lb/bbl
Crushed nut hulls	NUT PLUG MED	40 lb/bbl
Crushed nut hulls	NUT PLUG FINE	40 lb/bbl
Vegetable, polymer fiber blend	MI SEAL	40 lb/bbl
Cellulose fiber	MIX II Fine	25 lb/bbl
Cellulose fiber	MIX II MED	25 lb/bbl
Graphite	G-SEAL	10 lb/bbl
Calcium carbonate	SAFECARB-20	200 lb/bbl
Calcium carbonate	SAFECARB-40	200 lb/bbl
Calcium carbonate	SAFECARB-250	200 lb/bbl
Sodium chloride	stock product	100 lb/bbl
Resinated lignite	RESINEX	10 lb/bbl
Sulfonated asphalt	ASPHASOL SUPREME	8 lb/bbl
CONTINGENCY PRODUCTS		
Mixture	FORM-A-BLOK	40 lb/bbl
Cellulose	FORM-A-SET AK	Formulation pill
Zinc oxide	Sulf-X	2.5 lb/bbl
Biocide	Busan 1060	0.4 lb/bbl
Mixture	Pipelax ENV WH	4% v/v
Mixture	LUBE 945	3% v/v
Mixture	CLEAN SPOT	4% v/v
Surfactant	SCREENKLEEN	2% v/v
Lubricant	DRILLZONE	7% v/v
Mixture	SAFE-SCAV HS	0.1 lb/bbl

[1] Source: Shell drilling fluids plan for the Chukchi Sea (M-I SWACO 2013)

Table 2.6-3 Components of the Abandonment Fluids

Generic Description	Product Name	Maximum Concentration
BASE FLUID		
Soda ash	stock product	12 lb/bbl
Biopolymer	DUOVIS	2 lb/bbl
Sodium hydroxide	Caustic Soda	8 lb/bbl
Barite	M-I WATE	160 lb/ bbl
Sodium chloride in brine	Salt/NaCl	40 lb/bbl
Corrosion inhibitor	Conqor 404	0.5 lb/bbl
Hydrogen sulfide scavenger	SAFE-SCAV HS	0.1 lb/bbl
Oxygen scavenger	Sodium Metabisulfite	0.5 lb/bbl
ADDITIVES		
Acrylic polymer	IDCAP D	5 lb/bbl
Shale/clay inhibitor	KLA-STOP	20 lb/bbl
Polyanionic cellulose	POLYPAC SUPREME UL	5 lb/bbl
Copolymeric shale stabilizer	POROSEAL	19 lb/bbl
Deflocculant	CF Desco II	4 lb/ bbl
Sodium bicarbonate	stock product	10 lb/bbl
Citric acid	stock product	4 lb/bbl
Biocide	Busan 1060	0.4 lb/bbl
Liquid defoamer	DEFOAM-X	0.3 lb/bbl
Calcium carbonate	SAFECARB-20	200 lb/bbl
Calcium carbonate	SAFECARB-40	200 lb/bbl
Sodium chloride	stock product	100 lb/bbl
Resinated lignite	RESINEX	8 lb/bbl
Sulfonated asphalt	ASPHASOL SUPREME	8 lb/bbl
CONTINGENCY PRODUCTS		
Sodium bromide brine	NaBr	212 lb/bbl

[1] Source: Shell drilling fluids plan for the Chukchi Sea (M-I SWACO 2013)

The BOP fluid will be a mixture of fresh water (approximately 45%), concentrate (approximately 5%) and monoethylene glycol (approximately 50%). The concentrates may contain, but are not limited to, Stack Magic, Erifon HD603, and/or Pelagic.

2.7 Waste Management

The types and volumes of wastes that will be generated as a result of the exploration drilling program are described below by the method of disposal. Shell plans to use only water-based drilling fluids (mud).

Drilling Wastes

Drilling wastes as defined here include drill cuttings with adhered drilling fluids and bulk mixed drilling fluids. Drill cuttings are the geologic or earthen materials that are pulverized by the drill bit and brought to the surface by the circulating drilling fluids. Drill cuttings are chips of naturally occurring rocks including clays, limestone, shale, siltstone and sandstone and other benign materials that pose no harm to the environment. At the surface, the cuttings are separated from most of the drilling fluids with shakers, de-sanders, and de-silters, although some fluids remain adhered to the cuttings. Drilling fluids will be recovered, reconditioned, and reused when practicable; however, it is expected that all mixed drilling fluids in the reserve pit plus the circulating volume (total of approximately 1,500 bbl for the *Discoverer*, 2,427 bbl for the *Polar Pioneer*) will be discharged at the end of each well.

Volumes of drilling fluids and drill cuttings that would be generated and discharged per well were estimated based on planned wellbore volume, anticipated washout percentage; adhered drilling fluids on cuttings; and experience in the 2012 drilling season. Actual volumes will vary, due to the specific geologic materials encountered and drilling practices. The volumes expected to be generated and discharged are indicated in Tables 2.7-1 (drill cuttings per well using either the MLC bit or MLC ROV System) and 2.7-2 (maximum drilling fluids discharged - occurs when using the MLC bit). Volumes will also differ depending on what technology is used at the particular well for MLC construction. If the MLC ROV system is utilized, the MLC is of greater dimensions so the cuttings volume will be greater; however, the MLC ROV System does not require gel sweeps, so the drilling fluid volumes will be less.

Table 2.7-1 Estimated Volume of Drill Cuttings Generated at Each Drill Site

Portion of Well	Burger A[1,2] (bbl)	Burger F[1] (bbl)	Burger J[1] (bbl)	Burger R[1] (bbl)	Burger S[1] (bbl)	Burger V[1] (bbl)
Upper well (includes Intervals 1, 2 and 3	5,007	5,006	5,089	5,003	5,005	5,089
Lower well sections (includes Intervals 4, 5, and 6)	1,052	1,043	915	1,077	1,074	1,153
Total	6,059	6,049	6,004	6,080	6,079	6,242
Volume of Cuttings if the MLC ROV System is Used for the MLC						
Upper well (top hole)	not applicable	28,500	28,583	28,497	28,499	28,583
Lower well sections	1,052	1,043	915	1,077	1,074	1,153
Total	1,052	29,543	29,498	29,574	29,573	29,736

[1] Discharge values taken from Tables 6.b-1 of EP Revision 2 (March 2015)
[2] Upper well section drilled in 2012 season

Table 2.7-2 Estimated Maximum Drilling Fluid Discharges at Each Drill Site

	Burger A[1] (bbl)	Burger F[1] (bbl)	Burger J[1] (bbl)	Burger R[1] (bbl)	Burger S[1] (bbl)	Burger V[1] (bbl)
Drilling fluids[2]	6,231	9,308	8,753	9,473	9,463	9,943
Reserve tank [3]	2,427	2,427	2,427	2,427	2,427	2,427
Total	8,658	11,735	11,180	11,900	11,890	12,370

[1] Discharge values taken from Tables 6.b-1 of EP Revision 2 (March 2015). For example, Burger F drilling fluids total (11,735 bbl) is the sum total of drilling fluids used when drilling Intervals 1-3 (3,124 bbl), plus drilling fluids used when drilling Intervals 4-6 (6,184 bbl), and plus the reserve tank volume (2,427 bbl).
[2] Maximum drilling fluid discharges are anticipated when the MLC is constructed using the MLC bit.
[3] Reserve tank fluids to be discharged at end of the well, tank volume of *Polar Pioneer* used as volume slightly greater than the *Discoverer's*.

Drilling wastes will be discharged to ocean waters, in accordance with the NPDES exploration facilities GP. Drilling wastes from the upper well sections, which include the MLC and other intervals prior to installation of the marine riser, will be discharged at the seafloor via a seafloor pump as NPDES exploration facilities GP Discharge 013 (muds, cuttings and cement at the seafloor, Table 2.7-3). Drilling wastes from the lower well sections (intervals drilled after marine riser connection) will be discharged to the Chukchi Sea via the disposal caisson as NPDES exploration facilities GP Discharge 001 (Table 2.7-

3). The disposal caisson on the *Discoverer* is a 15-in. (38-cm) diameter open pipe (no float valve) that is welded to the sponson and extends from the main deck level down to a location 19.6 ft (6.0 m) below mean sea level. Because it remains open to the sea at all times, it is constantly filled with water. The disposal caisson on the *Polar Pioneer* is similar but is approximately 16.0 in. (40 cm) in diameter and would discharge at a depth of approximately 28 ft (8.5 m) below the surface. In addition to the drilling fluids and cuttings, BOP fluids will be discharged (Discharge 006, Table 2.7-3) when conducting pressure tests and function tests of the BOP, and excess cement and rinsate from the cement tank (Discharge 012, Table 2.7-3) will be discharged after cementing each casing string and after setting cement plugs in the wellbore during plugging and abandonment.

Table 2.7-3 Estimated Drilling Waste Discharges at Each Drill Site

		Burger A[1] (bbl)	Burger F[1] (bbl)	Burger J[1] (bbl)	Burger R[1] (bbl)	Burger S[1] (bbl)	Burger V[1] (bbl)
NPDES2 Discharge 001(drilling fluids and drill cuttings)		9,710	9,654	8,888	9,856	9,841	10,316
NPDES Discharge 006 (BOP fluid)		180	180	180	180	180	180
NPDES Discharge 012 (excess cement slurry)		45	45	45	45	45	45
NPDES Discharge 013 (muds, cuttings, cement at the seafloor)	using MLC bit	5,007	8,175	8,341	8,169	8,173	8,341
	using MLC ROV System[3,4]	--	31,669	31,835	31,663	31,667	31,835

[1] Discharge values taken from Tables 6.b-1 and 6.b-2 of EP Revision 2 (March 2015). For example, Burger F NPDES Discharge 001 total (9,654 bbl) is the sum total of drilling fluids discharged when drilling Intervals 4-6 (6,184 bbl), plus cutting when drilling Intervals 4-6 (1,043 bbl), and plus the reserve tank volume (2,427 bb).
[2] National Pollutant Discharge Elimination System Exploration Facilities General Permit AKG-28-8100 (Chukchi Sea)
[3] Discharge 013 volumes vary with MLC technology as MLCs constructed with the MLC ROV System are larger in volume as compared to the MLC bit.
4 MLC ROV System NPDES Discharge 013 total for Burger F (30,784 bbl) is the sum total of the cuttings generated during MLC excavation (Interval 1 - 27,197 bbl), plus cuttings generated while drilling the conductor and surface casing sections (Intervals 2 and 3 – 1,303 bbl), plus drilling fluids used when drilling Intervals 2 and 3 (3,124 bbl) and plus cement that is used to cement the well (45 bbl).

Shell has conducted dispersion modeling of the drilling waste discharges using the revised discharge volume estimates for EP Revision 2. The results of this modeling effort are discussed in Section 4.

Other Wastes Discharged at Sea

A number of other wastes will be generated by the drilling units and discharged to ocean waters. The compositions, projected rates and projected volumes of these discharges are presented below in Tables 2.7-4 and 2.7-5. These discharges will be conducted in accordance with, and authorized under NPDES exploration facilities GP, which contains a number of conditions that place limitations on effluent constituents and discharge rates, and mandate discharge monitoring and reporting. Volumes and rates will differ between the two drilling units because of the different numbers of persons on board, differing equipment, and differing technologies. Food wastes from the drilling units will most likely be incinerated; however, they could be shipped out of the Arctic for disposal if operations warrant.

Table 2.7-4 Projected Non-drilling Wastewater Discharges – *Polar Pioneer*

Type of Waste NPDES exploration facilities GP Discharge	Composition	Discharge Rate	Season Volume[1]	Treatment, Storage, and Disposal
Deck drainage Discharge 002	Uncontaminated fresh or seawater	70 bbl/day [2]	8,400 bbl	Uncontaminated water discharged overboard, contaminated water stored in waste oil tank, transferred by boat to TDS site
Sanitary wastewater Discharge 003	Treated human body waste from toilets	14.3 bbl/day [3]	1,716 bbl	Discharged via disposal caisson after treatment in MSD
Domestic wastewater Discharge 004	Gray water (laundry, galley, lavatory)	271 bbl/day [4]	32,520 bbl	Discharged through disposal caisson
Desalination unit brine water Discharge 005	Rejected water from watermaker unit	377 bbl/day	45,286 bbl	Discharged through disposal caisson
Boiler Blowdown Discharge 007	Water and minerals drained from boiler drums	6 bbl/day	754 bbl	Discharged overboard
Fire Control System Test Water Discharge 008	Uncontaminated seawater	36 bbl/test	607 bbl [5]	Discharged overboard
Non-contact cooling water Discharge 009	Uncontaminated seawater	21,385 bbl/day	2,566,200 bbl	Discharged to water through a number of outlets
Uncontaminated ballast water Discharge 010	Uncontaminated seawater	719 bbl/day plus 85,655 bbl when the drilling unit is moved	171,935 bbl [6]	Discharged through disposal caisson
Bilge water Discharge 011	Seawater that collects in internal parts of the drilling vessel hull	714 bbl	85,714 bbl	Treated in OWS, uncontaminated water discharged via disposal caisson, oily water stored aboard, transported by boat to approved TDS

Note: TDS = treatment/disposal/storage facilities, OWS = oily water separator, MSD = marine sanitation device
[1] Based on a season of approximately 120 days
[2] Based on unroofed deck surface and Chukchi Sea precipitation rates
[3] Based on 5.3 gallons per day (gpd) per person, 114 persons on board (POB)
[4] Based on 100 gpd per person on board, 114 POB
[5] Based on 36 bbl/test, weekly tests for season duration
[6] Based on 719 bbl/day during drilling and one time ballast of 85,655 bbl when drilling unit is moved, total assumes one well, additional drill sites would add 85,655 bbl each

Table 2.7-5 Projected Non-drilling Wastewater Discharges – *Discoverer*

Type of Waste NPDES exploration facilities GP Discharge	Composition	Discharge Rate	Season Volume[1]	Treatment, Storage, and Disposal
Deck drainage Discharge 002	Uncontaminated fresh or seawater	33 bbl/day [2]	3,960 bbl	Uncontaminated water discharged overboard, oily water stored aboard, transported by boat to approved treatment/disposal/storage (TDS) site
Sanitary wastewater Discharge 003	Treated human body waste from toilets	29.5 bbl/day [3]	3,540 bbl	Discharged via disposal caisson after treatment in MSD
Domestic wastewater Discharge 004	Gray water (laundry, galley, lavatory)	295 bbl/day [4]	35,400 bbl	Discharged via disposal caisson
Desalination unit brine water Discharge 005	Rejected water from watermaker unit	1,742 bbl/day	209,040 bbl	Discharged through disposal caisson
Boiler Blowdown Discharge 007	Water and minerals drained from boiler drums	1.3 bbl/day	151 bbl	Discharged through disposal caisson
Fire Control System Test Water Discharge 008	Uncontaminated seawater	36 bbl/day	607 bbl[5]	Discharged directly overboard
Non-contact cooling water Discharge 009	Uncontaminated seawater	107,314 bbl/day 55,200 bbl/day [6]	Range of 6,624,000 – 12,877,680 bbl	Discharged to water through a number of outlets around the hull
Uncontaminated ballast water Discharge 010	Uncontaminated seawater	variable	37,915 bbl	Discharged through disposal caisson
Bilge water Discharge 011	Seawater that collects in internal parts of the drilling vessel hull	754 bbl	90,514 bbl	Treated in OWS, uncontaminated water discharged via disposal caisson, oily water stored aboard, transported by boat to approved TDS

[1] Based on a season of approximately 120 days
[2] Based on unroofed deck surface and Chukchi Sea precipitation rates
[3] Based on 9 gpd/person and POB of 124
[4] Based on 100 gpd per person and POB of 124
[5] Based on 36 bbl/test, weekly tests for season duration
[6] Based on 107,314 bbl/day while drilling, 55,200 bbl/day non-drilling

Support vessels will discharge domestic waste and sanitary waste to the sea after treatment per MARPOL standards and requirements. Sanitary waste water will be treated in MSDs on all vessels. Estimated volumes to be discharged are indicated in Table 2.7-6. Each vessel has a USCG-approved MSD. These vessels will also discharge other waste streams incidental to the operations of the marine vessel (ex- non-contact cooling water, deck drainage, fire test water, etc.).

Table 2.7-6 Projected Vessel Wastewaters Discharge

Vessel	Crew Size[1]	Graywater[2]	Blackwater[2]
		bbl/day	bbl/day
Ice Management Vessels (x2)	82	195	18
Anchor Handlers (x3)	64	152	14
OSVs (x3)	50	119	11
Science Vessels (x2)	50	119	11
Shallow Water Vessels (x2)	22	52	5
Support Tugs (x2)	13	31	3
Supply Tugs (x2) and Barge (x2)	11	26	2
OSRV (x1)	41	98	9
OSR Tug (x1) and Barge (x1)	15	36	3
OST (x2)	25	57	5
Nearshore OSR Tug (x1) and Barge (x1)	8	19	2
Containment Tug (x2)	11	26	2
Containment Barge (x1)	72	171	15

[1] Based on total vessel berths as crew size
[2] Based on 100 gal/crew/day graywater and 9 gal/crew/day blackwater; these are rates per vessel

Environmental Monitoring at Drill Sites While Drilling

As part of the requirements under the NPDES exploration facilities GP, Shell will conduct an Environmental Monitoring Program (EMP) that meets the objectives in the permit AKG-28-8100. The specific details around this monitoring program will be submitted with the NPDES NOI; however, the EMP will generally consist of a 4 phase monitoring program.

- Phase I establishes the baseline conditions of the drill site prior to exploration drilling activities and will either be supported with historical data or supplemental data collected prior to exploration drilling activities. The baseline data generally consist of benthic samples, receiving water chemistry, sediment characteristics, and a visual assessment of the sea floor.
- Phase II requires monitoring to be conducted while exploration drilling activities are occurring and consists of discharge plume monitoring, metals analysis of the drilling fluid, and Phases III and IV are similar in nature and are conducted once exploration drilling activities are completed.
- Phase III monitoring will occur shortly after exploration drilling operations cease at a drill site.
- Phase IV is conducted no later than 15 months after exploration drilling operations cease. Benthic samples, sediment characteristics, and a sea bottom survey will be completed during these phases.

The results from this monitoring program will be submitted to EPA as required in GP AKG-28-8100.

Bird and mammal observations will be made from all transiting surface operation vessels throughout the exploration drilling activities in accordance with the 4MP and the Bird Strike Avoidance and Lighting Plan.

Other Wastes Generated by the Drilling Units and Support Vessels

The drilling units and many of the support vessels have incinerators, and combustible non-hazardous wastes such as paper and pallets may be incinerated onboard. Food waste may also be incinerated. Non-combustible wastes from the drilling units and support vessels will be transported to shore and disposed of in an approved landfill. Regulated wastes include such things as paint, solvents, unused chemicals, batteries, lamps, used oil, and glycol; these will be shipped to an approved facility for recycling or disposal. Estimated volumes of these types of wastes that may be generated during exploration drilling program activities are indicated in Table 2.7-7. Regulated waste will be transported to approve, licensed facilities (Table 2.7-8). All other wastes will be disposed of at an approved, appropriate treatment/disposal facility.

Table 2.7-7 Projected Generation of Solid and Hazardous Wastes from the Drilling Units and Support Vessels*

Waste Type	Composition	Projected Amount	Treatment / Storage/ Disposed
Household Trash	Refuse generated through domestic living activities (includes food wastes)	8,500 lb / month / drilling unit stored and transported for disposal 6,000 lb. / month / drilling unit incinerated onboard; -resulting ash weight of 200 lb. included in non-hazardous waste monthly total) Support Vessels: 23,454 lb./month	Not discharged to ocean waters; Burned in on board incinerator OR stored aboard in approved waste containers until removed at port and transferred to an approved TDS site
Non-hazardous Waste (solid and liquid)	Non-hazardous waste liquids and solids such as used oils, oily rags, and vessel slops, incinerator ash; steel (to be recycled); generated through vessel cleaning, maintenance and drilling operations	62,500 lb / month / drilling unit Support Vessels: Liquids 123,975 lb/month Solids 4,765 lb./month	Not discharged to ocean waters; stored aboard in approved waste containers until removed at port and transferred to an approved treatment/disposal site
Hazardous Waste CESEQG	Expired or spent chemicals left over from cleaning, maintenance and drilling operations	50 lb / month / drilling unit; no discharge CESQG status is anticipated)	Not discharged to ocean waters; stored aboard in approved United Nations (UN) rated waste containers until removed at port and transferred to an approved treatment/disposal site

*Solid and hazardous wastes are portrayed differently in this EIA Table 2.7-7 than they were in EP Revision 1. EP Revision 1 reported the non-discharged wastes on a per well basis, measured in barrels, for the drilling unit only. EP Revision 2 reports the non-discharged wastes on a monthly basis, measured in pounds, for the drilling unit and support vessels.

Table 2.7-8 Disposal of Projected Solid and Hazardous Wastes from the Drilling Units and Support Vessels

Facilities / Location	Type of Waste	Rate	Disposal Method
Waste Management Inc., Columbia Ridge Landfill, Arlington, OR (Subtitle D landfill)	Household trash Municipal Solid Waste (MSW) only	Drilling Units: 17,000 lb. (8,500 lb./month/drilling unit) Support Vessels: 23,454 lb./month	Landfill
Waste Management Inc., Chemical Waste Management, Arlington, OR (Subtitle C landfill)	Non-hazardous waste solids – including CESQC-exempt wastes (oily rags, unused chemicals, aerosols, batteries, lamps, cement, etc.)	Drilling Units: 12,100 lb. (6,050lb/month/ drilling unit; (includes approximately 50 lb./month/drilling unit of CESQG-exempt waste) Support Vessels: 4,765 lb./month	Landfill or recycle
Marine Vacuum Service Inc., Seattle WA, or Emerald Services, Inc., Seattle, WA, or Thermo Fluids, Portland, OR	Non-hazardous liquids in bulk shipments (bilge water, vessel slops, brine water)	Drilling Units: 100,000 lb., 50,000 lb./month/drilling unit Support Vessels: 123,975 lb./month	Treat and recycle
Seattle Iron & Metals Corp., Seattle WA, or Schnitzer Steel Industries, Anchorage AK	Non-hazardous waste solids Scrap Metal (uncontaminated scrap steel only)	Drilling Units: 13,000 lb. (6,500 lb./month/drilling unit) Support Vessels: 1,200 lb./month	Recycle

2.8 Air Emissions

Under EP Revision 1, releases of the air emission for the Chukchi Sea EP were authorized for the *Discoverer* under the air permit issued by the EPA. In December 2011, jurisdiction for regulating air emissions for projects on the OCS in areas off the coast of the NSB in Alaska was changed from EPA to BOEM (2012 Consolidated Appropriations Act, Page 1048). As a result, the air permit for the *Discoverer* drillship in the Chukchi Sea was terminated by the EPA in January 2014 (79 FR 2442). Shell now seeks authorization from BOEM for air pollutants emitted for activities described in EP Revision 2.

Under EP Revision 2, two drilling units and additional support vessels and equipment will emit air pollutants. Appendix K of EP Revision 2 includes two emissions inventories that describe the air pollutants estimated to occur for the activities associated with the Chukchi Sea exploration drilling program. These inventories are provided to fulfill BOEM's EP requirements. The Air Quality Regulatory Program (AQRP) emissions inventory provides a conservative estimate of air emissions within 25 miles of the drilling units for demonstrating compliance with the specific requirements of 30 CFR 550.218(a)(3). The NEPA emissions inventory is provided in Appendix K to assist with an evaluation of project air impacts under the EIA as required under 30 CFR 550.227.

Shell has elected to present maximum projected emissions in the AQRP emissions inventory for the 30 CFR 550.303(d) exemption formula analyses (see Section 7 of EP Revision 2) without consideration of existing emission controls; however, the NEPA emissions inventory presented in this EIA includes additional operational assumptions (e.g., application of particulate matter emission control technologies for some support vessels) for the EP Revision 2 plan that are not included within the AQRP emissions inventory. Therefore, the estimates in the emissions inventories presented in this EIA will not equal the emissions inventories presented in Section 7 of EP Revision 2 because of the additional operating assumptions.

These operational assumptions were applied for conducting the dispersion modeling analyses to evaluate potential air impacts under NEPA. Predicted maximum hourly and total annual mass NEPA emissions of the criteria air pollutants nitrogen oxide (NO_X), sulfur dioxide (SO_2), particulate matter less than 10 microns (PM_{10}) and less than 2.5 microns ($PM_{2.5}$), CO, VOC, and lead (Pb), assuming a 120-day drilling season for the drilling units and associated support vessels and activities, are provided below in Table 2.8-1 and 2.8-2. These totals include NEPA emissions from all sources associated with the drilling units, offshore support vessels, and onshore support activities associated with EP Revision 2. Predicted concentrations from dispersion modeling for the project activities are provided in Attachments B and C of the EIA of EP Revision 2.

Table 2.8-1 Maximum Projected Hourly NEPA Emissions - Drilling Units, Support Vessels, Onshore Support

Emission Source	Hourly Emissions (lb/hr) for the Exploration Drilling Program							
	NO_X	PM_{10} [3]	$PM_{2.5}$ [3]	CO	VOC	SO_2 [1]	Pb	GHG [4]
Discoverer [2]	273.8	10.9	10.9	69.5	15.5	1.9	0.03	22,309
Discoverer Support Vessels[2]	1,040.5	29.6	29.6	240.9	60.3	6.0	0.07	78,181
Polar Pioneer [3]	334.3	17.2	17.2	52.5	16.4	2.0	0.03	24,298
Polar Pioneer Support Vessels [2]	930.1	15.7	15.7	272.4	58.0	5.1	0.03	74,626
Common Support Vessels [2]	1,690.5	56.9	56.9	398.7	70.9	7.6	0.07	103,591
Onshore Support	23.3	1.6	1.6	40.7	27.1	1.6	3.73E-04	6,296
Total	4,292.7	131.9	131.9	1,074.8	248.2	24.2	0.2	309,302

[1] Use of Ultra Low Sulfur Diesel (ULSD) fuel across all vessels and drilling units.
[2] Short-term utilizations on engines (80 percent) on all vessels and drilling units.
[3] Use of particulate matter emission control technologies on ice management vessels (*Fennica and Nordica),* anchor handlers (*Aiviq and Tor Viking),* and OSRV (*Nanuq*).
[4] GHG= greenhouse gas emissions

Table 2.8-2 Projected Annual NEPA Emissions - Drilling Units, Support Vessels, Onshore Support

Emission Source	Annual Emissions (tpy) for the Exploration Drilling Program							
	NO_X	PM_{10} [4]	$PM_{2.5}$ [4]	CO	VOC	SO_2 [2]	Pb	GHG
Discoverer [3]	394.3	15.7	15.7	100.1	22.3	2.8	0.05	32,125
Discoverer Support Vessels [1,3]	356.4	15.7	15.7	75.2	24.2	3.3	0.09	31,652
Polar Pioneer [3]	481.5	24.7	24.7	75.7	23.6	2.8	0.04	34,989
Polar Pioneer Support Vessels [1,3]	395.0	9.9	9.9	118.4	28.5	2.6	0.03	33,607
Common Support Vessels[1,3]	716.5	32.9	32.9	190.0	38.8	4.8	0.08	55,252
Onshore Support	30.2	0.9	0.9	12.8	6.9	0.4	5.5E-04	3,937
Total	2,373.8	99.7	99.7	572.2	144.4	16.6	0.3	191,562.0

[1] Annual fuel restrictions on the support Vessels.
[2] ULSD fuel across all vessels and drilling units.
[3] Short-term utilizations on engines (80 percent) on all vessels and drilling units.
[4] Use of particulate matter emission control technologies on ice management vessels (*Fennica and Nordica),* anchor handlers (*Aiviq and Tor Viking*), and OSRV (*Nanuq*).
Tpy = tons of pollutant per year

2.9 Sound Generation

The following section provides information on the generation of sound by the drilling units, vessels, and aircraft Distances to certain received sound levels as identified below, were used to predict the area ensonified to threshold levels around the sound sources, and to then estimate potential exposures of marine mammals.

Sound Generation by Exploration Drilling

Prior to 2012, sounds from the *Discoverer* had not been measured in the Arctic, and analogs or modeling based on sound measurements outside the Arctic (Austin and Warner 2010), were used to estimate the distances at which the generated sound would attenuate to levels below effects thresholds and assess potential impacts. Shell measured the sounds produced by the *Discoverer* while drilling on the Burger Prospect in 2012. A broadband (10 Hertz [Hz] – 32 kilohertz [kHz]) source level of 182 dB was calculated for the *Discoverer* based on the measurements recorded when drilling the 26-inch hole interval. Radii to other received sound energy levels based on a best-fit relationship of these measurements are provided in Table 2.9-1.

Table 2.9-1 Distances to Received Sound Levels Drilling and other Activities

Received Level	Drilling 26 in. Hole [1,2]	Support Vessel in DP[3]	MLC Drilling [1]	Ice Management [1,4]	Anchor Handling [1,5]
≥ 190 dB	< 10 m	<64 m	< 10 m	< 10 m	< 10 m
≥ 180 dB	< 10 m	<64 m	< 10 m	< 10 m	20 m
≥ 170 dB	< 10 m	<64 m	20 m	20 m	60 m
≥ 160 dB	< 10 m	<64 m	71 m	60 m	180 m
≥ 150 dB	30 m	64 m	250 m	200 m	530 m
≥ 140 dB	100 m	260 m	870 m	730 m	1,600 m
≥ 130 dB	390 m	1,100 m	2,800 m	2,600 m	4,700 m
≥ 120 dB	1,500 m	4,500 m	8,200 m	9,600 m	14,000 m

[1] Based on linear fit to average sound levels recorded at 4 ranges at Burger A in the Chukchi Sea in 2012; source: Austin et al. 2013
[2] Drilling with the *Discoverer*
[3] Based on measurement of Nordica on DP from 2013; source: LGL and JASCO 2013
[4] Ice management as conducted by the *Tor Viking*
[5] Measurements of anchor handling using the anchor handler *Tor Viking* mooring the *Kulluk* were collected in Beaufort Sea 2012

Measurements of the sound energy generated by the *Polar Pioneer* are unavailable; however, sound measurements of some semi-submersibles are available in the literature. Greene (1986 In Richardson et al. 1995) reported measured sound energy levels generated by a semi-submersible, the SEDCO 708, while drilling in 374 ft (114 m) of water in the Bering Sea (Table 2.9-2). The SEDCO 708 is similar in size and shape to the *Polar Pioneer*. Sound measurements for two other semi-submersible drilling units were also found in the literature and the estimated source levels are presented in Table 2.9-3. This data and others indicate that semi-submersibles generate less underwater sound energy when drilling than drillships, probably because the drilling unit floor and engines are on a platform elevated above the sea surface. It is therefore likely that the *Polar Pioneer* will generate less underwater sound when drilling than the *Discoverer* or *Kulluk*. Further information on the modeling of sound with two drilling units operating simultaneously, as well as additional support vessels and aircraft, is provided in Section 4.7 of the EIA.

Table 2.9-2 Sound Levels Generated by a Semi-submersible in the Bering Sea

Parameter	Broadband [1]		Tones [1]		
Frequency (Hz)	10-500	80-4,000	60	181	301
Estimated source level (dB re 1 µPa-m)	154	154	149	137	136

[1] Source: Greene 1986 in Richardson et al. 1995a

Table 2.9-3 Estimated Broadband Source Levels Generated by Semi-submersibles

Vessel	Length	Width	Reference	Estimated Broadband Source Level
Polar Pioneer	279 ft (85.0 m)	233 ft (71.0 m)	none	
Ocean Bounty	353 ft (107.6 m)	267 ft (81.4 m)	Gales 1982, Cook Inlet	163 dB re 1 mPa
SEDCO 708	297 ft (90.5 m)	297 ft (90.5 m)	Greene 1986, Bering Sea	154 dB re 1 mPa
Ocean General	290 ft (88.4 m)	217 ft (66.1 m)	McCauley 1998, Timor Sea	144 dB re 1 mPa
Discoverer	514 ft (156.7 m)	85 ft (26.0 m)	Austin et al. 2013, Chukchi	181 dB re 1 mPa
Kulluk	266 ft (81.0 m)	266 ft (81.0 m)	Austin et al. 2013, Beaufort	172 dB re 1 mPa

Sound Generation by Vessels

Radii for support vessels in transit, also based on measurements taken in the Chukchi Sea or Beaufort Sea during the 2012 season, are provided in Table 2.9-4.

Table 2.9-4 Measured Radii to Sound Levels for Transiting Support Vessels

Received Level	*Affinity* 8.8 kts [1]	*Fennica* 8.8 kts [1]	*Guardsman / Klamath* [1]	*Aiviq* 8.8 kts [1,2]	*Tor Viking* 9 kts [1,2]	*Sisuaq* 8.7 kts [1,2]	*Arctic Seal* 9 kts [1,2]	*Nordica* 12.1 kts[1]
> 190 dB	0 m	0 m	< 10 m	0 m	0 m	< 10 m	0 m	<10 m
> 180 dB	0 m	< 10 m	< 10 m	< 40 m	< 10 m	< 10 m	0 m	< 10 m
> 170 dB	0 m	< 10 m	17 m	< 10 m	< 10 m	< 10 m	0 m	< 10 m
> 160 dB	< 10 m	< 10 m	49 m	44 m	25 m	18 m	<10 m	24 m
> 150 dB	< 10 m	26 m	140 m	280 m	110 m	61 m	<10 m	80 m
> 140 dB	36 m	97 m	400 m	1,400 m	470 m	200 m	13 m	260 m
> 130 dB	180 m	360 m	1,100 m	4,600 m	2,000 m	680 m	67 m	860 m
> 120 dB	900 m	1,300 m	3,300 m	9,500 m	8,700 m	2,300 m	350 m	2,800 m

[1] Determined by Best Fit Lines from measured sound radii in the Chukchi Sea in 2012; source: Austin et al. 2013
[2] No measurements analyzed in the Chukchi Sea in 2012; these distances are from the Beaufort Sea in 2012
[3] kts = knots

Sound Generation by ZVSPs

Sound levels expected to be generated by the ZVSP surveys air gun array have not been measured but were modeled; expected distances to the received sound levels are provided in Table 2.9-5. Underwater sound generation and attenuation was modeled for the ZVSP surveys in the Chukchi Sea based on the specifications in Table 2.4-1 using several different configurations. Distances from the source, at which various sound energy levels would be received based on the modeling are provided in Table 2.9-5.

Table 2.9-5 Modeled Distances to Received Sound Levels from the ZVSP Air gun Array

Received Level	Distance to Received Level [1]	
≥ 190 dB	0.16 mi	0.255 km
≥ 180 dB	0.86 mi	1.38 km
≥ 160 dB	7.42 mi	11.96 km

[1] Based on the configuration with maximum distances to isopleths; based on 7 m source depth, 3,000 psi firing pressure

Sound Generation by Aircraft

Both the level and duration of sounds received underwater from passing aircraft depend on altitude and aspect of the aircraft, receiver depth, and water depth. Received sound level decreases with increasing altitude of the aircraft and with increasing depth to the receiver when the aircraft is directly overhead.

Sound levels, both at the source and at receptors at various distances, are provided in Tables 2.9-6 and 2.9-7 for some of the models of aircraft commonly used in oil and gas exploration. The tables include some data for the models of helicopters (Sikorski S-61 or S-92 or Eurocopter EC225), and fixed-wing aircraft (Twin Otter) that could be used in the planned exploration drilling program; data for other models are provided in the table as sound levels generated by them are expected to be similar.

Table 2.9-6 Received Underwater Sound Levels from Aircraft

Aircraft	Water Depth ft/m	Received Underwater Sound Level (dB)								
		Altitude 2,000 ft (610 m)		Altitude 1,500 ft (457 m)		Altitude 1,000 ft (305 m)		Altitude 500 ft (152 m)		
		10 ft (3 m)	30 ft (9 m)	10 ft (3 m)	30 ft (9 m)	10 ft (3 m)	30 ft (9 m)	10 ft (3 m)	30 ft (9 m)	60 ft (18 m)
Twin Otter	72/22	nd	106	nd	101	nd	113	nd	nd	nd
	72/22	nd	104	nd	106	nd	nd	nd	nd	nd
B-N Islander	49/15	108	107	116	105	121	110	117	114	nd
	49/15	106	103	nd	105	122	112	123	113	nd
	49/15	104	105	119	106	nd	nd	nd	nd	nd
	49/15	109	108	nd	nd	nd	nd	nd	nd	nd
Bell 212	82/25	nd	108	nd	nd	nd	111	nd	nd	nd
Bell 214ST	72/22	nd	nd	nd	nd	nd	nd	104	nd	Ambient levels
Sikorsky 61	121/37	nd	nd	nd	nd	nd	nd	102	111	105

[1] Source: Greene 1985
[2] Measured sound levels relative to one µPa at one meter distant for five types of aircraft at altitudes of 152 m to 610 m from hydrophones at depths of 3 m, 9 m, and 18 m below the water surface
[3] ND – no data collected

Table 2.9-7 Duration and Audibility of Sound Generated from Aircraft

Aircraft	Altitude ft (m)	Water Depth ft (m)	Sea State	Sound Level (dB)[1,2]	Duration at Depth (sec) [1]	
					10 ft (3 m)	30 ft (9 m)
BN Islander	1,500 (457)	50 (15.2)	1	86	continuous	58-75
BN Islander	2,000 (610)	50 (15.2)	1	86	84-110	66-78
BN Islander	500 (152)	50 (15.2)	1	86	72-87	52-60
BN Islander	1,000 (305)	50 (15.2)	1	86	53-76	49-75
BN Islander	1,500 (457)	50 (15.2)	1	86	44-58	34-42
BN Islander	2,000 (610)	50 (15.2)	1	86	59-84	39-52
Bell 212	500 (152)	82 (25.0)	1	100	nd[3]	16-21
Bell 212	1,000 (305)	82 (25.0)	1	100	nd	18-27
Bell 212	1,500 (457)	82 (25.0)	1	100	nd	nd
Bell 212	2,000 (610)	82 (25.0)	1	100	nd	26
Twin Otter	500 (152)	74 (22.5)	0	95	nd	33-36
Twin Otter	1,000 (305)	74 (22.5)	0	95	nd	29
Twin Otter	1,500 (457)	74 (22.5)	0	95	nd	37
Bell 214ST	500 (152)	72 (22.0)	3	100	nd	11

[1] Source: Greene 1985
[2] In 20-1000 Hz frequency range
ND = no data collected

2.10 Oil Spill Prevention and Contingency Response

Shell is committed to conducting safe and environmentally responsible operations in the Chukchi Sea. To achieve this goal, oil spill prevention is a priority in all aspects of operations. Shell's Chukchi Sea Regional Exploration Program OSRP emphasizes the prevention of oil pollution by employing the best control mechanisms for blowout prevention and fuel transfer operations, as well as implementing mandatory prevention training programs for field operating personnel. Prevention training will include strict procedures and management practices to eliminate spills in all aspects of operations. All project personnel, including employees and contractors, involved in OSR, will receive response training as described in the OSRP. Training drills also will be conducted periodically as described in Shell's OSRP to familiarize personnel with on-site equipment, proper deployment techniques, and maintenance procedures.

The likelihood of a large oil spill event is very low. Shell has designed its response program based upon a regional capability of responding to a range of spill volumes, from a small operational spill up to and including the WCD from an exploration well blowout. Shell's program was developed to fully satisfy the response planning requirements of the SOA and federal oil spill planning regulations. The OSRP presents specific information on the response program that includes a description of personnel and equipment mobilization, the incident management team organization, and the strategies and tactics used to implement effective and sustained spill containment and recovery operations.

As described in Section 6.0, the WCD planning scenario Shell used in its OSRP in compliance with BSEE regulations is higher, and therefore more conservative, than the "calculated" WCD required for EP submissions by 30 CFR 550.213(g) and NTL No. 2015-N01. Although Shell calculated a maximum flow rate for the wells in EP Revision 2 of 23,100 bbl per day, which would diminish over time, Shell has conservatively planned for a WCD of 25,000 bbl/day. Pursuant to BSEE's regulations, Shell assumed a blowout lasting 30 days, for a total discharge of 750,000 bbl. The entire WCD planning scenario can be found within Appendix C of the OSRP.

A dedicated, offshore OSR tug and barge and OSRV will be staged in the vicinity of the drilling units. The on-site OSR tug and barge and OSRV will possess sufficient containment, recovery and storage capability for the initial operational period in the event of a WCD spill (see the Chukchi Sea Regional OSRP for details). By hour 42, two more VOSSs would arrive at the spill site to assist the on-site OSR tug and barge and OSRV with recovery and lightering operations. The OSR tug and barge and vessels would work in conjunction to sustain containment and skimming operations and transfer recovered fluids to the OSTs for the duration of the response.

An OST will be staged so that it will arrive at a recovery site, if needed, within 24 hr of departure from the staging location. The purpose of the OST would be to provide a place to store large volumes of recovered liquids in the unlikely event of a spill and OSR operations. The OST will possess a minimum liquid storage capacity of 106,000 bbl, which is sufficient to hold all recovered liquids until the arrival of the second OST, in the event of a spill from the maximum 30 day WCD.

A second OSR tug and barge (Nearshore OSR tug and barge) will be staged in or near Goodhope Bay, Kotzebue Sound and possess capacity to mobilize prior to the earliest time oil could arrive in the nearshore zone. It will carry response equipment including a 47 ft (14 m) skimming vessel, three 34 ft (10 m) workboats, four mini-barges, and boom and duplex skimming units for nearshore recovery. The workboats will also be used to shuttle OSR crews between the shorebase and the OSR tug and barge for OSR training and drills. The OSR tug and barge will carry designated response personnel and will mobilize to recovery areas, deploy equipment, and begin operations.

The Shell Chukchi Sea Regional Exploration Program OSRP is supported by three Oil Spill Removal Organizations (OSROs). AES-Response Operations, UIC-Arctic Response Services and Alaska Clean Seas (ACS) are Shell's primary response action contractors supporting the program. The OSROs would lead the spill response efforts in the offshore, nearshore, and shoreline environments. The OSROs response personnel and OSR equipment would be maintained on standby while critical exploration drilling operations into liquid hydrocarbon bearing zones are underway and provide offshore, nearshore, and shoreline response operations in the unlikely event of an actual oil spill incident. Additionally, each OSRO provides program oversight for their particular scope, overall spill management team support, response training, and additional responders through the Auxiliary Contract Response Teams, North Slope Spill Response Team, and Village Response Teams (VRTs).

Shell will provide dedicated response vessels and equipment for the onshore, nearshore and offshore operations. Response activities will be conducted using Shell or ACS tactics as defined in Shell's *Beaufort and Chukchi Seas Regional Tactics Manual* and/or ACS's *Technical Manual*, or otherwise as defined in the OSRP.

Potential Releases

Shell's analysis of liquid hydrocarbon spills defines and distinguishes between two categories of spills: "small" spills are 48 bbl (8 m^3) or less, and "large" spills are any spill greater than 48 bbl (8 m^3). These categories are different than the categories of spills by volume typically used by BOEM in its analyses. For BOEM, a "small" spill is <1,000 bbl (159 m^3), "large" spill is greater than or equal to 1,000 bbl (159 m^3), and "very large" is greater than or equal to 150,000 bbl (23,838 m^3). Shell's spill categories, however, are not incompatible with those used by BOEM. Shell chose to use these definitions because, as explained below, the most likely source of a liquid hydrocarbon spill is a spill incidental to a refueling operation, and the most likely maximum size of such a spill is 48 bbl (8 m^3).

There are three potential categories of liquid hydrocarbon spills in connection with exploration drilling: (i) a large spill from operations; (ii) a well blowout; and (iii) a small spill from operations. Historical data demonstrates that the probability of a large spill occurring during operations is insignificant, and therefore this EIA does not analyze the impacts of large spills from operations. The occurrence of a large spill resulting from a well blowout is similarly improbable. Nonetheless, this EIA incorporates by reference

BOEM's prior analyses of the impacts of a BOEM-defined very large spill and blowouts and provides a very large spill impact analysis in Section 6.0.

The historical record for offshore exploration drilling shows the probability of a spill to be very low and, in the unlikely event a spill does occur, the probability is that it will be a relatively small operational spill. Bercha Group (2008) found that spill frequency per year and per barrel-year decreases with increasing spill size. The possible sources from which a release of liquid hydrocarbons could occur for Shell's Chukchi Sea exploration drilling activities are summarized within Table 2.10-1. This table includes the WCD volume estimation (as defined and calculated by regulation) upon which Shell's OSRP has been designed.

Based upon spill data from historic exploration drilling in the Gulf of Mexico and Alaska OCS Regions, the most likely spill from the operations would be relatively small accidental release, with the potential for a large spill of more than 1,000 bbl (159 m^3) to occur from a well blowout being extremely low. The Final Second SEIS BOEM prepared for the Chukchi Sea Lease Sale 193 (BOEM 2015) reported that between 1971 and 2010, industry drilled 223 exploration wells in the Pacific OCS, 46 in the Atlantic OCS, 15,138 in the Gulf of Mexico OCS, and 84 in the Alaska OCS, for a total of 15,491 exploration wells. During this period, there were 77 well control incidents associated with exploration drilling. Of those 77 well control incidents, 14 (18%) resulted in oil spills ranging from 0.5 bbl to 200 bbl, for a total 354 bbl, excluding the estimated volume from the Deepwater Horizon (DWH) event. From 1971-2010 only one well control incident resulted in a spill volume of 1,000 bbl or more and that was the DWH event. For Alaskan Beaufort Sea and Chukchi Sea exploration drilling operations, 35 small spills totaling 26.7 bbl (4.2 m^3) were documented consisting primarily of fuels or other refined products. Three documented incidents involved small quantities of crude oil, 0.6 to 3.1 bbl (0.1 to 0.5 m^3), but none were associated with vessel operations as all the spills occurred on gravel islands. Out of the 26.7 bbl (4.2 m^3) spilled, approximately 24 bbl (3.8 m^3) were recovered. As a result, in its Final Second SEIS, BOEM chose a 50-bbl (8 m^3) diesel fuel-transfer spill as one spill volume and a 5 bbl (0.8 m^3) spill as the typical volume (BOEM 2015).

Table 2.10-1 Summary of Potential Discharges

Type	Cause	Product	Size	BOEM Size Category Equivalent	Duration	Actions to Prevent Discharge
Over-water fuel transfers	Hose rupture	Diesel	Approx. 48 bbl	Small (<1,000 bbl)	5.5 minutes (min)	Strict adherence to transfer procedures in place.
Diesel	Tank rupture (shipboard and onshore storage tanks)	Diesel	1,555 bbl	Large (≥1,000 bbl)	Minutes to hours	Diesel tanks are internal to the drilling unit rather than deck-mounted, where the potential for marine spills is much greater. Tanks are monitored in ongoing tank inspection program. Onshore storage tanks double-walled with containment dike for 110% of volume.
Blowout	Uncontrolled flow at the mudline	Crude oil	750,000 bbl	Very large (≥150,000 bbl)	30 days	BOP and related procedures for well control.

Small diesel fuel spills are more likely to be contained on the vessel or within pre-deployed booms, and may be fully recoverable. Shell has established prevention measures, including pre-booming, to avoid and mitigate spills during fuel transfers, a common potential source of discharge. The potential for discharges during transfers is further reduced by curtailing refueling operations to account for adverse weather and sea conditions. Fuel transfer operations would be planned, scheduled, and announced in advance. Transfers would be carried out with visual monitoring in combination with ongoing communication, which provides the best methods of discharge detection and control. Response equipment and trained personnel would be available on site to deploy boom and recovery equipment for the control and removal of any product spilled into the environment. Pre-booming of fuel transfers between vessels prior to operations will be conducted in accordance with BOEM lease stipulation No. 6, USCG requirements, and Shell transfer procedures for all fuel transfers. These prevention and response measures will reduce both the likelihood and potential consequences of a fuel spill.

Regardless of the discharge source or the low probability of a large or very large oil spill occurring, Shell's Chukchi Sea OSRP response scenario addresses the potential immediate release of crude oil to the environment by a loss of well control during the drilling season. As discussed above, to comply with BSEE and BOEM regulations and guidance, Shell conservatively assumed a total WCD scenario volume of 750,000 bbl (119,237 m^3) of oil during 30 days. Shell's OSRP demonstrates access to sufficient equipment and personnel needed to respond to the WCD planning scenario blowout flow rate of 25,000 barrels of oil per day (bopd) (3,975 m^3/day) for 30 days, for a total of 750,000 bbl. This WCD planning scenario rate and volume exceed the calculated WCD for any of the six drill sites.

While a well blowout is potentially the most substantial oil spill volume, BOEM has estimated that the risk is very low that an exploration well blowout event would occur and impact the water of the Chukchi Sea. No blowouts occurred during past Chukchi or Beaufort OCS exploration drilling of 35 exploration wells; nor have any occurred from the approximately 98 exploration wells drilled within the Alaskan OCS (MMS 2006c). BOEM estimated the low probability using historical data derived from U.S. OCS platform spill data including that from the US Gulf of Mexico (Anderson and LaBelle 2000).

Possible Small Liquid Hydrocarbon Spills

No BOEM-defined large spills or very large crude oil spills have occurred on the Alaskan OCS and the risk of blowout is highly unlikely based upon the historical record of offshore drilling. Therefore, the most likely event is a relatively small spill resulting from vessel fuel transfer operations or loss of containment aboard a vessel such as parted hydraulic lines. For purposes of analysis, the 48 bbl (7.6 m^3) fuel WCD was calculated for the BOEM in Shell's Chukchi Sea OSRP.

The 48 bbl (7.6 m^3) fuel discharge volume was selected as the upper volume limit of the most likely event based upon historical experience and risk analysis. The historical record of spills from all 35 Beaufort and Chukchi OCS exploration wells shows a total spill volume of 26.7 bbl (4.2 m^3) of which approximately 24 bbl (3.8 m^3) were subsequently recovered. The 48 bbl (7.6 m^3) volume is also larger than BOEM's estimate that a typical spill during exploration drilling operations in the Alaska Beaufort would be 25 bbl (4 m^3) or less of diesel or other refined product (BOEM 2015).

Spill Prevention and Response for Small Liquid Hydrocarbon Spill

Response equipment and trained personnel would be available on site to deploy boom and recovery equipment for the control and removal of product spilled into the environment. Additionally, the process of Shell's FTP for fuel transfers between vessels would be utilized in accordance with BOEM lease stipulation No. 6, USCG requirements, and Shell's operating procedures.

Shell's operating procedures ensure that transfer operations would be scheduled at least 24 hr in advance allowing operations personnel to review the planned transfer, ensure suitable weather conditions will occur, make appropriate notifications and ensure response personnel and equipment is properly staged and boom deployed as required. Transfer operations would be visually monitored at all times and in conjunction with continuous communications to provide prompt discharge detection and control.

Prior to initiating any fuel transfer operations, a pre-transfer conference is conducted between the fuel vessel, the receiving vessel, and response team personnel. During the transfer, the person-in-charge of the fuel transfer operation on each vessel, as well as the officer in the wheelhouse of the fuel vessel and the deck watch of the vessels involved in the fuel transfer, shall remain in radio contact. In addition, the deck watch of each vessel will have visual contact during the operation. The response team pre-deploys containment boom, as per the FTP, configured to minimize the effects of wind and currents to the extent possible. Response workboats will remain on standby during the entire transfer operation to tend boom, monitor the transfer process, and detect any discharges.

Fate and Effect of an Uncontrolled 48 bbl (7.6 m^3) Fuel Spill

For purposes of analysis only, Shell has estimated the fate and behavior of a 48 bbl (7.6 m^3) fuel spill assuming no response efforts. Because Shell will take significant preventative measures and would deploy immediate response to remove spilled product in the event of a small fuel spill, this is a highly conservative assumption.

The fate of a discharge from an uncontrolled small spill can be estimated based upon the predicted weathering of a particular type of oil in seawater over a certain period of time. The estimates of a diesel fuel discharge were derived using the NOAA's Automated Data Inquiry for Oil Spills (ADIOS2). This model uses the physical properties of oils in its database to predict the rate of evaporation and dispersion over time, as well as changes in the density, viscosity, and water content of the product spilled. Table 2.10-2 summarizes the results assumed for the fate and behavior of a 48-bbl (7.6-m^3) diesel fuel spill.

Table 2.10-2 Fate and Behavior of a Hypothetical Diesel Fuel Spill

Fate of Spilled Oil	Hours After a Hypothetical Release of 48-bbl (7.6-m^3) of Diesel During Summer [1]				
	6	**12**	**24**	**36**	**48**
Oil Remaining (%)	32	16	5	2	≤1
Oil Evaporated (%)	42	46	48	48	48
Oil Dispersed (%)	26	38	47	50	51

[1] Calculated with the NOAA ADIOS2 oil-weathering model and assuming diesel fuel no. 2, 11-knot wind speed, 4° C water temperature, 0.5-meter wave height.

Light refined products, such as diesel, are narrow-cut fractions that have low viscosity and spread rapidly into a thin sheen. Based on the viscosity of the diesel fuel to be used by Shell, the maximum continuous area of the sea with diesel on the surface in an uncontained 48 bbl (7.6 m^3) spill (i.e., no pre-booming) would be about 20-200 ac (0.1-0.8 km^2) depending on sea state and weather conditions.

2.11 Mitigation Measures

Table 2.a-1 in the EP lists the authorizations and permits necessary to conduct the planned exploration drilling program activities. Shell will adopt the mitigation measures written into these authorizations, and will therefore be working within regulatory requirements. In addition to meeting all regulatory requirements, Shell is committed to adopting additional voluntary mitigation measures, including those that will decrease any potential conflicts between exploration drilling activities and subsistence harvests.

The specific mitigation measures Shell has adopted and will implement during its Chukchi Sea exploration drilling operations are listed below. These mitigation measures have changed slightly, through deletions and additions, from those listed in EP Revision 1 (see Mandatory and Voluntary Mitigation Measures in the Preface). The following mitigation measures reflect Shell's experience conducting exploration drilling in Alaska since 1986, including the 2012 exploration drilling season, and its ongoing consultations with local subsistence communities to better understand their concerns and develop appropriate and effective mitigation measures to address those concerns.

<u>Communications</u>

- Shell has developed a Communication Plan and will implement this plan before initiating exploration drilling operations to coordinate activities with local subsistence users, as well as Village Whaling Captains' Associations, to minimize the risk of interfering with subsistence hunting activities, and keep current as to the timing and status of the bowhead whale hunt and other subsistence hunts. The Communication Plan includes procedures for coordination with Communication and Call Centers (Com Centers) to be located in coastal villages along the Chukchi Sea during Shell's proposed exploration drilling activities.

- Shell will employ local SAs from the Chukchi Sea villages that may be potentially impacted by Shell's exploration drilling activities. The SAs will provide consultation and guidance regarding the whale migration and subsistence activities. There will be one per village, working approximately 8-hr per day and 40-hr weeks during the exploration drilling seasons. The SA will use local knowledge (Traditional Knowledge) to gather data on subsistence lifestyle within the community and to advise in ways to minimize and mitigate potential negative impacts to subsistence resources during the drilling season. Responsibilities include reporting any subsistence concerns or conflicts; coordinating with subsistence users; reporting subsistence-related comments, concerns, and information; coordinating with the Com Center personnel; and, advising how to avoid subsistence conflicts.

<u>Aircraft Travel</u>

- Aircraft over land or sea shall not operate below 1,500 ft (457 m) altitude unless engaged in marine mammal monitoring, approaching, landing or taking off, in poor weather (fog or low ceilings), or in an emergency situation.
- Aircraft engaged in marine mammal monitoring shall not operate below 1,500 ft (457 m) in areas of active whaling; such areas to be identified through communications with the Com Centers and SAs.
- Except in an emergency, aircraft will not operate at an altitude lower than 1,500 ft (457 m) within 0.5 mi. (0.8 km) of polar bears when observed on land or ice.
- Helicopters will not operate at an altitude lower than 3,000 ft (914 m) within 1 mi (1.6 km) of walrus groups observed on land, and fixed-wing aircraft will not, except in an emergency, operate at an altitude lower than 1,500 ft (457 m) within 0.5 mi (805 m) of walrus groups observed on ice, or within 1 mi. (1,610 m) of walrus groups observed on land.
- If aircraft must be operated below 1,500 ft (457 m) because of weather, the operator will avoid areas of known walrus and polar bear concentrations and will take precautions to avoid flying directly over or within 0.5 mi (805 m) of these areas.

<u>Vessel Travel</u>

- The drilling unit(s) and support vessels anticipate they will enter the Chukchi Sea through the Bering Strait on or about 1 July, minimizing effects on marine mammals and birds that frequent open leads and minimizing effects on spring and early summer bowhead whale hunting.
- The transit route for the drilling unit(s) and drilling support vessels will avoid known fragile ecosystems and the LBCHU, and will include coordination through Com Centers.
- PSOs will be aboard the drilling unit(s) and transiting support vessels.
- Except in an emergency, vessels will not approach within 1.0 mi (1.6 km) of walruses or polar bears when observed on ice.
- Except in an emergency, vessels will not approach within 1.0 mi (1.6 km) of groups of walruses or 0.5 mi (0.8 km) polar bears when observed on land.
- When within 900 ft (274 m) of whales, vessels will reduce speed, avoid separating members from a group and avoid multiple changes of direction.
- Vessels will take all reasonable precautions (i.e., reduce speed, change course heading) to maintain a minimum operational exclusion zone of 0.5 mi (805 m) around groups of 12 or more walruses in the water.

- Vessel speed will be reduced during inclement weather conditions in order to avoid collisions with marine mammals.
- Shell will communicate and coordinate with the Com Centers regarding all vessel transit.
- Use of some lighting on the drilling unit(s) and support vessels will be minimized and shaded to reduce potential disorientation and attraction of birds and to reduce the possibility of a bird collision (Bird Strike Avoidance and Lighting Plan Chukchi Sea, Appendix E, EP Revision 2).

Exploration Drilling Operations

- Critical operations will not be started if potential hazards (ice floe, inclement weather, etc.) are in the vicinity and there is not sufficient time to finish the critical operation before the arrival of the hazard at the drill site (Critical Operations and Curtailment Plan [COCP], Appendix F, EP Revision 2).
- The blowout prevention program will be enhanced through the use of two sets of blind/shear rams.
- For drill sites at which a MLC is drilled by bit, a ROV control panel will be on the seafloor, linked to the BOP by an umbilical, with sufficient pressured water-based fluid to operate the BOP. In the event the MLC is drilled by the ROV like excavator, no additional control panel is required as an ROV will have direct access to the BOP panel located in the MLC.
- Provisions for a second relief well drilling unit will be in-place in the event that the primary drilling unit is disabled and not capable of drilling its own relief well. Both the *Discoverer* and *Polar Pioneer* will serve as their own primary relief well drilling unit. If the *Discoverer* or the *Polar Pioneer* cannot be used to drill a relief well, the other drilling unit (secondary relief well unit) would be used for that purpose. The drilling units will be in the Lease Sale 193 Area operating as primary drilling units, or one may be no further distant than Dutch Harbor when the other drilling unit is drilling in hydrocarbon bearing zones. In either case, the secondary relief well drilling unit could be mobilized to the location in the Burger Prospect, moored, and drill a relief well and kill the flow within 38 days.
- Air gun arrays will be ramped up slowly during ZVSP surveys to warn cetaceans and pinnipeds in the vicinity of the air guns and provide time for them to leave the area and avoid potential injury or impairment of their hearing abilities. Ramp ups from a cold start, when no air guns have been firing, will begin by firing a single air gun in the array. A ramp up to the required air gun array volume will not begin until there has been a minimum of 30 min of observation of the safety zone by PSOs to assure that no marine mammals are present. The safety zone is the extent of the 180 dB radius for cetaceans and 190 dB for pinnipeds. The entire safety zone must be visible during the 30-min lead-in to an array ramp up. If a marine mammal(s) is sighted within the safety zone during the 30-min watch prior to ramp up, ramp up will be delayed until the marine mammal(s) is sighted outside of the safety zone or the animal(s) is not sighted for at least 15-30 min: 15 min for small odontocetes and pinnipeds, or 30 min for baleen whales and large odontocetes.

Ice Management

- Real time ice and weather forecasting will be from the Shell Ice and Weather Advisory Center (SIWAC).
- Shell has developed and will implement an Adaptive Approach to Ice Management in Areas Occupied by Pacific Walruses (Appendix J of EP Revision 2).

Oil Spill Response

- The primary OSRV will be on standby at all times when drilling into zones capable of flowing liquid hydrocarbons in measurable quantities to ensure that OSR capability is available within one hr, if needed.

- Shell will deploy OSR support vessels capable of collecting oil on the water in excess of the calculated WCD flow rate of a blowout in the unlikely event that one should occur. The remaining OSR support vessels will be fully engaged within 72 hr.
- In addition to the OSR support vessels, oil spill containment equipment will be available for use in the unlikely event of a blowout. The containment system tugs and barge will be located in or near Goodhope Bay, Kotzebue Sound. This equipment is designed for maximum reliability, ease of operation, flexibility and robustness so it could be used for a variety of blowout situations.
- Capping stack equipment will be stored aboard one of the ice management vessels and will be available for immediate deployment in the unlikely event of a blowout. Capping stack equipment consist of subsea devices assembled to provide direct surface intervention capability with the following priorities:
  - Attaching a device or series of devices to the well to affect a seal capable of withstanding the maximum anticipated well head pressure (MAWP) and closing the assembly to completely seal the well against further flows (commonly called “Cap and Contain”).
  - Attaching a device or series of devices to the well and diverting flow to surface vessel(s) equipped for separation and disposal of hydrocarbons (commonly called “Cap and Flow”).
- A polar bear culvert trap has been constructed in anticipation of OSR needs and will be available prior to exploration drilling.
- Pre-booming will be conducted for all fuel transfers between vessels.

<u>Air Emissions</u>

- Procuring ULSD fuel or a fuel with equal or lower sulfur content to reduce SO_2 emissions for each of the drilling units and all vessels operating as part of the exploration drilling program;
- Establishing fuel restrictions on most of the propulsion and generators engines for the support vessels.

Appendix K of EP Revision 2 provides a summary of the emission reduction measure as applied in the AQRP analysis.

Shell has elected to present maximum projected emissions in the AQRP emissions inventory for the 30 CFR 550.303(d) exemption formula analyses without consideration of existing emission controls as reduction measures on the *Discoverer*’s primary generation units or any of the support vessels. These emission controls include the following:

- Use of selective catalytic reduction (SCR) emission controls to reduce NO_X emissions on *Discoverer*’s primary generation units and certain units on support vessels;
- Use of catalytic diesel particulate filters (CDPF) emission controls to reduce CO, particulate matter (PM), and VOC emissions on the *Discoverer*’s primary generation units and certain units on support vessels; and
- Use of oxidation catalysts (OxyCat) emission controls to reduce CO, PM, and VOC emissions on certain units on support vessels.

The 30 CFR 550.303(d) exemption analyses in Section 7(e) conservatively assume the emission controls are not employed as emission reduction measures. As a result, Shell is not required to operate these controls, but is voluntarily committing to do so. Therefore, emissions reductions resulting from the commitment to operate the controls are not quantified in the AQRP emission inventories presented in Appendix K of EP Revision 2 and no monitoring is proposed for these emission controls.

3.0 RESOURCES AND CONDITIONS

This section provides descriptions of the environmental conditions and the physical, biological and socio-cultural resources of the prospect areas that may be affected by the planned exploration drilling program as detailed in EP Revision 2, or which could affect the planned operation or activities. Most descriptions of existing conditions and resources are broadened to BOEM's Chukchi Sea Lease Sale 193 Area and adjacent SOA waters to address the vessel and aircraft traffic that will occur outside of Shell's leases and prospect areas. Many of the Section 3.0 Resources and Conditions sub-sections are largely unchanged from EP Revision 1. However, for clarity and to facilitate review of this document, Shell is submitting a comprehensive discussion of the resources and conditions in the EIA in EP Revision 2. There are limited changes to the Resources and Conditions section from the EIA in EP Revision 1 (May 2011) to the EIA in EP Revision 2. These changes are related to:

- Judicial ruling related to critical habitat previously designated for the polar bear
- ESA listing for bearded seal and ringed seal
- ESA listing vacated for bearded seal
- Additional baseline environmental surveys in the Chukchi Sea
- Changes in air quality jurisdiction from EPA to BOEM
- Designation of HSWUA

Descriptions of socio-cultural and socioeconomic resources are focused on those that occur in the marine environment and on the villages that have the most potential to be affected by the planned activities. These include the villages of Point Hope, Point Lay, Wainwright, and Barrow. Distances from the Burger Prospect to the coastline and the nearest villages are presented in Table 3.0-1.

Table 3.0-1 Distances from Chukchi Sea Villages to Nearest Burger Prospect Lease Block

Distance to Nearest EP Block				
Barrow	**Wainwright**	**Point Lay**	**Point Hope**	**Coastline**
140 mi (227 km)	78 mi (126 km)	92 mi (148 km)	206 mi (332 km)	64 mi (103 km)

Additional information on the environmental conditions in the region can be found in the following NEPA and ESA Section 7 Consultation documents:

- Final Second SEIS Chukchi Sea Planning Area, Oil and Gas Lease Sale 193 (BOEM 2015).
- Environmental Assessment for Ancillary Activities (Statoil shallow hazards surveys) in the Chukchi Sea (BOEMRE 2011a).
- Final SEIS Chukchi Sea Planning Area, Oil and Gas Lease Sale 193 (BOEMRE 2011b).
- Environmental Assessment for Shell's 2012 Exploration Drilling Program in the Chukchi Sea (BOEM 2011a).
- Environmental Assessment – Shell 2013 Ancillary Activities Survey, Chukchi Sea, Alaska (BOEM 2013).
- Biological Opinion and Conference Opinion for Oil and Gas Activities in the Beaufort and Chukchi Sea Planning Areas on Polar Bears (*Ursus maritimus*), Polar Bear Critical Habitat, Spectacled Eiders (*Somateria fischeri*), Spectacled Eider Critical Habitat, Steller's Eiders

(*Polysticta stelleri*), Kittlitz's Murrelets (*Brachyramphus brevirostris*), and Yellow-billed Loons (*Gavia adamsii*) (USFWS 2012).

- Final Environmental Assessment for Incidental Take Regulations for Walruses and Polar Bears in the Chukchi Sea (USFWS 2013a).
- Biological Opinion for Polar Bears and Conference Opinion for Pacific Walrus on the Chukchi Sea Incidental Take Regulations (USFWS 2013b).
- Biological Opinion for the USFWS Region 7 Polar Bear and Pacific Walrus Deterrence Program (USFWS 2014b).
- Biological Opinion for the Issuance of Incidental Harassment Authorization under Section 101(a)(5)(a) of the Marine Mammal Protection Act to Shell Offshore, Inc. for Exploratory Drilling in the Alaskan Chukchi Sea in 2012 (NMFS 2012a).NMFS. 2012b. Final Environmental Assessment for the Issuance of Incidental Harassment Authorizations for the Take of Marine Mammals by Harassment Incidental to Conducting Exploratory Drilling Programs in the U.S. Beaufort and Chukchi Seas. National Oceanic and Atmospheric Administration. National Marine Fisheries Service. May 2012.
- Supplemental Draft Environmental Impact Statement on the Effects of Oil and Gas Activities in the Arctic Ocean (NOAA 2013b).
- Biological Opinion, Oil and Gas Leasing and Exploration Activities in the U.S. Beaufort and Chukchi Seas, Alaska (NMFS 2013b).
- Biological Opinion for the Issuance of Incidental Harassment Authorization under 101(a)(5)(a) of the Marine Mammal Protection Act to Shell for Geophysical Surveys, and Equipment Recovery and Maintenance Activities in the U.S. Chukchi Sea, Alaska, During the 2013 Open Water Season (NMFS 2013c).

The only appreciable changes to the regional resources and conditions since these NEPA analyses and Shell's previous EIA (May 2011) that accompanied its EP Revision 1 are largely regulatory in nature as follows:

- In a Ninth Circuit court ruling on 6 January 2013, all critical habitat previously designated for the polar bear by the USFWS was vacated and remanded back to the agency.
- Effective 26 February 2013, the Arctic subspecies of ringed seal, which occurs in the Chukchi Sea, was listed as threatened under the ESA.
- Effective 26 February 2013, the Beringia distinct population segment of bearded seals, which occurs in the Chukchi Sea, was listed as threatened under the ESA, but was later vacated on 28 July 2014.

New Field Surveys in the Chukchi Sea

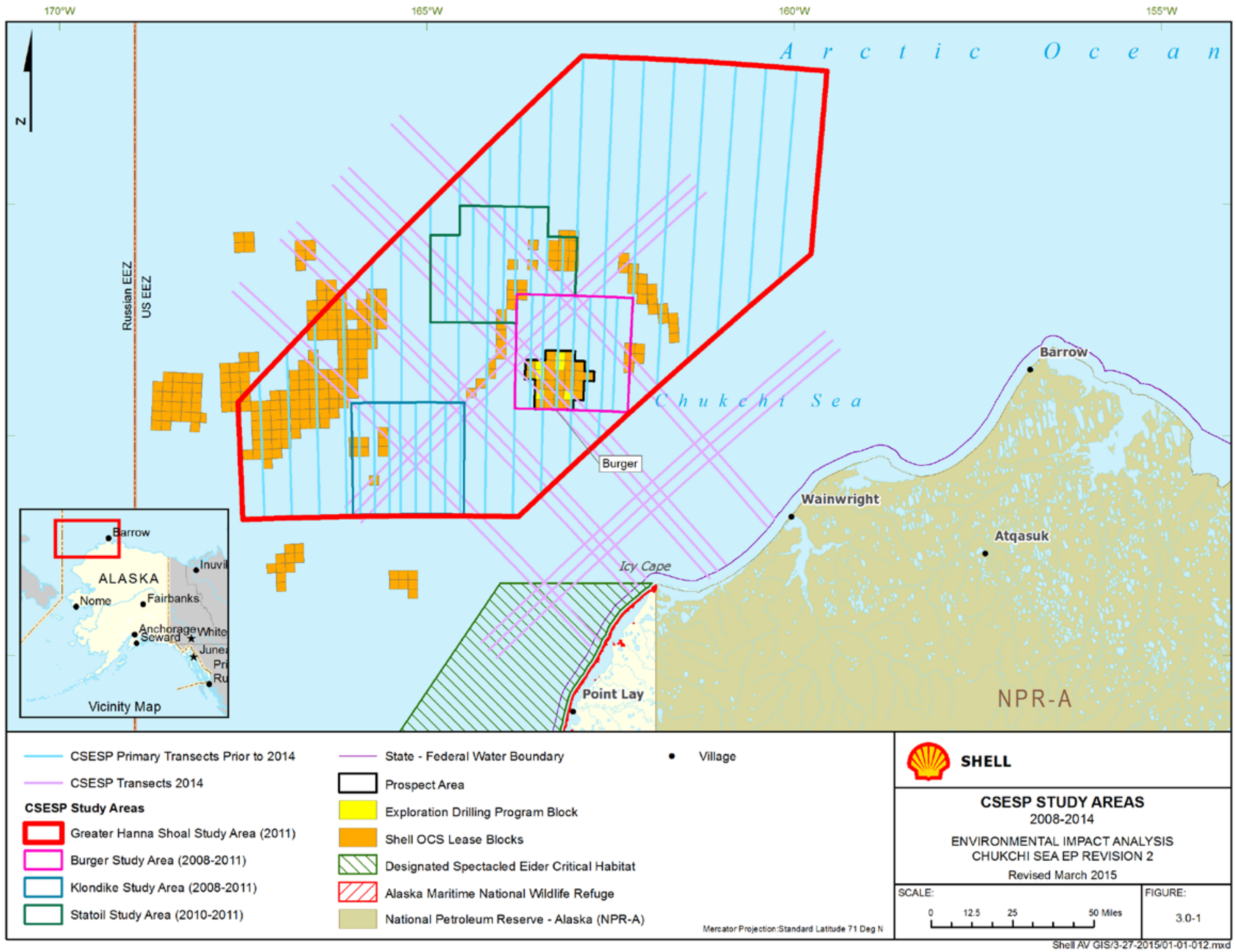
Joint industry surveys known as the Chukchi Sea Environmental Studies Program (CSESP) have been conducted in the Chukchi Sea each year from 2008 through 2014 (data from surveys completed in 2014 are not yet available through peer reviewed study reports). Vessel-based marine mammal surveys were conducted along transects in survey areas encompassing the Burger Prospect and ConocoPhillips Klondike Prospect in July-October 2008 and 2009 (Brueggeman 2009a, 2010). The study area was expanded to included Statoil's prospect in 2010 and the Greater Hanna Shoal Study Area in 2011 (Aerts et al. 2012) (Figure 3.0-1). Surveys for 2014 covered a reduced survey area encompassing the Burger Prospect and locations shoreward of the prospect. Surveys conducted in these study areas included those for chemical and physical oceanography, benthic and plankton communities, fish, birds, and marine mammals (Table 3.0-2). Data from these 2008-2014 CSESP surveys, where available, are used throughout the following sections.

Table 3.0-2 CSESP Studies in the Chukchi Sea 2008-2014

Study Area	Surveys Conducted by Year[1]						
	2008	2009	2010	2011	2012	2013	2014
Burger	physical oceanography, sediment contaminants, benthos, plankton, fish, birds, mammals	physical oceanography, contaminants, benthos, plankton, fish, birds, mammals	physical & chemical oceanography, benthos, zooplankton, fish, birds, mammals	chemical oceanography, plankton, fish, birds, mammals	chemical & physical oceanography, benthos, fish, birds, mammals	chemical & physical oceanography, benthos, fish, birds, mammals	chemical & physical oceanography, benthos, birds, mammals
Statoil	--	--	physical & chemical oceanography, benthos, zooplankton, fish, birds, mammals	chemical oceanography, plankton, fish, birds, mammals	chemical & physical oceanography, benthos, fish, birds, mammals	chemical & physical oceanography, benthos, fish, birds, mammals	No studies planned at the Statoil study area in 2014
Klondike	physical oceanography, sediment contaminants, benthos, plankton, fish, birds, mammals	physical oceanography, contaminants, benthos, plankton, fish, birds, mammals	physical & chemical oceanography, benthos, zooplankton, fish, birds, mammals	chemical oceanography, plankton, fish, birds, mammals	chemical & physical oceanography, benthos, fish, birds, mammals	chemical & physical oceanography, benthos, fish, birds, mammals	No studies planned at the Statoil study area in 2014
Greater Hanna Shoal	--	--	--	chemical oceanography, plankton, fish, birds, mammals	chemical & physical oceanography, benthos, fish, birds, mammals	chemical & physical oceanography, benthos, fish, birds, mammals	No studies planned in the Greater Hanna Shoal study area in 2014

[1] Survey areas encompassed Shell's Burger Prospect and ConocoPhillips' Klondike Prospect in July-October 2008 and 2009 (Brueggeman 2009a, 2010). The study area was expanded to included Statoil's prospect in 2010 and the Greater Hanna Shoal Study Area in 2011 (Aerts et al. 2012) (Figure 3.0-1). Surveys planned for 2014 cover a reduced survey area encompassing the Burger prospect and locations shoreward of the prospect.

Figure 3.0-1 Chukchi Sea Environmental Studies Program Study Areas



3.1 Meteorology and Air Quality

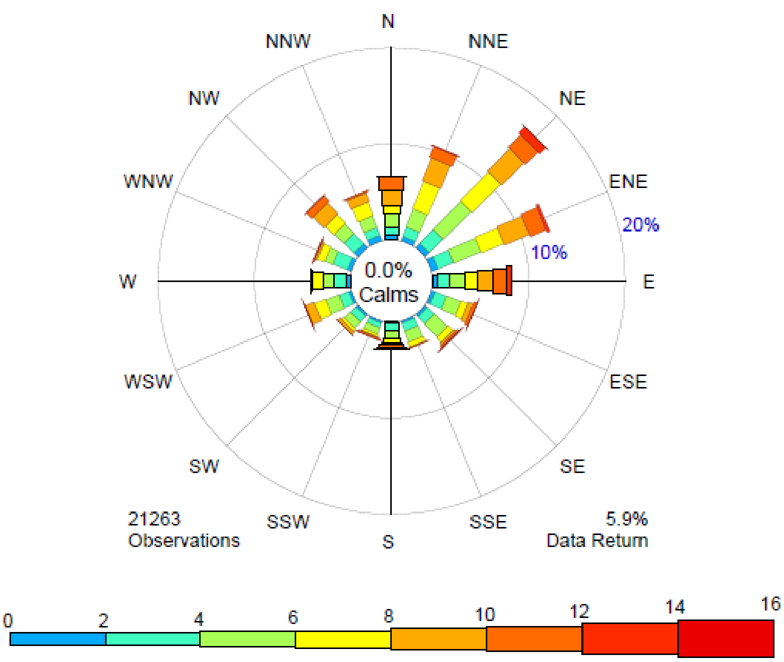
3.1.1 Climate

Shell's Burger Prospect is located in the Arctic Climatic Zone, which is characterized by cold temperatures, nearly constant wind, and low precipitation. The Chukchi Sea, including the Burger Prospect, experiences freezing temperatures for most of the year and is known for frequent and sustained stormy weather. In general, the region has 6 to 10 storm-days per month with each storm lasting from 6 to 24 hr. However, any individual storm may last from 8 to 14 days. Winds may gust from 75 to 85 miles per hour (mph) (65 to 74 kts) and be sustained at 55 mph (48 kts). This results in significant wind-induced wave erosion along the coastline and quickly shifting ice packs in the open water (MMS 2007b).

Ice-melt conditions are governed by the influx of warmer waters from the Bering Sea through the Bering Strait. Water flowing from the Bering Sea into the Chukchi Sea results in the breakup of sea ice in the east (near shore) beginning in mid-May, and migrating to the west around mid-July. During summer, pack ice retreats to the north. This leaves a limited operational window of two to five months when ice coverage is at a minimum (MMS 2007b).

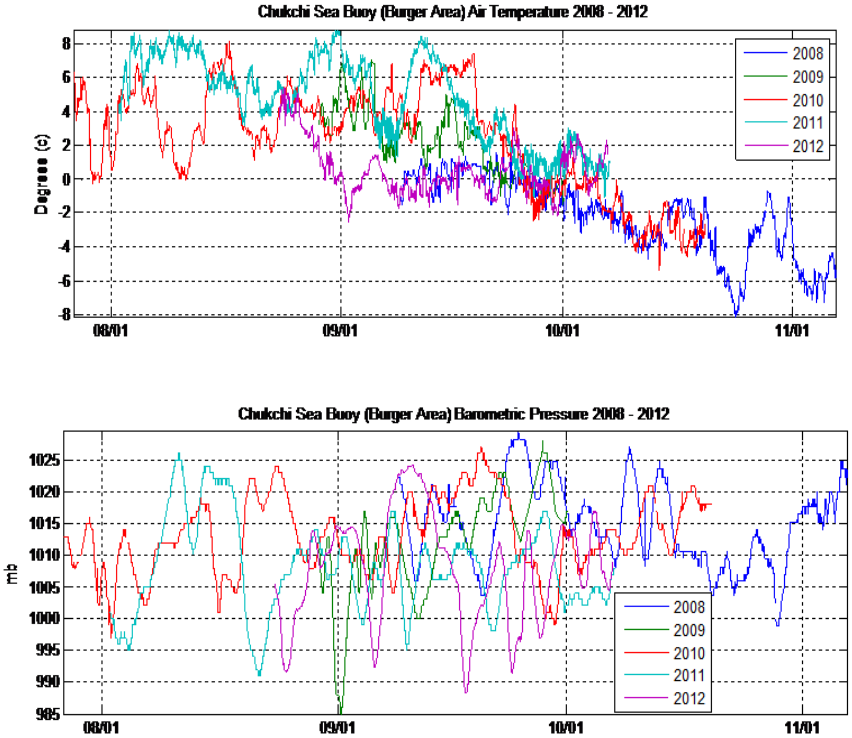
Shell collected meteorological data from a buoy deployed near the Burger Prospect during the open-water season in 2008 through 2012 (Figures 3.1.1-1 and 3.1.1-2; these figures are updated from EP Revision 1 EIA, which only had data for 2008). Data was not collected in 2013, due to ice conditions at the prospect during buoy deployment attempts. Data was collected in 2014; however, figures associated with the data collected in 2014 have not yet been finalized. Based on Shell's meteorological data collected near Burger, winds generally originated from the north-northeast 10.4 percent of the time, east-northeast 12.9 percent of the time, northeast 16.9 percent of the time, and east 8.1 percent of the time.

Figure 3.1.1-1 Wind Speed and Direction, Open-Water Season 2008-2012



[1] Units: m/s

Figure 3.1.1-2 Air Temperatures and Barometric Pressure



Note: X-axis indicates measurement date (e.g., 08/01 = August 1, 09/01 = September 01, etc.).

Summaries of the climatic data collected at Barrow, Point Lay, and Wainwright and are provided in Tables 3.1.1-1, 3.1.1-2, and 3.1.1-3 respectively.

Table 3.1.1-1 Barrow Period of Record Climate Summary[1]

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg Max Temp (°F)	-7.4	-11.1	-7.9	6.7	24.6	38.8	45.6	43	34.6	20.2	5.6	-4.8
Avg Min Temp (°F)	-19.8	-23.1	-20.6	-7.1	15	30	33.9	33.7	27.8	11.1	-5.7	-16.5
Avg Total Precip (in.)	0.17	0.15	0.13	0.17	0.16	0.35	0.9	1.02	0.67	0.47	0.24	0.16
Avg Snowfall (in.)	2.3	2.2	2	2.5	2	0.7	0.3	0.7	4	7.1	3.9	2.6
Avg Snow Depth (in.)	9	10	11	11	6	1	0	0	1	4	7	8

[1]Source: WRCC 2014.

Table 3.1.1-2 Point Lay Period of Record Climate Summary[1]

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg Max Temp (°F)	-3.7	-15.3	-7.4	11.7	29.6	44.3	51.6	50.8	39.9	25.4	10.0	-6.0
Avg Min Temp (°F)	-20.2	-30.5	-22.4	-4.5	17.7	32.7	38.5	38.9	31.3	15.2	-2.3	-19.6
Avg Total Precip (in.)	0.17	0.03	0.1	0.17	0.05	0.31	1.67	1.78	0.72	0.42	0.15	0.12
Avg Snow Fall (in.) [2]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Avg Snow Depth (in.)	7	7	10	12	7	0	0	0	0	2	5	6

[1]Source: WRCC 2014
[2]ND – no data available

Table 3.1.1-3 Wainwright Period of Record Climate Summary[1]

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg Max Temp (°F)	-6.4	-12.9	-8.3	7.9	26.9	41.6	50.0	47.3	36.7	23.0	8.0	-5.5
Avg Min Temp (°F)	-21.2	-26.9	-22.4	-6.8	15.2	30.3	36.3	36.1	28.1	12.2	-4.7	-18.6
Avg Total Precip (in.)	0.15	0.1	0.15	0.3	0.2	0.26	1.57	2.06	0.56	0.77	0.17	0.08
Avg Snow Fall (in.)[2]	0.9	1.1	0.2	ND	0.2	0	0	0	1.2	0	0	0.8
Avg Snow Depth (in.)	6	7	8	9	10	4	0	0	0	2	4	5

[21]Source: WRCC 2014
[2]ND – no data available

The sun remains below the horizon in the project area from December to January. Daylight hours representative of the area (70° North) latitude are presented in Table 3.1.1-4.

Table 3.1.1-4 Daylight Hours by Month in the Chukchi Sea at Latitude 70° North

May [1]	June [1]	July [1]	August [1]	September [1]	October [1]
18.4 hr.	24.0 hr.	24.0 hr.	20.3 hr.	15.1 hr.	10.7 hr.

[1] Average hours of daylight at 70° north latitude for the first day of each month. From the University of Nebraska-Lincoln astronomy group: http://astro.unl.edu/classaction/animations/coordsmotion/daylighthoursexplorer.html.

3.1.2 Climate Change

Many factors contribute to climate change. On a large scale, the orbital configuration of the earth described by Milankovitch (1998) has affected the glacial cycles over the Quaternary Period (last 1.6 million years). Milankovitch cycles include the orbital eccentricity (orbital shape) which has a periodicity of 100,000 years, obliquity (tilt angle of the earth's axis which varies between 22.1 and 24.5 degrees) with a periodicity of 41,000 years, and precession (axial rotation) which has a periodicity of 26,000 years. These changes in orientation and movement change the amount of solar radiation reaching specific locations on the Earth, which influences the Earth's climate system and global glacial cycles.

There are also natural cyclical variations or oscillations in the dominant patterns of sea-level pressures in the world oceans. These oscillations have positive and negative phases depending on where the high-pressure system is located. During the positive phase for the Arctic Oscillation (AO), the high pressure is located around 45° N and the low pressure is located over the pole. During this phase, Alaska typically receives wetter weather due to ocean storms moving farther north; the western U.S. typically has drier conditions, and east of the Rocky Mountains is often warmer than normal. Arctic sea ice tends to break up earlier during the positive phase of the AO due to the intrusion of warmer Atlantic sea water into the Arctic Sea. Weather patterns during the negative phase tend to be opposite of those occurring during the positive phase of the oscillation. Strong mid-latitude westerlies during the negative phase of the AO tend to drive ocean circulations that inhibit the melt and break up of Arctic sea ice (Mitchell 2004). The AO has historically alternated, tending more often towards the positive phase from the late 1980s through the 2000s, which resulted in higher than normal temperatures in the mid-latitudes and lower than normal arctic air pressure. More recently, the AO has favored the negative phase on average, accentuated by a record negative AO Index in February 2010 that corresponded to severe arctic air outbreaks in North America. (National Snow and Ice Data Center 2009).

Likewise, the North Atlantic Oscillation (NAO) and the Pacific Decadal Oscillation (PDO) occur in their respective ocean regions. The NAO is more tied to the AO because the cold meltwater flows into the Atlantic Ocean (Artic Climate Impact Assessment [ACIA] 2005). The effect of climate change on the oscillations is still under investigation. Changes predicted by models, incorporating increased GHG concentrations, have not been realized by 20th century observations of the AO/NAO patterns (Fyfe 2003). Recent studies at the Woods Hole Oceanographic Institution (WHOI) using measurements from a brain coral have indicated that anthropogenic warming does not seem to alter the polarity of oscillation phase on a multi-decadal timescale. However, the variability of phase changes appears to be increasing, which could increase the severity of storms and droughts (WHOI 2009).

The Council on Environmental Quality (CEQ) has issued draft guidance under NEPA indicating that climate change is a reasonably foreseeable impact of greenhouse gas (GHG) emissions. In 2012, the total GHG emissions from all sources in the U.S. were 6,525.6 million metric tons (MMt) of carbon dioxide equivalent (CO_2e) (EPA 2014). This figure is down from the previous year with total U.S. GHG emissions having decreased from 2011 to 2012 by 3.4 percent (EPA 2014). Industrial sectors in the U.S. accounted for 1,821.2 MMt CO_2e or 28% of the total GHG emissions. The total projected emissions from all Alaska sources were estimated at 56.5 MMt CO_2e for 2012 (ADEC 2008). For comparison, Shell's EP would generate 0.16 MMt CO_2e per year, or 0.3% of Alaska's estimated annual emissions.

Over the last few decades, the absorption of atmospheric carbon dioxide (CO_2) by the ocean has resulted in an increase in the acidity of ocean waters with a subsequent decrease in the availability of carbonate ions and a suppression of the saturation states of calcium carbonate minerals (Orr et al. 2005; Bates 2007; Byrne et al. 2010). These physical processes are collectively termed ocean acidification, and have occurred naturally over geologic time scales (Zachos et al. 2005). The loss of ice is leading to a much greater effect of absorption of radiative energy and subsequent rise of ocean temperatures in the Arctic region, and the positive feedback loop that is exacerbating the loss of sea ice and increasing effects of ocean acidification (Mathis and Monacci 2014).

Ocean acidification could be exacerbated in the Arctic because cold ocean waters retain more CO_2 and precondition the seawater to have lower calcium carbonate concentrations and saturation states than do more temperate ocean environments, potentially making Arctic Ocean shelves more vulnerable to ocean acidification (Orr et al. 2005; Bates and Mathis 2009; Steinacher et al. 2009). Ocean acidification in the Arctic is also a concern due to the combined effects of increased freshwater input from melting ice and snow, seasonally high rates of primary production (Bates and Mathis 2009; Bates et al. 2009), and increased CO_2 uptake as a result of sea ice retreat (Steinacher et al. 2009). Bates et al. (2009) and others (e.g., Mathis et al. 2007, 2009; Mathis 2011, 2012, 2013; Mathis and Monacci 2014) have begun reporting detectable effects of decreasing pH on the seasonal saturation states of inorganic carbonate in the Chukchi Sea.

A projected consequence of continued increases in atmospheric CO_2 levels is an acceleration of ocean acidification. This could result in a reduction of suitable marine habitat for benthic and pelagic organisms that produce structures (shells) made of calcium carbonate (Caldiera and Wickett 2003, 2005), with unknown, but potentially significant food web consequences in marine ecosystems (Fabry et al. 2008, 2009).

There are few historic data for establishing climatic trends in the Arctic; the meteorological station density in Alaska is one station per 38,600 mi^2 (100,000 km^2). The overall temperature trend increased during the 20th century; however, a period of decreasing temperatures occurred between the mid-1940s and mid-1960s. Between 1900 and 2003, data from the Global Historical Climatology Network database (Peterson and Vose 1997) and Climate Research Unit database (Jones and Moberg 2003) dataset indicate a warming trend of 0.16 ºF (0.09 degrees Celsius[ºC]) per decade (ACIA 2005).

Geophysical, biological, oceanographic, atmospheric, and anthropogenic sources provide evidence of the climate changing in the Arctic in recent decades. For example, temperature recordings taken by the National Weather Service Office in Barrow from 1961 through 2010 and compiled by the Western Regional Climate Center (WRCC) in Reno, Nevada provide evidence of the warming in the Arctic (WRCC 2014). The temperature recordings show that Barrow's mean temperature increased from 9.4 degrees °F /- 12.6 °C during the 30 years from 1961-1990, to 11.8°F/-11.2°C during the 30 years from 1981–2010, an increase of 2.4°F/1.4°C.

Climate models project more warming in the Arctic compared with the rest of the world (IPCC 2007). At this time there is no definitive evidence of an anthropogenic signal in the Arctic causing this warming. Data are fewer and natural fluctuations are greater in the Arctic than the rest of the world, making it challenging to detect any anthropomorphic signal (ACIA 2005). Temperature variations in Eurasian and North American regional studies are probably not due to natural variability alone (Karoly et al. 2003; Zwiers and Zhang 2003; Stott et al. 2003) and tend to support the conclusion that temperature variations in North America and Eurasia probably are not due to natural variability alone.

Traditional Knowledge (TK) can provide additional insight to arctic climate changes. Alaskan Natives who live within coastal communities along the Bering, Chukchi, and Beaufort Seas have noticed changes in the weather, oceans, and resources. Over the past 20 years, extreme weather such as strong winds and storms are increasing from Elim to Barrow (ACIA 2005). "Weather temperatures have been warmer in recent years than they have been in the past" (as quoted in Shell 2008). Warming conditions have affected sea ice as well. Increased temperatures and winds prevent the sea ice from setting up in the fall delaying the freezing season; early spring melting decreases the safety of the spring ice for hunting. "Multiyear ice near the North Slope shoreline is not as prevalent as it was a half a generation ago (Shell 2008)." Ice conditions have deteriorated to the point that some whalers from Barrow are choosing not to spring whale hunt due to safety concerns. Changes in wildlife have also been recorded in the Bering Sea. There has been a decrease in spotted seals and chum salmon and the spring bird migrations are earlier (ACIA 2005).

3.1.3 Air Quality

The EPA established Standards (NAAQS) for six criteria pollutants to provide protection from adverse effects on human public health and public welfare. The six criteria pollutants are: CO, NO_2, $PM_{2.5}$ and PM_{10}, SO_2, ozone (O_3), and Pb.

The Clean Air Act established two types of NAAQS. Primary standards set limits to protect human public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings (EPA 2013a). The Primary and Secondary NAAQS are identical for the following criteria pollutants: annual average nitrogen dioxide, 24-hr PM_{10} and $PM_{2.5}$, O_3, and Pb. The annual $PM_{2.5}$ Secondary NAAQS is less strict than its Primary standard, and there is no Secondary NAAQS for CO.

The NAAQS set a limit to the concentration of the criteria pollutants in the ambient air. When an area does not meet the air quality standard for one of the criteria pollutants, EPA designates the area as a nonattainment area. The Clean Air Act sets forth the regulatory process to be applied to an area in order to comply with the standards by a designated date. This date varies by the type of pollutant and the severity of the nonattainment air quality problem. As of 4 January 2013, the SOA adopted the federal NAAQS as Alaska Ambient Air Quality Standards (AAAQS) for the six criteria pollutants with one exception; the SOA has recently revised its annual $PM_{2.5}$ standard to be consistent with the federal standard of 12 micrograms (µg)/m^3 (promulgated 14 December 2012), but EPA has not yet approved that update. The

SOA has established state ambient standards for two air pollutants, reduced sulfur compounds and ammonia (ADEC 2013a). The NAAQS and AAAQS are summarized in Table 3.1.3-1.

The onshore area adjacent to the Chukchi Sea is the Northern Alaska Intrastate Air Quality Control Region (AQCR) 9. The EPA has designated this region as Class II and in attainment or unclassifiable for all criteria air contaminants pursuant to 40 CFR 81.302. The closest existing nonattainment area to the Lease Sale 193 Area is a portion of the Fairbanks North Star Borough located approximately 590 mi (950 km) southeast of the project area, which EPA designated as nonattainment for $PM_{2.5}$ in December 2010. The Eagle River area of Anchorage, located approximately 780 mi (1,260 km) from the project area, is also designated as nonattainment for PM_{10}. The nearest Prevention of Significant Deterioration (PSD) Class I area is Denali National Park, including the Denali Wilderness but excluding the Denali National Preserve. Denali National Park is located approximately 650 mi (1,050 km) south, southeast of the project area (ADEC 2013b).

The existing air quality in the Lease Sale 193 Area and adjacent onshore areas is considered to be good because of the lack of pollutant emission sources. Concentrations of regulated air pollutants are much lower in the area than the maximum allowed by the NAAQS and AAAQS.

Emissions in the area come primarily from electrical power generating facilities in small villages such as Barrow, Wainwright, Point Lay, and Point Hope. Small amounts of pollutants are also emitted from vehicles such as cars, trucks, and all-terrain vehicles (ATVs) and heavy construction equipment such as bulldozers and graders. Industrial sources exist within the oil fields near Prudhoe Bay located to the east, and at the Red Dog Mine well south of the Lease Sale 193 Area, but both have little effect on ambient air quality in northwest Alaska onshore areas.

Arctic Haze

Air quality on the North Slope is affected regionally by arctic haze and locally by smoke and windblown dust. Arctic haze refers to the visible haze layers observed generally in late winter and spring in arctic Alaska and Canada far from any known sources of pollution. Scientists believe the pollutants known as arctic haze are transported to arctic Alaska from Europe and Asia. The haze consists primarily of sulfate aerosols and soot (Wilcox and Cahill 2003). These pollutants are effective at scattering light and reducing visibility. Even under haze conditions, however, the concentrations of these pollutants are low and found several miles (several kilometers) above the ground.

Onshore Air Quality

Shell (AECOM, Inc. 2010a) established an air quality monitoring station at Wainwright in November of 2008 and Point Lay, Alaska in June 2010 to collect data in support of air quality permitting efforts. Data for 2009-2013 are summarized in Table 3.1.3-1. Data from 2014 were not available for Pt. Lay at the time this EIA was prepared. The Wainwright monitoring station was not in operation in 2014. Maximum measured background pollutant concentrations collected from July through November (the drill season period) are compared to the NAAQS and AAAQS in Table 3.1.3-1 for CO, NO_2, PM_{10} and $PM_{2.5}$, O_3 and SO_2. The values reported for both stations were determined according to the statistical methods required for direct comparison to the NAAQS, described in the Table 3.1.3-1 “How standard is applied” column. The period averages and percentiles determinations were calculated using the July-November period only. Note that these values are likely highly conservative given that the monitoring stations are located adjacent to villages, therefore exposed to local sources of combustion and unpaved road dust from vehicles. Note that PM concentrations are particularly high at the Wainwright monitoring station because the station was sited adjacent to an unpaved road.[6] All measured concentrations of criteria air pollutants were well below NAAQS and AAAQS during these periods.

[6] As noted in Wainwright station annual monitoring reports from 2012 and 2011:

Table 3.1.3-1 NAAQS, AAAQS, and Measured Pollutant Concentrations, Wainwright 2009-2013

Pollutant	Averaging Times	NAAQS [a]	AAAQS [b]	How standard is applied	Wainwright [c]	Pt. Lay[c]
CO	8-hr average (avg)	9 parts per million (ppm) (10 milligrams [mg]/m^3) [d]	9 ppm [d]	Not to be exceeded more than once per year (2nd high)	0.9 ppm	1.1 ppm
	1-hr avg	35 ppm (40 mg/m^3) [d]	35 ppm[d]	Not to be exceeded more than once per year (2nd high)	1.0 ppm	1.3 ppm
NO_2	Annual	0.053 ppm (100 μg/m^3) [d]	0.053 ppm [d]	Maximum arithmetic average	0.001 ppm	0.001 ppm
	1-hr avg	0.1 ppm (188 μg/m^3) [e]	0.1 ppm [e]	3-year average of 98th percentile daily maximum 1-hr averages	0.021 ppm	0.023 ppm
PM_{10}	24-hr avg	150 μg/m^3 [e]	150 μg/m^3 [e]	Not to be exceeded more than once per year (2nd highs), averaged over 3 years	73 μg/m^3	24 μg/m^3
$PM_{2.5}$	Annual	12 μg/m^3 [f]	15 μg/m^3	3-year average of annual arithmetic averages	2.9 μg/m^3	2.0 μg/m^3
	24-hr avg	35 μg/m^3 [e]	35 μg/m^3	3-year average of 98th percentile daily averages	10.7 μg/m^3	5.5 μg/m^3
O_3	8-hr avg	0.075 ppm (150 μg/m^3)[e]	0.075 ppm[e]	3-year average of annual 4th highest daily maximum 8-hr average concentration	0.047 ppm	0.044 ppm
SO_2	Annual	--	0.03 ppm (80 μg/m^3)	Maximum arithmetic average	0.0002 ppm	0.0018 ppm
	24-hr avg	--	0.14 ppm (365 μg/m^3)	Not to be exceeded more than once per year (2nd high)	0.0008 ppm	0.0051 ppm
	3-hr avg	0.5 ppm (1,300 μg/m^3) [g]	1,300 μg/m^3 [d]	Not to be exceeded more than once per year (2nd high)	0.0049 ppm	0.0054 ppm
	1-hr avg	0.075 ppm (196 μg/m^3)[d]	196 μg/m^3	3-year average of 99th percentile daily maximum 1-hr averages	0.0031 ppm	0.0044 ppm

[a] National Primary and Secondary Ambient Air Quality Standards, 40 CFR Part 50, February 22, 2013
[b] SOA Ambient Air Quality Standards, 18 AAC 50.010, January 4, 2013
[c] Maximum background air quality concentrations from Wainwright (2009-2012) and Pt. Lay (2010-2013) monitoring stations, calculated for the July – November drill season period according to the methods described in the "how standard is applied" column for comparison to NAAQS/AAAQS.
[d] No secondary standard
[e] Primary standard is the same as secondary standard
[f] Secondary standard for annual $PM_{2.5}$ is 15 g/m^3
[g] Secondary standard

Offshore Air Quality

Background concentrations of air pollutants are expected to be quite low in the drilling lease blocks of the Chukchi Sea because there are no permanent or substantive sources of pollution in the vicinity. The nearest land is 64 mi (103 km) from the lease area, and the ocean is uninhabited except for occasional small groups occupied with seasonal subsistence hunting and fishing. The Prudhoe Bay region is the

SLR, Inc. 2012a: 2011 Annual Data Report, Wainwright Ambient Air Quality and Meteorological Monitoring Program. Prepared for ConocoPhillips, Alaska, Inc., Anchorage.

SLR, Inc. 2013a: 2012 Annual Data Report, Wainwright Ambient Air Quality and Meteorological Monitoring Program. Prepared for ConocoPhillips, Alaska, Inc., Anchorage.

major source of air pollution along the northern coast of Alaska, but it is located more than 300 mi (482 km) east of the Burger Prospect.

Air quality monitoring of offshore regions is extremely rare because monitors are typically located in regions where air pollution is a concern, such as urban industrialized areas. An exhaustive search reveals no source of offshore background monitoring data within the Arctic except upper atmosphere satellite data. Continuous monitoring at the surface would be difficult, costly, and impractical due to the extreme marine and atmospheric conditions that occur on the Arctic Ocean.

The only monitoring station that could be considered remotely representative to the offshore region in question is a U.S. IMPROVE monitoring station located in Simeonoff, Alaska, an island in the upper Aleutian chain. The IMPROVE monitoring network measures air quality and visibility in sensitive Class I areas within the U.S., which include relatively pristine national parks and wilderness areas. The Simeonoff station recorded $PM_{2.5}$ and PM_{10} background concentrations from September 2001 through December 2004. These concentrations, summarized in Table 3.1.3-2, may provide an indication of background particulate matter concentrations in a relatively pristine near-shore environment in western Alaska.

Table 3.1.3-2 Summary of Simeonoff IMPROVE Station Observations in 2001-2004

Observation	$PM_{2.5}$ (µg/m^3)	PM_{10} (µg/m^3)
Records	363	365
Min.	0.33	0.95
Max.	16.41	26.5
Average	2.95	7.38
Standard Deviation	2.12	4.97
98th Percentile	9.34	21.9

Onshore ambient air quality monitors located on the North Slope of Alaska may also provide an estimate of the offshore background air quality at the lease blocks. However, due to the proximity to stationary industrial sources, vehicles, wind-blown dust, and other onshore sources, pollutant concentrations measured at onshore monitors would likely be much greater than measurements offshore. Therefore, the onshore data provides very conservative background values.

Onshore monitoring along the North Slope has been conducted sporadically over the past decade by commercial entities such as British Petroleum Exploration Alaska Inc., ConocoPhillips Alaska Inc., and Shell. These sites are concentrated near Prudhoe Bay, but two private stations are located in Wainwright, Alaska and Point Lay, Alaska. The Wainwright and Point Lay sites likely present the most representative data for the lease blocks considering their proximity, but even these data sets are likely to significantly overstate offshore concentrations. Potential effects on air quality from Shell’s planned exploration drilling program in EP Revision 2 are discussed in Section 4.1.

3.2 Oceanography and Water Quality

The Chukchi Sea is the northernmost shelf sea bordering western Alaska. It encompasses the waters north of Bering Strait to Point Barrow, Alaska, in the east and Wrangel Island and the Russian Chukotka coast in the west (Figure 3.2.2-1). This section summarizes available information on the regional bathymetry, water level variations and movement, fluctuations, and water circulation and currents in the northeastern Chukchi Sea and Shell’s Burger Prospect. Oceanographic and atmospheric connections between the Chukchi Sea and Pacific Ocean strongly influence the Chukchi Sea’s wind and wave regime, its seasonal sea ice distribution, regional hydrologic cycle water masses and circulation characteristics. The oceanographic connection that draws water from the Bering Sea into the Chukchi Sea is the result of a large-scale pressure gradient between the Pacific and Atlantic oceans (Coachman et al. 1975).

3.2.1 Bathymetry and Relief

The blocks and planned drill sites for Shell's exploration drilling program are located on the relatively shallow continental shelf of the Chukchi Sea. Major seafloor topographical features near Shell's Burger Prospect are Hanna Shoal to the northeast and Herald Shoal to the southwest. Water depths over most of the Lease Sale 193 area range from approximately 100 to 160 ft (30 to 50 m), with the exception of the shoals, which rise to approximately 66 ft (20 m) depth below sea level. Water depths at the planned drill sites and vicinity are presented in Table 3.2.1-1. Bathymetry and seafloor relief in the vicinity of the proposed drill sites is described below. (Note that there have been no identified changes to bathymetry and relief since the EIA was prepared for EP Revision 1, with the exception of Shell's exploration activity at Burger A during the 2012 season.)

Table 3.2.1-1 Water Depths at Exploration Blocks and Planned Drill Sites

Drill Site	OCS Block	Water Depth Range within Block		Water Depth at Proposed Drill Site	
Burger A	Posey 6764	147 – 153 ft	44.9 – 46.6 m	150 ft	(45.8 m)
Burger F	Posey 6714	145 – 156 ft	44.2 – 47.4 m	149 ft	(45.4 m)
Burger J	Posey 6912	143 – 146 ft	43.5 – 44.5 m	144 ft	(44.0 m)
Burger R	Posey 6812	139 – 146 ft	42.3 – 44.6 m	143 ft	(43.7 m)
Burger S	Posey 6762	143 – 150 ft	43.5 – 45.7 m	147 ft	(44.8 m)
Burger V	Posey 6915	144 – 149 ft	43.9 – 45.4 m	147 ft	(44.8 m)

Burger A

The seafloor in the vicinity of the proposed Burger A drill site is largely flat with a low gradient and featureless except for ice gouges. On average the seafloor near the Burger A drill site slopes very slightly (< 1º) to the southeast but is virtually horizontal. Several ice gouges cross the block exhibiting a northeast-southwest preference. Gouge troughs are as much as about 1.3 ft (0.4 m) deeper than the elevation of the surrounding seafloor, and the associated ridges can rise by about as much as 2.3 ft (0.7 m). Widths of gouges typically range from approximately 66 to 98 ft (20 to 30 m). The nearest prominent gouge is located approximately 1,854 ft (565 m) southeast of the drill site, where the total relief from top of ridge to bottom of trough is about 1.3 ft (0.4 m). Comparison of 1989 and 2009 data sets, which overlap, indicates that while ice gouging has had significant impact on the seafloor at the survey site, there has been no identifiable ice gouging in the last 20 years (Fugro GeoConsulting, Inc. 2010b).

Burger F

The seafloor in the vicinity of the proposed Burger F drill site is largely flat with a low gradient and featureless except for ice gouges. On average the seafloor appears to slope very slightly (< 1º) to the southeast, but is virtually horizontal. Ice gouges crisscross the block, with most gouges exhibiting an east-west preference. Gouge troughs are as much as about 5 ft (1.5 m) deeper than the elevation of the surrounding seafloor, and the associated ridges can rise by about as much as 3.28 ft (1.0 m). Widths of the mapped gouges typically range from approximately 66 to 98 ft (20 to 30 m). The nearest prominent gouge is located approximately 82 ft (25 m) south of the drill site, where the total relief from top of ridge to bottom of trough is about 5 ft (1.5 m). Comparison of 1989 and 2009 data sets, which overlap, indicates that while ice gouging has had significant impact on the seafloor at the survey site, there has been no identifiable ice gouging in the last 20 years (Fugro GeoConsulting, Inc. 2010c).

Burger J

The seafloor in the vicinity of the proposed Burger J drill site is largely flat with the notable exception of several ice gouges that crisscross the block exhibiting both southwest-northeast and northwest-southeast trends (GEMS 2009). Gouge troughs are as much as about 1.6 ft (0.5 m) deeper than the elevation of the surrounding seafloor and the associated ridges can rise as much as about 1.6 ft (0.5 m) above the seafloor. Widths of the mapped gouges typically range from approximately 66 to 164 ft (20 to 50 m). The closest gouges are located about 328 ft (100 m) to the northwest and 328 ft (100 m) to the southeast of the drill site. The northern gouge has relief up to 3.28 ft (1.0 m) from the sediment ridge to trough base, while the southern gouge has less than 1.6 ft (0.5 m) of relief from ridge to trough base. GEMS (2009) commented that a few of the gouges appeared to be “fresh-looking gouges based upon sharpness” but did not speculate as to how recently they had been formed.

Burger R

The seafloor in the vicinity of the proposed Burger R drill site is largely flat with a low gradient and features a low-relief, elongated (northwest –southeast trending) slight topographic high to the northeast of the proposed drill site. Locally, the seafloor is irregular and the gradient is higher due to the presence of ice gouges. Ice gouges crisscross the block, with most gouges exhibiting a northeast-southwest preference. Gouge troughs are as much as about 3.9 ft (1.2 m) deeper than the elevation of the surrounding seafloor, and the associated ridges can rise by about as much as 2.8 ft (0.86 m). Widths of the mapped gouges typically range from approximately 98 to 263 ft (30 to 80 m), with the exception of an approximately 394 ft (120 m) wide gouge trending west to east in the northern half of the survey area. The nearest prominent gouge is located approximately 410 ft (125 m) north of the drill site, where the total relief from top of ridge to bottom of trough is about 3.0 ft (0.9 m). Comparison to other nearby shallow hazards survey data within the vicinity of the Burger R drill site suggest that while ice gouging has had significant impact on the seafloor at the survey site, there has been no identifiable ice gouging in the last 20 years.

Burger S

The seafloor in the vicinity of the Burger S drill site is largely flat with a low gradient and featureless except for ice gouges (Fugro GeoConsulting, Inc. 2010d). On average, the seafloor appears to slope very slightly (< 1º) to the northeast but is virtually horizontal. Ice gouges cross the block, with overall gouge trends appearing to be random. Gouge troughs are as much as about 2.0 ft (0.6 m) deeper than the elevation of the surrounding seafloor, and the associated ridges can rise by about as much as 1.3 ft (0.4 m). Widths of the mapped gouges typically range from approximately 66 to 98 ft (20 to 30 m), with the exception of a 492 to 656 ft (150 to 200 m) wide, arc-shaped gouge in the southwest portion of the survey area. The proposed drill site is approximately 2,870 ft (875 m) south of the ice gouge with the greatest total relief. The total relief from the top of ridge to bottom of trough of this east-west trending ice gouge is about 3.3 ft (1.0 m). Comparisons to other nearby shallow hazards surveys in the vicinity of the Burger S drill site suggest that the rate of gouging on the Chukchi Shelf is low. These studies indicate that while ice gouging has had a significant impact on the seafloor nearby the Burger S drill site, that there has been no identifiable gouging in the past 20 years (Fugro GeoConsulting, Inc. 2010d).

Burger V

The seafloor in the vicinity of the Burger V drill site is largely flat (very slight dip to the northeast) and featureless except for ice gouges (Fugro GeoConsulting, Inc. 2010f). Locally, the seafloor is irregular and the gradient is higher due to the presence of ice gouges. Ice gouges cross the block, with most gouges exhibiting a northeast-southwest preference. The exceptions are two northwest-southeast trending gouges in the northeast portion of the survey area. Gouge troughs are as much as about 1.6 ft (0.5 m) deeper than the elevation of the surrounding seafloor, and the associated ridges can rise by about as much as 2.3 ft (0.7 m). Widths of the mapped gouges typically range from approximately 82 to 148 ft (25 to 45 m), with the exception of an approximately 787 ft (240 m) wide gouge trending northwest-southeast in the northeast portion of the survey area. The nearest prominent gouge is located approximately 590 ft (180 m) northwest of the drill site, where the total relief from top of ridge to bottom of trough is about 2.3 ft (0.7 m). Comparison to other nearby shallow hazards survey data within the vicinity of the Burger V drill site suggests that while ice gouging has had significant impact on the seafloor at the survey site, there has been no identifiable ice gouging in the last 20 years (Fugro GeoConsulting, Inc. 2010f).

3.2.2 Water Movement and Residence Time

Ocean currents move Pacific water through the Chukchi Sea, traveling from the Bering Strait to the Arctic Ocean. Three water masses move through the Bering Strait, the nutrient-rich Anadyr Current passes through the western channel of the Bering Strait while the Bering Shelf Water and the Alaska Coastal Water travel through the eastern channel of the Bering Strait. Bering Sea Water of the Chukchi Sea is formed by the mixing of the Anadyr Current and the Bering Shelf Water. An additional water mass outside of the Bering Strait, the Siberian Coastal Current, is a seasonal current that moves from north to south along the Chukotka Peninsula of Russia (MMS 2007b).

The mean flow through the Chukchi Sea is northward along three recognized general pathways of flow that are influenced largely by topography (Weingartner and Danielson 2010; Weingartner et al. 2011). These pathways of flow are shown in Figure 3.2.2-1. The first pathway of flow is the Alaska Coastal Current, which moves along the Alaskan Chukchi coast and flows into the Arctic Ocean through Barrow Canyon. The second pathway flows north and west of Herald Shoal, and through Herald Valley. The third pathway flows between Herald Shoal and Hanna Shoal, along the Central Channel, in the area of Shell's planned drill sites. The nutrient content of the waters varies throughout the Bering Strait, and the western Chukchi Sea waters are generally richer in nutrients than the eastern Chukchi Sea waters (Woodgate et al. 2005).

Mean flow velocity in the central Chukchi Sea is 0.1 knot, and the mean flow velocity along the Bering Strait, Herald Valley, and Barrow Canyon ranges from 0.2 to 0.4 knot. The highest flow velocities occur in the Bering Strait, with individual 1-hr averages that peak at 1.9 to 2.9 kts. Although the mean flow in the Chukchi Sea is northward, flow reversals frequently occur. These flow reversals are generally due to wind effects, including a strong mean southward wind. Flow reversals are common in the Bering Strait, Herald Valley, and Barrow Canyon and can persist for more than a week (Woodgate et al. 2005).

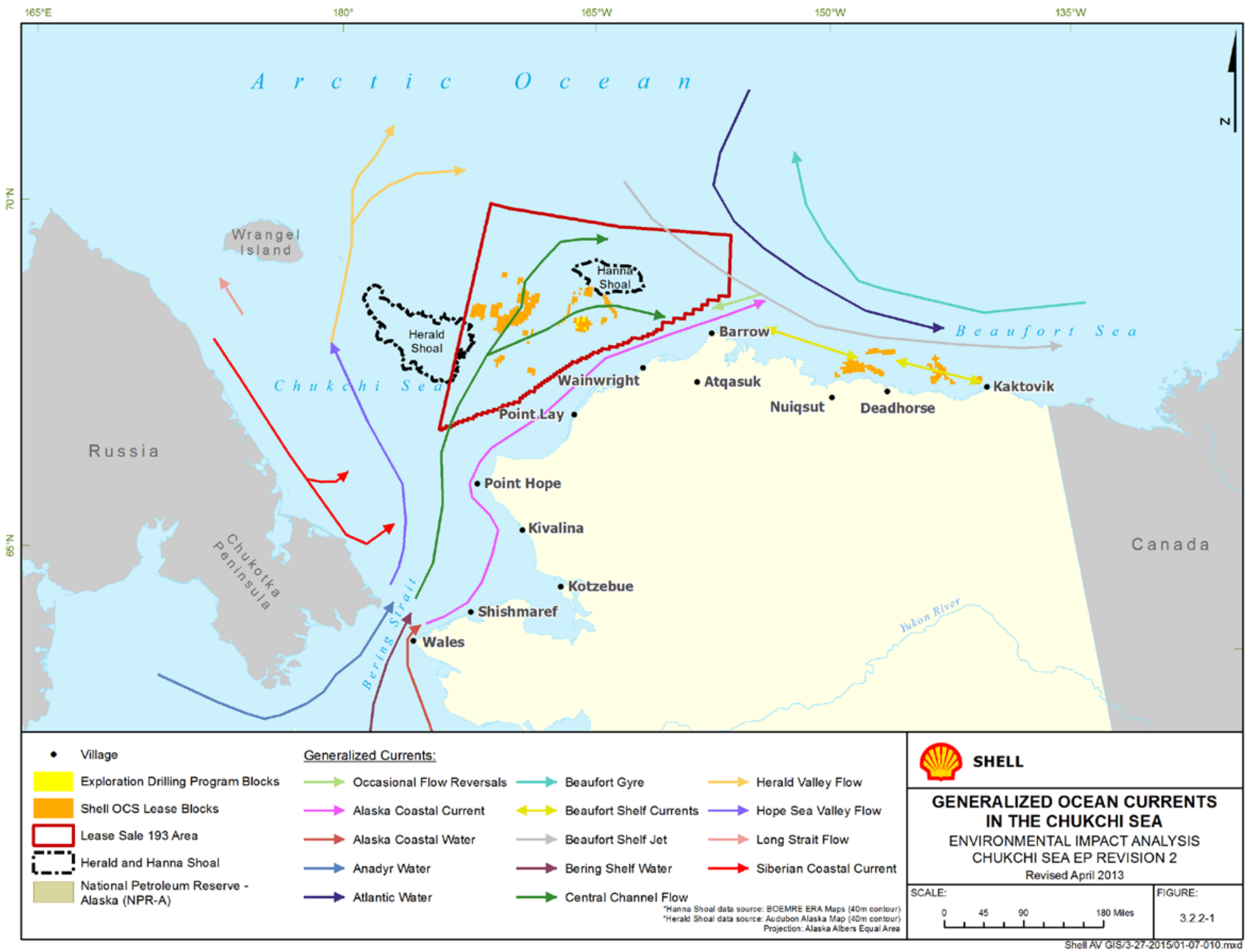
The temperature and salinity of the Chukchi Sea waters show an annual cycle in which the water cools in the autumn, increases in salinity in the winter, and warms and decreases in salinity in the spring and summer. The Anadyr waters that flow through the Bering Strait bring cold, high-salinity waters into the western Chukchi Sea, while the eastern Alaska Coastal Waters from the Bering Strait are warmer and have a lower salinity. The temperature and salinity cycles show the greatest variability in the eastern Chukchi Sea (Woodgate et al. 2005).

Tides in the Chukchi Sea are generally small, ranging from 2 to 12 in. (5 to 30 cm), with the largest tides recorded in the western portion of the Chukchi Sea. Storm surges significantly increase or decrease sea level from the mean level as a result of meteorological conditions interacting with the physical elements of the water surface. Storm surges can be severe in the Chukchi Sea, as evidenced by a storm that battered Barrow on October 3, 1963. Sustained winds of 55 mph (48 kts) were recorded during the storm, with possible gusts of up to 75-80 mph (65-70 kts). A storm surge of 10-12 ft (3.0-3.7 m) with concurrent wave action resulted in flooding and bluff retreat of up to 9.8 ft (3.0 m) (MMS 2007b).

Residence times of Chukchi Sea waters are variable and are dependent on the frequency of flow reversals, with an average flow of 2 in/sec (5 cm/sec) across the entire region. This results in residence times of one month to six months, with longer residence times in winter (Woodgate et al. 2005).

After the waters of the Chukchi Sea flow generally northward, they play a significant role in the Arctic waters. The Pacific waters that have traveled through the Bering Strait and across the Chukchi Sea provide nutrients for the Arctic ecosystems, influence the freshwater balance of the Arctic Ocean, and bolster the halocline (warm and cold layers in the water column) in the Arctic Ocean (MMS 2007b).

Figure 3.2.2-1 Generalized Ocean Currents in the Chukchi Sea



3.2.3 Sea Ice

Pan-Arctic Sea Ice Trends

Sea ice within the Arctic has undergone rapid changes over the past several decades. These changes include a reduction in summertime ice extent, a shift downwards in the mean age of the ice, and loss of ice volume. Numerous records in the September minimum extent have been set within the past decade (Nghiem et al 2014; Stroeve et al. 2011; Stroeve et al. 2005; NASA 2005; Comiso 2006). The September 2012 minimum ice extent is now recognized as the most significant summer retreat. The September 2012 minimum ice extent of 3.41 million km^2 is approximately 50% below the 30 year mean ice extent.

There has been a shift in the mean age of sea ice within the Arctic from older to younger (Maslanik et al. 2007; Kwok and Cunningham 2010). The oldest ice, ice that has survived five or more melt seasons, is nearly depleted. Multiyear ice loss may be attributed to increased export out of the Arctic (e.g. Kwok 2004; Rigor and Wallace 2004) in addition to an overall rise in Arctic surface temperatures (Polyakov et al. 2012; Screen and Simmons 2010; Francis et al. 2005). Loss of old ice in the western Arctic has progressed at a rate of 4.2 percent annually, and has resulted in an increase in the coverage of first-year ice.

Arctic sea ice began thinning rapidly during the 1990s (Rothrock et al. 1999). A comparison of sea-ice draft data between 1993 and 1997, as well as similar data acquired between 1958 and 1976, shows that the average ice draft at the end of the melt season has decreased about 10 ft (1.3 m) in most of the Arctic Ocean (Yu et al. 2004). The decrease was larger in the central and eastern Arctic than in the Beaufort and Chukchi Seas (Rothrock and Zhang 2005).

Warmer waters are now flowing into the Pacific sector of the Arctic Ocean due to recent oceanic heating (Steele et al. 2008; Polyakov et al. 2007; Shimada et al. 2006). This may result in a continued increase in the temperature of the Chukchi Sea in future years.

Sea Ice in the Chukchi Sea

Three different periods of ice coverage can be defined for the Chukchi Sea: 1) Freeze-up – a transition period when new and thin ice forms on the sea surface, 2) Winter when the ocean surface is ice covered, and 3) Break-up the second transition period with thick ice present accompanied by increasing ice decay and open water. There are many different forms of ice that can be found within the Chukchi Sea during a winter season, but all sea ice can be categorized into three main categories: first-year ice, multiyear ice and landfast ice.

First Year Ice

Ice found within the Chukchi Sea is mainly a form of first year sea ice. First-year ice growth is related to freezing degree days (FDD), which is defined by the difference between the temperature at which sea water freezes (~-1.9 °C or 29 °F) and the average daily surface air temperature. FFD are summed from the start of freeze-up and are used in equations such as those presented in Brown and Cote (1992) to calculate a theoretical ice thickness. The theoretical thickness estimate is for an ice sheet growing within a stationary environment, such as a bay or behind a barrier island. Recent data (surface air temperatures at Barrow, Alaska) has shown a decrease in FDD caused by an increase in winter air temperature, which has resulted in lower ice thickness values. Typical mean ice thickness values are now in the 60 in. (1.5 m) range as opposed to the 80 in. (2 m) range observed in the 1980s – 1990s.

In moving ice environments like the offshore region, leads (open water areas between ice floes) will often form causing the sea surface to refreeze and begin the growth processes again. Alternatively, sea ice can be rafted, when ice sheets slide over one another to form thicker ice. Also, ice floe interaction can cause deformation, when large ridges form. Any ice movement can thus cause a variable range of thicknesses to be found in the offshore environment.

Multiyear Ice

Multiyear ice can be found in the Chukchi Sea at the prospect sites, but not on an annual basis.

If ice survives one summer season, it is called second year ice. If it survives a second summer or more it is called multiyear ice (MYI). In reality, unless an ice feature is clearly tracked over its life, it is extremely difficult to separate second year ice from multiyear. MYI can be found in the Polar Pack of the Beaufort Gyre which is north of the Alaskan coast and extends into the northern Chukchi Sea (north of 72° N). At Point Barrow, the Beaufort Gyre is at its closest point to Alaska. MYI does enter the northern Chukchi Sea, poleward of the prospect sites, on an annual basis during the winter.

Landfast Ice

Landfast sea ice, also known as shorefast sea ice, is a ribbon of ice that is fastened to the shore by either direct freezing to the seabed or by anchoring on its seaward edge by grounded ridges. The ice shoreward of the grounded ridges is considered stable and often has a width of 5 to 10 km (3 to 6 mi), but temporary extensions to greater widths can occur (Mahoney et al. 2007). The stable shorefast ice zone can often be frozen to the seabed in water depths less than 1 to 1.5 m (3 to 5 ft). A region’s bathymetry, local ocean currents, and prevailing wind direction are key variables that can impact the extent of the stable landfast ice zone. Land fast ice is minimal off the Alaskan Chukchi coastline due to easterly winds that often cause offshore ice motion.

Ice Movement

The direction of ice movement is controlled by winds, ocean currents and the ability for ice to move into ocean areas unoccupied by sea ice or with lower concentrations of sea ice. Ice movement beyond the Chukchi Sea landfast ice zone tends to be nearly continuous with few periods of little to no ice motion (See Mudge et al. 2010 and Fissel et al. 2010 for annual statistics.) As can be noted, during early winter, ice is in continuous motion and it is not until January that periods of little or no ice motion appear. By April, ice is again in almost continuous motion. January is the month with the largest percentage of little or no motion; on the order of 20%.

Ice motion in the Chukchi Sea differs from the Beaufort Sea as it lacks a large scale circulation feature such as the Beaufort Gyre. The Chukchi Sea ice pack movement is dominantly driven by easterly winds, which pull ice away from the Alaskan coastline creating a coastal flaw lead (a linear waterway opening between the moving pack ice and the landfast ice) that will continue to expand for the event duration. New ice will form in the lead causing varying ice thickness to be found in lead. The width of the flaw lead can reach as much as 100 nmi during a lengthy period of easterly winds. Alternatively, westerly winds that often occur in the Chukchi Sea push sea ice back towards the coast closing the flaw lead and causing ice deformation.

3.2.4 Turbidity and Dissolved Oxygen

The erosion of organic material from along the coastlines, due to storms that bring high winds and onshore flooding can locally increase turbidity and lower oxygen levels. However, these effects are limited to waters less than 16 ft (5 m) deep. The formation of sea ice in the winter can also change the local water quality by removing particulates as the ice forms and locking the material into the ice cover. This sea-ice formation results in very low turbidity levels in the winter, due to less wind effect and fewer particulates in the water (MMS 2007b). Feder et al. (1994b) reported that suspended sediment loads in the water column within 15 ft (5 m) of the seafloor range across the northeastern Chukchi Sea ranged from 1 to 5 ppm in August 1986, with concentrations being in the higher part of the range at Hanna Shoal near Shell's Burger Prospect.

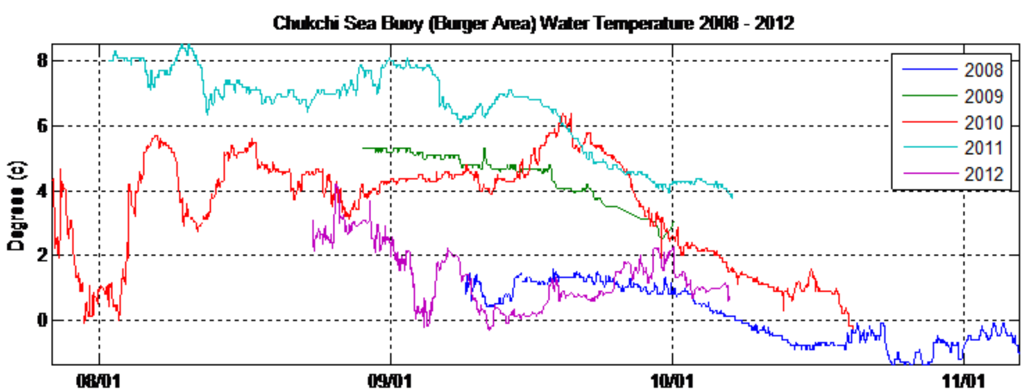
3.2.5 Temperature and Salinity

The water chemistry of the Chukchi Sea is largely controlled by the oceanographic currents that enter through the Bering Strait. The temperature and salinity of the eastern Chukchi Sea are influenced by the warm, relatively fresh Alaska Coastal Current. In the summer, fresh riverine waters flow into the Alaska Coastal Current, forming a hydrographic front along the coast approximately 25 mi (40 km) wide. The colder, saltier, and nutrient-rich waters of the Anadyr Current flow through the western Chukchi Sea, with high summer productivity on the relatively shallow continental shelf (Woodgate et al. 2005).

Greater Chukchi Sea ice cover in the fall limits cooling and generates increased ice cover. Salinity in the water column is also reduced. When the water remains open during the fall, more heat escapes from the water, cooling the water, and eventually leading to more intense ice production and more saline waters. Typically, the Chukchi Sea water cools during the fall, salinity levels increase during the winter freeze, and freshwater circulates during increased spring temperatures (MMS 2006a). Increased salinity levels also bring higher water density during the ice-covered winter season from January to April, and salinity levels in the Bering Strait contribute largely to the Chukchi Sea salinity levels (MMS 2006a). When ice is formed, salt is expelled into the water column, which leads to greater density and an increased water pressure that drives the ocean to circulate in a horizontal direction. In the spring, the melting ice contributes to greater freshwater reserves (Aagaard 1984). Bering Sea water moves north through the Bering Strait and central channel in the summer, replacing bottom water from the previous winter.

Weingartner et al. (2014) used shipboard conductivity, temperature, and depth (CTD), mooring, meteorological, glider, and high-frequency radar data to examine spatial and temporal variations in the circulation and water properties over the CSESP study areas in 2008-2014. Results included temperature, salinity, beam attenuation, and fluorescence profiles collected across the 30 x 30 nmi (55 x 55 km) CSESP Burger Study Area surrounding the Burger Prospect. These data support prior notions of circulation and water masses in the Chukchi Sea, further documenting the influx of warm, saline, nutrient rich waters from the Bering Sea pushing northward and normally replacing the cold saline bottom water formed the previous winter. Water temperatures collected on a buoy deployed by Shell in the Burger Prospect in 2008-2012 are presented in Figure 3.2.5-1. Data was not collected at the Burger prospect in 2013 due to ice conditions during deployment attempts. Shell collected data at the prospect in 2014.

Figure 3.2.5-1 Water Temperature in the Burger Prospect August-November 2008-2012



3.2.6 Trace Metals

Trace metal concentrations in the Chukchi Sea are relatively higher in the Russian Arctic Shelf than in the U.S. portion of the Chukchi Sea; however, this is likely related to natural regional differences rather than anthropogenic input (Naidu et al. 1997). As a whole, the concentrations of metals remain significantly below levels that are considered to have potentially adverse biological effects. The northeastern Chukchi Sea has relatively low metal concentrations, and baseline monitoring efforts are available for comparison from Naidu et al. (1997). Trace metal concentrations in Chukchi Sea sediments are described below in Section 3.3.1.

3.2.7 Water Quality

The quality of the water in the Chukchi Sea – meaning the chemical, physical, and biological characteristics of the seawater – is considered to be relatively pristine (Naidu et al. 1997; MMS 2007b). The region is remote, and humans have little direct influence on the water quality because few people live in the vast region surrounding the Chukchi Sea. In regard to Section 303(d) of the CWA, the Arctic Subregion contains no impaired water bodies (ADEC 2006). Historic offshore oil and gas activities in the Chukchi Sea have not caused long-term deleterious effects to biological resources. The contaminants that do occur in the Chukchi Sea are found only at very low levels (MMS 2007b). Potential effects on water quality from the planned exploration drilling program are discussed in Section 4.2.

Hydrocarbons

Hydrocarbon concentrations in the Chukchi Sea are on the order of 1 part per billion (ppb) or less, and are considered to be of natural origin. The levels generally found in unpolluted marine waters and sediments correspond with the levels found in the Chukchi Sea (MMS 2007b).

Persistent Organic Pollutants

Persistent organic pollutants (POPs) are carbon-based compounds (normally anthropogenic) that do not readily degrade, and therefore persist in the environment. They are capable of being transported over long distances, tend to bioaccumulate in animal tissue, and increase in concentration higher in the food chain. Many POPs have been used or are currently used as pesticides, solvents, or in industrial processes (Ritter et al. 1995). The presence of POPs such as polychlorinated biphenyls (PCBs) and organochlorine pesticides (such as dichloro-diphenyl-trichloroethanes, or DDT) in Arctic seawater is generally a result of circumpolar transport by atmospheric transport and deposition or seawater transport, and river water transport (Chernyak et al. 1996; Weber et al. 2006; Hoferkamp et al. 2010).

Low concentrations of pesticides have been found in the Chukchi Sea. The unique environment of low temperatures combined with low-intensity solar radiation may result in longer environmental lives for compounds that remain on top of sea ice during the winter. As the sea ice melts in the spring, the compounds are released into the seawater and may have adverse environmental impacts (Chernyak et. al. 1996).

Water Quality Degradation

Other large rivers that flow into the Chukchi Sea remain relatively unaffected by human activities, although they do deposit sediments and carry suspended particles with some trace metals, hydrocarbons from natural and anthropogenic resources, and other pollutants. The Arctic Monitoring and Assessment Programme (AMAP 2006) reported that while acidification of surface waters occurs in other arctic regions (Norway, Finland, and Russia), it is highly unlikely in Alaska, due to the low levels of deposition of acidifying pollutants and the limited regions of sensitive geology.

Generally, any other water quality degradation that exists in the Chukchi Sea is part of naturally occurring processes. These processes include seasonal biological activity, such as plankton or algal blooms, water column stratification based on the density and salinity of the waters, natural oil or hydrocarbon seeps, turbidity, and ice.

3.3 Geology and Shallow Hazards

3.3.1 Geology

The Lease Sale 193 Area is located over the U.S. portion of the Chukchi Shelf and is part of the Arctic Ocean northwest of the Alaskan coast. The Chukchi Shelf is a broad, low-relief continental shelf that gently dips to the north (MMS 2007b). The Chukchi Shelf has been subaerially exposed at various times of low sea level. During the last glacial maximum (approximately 20,000 years ago), the shelf was exposed and formed the Bering Land Bridge between Russia and Alaska.

While the Chukchi Shelf transitions into the Amerasian Basin to the north, it is separated from the Beaufort Shelf near Barrow by Barrow Canyon, a northeast-southwest trending relict channel formed during a period of low sea level. The Herald Thrust, a Cretaceous thrust fault with basement uplift, borders the Lease Sale 193 Area to the southwest, separating the Chukchi Platform and Hanna Trough to the north from the Hope Basin to the south. The Herald Thrust is exposed onshore on the Cape Lisburne Peninsula and extends offshore in a northwesterly fashion towards the Russian Chukchi.

The major geologic structure in the Chukchi Sea Planning Area is the Hanna Trough, which trends generally north-south and is a branch of the east-west trending Colville Basin of North Alaska (Thurston and Theiss 1987; Sherwood et al. 2002). The Hanna Trough structure is flanked by the Arctic Platform to the northeast and the Chukchi Platform to the west. These shallow platforms are basement highs cored by the lower Paleozoic Franklinian Sequence.

Stratigraphy

In general, the near-surface geology (upper 3,300 ft [1,000 m]) of the Chukchi Shelf can be characterized by nonexistent to thick (0 to > 3,300 ft [0 to > 1,000 m]) Tertiary age clastic strata overlying thick (> 3,000 ft [914 m]) Cretaceous age clastic strata (Sherwood 1998). Immediately overlying the Tertiary and Cretaceous rocks in the Chukchi Sea area is a thin veneer of Quaternary (Pleistocene and/or Holocene) clastic sediment. These youngest units (most recent sediments) range in thickness from several feet over much of the Lease Sale 193 Area, to locally thick areas with accumulations up to 200 ft (61 m) thick.

Geologic Structure and Petroleum Geology

Five exploration wells have been previously drilled, evaluated, and abandoned (1989-1991) in the U.S. Chukchi Sea area. These wells encountered thermal hydrocarbons in the Ellesmerian, Beaufortian and Lower Brookian Sequences (Sherwood 1998). These same sequences contain major oil and gas accumulations (fields) on the North Slope of Alaska. The Burger Prospect located within the Lease Sale 193 Area was found to have gas in Lower Cretaceous Kuparuk-equivalent sandstones (Sherwood et al. 2002).

One recent exploration well, the Shell Gulf of Mexico, Inc. OCS-Y-2280 #001 (Burger A), was spud in 2012 and drilled to a total depth of 1,505 ft total vertical depth (TVD) before being abandoned at the end of that season. This well penetrated approximately 5 ft of the Upper Brookian and 1,500 ft of Lower Brookian Sequence clastics. No hydrocarbons were encountered in this well; however it was not drilled to total objective depth.

Seafloor Sediments

The shallow seafloor sediments of the Chukchi Sea consist of Pleistocene and Holocene age mud, gravelly mud, muddy gravel, gravelly sand, and muddy sand, and have been mapped by several investigators (McManus et al. 1969; Naidu 1988; Feder et al. 1989; Nelson et al. 1994). The generalized map of the distribution of sediment types developed by Nelson et al. (1994) indicates that the shallow, surficial sediments over most of the Chukchi Sea Shelf, including Shell's Burger Prospect, are predominantly mud. Gravels are found on the inner shelf and on the regional bathymetric highs "offshore shoals" such as the Herald Shoal and Hanna Shoal.

Although much of the Chukchi seafloor is relatively flat, BOEM (MMS 2007b) has described the occurrence of asymmetric bedforms observed in water depths of less than 49 to 213 ft (15 to 65 m) for a distance of up to 100 mi (161 km) offshore within the Lease Sale 193 Area. The bedforms are interpreted to be sand waves that are derived from currents or waves associated with storm events, or that are derived from these currents or waves in combination with effects of the Alaska Coastal Current.

The thickness of the Pleistocene and Holocene sediments varies across the Chukchi Shelf, and can be locally thick where paleochannels have been filled following a rise in sea level. The paleochannel fill typically consists of mud, muddy sand and gravel and may exceed 100 ft (30 m) in thickness (MMS 2007b). This is witnessed more often in the northern part of the Chukchi Shelf where paleochannel features, or remnant paleo streams, cut into older rock and are usually filled with younger sediment deposits.

The reported thickness of Pleistocene and/or Holocene sediments immediately offshore of Wainwright is generally more than 78 ft (24 m), which reflects the offshore extension of the Kuk River channel (MMS 2007b). However, the Pleistocene sediments are reported to be much thinner, about 5.6 ft (1.7 m) thick at the Burger Prospect, which sits approximately 78 mi (126 km) to the northwest of Wainwright. Quaternary sediments in the western portion of the Chukchi Basin, have been described as ranging in thickness from 66 to 140 ft (20 to 42 m) with soft silty clay in the upper 5 ft (1.5 m) to well-consolidated sediments of silty sandy clay to a depth of about 80 ft (24 m) below the seafloor (Fugro 1989b).

Holocene sediments are generally marine silts and clays that locally grade to sands and gravels (Fugro 1990a). Holocene deposits may cover older, previously exposed Pleistocene lagoons and stream channels, as well as more recent ice gouge depressions (and strudel scour depressions nearer shore). Holocene sediments are generally thin, about 6.6-16 ft (2-5 m), and are reported to be about 3.3 ft (1 m) thick offshore of Wainwright (Fugro 1989a).

Depth of Holocene Sediments at the Drill Sites – Shell Geophysical Surveys

Interpretation of shallow hazards survey data over the Burger Prospect at the six proposed drill sites indicates that the seafloor in the prospect is overlain with a veneer of Holocene sediments that is relatively uniform, but varies in thickness (Table 3.3.1-1) from 2.6 to 11.5 ft (0.8 to 3.5 m). These Holocene sediments consist largely of soft silty clays and are underlain by Pleistocene sediments consisting of sands, silts, and clays of variable strength and Cretaceous strata consisting of hard silts and clay with some coal and dense sand at the drill sites.

Table 3.3.1-1 Thickness of Quaternary Sediments in the Vicinity of the Drill Sites

Units	Burger A	Burger F	Burger J	Burger R	Burger S	Burger V
Holocene ft (m) [1]	~5.0 (1.5)	7.9 (2.4)	11.5 (3.5)	3.6 (1.1)	11.5 (3.5)	2.6 (0.8)
Pleistocene ft (m) [1]	0	0	0	0	2.0 (0.6)	0

[1] Inferred from shallow hazards surveys; Source: GEMS 2009, Fugro GeoConsulting, Inc. 2010b,c,d,f; 2011b

Shallow hazards surveys (Fugro 1990a,b,c,d; 1989b) conducted at other historical prospects (Azurite, Ruby, Tourmaline and Popcorn) located in the Chukchi Sea area similarly concluded that the thin Quaternary surficial sediments also consist of silts and clays. This interpretation of sediment character was also supported by underwater video reconnaissance at historic well sites in the Burger Prospect (Finney 1989).

Grain Size Analysis of Sediments at the Burger Prospect – Shell Baseline Studies

Sediment samples were collected at 34 stations in a 30 x 30 nmi (55 x 55 km) Burger Study Area that surrounds the Burger Prospect (Neff et al. 2010). Surficial sediments in the study area were found to consist of sandy mud with lesser amounts of gravel. Mud (silt and clay) content of the surface sediments averaged 52.9 percent with sediment cores averaging 58.2 percent. Average grain size percentages of the sediments are presented below in Table 3.3.1-2. Studies of the benthic communities (Blanchard et al. 2010a,b) also conducted by Shell in the same study area in 2008-2010 obtained similar results, reporting an average mud content of approximately 61 percent (Table 3.3.1-3).

Table 3.3.1-2 Surface Sediments Grain Size in the Burger Prospect Area

Sediment Samples	Statistic	Gravel (percent)	Sand (percent)	Silt (percent)	Clay (percent)	Silt & Clay (percent)	TOC [4] (percent)
Surface Sediments[2] (n = 32)	Avg	4.4	42.7	33.2	19.7	52.9	0.95
	SD[5]	7.7	14.1	11.2	6.8	17.2	0.26
	Max[6]	32.0	68.9	54.7	36.2	84.9	1.54
	Min[7]	0.0	13.7	14.2	7.7	21.9	0.47
Sediment Cores[3] (n = 6)	Avg	1.2	35.9	35.6	27.4	58.2	1.01
	SD	1.6	9.2	12.1	5.5	9.7	0.13
	Max	4.4	52.7	43.1	36.2	71.0	1.26
	Min	0.0	28.5	11.0	19.3	43.5	0.90

[1] Source: Neff et al. 2010
[2] Surface sediments are from depths of 0 to 2 cm below the seafloor surface
[3] Sediment core samples are for depths of 2 to 12 cm below the seafloor surface
[4] TOC - Total organic carbon
[5] SD = standard deviation
[6] Max = Maximum
[7] Min = Minimum

Table 3.3.1-3 Gravel, Sand, and Mud in Surface Sediments, Burger Prospect Area 2008-2010[1,2]

Sediment Samples	Statistic	Gravel (percent) [1]	Sand (percent) [1]	Mud (Fines) (percent) [1]
2008 n = 26	avg	2.5	36.9	60.6
	SD	3.93	14.62	15.74
	95% CI	(0.99, 3.98)	(31.32, 42.44)	(54.65, 66.63)
2009 n = 26	avg	5.2	34.1	60.6
	SD	9.7	15.2	17.2
	95% CI	(0.7, 9.7)	(27.0, 41.2)	(52.6, 68.7)
2010 n = 26	avg	N/A	33.9	61.0
	SD	-	18.6	19.7
	95% Cl	-	(25.4, 42.4)	(52.3, 69.7)

[1] Source: Blanchard et al. 2010 a,b
[2] Notes: SD=standard deviation; CI=confidence interval

Modern Sedimentation Rates

Feder et al. (1989) investigated sedimentation rates in the Chukchi Sea area. They concluded that the Chukchi Sea could be divided into two broad areas regarding modern sedimentation rates, with inshore areas having low rates or even no deposition, and offshore areas having sedimentation rates of 0.06 to 0.10 in. (0.16 to 0.26 cm) per year. Shell's Burger Prospect is located within the latter area. Cooper and Grebmeier (2012) collected core samples in 2009 and estimated an average sedimentation rate of ~0.25 cm per year. This estimate was derived from sediment core samples throughout the COMIDA continental shelf study area and is consistent with previous work conducted in the Chukchi Sea area.

Sediment Quality

Sediments in the Chukchi Sea, including the area of Shell's Burger Prospect, are thought to have remained relatively free of pollutants such as metals. Naidu et al. (1997) collected samples of surficial sediments at 31 locations within the Chukchi Sea area, including samples from both the Lease Sale 193 Area and the nearshore coastal waters region, and analyzed them for concentrations of metals. Trefry et al. (2012) took 207 bottom samples from the eastern Chukchi Sea to test for concentrations of trace metals. The results of Naidu et al. (1997) and Trefry et al. (2012) are summarized below in Table 3.3.1-4.

Trace metal concentrations in the Chukchi Sea region were found to be lower than in similar sediments in the Russian Arctic Shelf and the U.S. Beaufort Sea. The authors concluded that these observed differences in metal concentrations are likely related to natural regional differences in the chemical make-up of sediments inherited from terrigenous sources, and are not due to anthropogenic input. As a whole, concentrations of metals remain significantly below levels that are considered to have potentially adverse biological effects. It should be noted that the U.S. Chukchi Sea samples were collected six years after the last of five historic exploration wells were drilled in the Chukchi Sea.

Table 3.3.1-4 Mean Concentrations of Elements in Sediments of Circumpolar Arctic Seas

Shelf[1]	Sample size[3]	Fe	Mn	Org C	Cu	Cr	CO	Ni	Zn	V
Chukchi Sea[2]	89	2.93	356	-	14	72	-	25	72	104
	SD	0.87	109	-	4	19	-	7	22	31
Chukchi Sea	12	3.46	295	0.75	22	82	26	27	79	116
	SD	0.64	37	0.44	6	21	5	6	18	30
Beaufort Sea	23	3.36	410	0.83	33	89	89	47	98	152
	SD	1.12	174	0.20	9	14	14	11	18	26
Pechora Sea	40	-	-	-	21	110	-	43	84	175
	SD	-	-	-	2	15	-	9	9	46
Kara Sea	36	-	-	-	20	110	-	42	-	147
	SD	-	-	-	6	25	-	10	-	27
Svalbard	15	-	-	-	-	153	-	50	107	248
	SD	-	-	-	-	5	-	1	3	11
E. Greenland	10	-	-	-	50	117	-	62	92	167
	SD	-	-	-	36	37	-	27	16	64
W. Baffin Is.	12	-	-	-	29	63	-	22	61	92
	SD	-	-	-	8	19	-	9	14	32

[1] Concentrations of iron and organic carbon are in milligrams per gram (mg/g); other elements are in μg/g
[2] Source: Trefry et al. 2012; All other shelf locations from Naidu et al. 1997
[3] SD = standard deviation, Fe = iron, Mn = manganese, org C = organic carbon, Cu = copper, CO = carbon monoxide, Ni = nickel, Zn = zinc, V = vanadium

Sediment samples at the 34 stations in a 30 x 30 nmi (55 x 55 km) CSESP Burger Study Area were analyzed for metal and hydrocarbon concentrations (Neff et al. 2010). The results of the analyses are summarized below in Table 3.3.1-5. Concentrations of all measured hydrocarbon types were found to be well within the range of non-toxic background concentrations reported by other Alaskan and Arctic coastal and shelf sediment studies (Neff et al. 2010; Dunton et al. 2012). Metal concentrations were found to be quite variable. Average concentrations of all metals except for arsenic and barium were found to be lower than those reported for average marine sediment.

Table 3.3.1-5 Metal, TPH, and PAH in Burger Study Area Surface Sediments

Parameter	Burger Study Area Surface Sediments [1]			Reference Sediments [1]	
	Mean	Standard Deviation	Minimum	Avg Marine Sediment	Avg Cont. Crust
Silver (ppm)	0.12	0.01	0.10	0.16	0.07
Aluminum (ppm)	5.77	0.85	4.31	7.2	8.0
Arsenic (ppm)	16.7	6.3	10.1	7.7	1.7
Barium (ppm)	639	76	519	460	584
Cadmium (ppm)	0.18	0.02	0.15	0.17	0.1
Chromium (ppm)	79.0	11.1	64.2	72	126
Copper (ppm)	14.8	3.1	9.2	33	25
Iron (ppm)	3.19	0.67	2.20	4.1	4.3
Mercury (ppm)	0.033	0.007	0.018	0.19	0.040
Manganese (ppm)	300	54	225	770	716
Lead (ppm)	12.3	1.7	10.6	19	15
Selenium (ppm)	0.75	0.34	0.25	0.42	0.12
Zinc (ppm)	77.8	15.5	49.4	95	65
TPH (ppb) [2]	13,800	7,600	1,870	--	--
Total PAH (ppb) [3]	445	144	253	--	--

[1] Source: Neff et al. 2010
[2] TPH is total petroleum hydrocarbons
[3] PAH is polycyclic aromatic hydrocarbons

Trefry et al. (2012) confirmed findings by Neff et al. 2010 that concentrations of all measured hydrocarbon types were well within the range of non-toxic background concentrations reported by other Alaskan and Arctic coastal and shelf sediment studies.

3.3.2 Geological Hazards

The following discussion of shallow geologic hazards pertains to those hazards that might impact the location and drilling of exploration wells from a drilling unit in the Chukchi Sea.

Historic Shallow Hazards Surveys

Shallow hazards surveys were conducted in 1988 and 1989 over ten historical industry prospects as listed in Table 3.3.2-1. Locations of these surveys in reference to the Lease Sale 193 Area and Shell’s Burger Prospect and lease blocks are indicated in Figure 1.2-1. The historical Burger survey (Fugro 1990a) covers portions of Shell’s current Burger Prospect including two of Shell’s revised Chukchi Sea EP Blocks Posey 6714 and 6764. The legacy shallow hazards survey data collected over the Burger Prospect (Fugro 1989a) were re-analyzed by Fugro GeoConsulting, Inc. (2009) for the Burger C and F drill sites; the updated shallow hazards and cultural resources/archaeological assessment was submitted to BOEM in April 2009.

Table 3.3.2-1 Historical Shallow Hazards Surveys

Historical Survey		Shell EP Blocks Covered	
Survey	**Year**	**Current Shell Prospect**	**Revised Chukchi Sea EP Blocks**
Azurite	1989	none	none
Brandt	N/A	none	none
Bowhead	N/A	none	none
Burger	1989	Burger	Posey 6714, 6764
Crackerjack	1988	none	none
Diamond	N/A	none	none
Klondike	1988	none	none
Popcorn	1989	none	none
Tourmaline	1988	none	none
Ruby	1989	none	none

N/A – not available

Shell's 2008 and 2009 Shallow Hazards Surveys

During the 2008 and 2009 survey seasons, Shell collected high-resolution shallow hazards survey data to characterize potential shallow hazards, document seafloor morphology, measure bathymetry, and assess potential archaeological resources as required by BOEM NTL No. 05-A01 and NTL No. 05-A03. Deployed equipment included a high-resolution multi-channel 2D system, medium penetration subbottom profiler, shallow penetration subbottom profiler, side-scan sonar, and single and multibeam echosounders.

Shell conducted shallow hazards surveys at the Burger J drill site in 2008 and at the Burger A, F, R, S, and V drill sites in 2009. These surveys are on existing Shell OCS leases and delineated in Figure 1.4-1. Shallow hazards survey and archaeological assessment reports have been prepared and submitted to BOEM. The results of these surveys are summarized below in the Shallow Hazards section.

Types of Shallow Hazards

Various geological conditions and fluid accumulations can constitute hazards to drilling operations within the upper part of the drill hole (uncased well bore) including shallow faults, natural gas hydrates, sediment slides, permafrost, ice gouging. Each of these is discussed below.

Shallow Faults

Normal faults are common in the Burger Prospect area; however, all mapped faults are buried below the Quaternary (Holocene and Pleistocene) sediments with no seafloor expression, are considered to be inactive, and will not pose a hazard to exploration drilling operations. Distances from the proposed drill sites to the nearest fault are indicated below in Table 3.3.2-2.

Table 3.3.2-2 Distance to Nearest Mapped Fault from the Burger Prospect Drill Sites

Drill Site	Burger A	Burger F	Burger J	Burger R	Burger S	Burger V
Nearest Fault [1]	197 ft	1,788 ft	2257 ft	486 ft	Vertical [2]	1,312 ft
	60 m	545 m	688 m	148 m	Vertical [2]	400 m
Burial Depth [1,3]	25 ft	25 ft	> 6 ft	53 ft	16.7 to 86.7 ft	10 ft
	7.7 m	7.5 m	few meters below seafloor	16 m	5.1 to 26.4 m	3 m

[1] Source: GEMS 2009; Fugro GeoConsulting, Inc. 2010b,c,d,f; 2011b
[2] A vertical well from the drill site will intersect a shallow fault at approximately 215.6 m (approximately 707 ft) below mudline
[3] Burial depth below surface for fault nearest the drill site

Natural Gas Hydrates

Gas hydrates are mainly methane trapped in a water lattice and resemble ice. These can occur in deep water areas of continental margins under low-temperature and high-pressure conditions (MMS 2003a). They can also exist in cold regions such as Arctic or Antarctic areas, or in production equipment where gas from a formation expands and cools. They are sometimes interspersed in permafrost (MMS 2003a). There is no indication of gas hydrates in recently completed shallow hazards surveys over the Burger A, F, J, R, S, and V drill sites (GEMS 2009; Fugro GeoConsulting, Inc. 2010 b, c, d, f; 2011b). Further there is no evidence of gas hydrates within the Shell Gulf of Mexico, Inc. OCS-Y-2280 #001 (Burger A) well, which was drilled to a TVD of 1,505 ft in 2012. The presence of gas hydrates at Burger Prospect is unlikely.

Sediment Slides

Mud slides and slumps have not been observed in the Chukchi Sea. If they do occur, it would most likely be associated with the northern shelf margin (MMS 1991). There are no indications of sediment slides in the recently completed shallow hazards surveys over the Burger A, F, J, R, S, and V drill sites (GEMS 2009; Fugro GeoConsulting, Inc. 2010 b,c,d,f; 2011b). Sediment slides are not expected to occur during exploration drilling operations.

Permafrost

Permafrost along the coast of the Chukchi Sea is restricted to small areas or does not exist (MMS 2007b). Ice-bearing subsea permafrost is reported to be thin or nonexistent at distances 0.6 mi (1 km) or more from shore (MMS 2007b). No indication of permafrost was observed in recently completed shallow hazards surveys over the Burger A, F, J, R, S, and V drill sites (GEMS 2009; Fugro GeoConsulting, Inc. 2010 b,c,d,f, 2011b). Further there is no evidence of permafrost within the Shell Gulf of Mexico, Inc. OCS-Y-2280 #001 (Burger A) well, which was drilled to a TVD of 1,505 ft in 2012. The presence of permafrost at the Burger Prospect is unlikely.

Ice Gouging

Based on shallow hazards surveys collected on the continental shelf within the Burger Prospect area of the Chukchi Sea, the seafloor is essentially flat with scattered ice gouges that create some disturbance to the seafloor (Table 3.3.2-3). Comparison of historic and recent shallow hazards survey data indicates that little or no ice gouging has occurred in the last 20 years (Fugro GeoConsulting, Inc. 2010b,c,d,f; 2011b).

Table 3.3.2-3 Nearest Ice Gouge to Burger Prospect Drill Sites and Associated Relief

Measure	Burger A	Burger F	Burger J	Burger R	Burger S	Burger V
Nearest Gouge [1]	1,854 ft	82 ft	328 ft	410 ft	2,870 ft	590 ft
	565 m	25 m	100 m	125 m	875 m	180 m
Gouge Trends [1]	NE-SW	E-W	SW-NE & NW - SE	NE-SW	random	NE-SW
Range of Gouge Widths[1]	66-98 ft	66-98 ft	66–164 ft	98–263 ft	66-98 ft	82-148 ft
	20-30 m	20-30 m	20-50 m	30–80 m	20-30 m	25-45 m
Max Gouge Depth [1]	1.3 ft	5.0 ft	1.6 ft	3.9 ft	2.0 ft	1.6 ft
	0.4 m	< 1.5 m	< 0.5 m	1.2 m	0.6 m	0.5 m
Max Ridge Height [1]	2.3 ft	3.3 ft	1.6 ft	2.8 ft	1.3 ft	2.3 ft
	0.7 m	< 1.0 m	< 0.5 m	0.9 m	0.4 m	0.7 m

[1] Source: GEMS 2009; Fugro GeoConsulting, Inc. 2010b,c,d,f; 2011b

Man-made Hazards

No facilities, shipwrecks, significant debris, or other man-made seafloor obstructions were detected in the shallow hazards surveys around the planned drill sites (GEMS 2009; Fugro GeoConsulting, Inc. 2010b,c,d,f; 2011a,b). All of the observed unidentified sonar contacts and magnetic anomalies at each drill site will be avoided during the planned exploration drilling operations.

Remaining man-made objects in the area include the legacy Burger OCS-Y-1413 (Burger #1 Well), which was drilled in 1989-1990 in Posey Area Block 6814. The historic well site is located approximately 4.0 to 8.0 mi (6.5 to 12.9 km) from the proposed drill sites. The historic well was plugged and abandoned in 1990, with all surface wellhead equipment contained well below the seafloor at the bottom of the MLC. The only other man-made object around the proposed sites is the legacy Burger #1 well and wet stored anchors at Burger A set in 2012.

Seismicity

The Alaskan Chukchi Shelf is generally not seismically active, and earthquakes are not expected in the area. Shallow hazards survey data indicates that all of the shallow faults are listric and most trend (strike) north-south. All of the shallow faults are buried beneath Holocene sediment, none extend to the modern day seafloor, and all are deemed to be inactive (Fugro 1989a; GEMS 2009; Fugro GeoConsulting, Inc. 2010b,c,d,f; 2011a,b). Earthquakes, associated ground shaking, and possible seafloor rupture, are not expected to occur during exploration drilling operations.

3.4 Lower Trophic Organisms

Lower trophic level organisms provide much of the diet for fish, birds, and marine mammals in the Alaskan Chukchi Sea. Plankton and marine invertebrates are found in the project area in various stages of their life cycles, while drifting in ocean currents. Their abundance and distribution depends largely on physical factors (e.g., wind, currents, turbidity, nutrient availability, and light) and ecological attributes (e.g., competition and predation). Lower trophic level communities include phytoplankton, zooplankton, epontic, benthic, and hard-bottom organisms. Currents flowing from the Bering Sea into the Chukchi Sea transport phytoplankton, zooplankton, and nutrients into the ecosystem (MMS 1990).

3.4.1 Phytoplankton

Phytoplankton are small (< micrometer [µm]), unicellular algae that drift suspended in the water column and are influenced by seasonal patterns in oceanographic conditions, particularly light and nutrient availability. Phytoplanktons are important primary producers in the arctic ecosystem because they provide nutrition for zooplankton and serve as a crucial food source for higher trophic organisms (Arhonditsis et al. 2008).

The greatest abundance of phytoplankton occurs in water depths of less than 16 ft (4.8 m) due to the inability of light to penetrate below these depths and through the ice layer (Gradinger et al. 2005). Factors that influence light penetration are ice thickness, snow cover and water turbidity. Phytoplankton populations peak in late July and early August, due to the increased light intensity during the open water period.

Primary productivity in coastal areas, such as Ledyard Bay, is generally higher than in offshore areas near Shell’s Burger Prospect (MMS 2007b). There are also high concentrations of primary production near Point Hope, Cape Lisburne, and Ledyard Bay (MMS 2007b). Figure 3.4.1-1 shows areas of high primary productivity in the Chukchi Sea as indicated by the chlorophyll ‘a’ concentration in seawater, and indicates a different geospatial pattern of primary productivity, with higher productivity occurring in offshore areas. The abundance of phytoplankton in the Chukchi Sea Lease Sale 193 Area may be considerably less than that of the Bering Sea and waters further south (NRC 1996) but multi-decadal syntheses (Dunton et al. 2005; Grebmeier et al. 2006a) suggest that may be changing. Chlorophyll ‘a’ concentrations recorded in the Burger Prospect area from July through October 2008-2012 are presented summarized below in Table 3.4.1-1.

Table 3.4.1-1 Chlorophyll Concentrations in the Burger Prospect 2008-2013

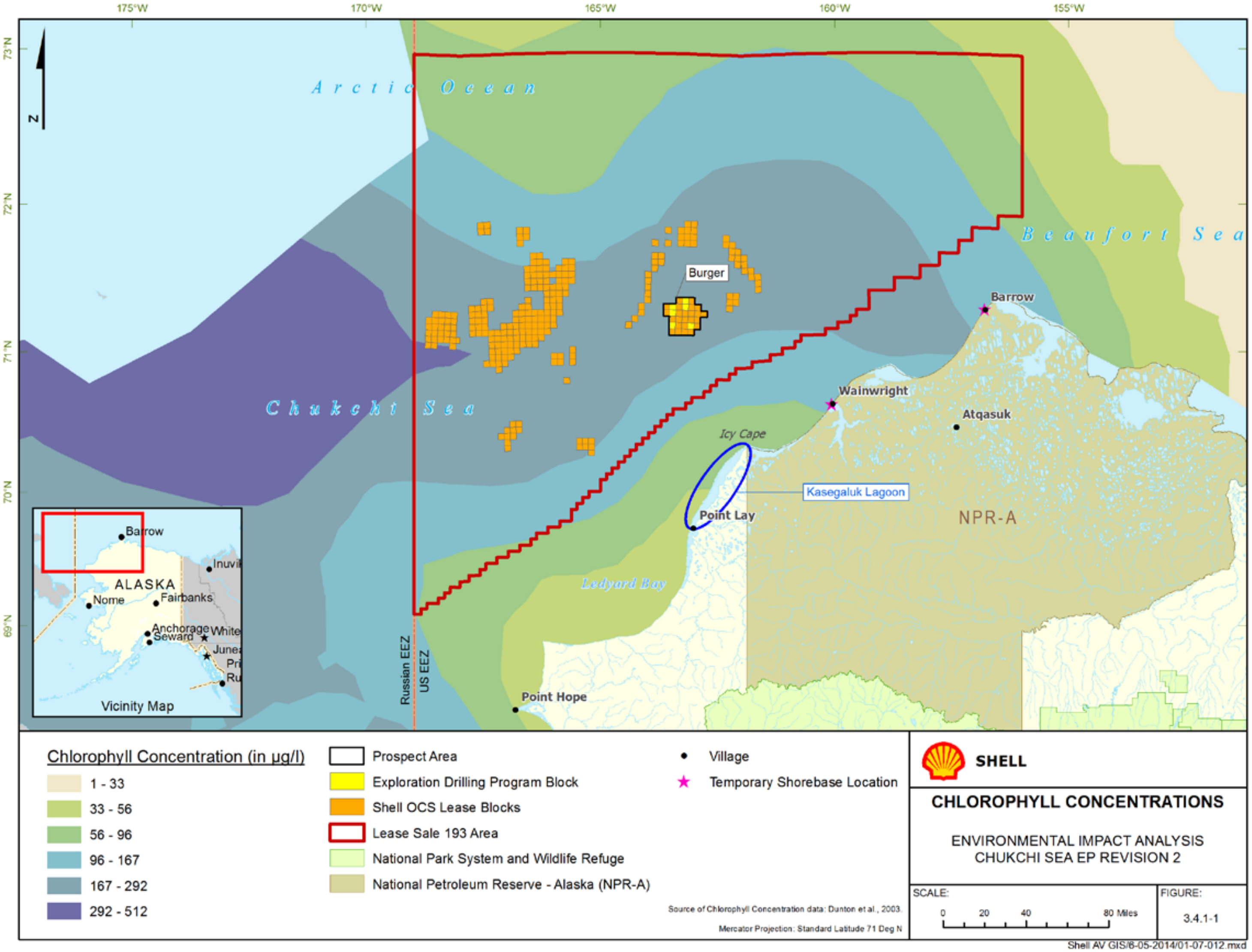
Time Period	Average Chlorophyll Concentration (mg / m^2) [1,2]					
	2008	**2009**	**2010**	**2011**	**2012**	**2013**
July-August	104.8	21.4	42.7	43.5	--	--
August-September	47.1	20.1	40.2	29.3	47.9	40.8
September-October	30.9	25.1	42.2	--	13.3	22.5

[1] Source: Hopcroft et al. 2009, 2010, 2011, 2012, 2013a,b, 2014

[2] Data from the CSESP Burger Study Area, which encompasses all of the Burger Prospect

Planktonic communities were sampled at 25 stations in the 30 x 30 nmi (55 x 55 km) Burger Study Area from July to October 2008-2012 (Hopcroft et al. 2009, 2010, 2011, 2013a,b, 2014). Data was collected in a reduced survey area encompassing the Burger prospect and shoreward locations in 2014; however, the final report was not available at the time this analysis was prepared. Observed concentrations of nutrients and chlorophyll indicated that the 2008 surveys took place during the spring phytoplankton bloom. In 2009, low concentrations observed throughout the entire water column indicated that the surveys were conducted post-phytoplankton bloom. In 2010, surveys near the Burger Prospect, high subsurface nutrients and chlorophyll persisted throughout the open water season (July through September), suggesting the phytoplankton bloom was still underway (Hopcroft et al. 2011). In 2011, subsurface nutrients and chlorophyll were present in August, but declined in September, indicating the bloom had already occurred (Hopcroft et al. 2013a). In 2012, chlorophyll and nutrient concentrations together with phytoplankton composition indicated that the August sampling occurred after the seasonal phytoplankton bloom, with some elevated chlorophyll concentrations maintained by the winter-water cold pools over the Burger prospect (Hopcroft et al. 2013b). In 2013, chlorophyll concentrations were consistent with nutrient batters (i.e. low in the upper 33 ft. [10 m], higher at depths of 66 to 98 ft. [20 to 30 m]). Concentrations showed mid-depth maxima in the northern portion of the Burger Prospect (Hopcroft et al. 2014). It is speculated that differing water transport rates and their masses contribute to the differences between years. Historical chlorophyll values for the Lease Sale 193 Area are within 80 to 200 mg/m^2 (Dunton et al. 2005), but 2009-2011 values fell at the low end of this range or completely below it (Hopcroft et al. 2011, 2013a). 2012 observations overlapped historical values, but generally fell below those estimates (Hopcroft 2013b).

Figure 3.4.1-1 Chlorophyll α Concentrations



3.4.2 Zooplankton

Zooplankton are larger than phytoplankton (greater than 20 µm) and include larval forms of marine invertebrates and fish (meroplankton), as well as macroscopic crustaceans such as copepods. Zooplankton drift in the water column and have little ability to control their movements against the ocean currents. Larger species with weak swimming abilities may be present as well, such as medusae (jellyfish), ctenophores (comb jellies), chaetognaths (arrow worms), euphausiids (krill), amphipods, and mysids. Euphausiids, amphipods, and mysids are abundant in the Alaskan Chukchi Sea (Richardson et al. 1987). These organisms are a food source for birds and marine mammals. During both the summer and winter, calanoid copepods may dominate the zooplankton community in biomass and density, providing important prey for seabirds, shorebirds, whales, and several fish species (Craig et al. 1984; Lowry 1993). Euphausiids are important prey for bowhead whales (Lowry 1993) and ringed seals (Frost and Lowry 1984).

Planktonic communities were sampled at 25 stations in the 30 x 30 nmi (55 x 55 km) CSESP Burger Study Area, from July to October 2008-2012 (Hopcroft et al. 2009, 2010, 2011, 2013a,b). Data was also collected in 2013; however the final report was not available at the time this analysis was prepared. Similar surveys are planned for 2014 in a reduced study area encompassing the Burger prospect and shoreward locations. The greatest numbers of taxa were observed in the copepods followed by the cnidarians (Table 3.4.2-1). Dominant taxa in the 150 µm and 505 µm nets were similar in 2008 and 2009 and are summarized in Table 3.4.2-2. Meroplankton formed a substantial part of the zooplankton community regarding both abundance and biomass in both sampling years but was greatest in 2008 (Hopcroft et al. 2009, 2010). In 2010, there was a large increase in several herbivorous and predatory copepod species, many of which have great value to vertebrates that feed on zooplankton (Hopcroft et al. 2011). In 2011 and 2012, meroplankton groups declined, while large copepods increased (Hopcroft et al. 2013a,b). It is believed that the inter-annual variability observed for the planktonic communities from 2008-2012 is related to a combination of physical parameters observed at the study area and the intensity of physical transport from the Bering Strait (Hopcroft et al. 2013b). Analysis of water circulation patterns around Hanna and Herald Shoals, Barrow Canyon, and the Central Channel suggest a mechanism for transporting zooplankton species to the Burger area (Hopcroft et al. 2013a, 2014).

Table 3.4.2-1 Zooplankton Diversity & Abundance August to October

Year	Number of Species [1,2]			Average Abundance [1,2]			
	Copepods	Cnidarians	Total Taxa	Individuals/m³		Dry Weight mg/m³	
				150 µm net	505 µm net	150 µm net	505 µm net
2008	20	9	76	3,330	189	18.5	11.4
2009	23	10	70	7,030	196	20.4	7.0
2010	25	11	77	16,712	158	115.0	33.7
2011	25	11	77	4,662	105	66.7	26.3
2012	20	11	71	2,190	393	66.0	72.1
2013	20	9	70	1,635	438	39.0	38.0

[1] Source: Hopcroft et al. 2009, 2010, 2011, 2013a,b, 2014

[2] Number of species and average abundance in the Burger, Klondike, and Statoil (for applicable years) Study Areas combined

Table 3.4.2-2 Top Zooplankton Taxa in CSESP Study Areas 2008-2013

Parameter	Net	2008 [1,2,3]	2009 [1,2,3]	2010 [1,2,3]	2011 [1,2,3]	2012 [1,2,3]	2013 [1,2,3]
Abundance	**150 µm net**	*Fritillaria borealis* *Pseudocalanus* spp. Barnacle larvae Calanoid copepod nauplii Bivalve larvae	*Fritillaria borealis* *Oithona similis* *Pseudocalanus* spp. *Limacina helicina* Calanoid copepod nauplii	Bivalve larvae *Pseudocalanus* spp. *Oithona similis* *Fritillaria borealis* Copepod nauplii	*Oithona similis* *Fritillaria borealis* *Pseudocalanus* spp. Copepod nauplii *Oikopleura vanhoeffeni*	*Pseudocalanus spp.* *Calanus glacialis* *Oithona similis* *Copepod nauplii* Barnacle larvae	*Pseudocalanus spp.* *Oithona similis* Calanoid copepod nauplii *Calanus glacialis/marshallae* Barnacle larvae
Biomass		Barnacle larvae *Calanus marshallae* *Parasagitta elegans* *Pseudocalanus* spp. Polychaete larvae	*Calanus marshallae* Barnacle larvae *Parasagitta elegans* *Oithona similis* *Pseudocalanus* spp.	*Parasagitta elegans* *Calanis glacialis/marshallae* Hippolytid decapods *Catablema vesicarium* *Aglanta digitale*	*Calanus glacialis* *Parasagitta elegans* Barnacle larvae *Pseudocalanus* spp. *Aglanta digitale*	*Calanus glacialis* *Parasagitta elegans* *Oikopleura vanhoeffeni* *Pseudocalanus* copepods Barnacle larvae	*Calanus glacialis/marshallae* *Limacina helicina* *Pseudocalanus* copepods Barnacle larvae *Parasagitta elegans*
Abundance	**505 µm net**	Barnacle larvae *Fritillaria borealis* *Pseudocalanus* spp. *Oikopleura vanhoeffeni* *Calanus marshallae*	*Fritillaria borealis* *Calanus marshallae/glacialis* *Eucalanus bungii* Barnacle larvae *Parasagitta elegans*	*Calanus marshallae/glacialis* Barnacle larvae *Fritillaria borealis* *Aglanta digitale* *Parasagitta elegans*	*Calanus glacialis* *Oikopleura vanhoeffeni* *Aglanta digitale* Barnacle larvae *Parasagitta elegans*	*Calanus glacialis* Barnacle larvae *Oikopleura vanhoeffeni* *Pseudocalanus spp.* *Parasagitta elegans*	*Calanus glacialis* Barnacle larvae *Pseudocalanus spp.* *Oikopleura vanhoeffeni* *Parasagitta elegans*
Biomass		Fish larvae *Parasagitta elegans* *Calanus marshallae* *Aglantha digitale* Barnacle larvae	*Calanus marshallae /glacialis* *Thysanoessa raschii* *Aurelia aurita* *Cyanea capillata* *Mertensia ovum*	*Parasagitta elegans* *Calanus marshallae/glacialis* *Aglantha digitale* *Neocalanus cristatus* *Thysanoessa raschii*	*Calanus glacialis* *Parasagitta elegans* *Aglantha digitale* *Neocalanus cristatus* Crab larvae	*Calanus glacialis* *Parasagitta elegans* *Oikopleura vanhoeffeni* *Neocalanus* copepods *Clione limacina*	*Calanus glacialis/marshallae* *Parasagitta elegans* *Neocalanus* copepods *limacine helicina* *Aglantha digitale*

[1] Source: Hopcroft et al. 2009, 2010, 2011, 2013a,b, 2014

[2] Limited to top five taxa by abundance (numbers) and biomass

[3] Study areas in 2008 & 2009 were Burger and Klondike; Burger, Klondike and Statoil in 2010 and 2013, and Greater Hanna Shoal in 2011 and 2012.

3.4.3 Benthic Communities

Benthic invertebrate communities include organisms living within bottom sediments (infauna) or on the surface of the sediments (epifauna). Sediment grain size influences species composition, with deposit feeders predominating in fine sediments and suspension feeders thriving in coarse sediments. The epifaunal species that inhabit the nearshore waters are amphipods, isopods, and mysids, which are motile and opportunistic. The primary infaunal species include polychaetes and bivalves. Meiofauna, infaunal species that range in size between micro- and macro-benthos, are important because they provide a crucial link between primary producers and larger organisms within the benthic community, contributing greatly to the transfer of energy within the ecosystem (Bessiere et al. 2007). A high abundance of benthic-feeding animals, such as walruses, gray whales, and spectacled eiders, indicates a dense benthic population in the Chukchi Sea (Feder et al. 2007).

Stoker (1981) conducted benthic surveys with van Veen samplers across the Chukchi Sea, identified benthic invertebrate communities (cluster groups) based on similarity of dominant species, and noted where they were found. Only two cluster groups (Cluster Groups VI and VIII) were identified in the northeastern Chukchi Sea. Key species in these cluster groups are listed in Table 3.4.3-1. Shell's Burger Prospect is located in the area mapped by Stoker (1981) as being predominantly Cluster Group VI.

Table 3.4.3-1 Common Benthic Species Found in the Chukchi Sea

Dominant Species	Common Name
Cluster Group VI	
Maldane sarsi	polychaete worm
Ophiura sarsi	brittle star
Golfingia margariticea	sipunculid - peanut worm
Astarte borealis	clam
Cluster Group VIII	
Macoma calcarea	clam
Nucula tenuis	clam
Yoldia hyperborea	clam
Ponteporeia femorata	amphipod

[1] Source: Stoker 1981

Shallow hazards surveys conducted by Shell at the drill sites, and surveys conducted at historical prospects in the area have not revealed any unusual or special benthic features such as relief or hard bottom that might be colonized by special benthic communities. Video reconnaissance surveys (Finney 1989) were conducted along with shallow hazards surveys within the historical Burger Prospect within a few miles of Shell's current drill sites. The benthic communities were considered by BOEM (Boudreau 1989) to be consistent with Cluster Group VI in Table 3.4.3-1. Similar video surveys were conducted at the historical Crackerjack and Popcorn Prospects, which are in the same general area, and the benthic community in these prospects was found to be similar in composition to those at the Burger Prospect, but at a lower density (Finney 1989). About 15 species were identified. The brittle star, *Ophiura sarsi*, was found to be the predominant organism with densities of 9 to 37/ft^2 (100 to 400/m^2). Other abundant macro-invertebrates observed at the sites were a soft coral (*Eunephthya spp.*), the basket star Gorgonocephalus caryi, and sea cucumbers (*Psolus spp*., *Cucumaria spp*.).

The diversity of benthic species in the Beaufort Sea has been shown to increase with water depth until the shear ice zone is reached at depths of about 49 to 82 ft (15 to 25 m) and this is likely true for the Chukchi Sea; biodiversity then declines due to ice gouging between the landfast ice and the moving polar pack ice (BPXA 1996). Long term stability of diverse benthic communities in nearshore waters is prevented by the annual formation of bottomfast ice in depths of less than 6.6 ft (2 m). Re-colonization from sources in offshore areas takes place in these areas during the summer (MMS 1990). A study by Feder et al. (1994a) in the northeast Chukchi Sea determined that mollusk abundance was much higher in coastal waters than in the project area. However, large "pockmarks" have been found north of the Chukchi Sea Lease Sale 193 Area that house much higher benthic diversity and abundance than surrounding areas. It has been speculated that these pockmarks could be indicative of methane seeps, and the same sort of pockmarks may be present in the northern portion of the Lease Sale 193 Area (MacDonald et al. 2005, 2003).

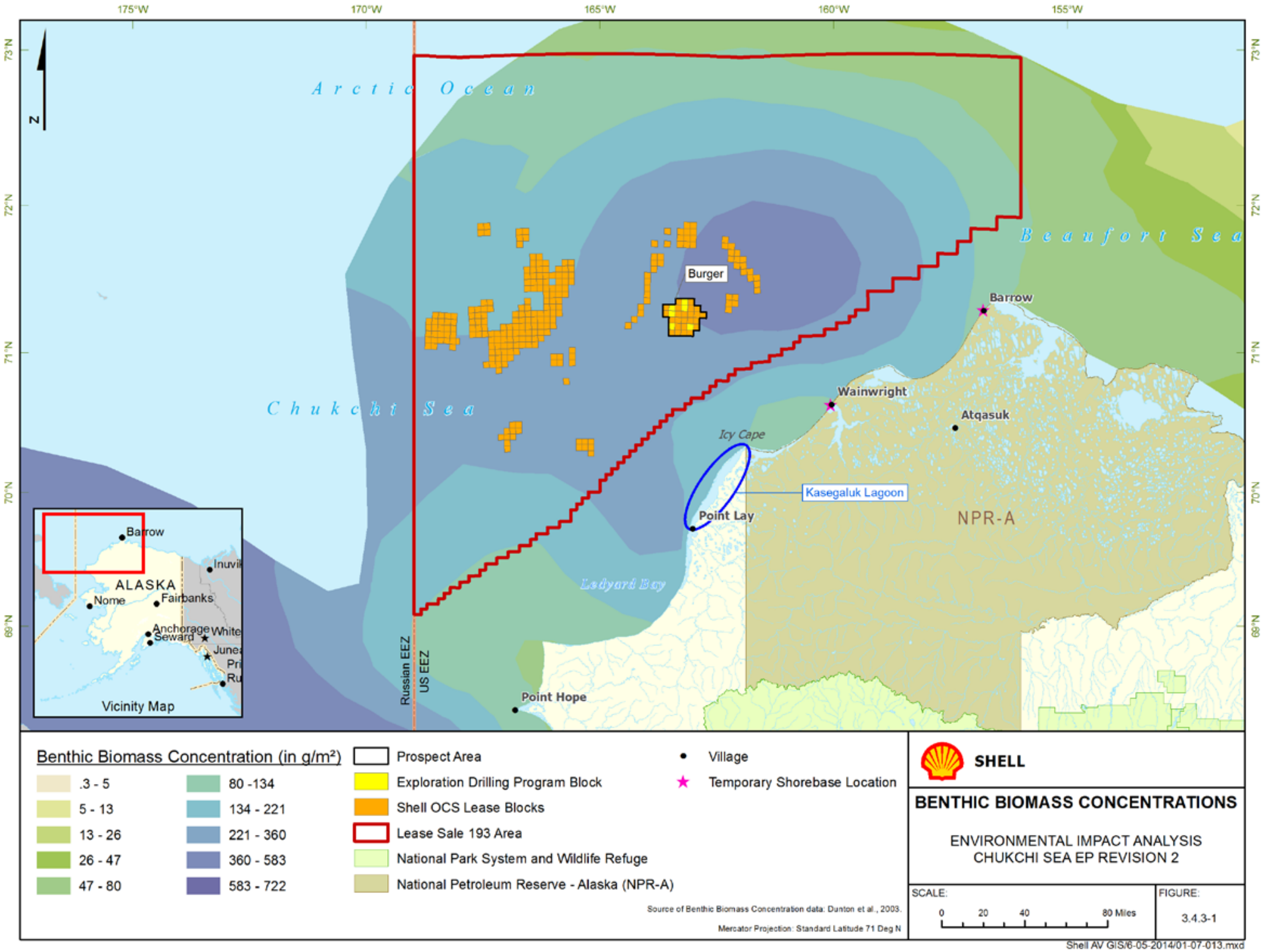
The northeastern Chukchi Sea generally supports a higher biomass of benthic organisms than other areas of the Chukchi Sea (Grebmeier and Dunton 2000). This may be because the pelagic fauna is incapable of consuming all of the phytoplankton; the unconsumed phytoplankton sinks to the bottom, providing food for the benthos. These areas of high benthic biomass serve as important feeding grounds for benthic grazers, such as gray whales, walruses, and ducks.

Hard-bottom communities contain aggregations of macrophytic algae (large kelps), benthic microalgae, and benthic invertebrates associated with rocks and other hard substrate. No kelp beds or other special benthic habitats or communities are known to occur in the prospect area. All known large kelp beds in the Chukchi Sea are located south of the Lease Sale 193 Area (MMS 2008a). There are coastal kelp beds located near Skull Cliff (Phillips et al. 1982; Phillips and Reiss 1985b) northeast of Peard Bay, and 16 mi (25 km) southwest of Wainwright (Phillips and Reiss 1985a; Mohr et al. 1957). Benthic fauna in hard-bottom communities include sponges, soft corals, hydroids, sea anemones, bryozoans, nudibranchs, and sea squirts (Dunton and Schonberg 1980).

Herald and Hanna Shoals are shallow areas within the Lease Sale 193 Area. These areas also have the highest gravel concentration of surface sediments near the prospect areas. The shoals are important feeding grounds for bottom-feeding animals because of their high benthic biomass. Figure 3.4.3-1 shows relative benthic biomass in the Chukchi Sea.

Surveys of benthic communities were conducted within a 30 x 30 nmi (55 x 55 km) study area that surrounds the Burger Prospect from 2008 to 2013 (Table 3.4.3-2) (Blanchard et al. 2010a; Blanchard et al. 2010b; Blanchard et al. 2011; Blanchard and Knowlton 2013a,b, 2014). The benthic infauna was sampled using a double van Veen grab. Epifauna were sampled with a plumb staff 19.0 ft (3.05 m) beam trawl with a 0.16-in. (4-mm) codend liner and 0.27-in. (7-mm) mesh. Similar studies were conducted in 2014 as well; however, final peer-reviewed data was not available at the time this analysis was prepared.

Figure 3.4.3-1 Benthic Biomass Concentrations



In 2009, the beam trawl collected 294 unique taxa, of the total number of organisms collected, about 89 percent were brittle stars, 4 percent were shrimp, 2 percent were barnacles, sea cucumbers, and bivalves, and <1 percent were gastropods and other taxa. In the Burger study area, brittle stars represented about 74 percent of the biomass, sea cucumbers and crabs comprised about 6 percent, bivalves and gastropods comprised about 4 percent, and sea anemones, shrimp, and sea stars represented about 1 to 2 percent of the epifaunal biomass. There was an average of about 106,796 individual organisms per 1,000 m^2 with a biomass of about 76,103 g/1,000 m^2 (Blanchard et al. 2010b).

Table 3.4.3-2 Top Infauna Taxa by Abundance and Biomass, CSESP Burger Study Area[1,2,3]

Year	Taxon	Density[4]	Taxon	Biomass[5]
2008	*Maldane sarsi*	748	*Ophiura sarsi*	62.23
	Ostracoda	287	*Astarte borealis*	54.59
	Scoletoma spp.	189	*Golfingia margaritacea*	38.16
2009	*Maldane sarsi*	750	*Astarte borealis*	57.51
	Ostracoda	289	*Macoma calcarea*	44.56
	Photis spp.	212	*Ennucula tenuis*	28.81
2010	*Maldane sarsi*	1,085	*Golfingia margaritacea*	55.62
	Ostracoda	136	*Astarte borealis*	42.29
	Ennucula tenuis	131	*Macoma calcarea*	40.10
2011	*Maldane sarsi*	1,788	*Maldane sarsi*	74.44
	Ostracoda	415	*Macoma calcarea*	61.45
	Ennucula tenuis	312	*Golfingia margaritacea*	52.65
2012	*Maldane sarsi*	1,536	*Astarte borealis*	82.53
	Ennucula tenuis	343	*Macoma calcarea*	48.23
	Ostracoda	245	*Golfingia margaritacea*	46.75
2013	*Maldane sarsi*	975	*Ophiura sarsi*	69.46
	Ostracoda	567	*Astarte borealis*	62.56
	Ennucula tenuis	386	*Golfingia margaritacea*	44.34

[1]Infaunal organisms are those found in the sediment and retained on a 1.0 mm mesh screen

[2]Source: Blanchard and Knowlton 2014

[3]Number of stations sampled = 26

[4]Density is individuals/m^2

[5]Biomass is grams/m^2 dry matter

The average macrofaunal density at the Burger study area during the CSESP from 2008 to 2013 was 6,077 individuals/m^2, and the biomass was 446.5 g/m^2 (Blanchard and Knowlton 2014). The total number of taxonomic categories identified at the Burger stations indicate a decrease in number of taxa since 2008, from 268 categories to 196 different taxonomic categories in 2012 (Knowlton and Blanchard 2013b) to

120 categories in 2013 (Knowlton and Blanchard 2014); however the lower number of taxonomic categories in 2011-2013reflect the decreases in the number of stations sampled during those years of the CSESP.

The high density and biomass values in the Burger study area reflect the high availability of food resources within the sediments due to interactions of the bottom topography with water currents (Blanchard et al. 2013b). Data collected from 2008-2013 reflect high densities of animals, largely driven by very high numbers of *Maldane sarsi*. The non-metric multidimensional scaling analysis for the regional study indicated that bottom water temperature is the variable most loosely associated with benthic community structure, followed by percent mud and water depth. The areas of highest density and biomass were in areas with the greatest depth, greatest proportion of mud, and lowest bottom-water temperatures (Blanchard and Knowlton 2013b).

Additional recent studies from the COMIDA-CAB project found that annelid worms, mollusks, and arthropods were the three dominant benthic groups in the northeastern Chukchi Sea (Schonberg and Dunton 2012). They found high concentrations of a broad spectrum of species located near Hanna Shoal and Barrow Canyon. Locations of benthic communities were correlated with the distribution of organic matter, nutrients, and chlorophyll.

Soft Corals

A soft coral, the sea raspberry (*Gersemia rubiformis*), was found at 10 of 58 benthic sampling stations in the CSESP Study Areas. It represented the 2nd most abundant epifaunal taxon by biomass and 8th most abundant taxon by number in the Burger Study Area in 2008 (Blanchard et al. 2010a). This soft coral is abundant but forms rather discrete colonies in a patchy distribution (Blanchard and Knowlton 2013b). The species is found worldwide from Antarctic to Arctic waters, including the Chukchi Sea, and has the widest distributional, temperature, and substrate preference range of any coral species found in Alaska. It is also considered common in waters north of the Alaska Peninsula. Colonies are formed from small polyps and are found attached to stones or shells (NOAA 2013a).

In August 2012, the Center for Biological Diversity petitioned the NMFS to list 44 species of corals off the coast of Alaska as threatened or endangered under the ESA (the sea raspberry was not included in the petition). NMFS found that the petition did not present substantial information to indicate that a listing action was warranted for any of the requested species (NMFS 2013a).

3.4.4 Epontic Communities

Epontic communities are composed of organisms (both plants and animals) that live on or in the undersurface of sea ice. In addition to the pelagic bloom, there is an epontic bloom, which is small in comparison. The timing of the epontic community bloom is important in providing food for zooplankton prior to the phytoplankton bloom. Abundance of sea-ice biota varies across seasons and years and is highly correlated to abiotic factors such as light and nutrient availability (Werner et al. 2007).

Pennate diatoms and microflagellates are the most abundant of these organisms, existing in the bottom of the ice and in the water just below the ice during spring (Horner et al. 1974). Responding to increased light, epontic populations develop in April, peak in May, and decline in June as the ice layer melts (Alexander et al. 1974). Lower trophic epontic organisms found in the Chukchi Sea include diatoms, algae, euphausiids, amphipods, nematodes, and larval polychaetes (Gradinger 2008).

3.5 Fish Resources

Major studies of fish distribution and abundance in the northeastern Chukchi Sea have taken place in the last 50 years, culminating in the CSESP (Norcross 2011; Priest et al. 2011a; Goodman et al. 2012; Goodman et al. 2013). The CSESP built on past studies (Alverson and Wilimovsky 1966; Quast 1972;

Frost and Lowry 1983; Fechhelm et al. 1984; Barber et al. 1997) to continue to investigate the fish resources in the Chukchi Sea. Data collected from 2009-2012 are used in the following analysis. Fish surveys were not conducted in the Burger Prospect in 2014. The locations of these surveys are indicated in Figure 3.5.1-1 in relationship to Shell's Burger Prospect. The studies have documented the occurrence of more than 80 fish species in the northeastern Chukchi Sea (Barber et al. 1997; Gallaway et al. 2011; Goodman et al. 2012). The CSESP and other studies documented fish that are largely restricted to marine habitats and diadromous migratory fish that utilize both marine and freshwater habitats. Discussions of the species of both types of fish that are found in the Lease Sale 193 Area and in Shell's Burger Prospect are provided below in Sections 3.5.1 and 3.5.2 respectively along with descriptions of the distribution, life history, and abundance of the key species. The use of fish as subsistence resources is discussed in Section 3.11.6. Analyses of the potential impacts to fish and subsistence fishing are provided in Section 4.5 and 4.11.

3.5.1 Marine Fish

While over 80 fish species have been documented in the Chukchi Sea, Arctic cod dominate as the most abundant species (Barber et al. 1997; Gallaway et al. 2011; Priest et al. 2011a), and other species occur frequently. Some of the more common species are listed below in Table 3.5.1-1. The distribution of marine fish species in the Chukchi Sea is driven by environmental factors, such as salinity, water depth, and percent of gravel in the sediments (Barber et al. 1997; Priest et al. 2011a), and often shifts as seasonal changes occur. The Chukchi Sea is influenced by water influx from the Bering Sea, importing fish and nutrients into the Arctic (Priest et al. 2011a). Species richness was found to be low when compared to non-Arctic communities. Both the number of species and fish biomass found in the northeastern Chukchi Sea are similar to the southern Chukchi Sea and Bering Sea, but the diversity is much lower due to the predominance of Arctic cod and sculpins (Barber et al. 1997; Priest et al. 2011b, Goodman et al. 2012).

Figure 3.5.1-1 Locations of Major Fish Surveys in the Northeastern Chukchi Sea

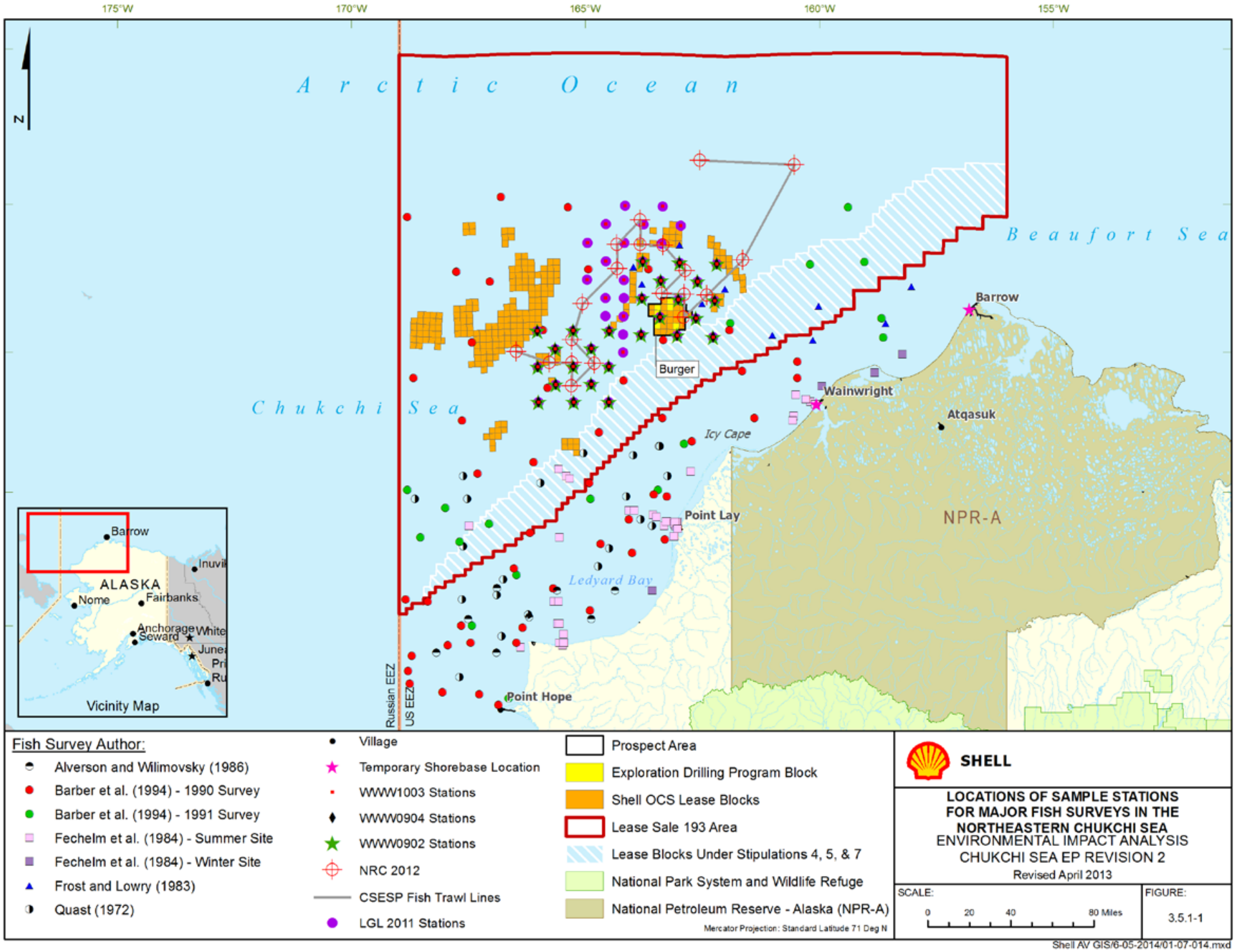


Table 3.5.1-1 Most Common Marine Fish Species Found in the Northeastern Chukchi Sea

Common Name	Scientific Name	Total Catch [1]	Percent of Catch [1]	Biomass [1]	Percent Fish Biomass [1]
Arctic alligatorfish	*Ulcina olrikii*	14	3.3%	8	0.6%
Arctic cod	*Boreogadus saida*	203	47.7%	469	36.9%
Arctic staghorn sculpin	*Gymnocanthus tricuspis*	5	1.2%	11	0.9%
Bering flounder	*Hippoglossoides robustus*	1	0.2%	5	0.4%
Fish doctor	*Gymnelus viridis*	8	1.9%	34	2.7%
Fourline snakeblenny	*Eumesogrammus praecisus*	1	0.2%	4	0.3%
Gelatinous seasnail	*Liparis fabricii*	2	0.5%		0.0%
Halfbarred pout	*Gymnelus hemifasciatus*	21	4.9%	31	2.4%
Hamecon	*Artediellus scaber*	22	5.2%	84	6.6%
Kelp snailfish	*Liparis tunicatus*	7	1.6%	41	3.2%
Marbled ellpout	*Lycodes raridens*	15	3.5%	93	7.3%
Pacific sandlance	*Ammodytes hexapterus*	2	0.5%		0.0%
Polar eelpout	*Lycodes polaris*	37	8.7%	177	13.9%
Pricklebacks - unidentified	*Stichaeidae* spp.	3	0.7%		0.0%
Ribbed sculpin	*Triglops pingelii*	1	0.2%	3	0.2%
Sculpin - unidentified	*Cottidae* spp.	2	0.5%		0.0%
Shorthorn sculpin	*Myoxocephalus scorpius*	29	6.8%	100	7.9%
Slender eelblenny	*Lumpenus fabricii*	6	1.4%	24	1.9%
Spatulate sculpin	*Icelus spatula*	7	1.6%	45	3.5%
Stout eelblenny	*Anisarchus medius*	40	9.4%	141	11.1%

[1] Source: (Priest et al. 2011a)

Barber et al. (1994) surveyed demersal marine fish in the northeastern Chukchi Sea in 1990 and 1991 and identified six different fish assemblages through statistical analysis. The distributions of these marine fish assemblages are indicated in Figure 3.5.1-2. The abundance of each of the 21 most common species found in these assemblages is indicated in Table 3.5.1-2. Shell's Burger Prospect is an area where Assemblage VI is predominant (Figure 3.5.1-2). The most abundant demersal fish species in the assemblages found in Shell's Burger Prospect was the Arctic cod; most other species were found in very low numbers. Abundant pelagic species in the northeastern Chukchi include Pacific herring and capelin (Craig 1984a, 1984b). Although capelin is most abundant in nearshore waters (Craig 1984a) it is included here due to its importance as a forage species. Aspects of the life history and ecology of these abundant species are summarized below.

Figure 3.5.1-2 Fish Assemblages, Essential Fish Habitat (EFH), and Anadromous Streams

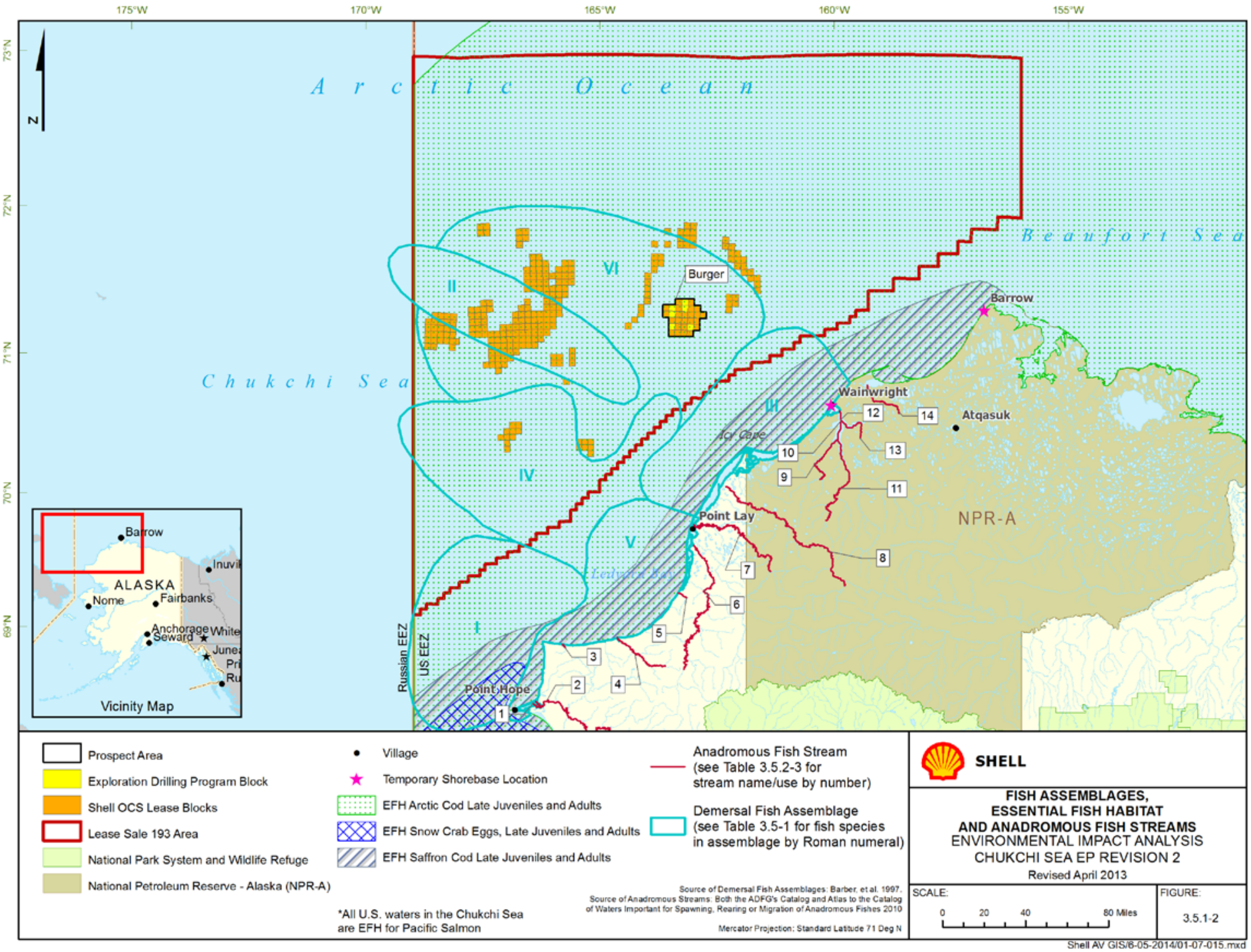


Table 3.5.1-2 Abundance of the Most Abundant Demersal Fish Species in the Chukchi Sea

Common Name	Abundance (fish/km^2) by Assemblage [1]					
	I	II	III	IV	V	VI
Arctic cod	43,733	16,419	5,280	8,172	16,096	6,100
Saffron cod	684	2	170	19	10,956	0
Sculpin	3,391	49	44	2	4,492	0
Staghorn sculpin	1,005	87	889	156	2,618	7
Bering flounder	1,599	72	0	61	15	3
Warty sculpin	178	0	429	177	773	9
Hamecon	20	0	0	11	1,061	4
Walleye pollock	69	0	0	26	861	0
Ribbed sculpin	70	3	120	59	722	0
Capelin	437	0	0	40	0	0
Wattled eelpout	453	0	0	139	323	0
Pacific herring	195	0	0	139	323	0
Slender eelblenny	235	18	2	14	141	0
Canadian eelpout	260	64	2	0	6	0
Marbled eelpout	76	7	4	284	13	5
Sturgeon poacher	60	0	18	5	280	0
Pacific cod	21	0	1	6	273	0
Variegated snailfish	129	2	0	15	29	0
Rainbow smelt	0	0	0	0	258	0
Butterfly sculpin	89	0	0	13	0	0
Hookear sculpin	80	0	0	0	20	0

[1] Source: Barber et al. 1994

Goodman et al. (2012) conducted pelagic and bottom trawls in 2011 across the Burger, Klondike, and Statoil Study Areas as part of the CSESP. They captured individuals of at least 20 species. In numbers, the five most abundant fish species captured when both trawl types were considered were Pacific sandlance, Arctic cod, an unidentified eelblenny, capelin, and shorthorn sculpin. Abundance estimates of the most commonly captured fish species in the bottom trawls in the Burger Study Area are provided in Table 3.5.1-3 below. Bottom trawl surveys were not conducted as part of the CSESP in 2012.

Table 3.5.1-3 Abundance of Major Fish Species in Burger Study Area Bottom Trawls

Bottom Trawl ID [2] (trawled in 2011)	Estimated Abundance (millions of fish/study area) of Major Fish Species Captured in Bottom Trawls in Burger Study Area in 2011 [1,2]			
	Arctic Cod	Capelin	Polar Eelpout	Marbled Eelpout
Burger 14B	7.30	1.83	0.00	3.65
Burger 15B	6.59	0.00	0.00	2.03
Burger 17B	2.67	0.00	0.53	0.53
Burger 18B	2.92	0.49	0.49	0.49
Total CPUE (fish/ac)	7.89	0.93	0.41	2.67
Total CPUE (fish/ha)	19.49	2.31	1.02	6.60
Average CPUE (fish/ac)	2.95	0.74	0.00	1.48
Average CPUE (fish/ha)	7.30	1.83	0.00	3.65

[1] Source: Goodman et al. (2012), abundance is millions of fish per study area (Greater Hanna Shoal), CPUE= catch per unit effort, ha= hectares

[2] Trawl identification number of each of the four trawls with a 400 Eastern bottom trawl conducted in Burger Study Area with a total trawled area of 308,899 ha.

Arctic Cod

The Arctic cod is an extremely important component of the ecosystem in the northeastern Chukchi Sea. It is often referred to as a keystone species due to its importance in the food chain forming the link between lower trophic organisms such as plankton and consumers such as marine mammals and birds (Frost and Lowry 1984; Lowry and Frost 1981). Though their use as a subsistence resource has apparently declined, the Arctic cod has been harvested in small quantities, primarily by jigging through the ice during winter (Craig 1989b). The use of marine fish as subsistence resources is discussed in Sections 3 and 4.

Arctic Cod Distribution

The distribution of the Arctic cod is circumpolar. In Alaska they are found continuously from the northern Bering Sea through the entire Chukchi Sea and eastward through the Beaufort Sea to the Canadian border (Gillispie 1997). The Arctic cod uses nearshore waters such as lagoons (Craig et al. 1982), and has been found to enter river systems occasionally (Morrow 1980). Use of nearshore waters appears to be greatest during open water periods (Craig et al. 1982). The species is also found in offshore waters possibly as far as the North Pole, and is thought to utilize waters under the polar ice cap (Andriyashev 1954).

Distribution is often associated with ice. Ice provides protective cover from predation by birds and marine mammals. The ice edge holds higher primary productivity for feeding and Arctic cod consume invertebrate and other prey present in the ice edge and ice undersurface (Gillispie 1997). The distribution of the Arctic cod in the Chukchi Sea has been studied by Quast (1974), Wolotria et al. (1977), Frost and Lowry (1983), Fechhelm et al. (1984), Barber et al. (1997), Gillispie et al. (1997) and others. Arctic cod are found within the Burger Prospect, and would be expected to occur there during the exploration drilling season.

Arctic Cod Life History

Arctic cod are considered to have an r-selected reproductive strategy in that they exhibit small body size, early maturity, rapid growth, and large numbers of offspring (Craig et al. 1982; Gillispie et al. 1997). This type of strategy allows the species to survive in unpredictable environments with the possibility of high mortality rates. They spawn under the ice typically in January and February (Gillispie et al. 1997). The eggs float in the water column (Dunn and Matarese 1984), developing and hatching under the ice, usually in May or June (Lowry et al. 1980). The larvae live in surface waters until August or September at which time they metamorphose into juvenile stage and descend to the seafloor. Arctic cod in the coastal Beaufort Sea were found to mature at ages 2 to 3 for males and 3 for females (Craig et al. 1982), and they may live to ages 7 to 8 (Wolotira et al. 1977; Gillespie 1997). Mysid shrimp, amphipods, copepods, and small fish are the primary prey of Arctic cod in the Beaufort and Chukchi Seas (Lowry and Frost 1981; Frost and Lowry 1983; Craig et al. 1982).

Arctic Cod Abundance

Arctic cod is the most abundant fish species in the northeastern Chukchi Sea. During trawl surveys in the northeastern Chukchi Sea, Craig (1984b) found 85 percent of the catch in the surface and mid-water trawls was comprised of Arctic cod. Barber et al. (1994) found Arctic cod to be the most abundant fish in of the Chukchi Sea, representing over 90 percent of the total fish abundance. Arctic cod is present nearshore (Thedinga et al. 2012), but was especially dominant in areas located far offshore where Shell's Burger Prospect is located. Barber et al. (1994) reported densities of 1,018 to 146,009 Arctic cod/mi^2 (393 to 56,374 cod/km^2) based on capture of fish at a number of stations in the northeastern Chukchi Sea. Mean density of Arctic cod in 1990 and 1991 was 3,355/mi^2 (6,100/km^2) around the Burger Prospect.

Arctic Staghorn Sculpin

A number of sculpin species use the waters of the northeastern Chukchi Sea (Mecklenburg et al. 2002). Common species in some areas include arctic staghorn sculpin (Frost and Lowry 1983; Fechhelm et al. 1984), fourhorn sculpin (Fechhelm et al. 1984), shorthorn sculpin (Craig 1984b), warty sculpin (Barber et al. 1997), hamecon (Barber et al. 1997), butterfly sculpin (Barber et al. 1997), and hookear sculpin (Barber et al. 1997). Barber et al. (1997) found the staghorn sculpin to be the most common sculpin in the area of Shell's Burger Prospect.

Sculpins are consumed by ringed seals, bearded seals, Arctic cod (Craig and Skvorc 1982), and marine birds (Springer and Roseneau 1978). Due to their prevalence, sculpins are an important forage fish in the food web. Sculpins have in the past been utilized as a subsistence resource along the Chukchi coast (Schneider and Bennett 1979), but are rarely harvested today (Craig 1989b).

Arctic Staghorn Sculpin Distribution

The arctic staghorn sculpin is circumpolar in its distribution (Andriyashev 1954), and is common in U.S. portions of both the Beaufort and Chukchi Seas (Frost and Lowry 1983; Fechhelm et al. 1984; Barber et al. 1997). Fechhelm et al. (1984) captured the arctic staghorn sculpin in 24 of 25 trawls conducted across much of the northeastern Chukchi Sea in depths of 13 to 158 ft (4 to 48 m). Smith et al. (1997a) captured the arctic staghorn sculpin in 39 of 48 locations across the northeastern Chukchi Sea in 1990, and 10 of 17 locations in 1991 with water depths ranging from 59 to 170 ft (18 to 52 m). The arctic staghorn sculpin is found throughout the Shell prospect areas in these water depths.

Arctic Staghorn Sculpin Life History

The arctic staghorn is a small, marine fish typically found at the seafloor. Fechhelm et al. (1984) reported that staghorn sculpin caught in otter trawls in the Chukchi Sea ranged from 1 to 5 in. (25 to 135 mm) in length with one year-old fish being about 2.0 in (40 mm) long and two year-old fish being about 3.0 in (70 mm) long.

Spawning usually occurs in late fall or winter (Smith et al. 1997a). The eggs are demersal and adhesive. The hatched larvae are planktonic. Young of the year recruit to benthic habitats in late summer (Andriyashev 1954). Adult sculpins are also benthic, often burrowing in sandy habitats (Andriyashev 1954). Smith et al. (1997a) found that males and females reached reproductive maturity at ages of 3 to 4 at lengths of about 3 to 4 in. (75 to 105 mm), and that females produced 91 to 154 eggs. The oldest arctic staghorn sculpins caught by Smith et al. (1997a) were nine years old and about 5 in. (134 mm) long.

Arctic Staghorn Sculpin Abundance

The arctic staghorn sculpin is one of the most abundant demersal fish species of the Chukchi Sea. Abundance can vary greatly from year to year (Smith et al. 1997a). Barber et al. (1997) reported a mean abundance of 1,854 staghorn sculpin / mi^2 (716 / km2) with a range of 34 to 20,849/mi^2 (13 to 8,050/km^2) across the northeastern Chukchi Sea in 1990, and a mean abundance of 1,111 sculpin/mi^2 (429/km^2) with a range of 83 to 7,045/mi^2 (32 to 2,720/km^2). Abundance was typically greater shoreward of Shell's Burger Prospect, but arctic staghorn sculpin is a representative species for the entire area.

Bering Flounder

Common flounders of the Chukchi Sea include the Bering flounder, arctic flounder, yellowfin sole, Alaskan plaice, longhead dab, and starry flounder. The Bering flounder has been reported as the most abundant flatfish in offshore areas of the northeastern Chukchi Sea, and was the most commonly caught flatfish in the area of Shell's Burger Prospect (Barber et al. 1997). Other species are not expected to be found in large numbers in the prospect area, so only the Bering flounder is discussed below. Species such as the yellowfin sole may be more abundant in shallow waters near shore (Fechhelm et al. 1984).

Bering Flounder Distribution

The Bering flounder is found in the north Pacific including the Bering Sea, Chukchi Sea, and portions of the Beaufort Sea (Mecklenberg et al. 2002). The Bering flounder is commercially harvested in waters to the south and west of the Chukchi Sea.

Bering Flounder Life History

Andriyashev (1954), Pruter and Alverson (1962), and Wyllie-Echeverria et al. (1997) have suggested and provided some evidence that the Chukchi Sea is not conducive to reproduction by the Bering flounder, and that recruitment to the Chukchi Sea population is from the transport of pelagic eggs and larvae northward from the Bering Sea, through the Bering Strait to the Chukchi Sea. Smith et al. (1997b) reported that Bering flounder in the Chukchi Sea are much smaller than those captured in the Bering Sea and elsewhere. Maximum length of the captured fish was 7.9 in. (20 cm) and maximum age was 11 years. Coyle et al. (1997) reported that Bering flounders captured in the northeastern Chukchi Sea were found to have consumed primarily fish with the most common prey being eelblennys (*Lumpenus spp*.). Benthic and epibenthic crustaceans were also consumed.

Bering Flounder Abundance

Smith et al. (1997b) reported that the Bering flounder was numerically the most dominant flatfish caught in their otter trawls in the northeastern Chukchi Sea; Bering flounders were captured at 32 of 48 locations in 1990 and at 19 of 24 sampled locations in 1991. Mean abundance was 1,259/mi^2 (486/km^2) in 1990 and 65/mi^2 (25/km^2) in 1991. Abundance was typically greater shoreward of Shell’s prospect area. In this area (Table 3.5.1-2, Figure 3.5.1-1), they found a mean of 39 to 186/mi^2 (15 to 72/km^2). Surveys prior to those conducted by Barber et al. (1997) in 1990-1991, resulted in much lower catches of Bering flounder. Some have suggested that Bering flounder were not previously found in the Chukchi Sea (Andriyashev 1954) but have been increasing in recent years (Smith et al. 1997b).

Capelin

The capelin is a small, (4 to 6 in. [110 to 155 mm]) forage fish found in large schools. It is an important prey species for marine mammals such as the spotted seal (Lowry et al. 1980), beluga whale (Seaman and Burns 1980), and seabirds such as the common murre (Roseneau et al. 2000). Capelin is not a target for subsistence in most Chukchi Sea villages (Craig 1989b), although it is sometimes utilized in Barrow (Bendock 1977; Craig 1989b).

Capelin Distribution

The capelin has a circumpolar distribution that encompasses all of the coastal Alaskan and Canadian Beaufort Seas (Mecklenburg et al. 2002). Capelin are found in nearshore waters (Craig 1984b; Fechhelm et al. 1984) mostly within 2.5 mi (4 km) of the coastline in waters less than 10 ft (3.0 m) deep (Thorsteinson et al. 1991). Common habitat includes the shallow coastal locations, such as mouths of rivers where marine and freshwaters mix (Mecklenburg et al. 2002). Juveniles typically float on the surface coastal waters (Thorsteinson et al. 1991). Given their nearshore distribution, capelin is not likely to occur in large numbers in Shell’s prospect area.

Capelin Life History

Capelin travel in large schools, spawning on smooth sand and gravel beaches (Jangaard 1974). Spawning has been reported to take place in July and August near Barrow (Bendock 1977). Fechhelm et al. (1984) reported large catches of capelin in spawning condition off Point Lay in early August and concluded they spawn at that time along the outer edge of the barrier island off Kasegaluk Lagoon. The eggs are demersal and adhesive, attaching to the gravel substrate (Jangaard 1974). The eggs hatch in about 55 days and the larvae are pelagic. Fechhelm et al. (1984) reported that the capelin is the fastest maturing fish in the arctic, with most of the spawning population at Point Lay being two years of age. Capelin feed on small crustaceans such as copepods and shrimp. In one study near Point Lay (Fechhelm et al. 1984), the diet of the capelin was found to consist mostly (95 percent) of the mysid shrimp (*Mysis littoralis*).

Capelin Abundance

Capelin have not been found to be abundant in offshore waters in the northeastern Chukchi Sea (Craig 1984b) and would not be expected to be found in great numbers in the offshore area near Shell's Burger Prospect. They are sometimes found in great numbers in nearshore waters (Thedinga et al. 2012), and these occurrences may be related to spawning activity. Fechhelm et al. (1984) found them to be the second most abundant fish in nearshore waters of the northeastern Chukchi Sea, but most of the captures occurred during a brief period of time (August 1 to3).

Pacific Herring

The Pacific herring is a small, 8 to 10 in. (225 to 260 mm) forage fish found in large schools. It is a prey species for marine mammals such as the spotted seal and beluga whale (Lowry et al. 1980), but does not make up a large proportion of their diets in the northeastern Chukchi Sea. Herring is a subsistence species in Barrow and Point Lay and perhaps other Chukchi Sea villages (Craig 1989b).

Pacific Herring Distribution

The Pacific herring is distributed along the North American coast from Baja California to the Canadian Arctic (Hart 1973). Herring density in the Chukchi Sea is relatively low with the bulk of the Alaska population being found south of the Bering Strait. It is primarily a nearshore species but is also found offshore. Spawning grounds are usually located in high-energy nearshore environments with submerged vegetation, rocks, or other substrates free of silt.

Pacific Herring Life History

Pacific herring in the northeastern Chukchi Sea spawn in the spring and early summer. They are thought to spawn in the Kasegaluk Lagoon in the spring (Fechhelm et al. 1984). Eggs are demersal and adhesive attaching to vegetation, rocks, and other objects. Herring are opportunistic feeders - in the Chukchi Sea they have been found to feed heavily on mysid shrimp, copepods, and fish larvae (Fechhelm et al. 1984).

Pacific Herring Abundance

Craig (1984b) concluded that the Pacific herring was one of the principal species found in nearshore and offshore waters of the northeastern Chukchi Sea, although it has also been found in offshore waters in lower numbers. They would not be expected to occur in large numbers within the offshore area near Shell's Burger Prospect.

3.5.2 Diadromous Fish

Diadromous fish of the northeastern Chukchi Sea include both anadromous and amphidromous forms (Tables 3.5.2-1 and 3.5.2-2, respectively). Amphidromous fish (Table 3.5.2-2), such as the least cisco, spend their lives migrating between freshwater and brackish and nearshore coastal waters, specifically to feed in coastal waters and overwinter in freshwater. The abundance of amphidromous fish is dependent on the existence of adequate freshwater overwintering habitat. In winter, amphidromous fish require freshwater that is deep enough, usually 5 to 6 ft (1.5 to 2.0 m), so it does not freeze during the winter (Craig 1984b). Anadromous fish (Table 3.5.2-1), such as Pacific salmon, migrate from freshwater streams to the sea to optimize feeding and growth. At maturity, they return to freshwater to spawn where they die soon after spawning. Sufficient water is required for overwintering of the eggs, larvae and fry of these species.

Table 3.5.2-1 Anadromous Fish Species Found in the Northeastern Chukchi Sea

Common Name [1]	Scientific Name [1]
Rainbow smelt	*Osmerus mordax*
Arctic lamprey	*Lampreta japonica*
Chum salmon	*Oncorhynchus keta*
Coho salmon	*Oncorhynchus kisutch*
Chinook salmon	*Oncorhynchus tshawytscha*
Sockeye salmon	*Oncorhynchus nerka*
Pink salmon	*Oncorhynchus gorbuscha*
Arctic char	*Salvelinus malma*
Arctic cisco	*Coregonus autumnalis*

[1] Source: Gallaway et al. 2011, MMS 1990, Morris 1981

Table 3.5.2-2 Amphidromous Fish Species Found in the Northeastern Chukchi Sea [1]

Common Name	Scientific Name
Bering cisco	*Coregonus laurette*
Least cisco	*Coregonus sardinella*
Broad whitefish	*Coregonus nasus*
Humpback whitefish	*Coregonus oidschian*

[1] Source: MMS 1990; Morris 1981

Diadromous fish are not as abundant in the northeastern Chukchi Sea as they are in either the southern Chukchi Sea or the Beaufort Sea (Craig 1984b). This is likely related to the small stock of these species in the streams in the area, restricted amounts of over-wintering habitat, and cold-water barriers to coastal dispersion (Craig 1984b). Fish surveys also indicate that they are largely restricted to nearshore waters (Craig 1984b) therefore numbers of these fish would not be expected to occur in the Burger Prospect.

Key species are discussed below because they are subsistence resources. Least cisco and rainbow smelt are the principal diadromous species in the northeastern Chukchi Sea (Craig 1984b) along with pink and chum salmon. Only these four species are discussed below in detail; other species, while they may be present, are not expected in the area of Shell's planned exploration drilling operations in significant numbers.

The Alaska Department of Fish and Game's (ADF&G) catalogue of streams supporting anadromous fish species (Johnson and Daigneault 2012) identifies streams along the Alaskan Chukchi Sea coast as being used by anadromous fish species (Table 3.5.2-3). The locations of these streams are indicated on Figure 3.5.1-2. The nearest anadromous stream (Utukok River) is more than 90 mi (145 km) from the Burger drill sites.

Table 3.5.2-3 Northeastern Chukchi Sea Rivers Supporting Anadromous Fish Species

Stream Name [2]	Use by Selected Diadromous Fish Species [1]			
	Chum Salmon	Pink Salmon	Coho Salmon	Dolly Varden
1 - Sulupoaktak Channel		spawning	--	present
2 - Kukpuk River		spawning	--	present
3 - Ayugatak Creek		spawning	--	--
4 - Pitmegea River	spawning	spawning	--	present
5 - Kuchiak Creek	spawning	--	spawning	--
6 - Kukpowruk River	present	spawning	--	present
7 - Kokolik River	present	spawning	--	present
8 - Utukok River	present	spawning	--	present
9 - Ivisaruk River	--	spawning	--	--
10 & 11 - Kuk River	present	present	--	--
12 & 13 - Kungok River	present	present	--	--
14 - Kugrua River	spawning	spawning	--	--

[1] Source: Johnson and Daigneault 2012

[2] Stream number corresponds to identifier on Figure 3.5.1-2

[3] -- is not present

3.5.3 Essential Fish Habitat

The Northern Pacific Fishery Management Council (NPFMC) has designated EFH in the northeastern Chukchi Sea for Pacific salmon, Arctic cod, saffron cod, and snow crab under the Magnuson-Stevens Fishery Conservation and Management Act (MSA). Congress has defined EFH as “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity” (MMS 2007b). The designated Arctic cod and saffron cod EFH encompass most of the northeastern Chukchi Sea including Shell’s Burger Prospect as shown in Figure 3.5.1-2.

Marine EFH for salmon includes all estuarine and marine areas used by Pacific salmon of Alaskan origin, extending from the influence of tidewater and tidally submerged habitats to the limits of the U.S. Exclusive Economic Zone (EEZ), which includes waters of the OCS, including the Chukchi Sea, out to the 660 ft (200 m) isobath (MMS 2007b). All five species of Pacific salmon (pink, chum, sockeye, coho, and chinook) are found in the Chukchi Sea although pink and chum are the most common. EFH for pink and chum salmon in the marine environment include the estuarine and marine zones. EFH of the estuarine zone includes the salinity transition zone (ecotone) and the mean higher tide line within the nearshore waters from late-April through June. In the marine environment, EFH is located off the coast of Alaska to water depths of approximately 160 ft (50 m) from the mean higher tide line to the 230 mi (370 km) limit of the EEZ, including Chukchi Sea (ADF&G 1998).

Pink salmon are found in the Sulupoaktak Channel, Kukpuk River, Ayugatak Creek, Pitmegea River, Kukpowruk River, Kokolik River, Utukok River, Ivisaruk River, Kuk River, Kungok River, and Kugrua River, and small stocks of chum salmon are found in the Pitmegea River, Kuchiak Creek, Kukpowruk River, Kokolik River, Utukok River, Kuk River, Kungok River, and Kugrua River (Johnson and Daigneault 2012). Pink and chum salmon can also be expected around Peard Bay, Wainwright Inlet, Kasegaluk Lagoon, and Ledyard Bay as the waters offer warm productive waters for prime feeding during the summer (Fechhelm et al. 1984).

NPFMC (2009) designated EFH for Arctic cod, saffron cod, and snow crab in 2009 with finalization of the Fishery Management Plan for Fish Resources of the Arctic Management Area. The EFH includes all areas of suitable habitat where the life stages are found within the stated geographic areas (Table 3.5.3-1). Designated Arctic cod and saffron cod EFH encompass most of the northeastern Chukchi Sea including Shell’s Burger Prospect.

Table 3.5.3-1 Designated EFH in the Northeastern Chukchi Sea

Species	Eggs	Early Juvenile	Late Juvenile [1]	Adult [1]
Arctic cod	-	-	Pelagic/epipelagic 0 to 1,640 ft (0 to 500 m) and often deeper when associated with ice floes	Pelagic/epipelagic 0 to 1,640 ft (0 to 500 m) and often deeper when associated with ice floes[1]
Saffron cod	-	-	Pelagic/epipelagic 0 to 164 ft (0 to 50 m) with substrates of sand & gravel	Pelagic/epipelagic 0 to 164 ft (0 to 50 m) with substrates of sand & gravel
Snow crab	Inferred [2]	-	Pelagic/epipelagic 0 to 328 ft (0 to 100 m) south of Cape Lisburne with mud substrate	Pelagic/epipelagic 0 to 328 ft (0 to 100 m) south of Cape Lisburne with mud substrate

[1] EFH includes suitable habitat for these life stages within the stated geographic area

[2] Inferred from egg-bearing females – same as adult

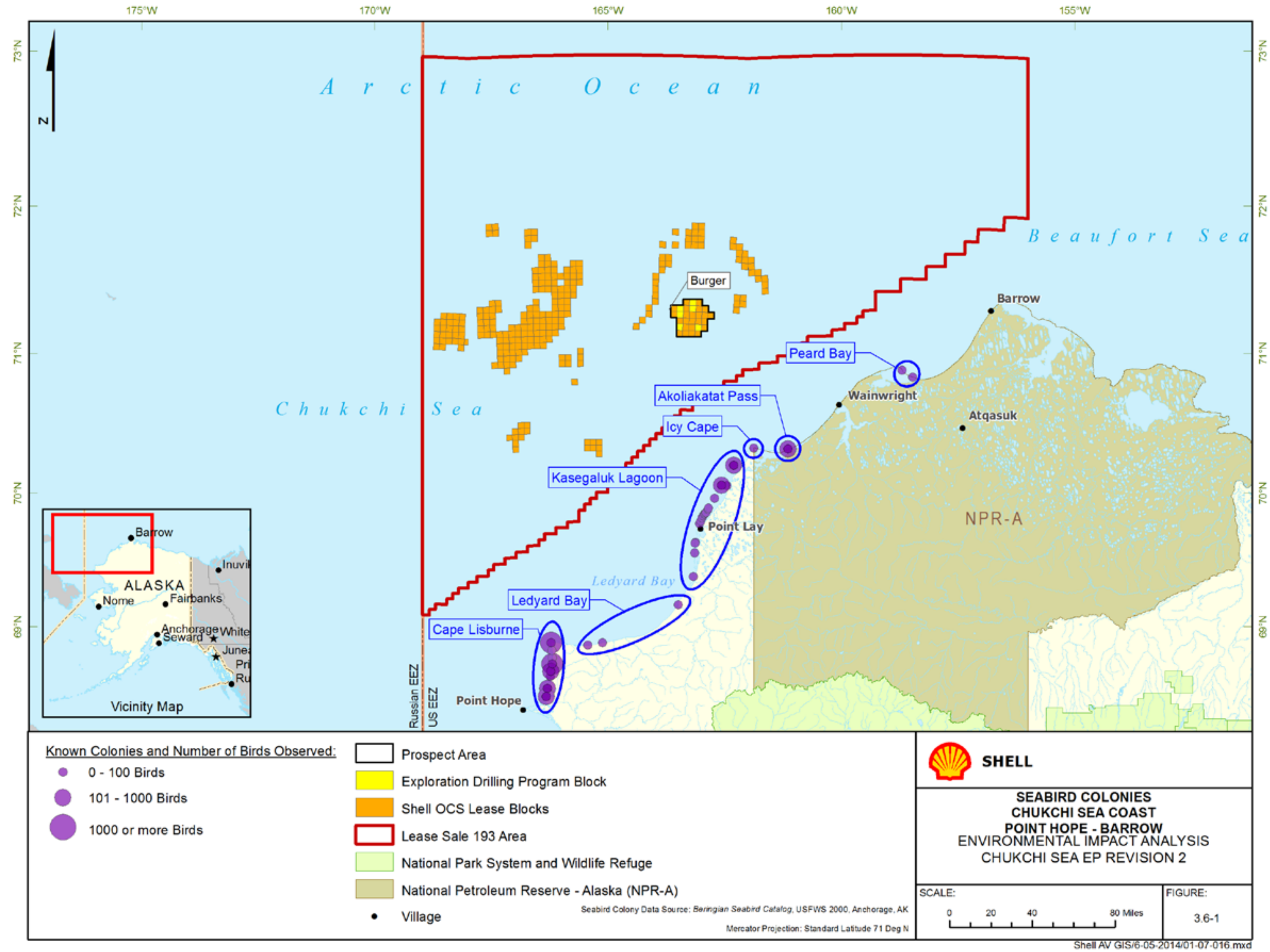
Source: NPFMC 2009

3.6 Coastal and Marine Birds

The Chukchi Sea and adjacent onshore areas are important habitat for non-breeding, staging, and migratory birds from June to October, including a number of species of alcids, gulls, terns, jaegers, loons, waterfowl, and shorebirds. Two species of federally-listed (threatened) sea ducks spectacled eider (*Somateria fischeri*) and Steller's eider (*Polysticta stelleri*) are found in the Chukchi Sea. These and other special status species are discussed in Section 3.8. Most of the birds that use the Chukchi Sea are migrants and use the coastal areas for breeding and nesting. Spring migration for some birds starts with the ice lead openings; many birds closely follow open leads that typically form along the edges of landfast ice. Other birds migrate as onshore areas thaw. Nearly all species of birds found in the Chukchi Sea are seasonal residents from May through September with most birds migrating south by late fall before the formation of sea ice.

Vessel surveys and satellite telemetry studies of the Chukchi Sea have documented widespread bird use in coastal and offshore waters (Divoky 1987; Hatch et al. 2000; Gall and Day 2011; Gall et al. 2013, 2014). The USFWS (2000) has identified 34 seabird nesting colonies along the northeastern Chukchi Sea coast between Point Hope and Barrow (Figure 3.6-1). The distribution of seabirds, particularly the planktivorous species, is strongly influenced by advective processes that transport oceanic species of zooplankton from the Bering Sea to the Chukchi Sea (Gall et al. 2013).

Figure 3.6-1 Seabird Colonies: Chukchi Sea Coast Point Hope - Barrow



The numbers of birds that nest at these colonies are indicated by species in Table 3.6-1 in which the colonies are grouped by geographical area. Distances from the drill sites to the closest nesting colony are provided in Table 3.6-2 provided below.

Table 3.6-1 Numbers of Birds in Colonies along the Chukchi Sea

Species	Number of Birds in Colonies by General Location [1]					
	Peard Bay	Akoliakatat Pass	Icy Cape	Kasegaluk Lagoon	Ledyard Bay	Cape Lisburne
Pelagic cormorant	-	-	-	-	33	238
Common eider	-	442	62	914	-	-
Glaucous gull	-	10	2	234	40	168
Black-legged Kittiwake	-	-	-	-	-	18,100
Arctic tern	50	42	6	62	10	-
Common murre	-	-	-	-	-	77,500
Thick-billed murre	-	-	-	-	-	147,500
Unidentified murre	-	-	-	-	-	40
Black guillemot	-	-	-	-	9	198
Tufted puffin	-	-	-	-	3	40
Horned puffin	4	-	-	-	-	1,869
Total Birds	**54**	**494**	**70**	**1,210**	**95**	**245,653**

[1] Source: Adapted from Beringia Seabird Catalog (USFWS 2000).

Table 3.6-2 Distances from Drill Sites to Nearest Bird Colonies

Prospect	Distance to Nearest Bird Colony [1]					
	Peard Bay	Akoliakatat Pass	Icy Cape	Kasegaluk Lagoon	Ledyard Bay	Cape Lisburne
Burger A	106 mi (170 km)	83 mi (134 km)	75 mi (120 km)	79 mi (128 km)	149 mi (239 km)	183 mi (295 km)

[1] Distance to nearest bird colony by area as designated on Figure 3.6-1.

3.6.1 Cliff-nesting Birds

Cliff-nesting species that nest along the coastline of the northeastern Chukchi Sea or are commonly found in offshore waters are listed in Table 3.6.1-1. Some species, such as the murres, are known to nest along the coastline with larger numbers of non-breeding birds being found in coastal waters. Large numbers of cliff-nesting birds are found in cliff colonies around Cape Lisburne where over 200,000 murres and 18,000 kittiwakes nest (Table 3.6-1). Other species such as the auklets are not known to nest along the coastline of the northeastern Chukchi Sea but are found in great numbers in adjacent offshore waters. The distribution, life history, and abundance of these species are described below.

Table 3.6.1-1 Species of Cliff-Nesting Seabirds Found in the Northeastern Chukchi Sea

Common Name	Scientific Name
Common murre	*Uria aalge*
Thick-billed murre	*Uria lomvia*
Black guillemot	*Cepphus grylle*
Tufted puffin	*Fratercula cirrhata*
Horned puffin	*Fratercula corniculata*
Parakeet auklet	*Aethia psittacula*
Least auklet	*Aethia pusilla*
Crested auklet	*Aethia cristatella*
Kittlitz's murrelet	*Brachyramphus brevirostris*
Black-legged kittiwake	*Rissa tridactyla*
Short-tailed shearwater	*Puffinus tenuirostris*
Northern fulmar	*Fulmarus glacialis*
Pelagic cormorant	*Phalacrocorax pelagicus*

Distribution of Cliff-nesting Birds

The worldwide and Alaska distributions of the cliff-nesting species as described by Denlinger (2006) are summarized below in Table 3.6.1-2. The distribution of nesting colonies used by these species is indicated above in Section 3.6 and Figure 3.6-1. Their use of offshore waters of the northeastern Chukchi Sea, including the Lease Sale 193 Area and Shell's Burger Prospect, is discussed below in Section 3.6.6.

Table 3.6.1-2 Distribution of Cliff-Nesting Seabirds Found in the NE Chukchi Sea

Common Name	Worldwide	Alaska / Northeastern Chukchi Sea [1]
Common murre	North Pacific and North Atlantic	Nest SE Alaska to Cape Lisburne. Winter south of ice edge Bering Sea
Thick-billed murre	Circumpolar – Arctic, Atlantic, Pacific	Nest SE Alaska to Cape Lisburne. Winter in open water Bering Sea, Gulf of Alaska
Black guillemot	Circumpolar	Nest Cape Thompson to Barter Island. Winter in open water near pack ice (ice dependent species)
Tufted puffin	North Pacific – British Columbia, Alaska E. Asia	Nest SE Alaska to Cape Lisburne. Winters in ice free north central Pacific.
Horned puffin	North Pacific – California to Alaska, Japan to NE Asia	Nest SE Alaska to Cape Lisburne. Winters in ice free north central Pacific over deep water.
Parakeet auklet	SE Alaska, Gulf of Alaska, Chukchi, Sea of Okhotsk	Nest PWS - Cape Lisburne. Non-breeding in Chukchi Sea. Winters offshore S. Pacific Ocean.
Least auklet	Bering Sea, Chukchi, Sea of Okhotsk	Nest AK Peninsula/Aleutians - Bering Sea islands. Non-breeding in Chukchi. Winters offshore.
Crested auklet	SE Alaska, Gulf of Alaska, Chukchi, Sea of Okhotsk	Nest Aleutian / Bering Sea islands. Non-breeding in Chukchi. Winters offshore.
Black-legged kittiwake	North Atlantic and Pacific	Nest southeast Alaska north to Point Hope; winters at sea Bering Sea, Gulf of Alaska
Short-tailed shearwater	Breeds in southern hemisphere; North Pacific during boreal summer	Most at sea in south Bering Sea, Gulf of Alaska, fewer in Chukchi & Beaufort Sea
Northern fulmar	North Atlantic and Pacific Oceans	Nests on Alaska Peninsula and Bering Sea islands. Winters at sea – Bering Sea, Gulf of Alaska
Pelagic cormorant	Chukchi Sea south to Baja California and S. China	Nest SE Alaska to Ledyard Bay. Winters off Pribilofs and southward, Bering Sea, Gulf Alaska
Kittlitz's murrelet	SE Alaska to Point Lay and Russian Far East from Okhotsk Sea to the Chukchi Sea.	Nest SE Alaska to Point Lay and Russian Far East from Okhotsk Sea to the Chukchi Sea. Winters in Southeast and western Alaska and in a few locations in southcoastal Alaska.

[1] SE = Southeast, PWS = Prince William Sound, NE = Northeast, E = East, S = South

Life History of Cliff-nesting Birds

Common and thick-billed murres that utilize the northeastern Chukchi Sea winter in ice-free areas in the Bering Sea and southward. They migrate into the northeastern Chukchi Sea through the Bering Strait following the system of open leads, arriving in April and occupying the nesting colonies in May. Both species nest together in dense colonies primarily located on rocky cliffs. Single eggs are laid on bare rock ledges, hatching in late June or July. Flightless chicks go to sea starting in mid-August, with departure from the nesting colonies generally complete by late September. Seabirds at these colonies are known to regularly forage out 30 mi (60 km) into the Chukchi Sea from these colonies and sometimes as far as 75 mi (120 km) (Roseneau and Herter 1984). Shell's Burger Prospect is not within this range. The diet of both species is primarily fish obtained by surface dives, but some crustaceans are utilized. Primary fish prey species are Arctic cod and sculpin species in early summer with sand lance and capelin more prominent in the diets later in the summer. Divoky (1987) reported that few murres were observed in Chukchi Sea waters north of latitude 70^{o} N after 24 August. Most are gone from all of Lease Sale 193 Area by late October (Roseneau and Herter 1984), although a few may winter in any ice free water available (Swartz 1966; Roseneau and Herter 1984).

Black guillemots are an ice-dependent species. They winter in the open ocean generally near or within the pack ice, with a number wintering in the eastern Chukchi Sea at open leads and polynyas (Bailey 1948).

Black guillemots wintering south of the northeastern Chukchi Sea migrate into the area following the spring lead system (Roseneau and Herter 1984). They nest in crevices and rocky sea cliffs, laying 1-2 eggs in late June or early July (Roseneau and Herter 1984). Hatching occurs in late July or August and the chicks fledge in late August and early September. Divoky (1987) found them to be common throughout the Lease Sale 193 Area including the area of Shell's Burger Prospect. Black guillemots dive for their food, which consists primarily of Arctic cod along with sand lance, snailfish, and small crustaceans (Roseneau and Herter 1984; Divoky 1987). Black guillemots are associated with sea ice throughout their lifetime (Divoky 1987). They retreat south of the Chukchi Sea with the advancing ice in the winter.

Along the shoreline of the northeastern Chukchi Sea only about 1,900 puffins nest at six colonies; most of these are in the Cape Lisburne area (Table 3.6-1). In winter they are found over broad areas of the ice-free North Pacific. They migrate into the Chukchi Sea for nesting. Swartz (1966) reported that puffins were first seen arriving near Cape Lisburne in early June with occupation of ledges near nesting crevices occurring soon after. They nest in rock crevices with only rudimentary nest formation such as scattered plant material and some evidence of burrowing. They usually lay one egg, with incubation lasting around 38 days. The young remain in the nest for 36 to 42 days. Adults were last seen by Swartz (1966) at the Cape Lisburne colonies on 2 October. The diets of horned and tufted puffins consist of small fish obtained by diving, and include Arctic cod, sand lance, and sculpin (Swartz 1966). In surveys of offshore waters of the central northeastern Chukchi Sea, Divoky (1987) found them to be regular but not common in August, but found in greater numbers in September after the nesting season.

Parakeet, least, and crested auklets are not known to nest north of the Bering Strait (Roseneau and Herter 1984), but non-breeding birds regularly use the offshore waters in the northeastern Chukchi Sea, sometimes in large numbers (Divoky 1987). Numbers of birds of these species peak in the northeastern Chukchi Sea in August or September, and most depart by late October (Roseneau and Herter 1984; Divoky 1987). The birds forage by diving, preying on small crustaceans, including copepods, euphausiids, and amphipods.

Black-legged kittiwakes winter in ice-free offshore areas. They migrate into the Chukchi Sea following the spring lead system, arriving in the vicinity of the Cape Lisburne nesting cliffs in May (Roseneau and Herter 1984). Nest building commences in mid-June (Swartz 1966) with 1-2 eggs per nest. The fledged young depart the nests starting in late September or early October. Colonies are usually depleted by mid-October (Roseneau and Herter 1984). Kittiwakes obtain their food near the water surface by hovering, dipping, and plunging, with Arctic cod, sand lance, and capelin being important prey species. Foraging occurs out as far as 75 mi (120 km) from the Cape Lisburne nesting colonies (Roseneau and Herter 1984). Non-breeders and migrants are found at greater distances from shore across the Lease Sale 193 Area.

Short-tailed shearwaters breed in the Southern Hemisphere and migrate into Chukchi Sea in May following Bering Sea water, which brings large populations of zooplankton and other prey. Shearwaters are found in the northeastern Chukchi Sea from May through November, but most are gone from the central northeastern Chukchi Sea near Shell's Burger Prospect by late September (Divoky 1987). They feed from the water surface making shallow dives. Principal prey items include sand lance, capelin, squid, and euphausiids (Roseneau and Herter 1984). Concentrations of these prey species can attract thousands of shearwaters to one locale.

Northern fulmars are truly pelagic species spending most of their lives far out at sea and coming to land only for nesting. They do not nest in Alaska north of Mathew Island in the Bering Sea. Most northern fulmars remain south of the Bering Strait but some non-breeders utilize the Chukchi Sea each year (Divoky 1987; Roseneau and Herter 1984). They feed primarily on fish and squid, which are captured both by surface and plunge diving (Denlinger 2006).

Pelagic cormorant winter in the Bering Sea and Gulf of Alaska, they arrive along the coastal waters of the northeastern Chukchi Sea in May and depart in October (Swartz 1966). They feed in coastal waters by diving, preying on small fish including Arctic cod, snailfish, and sand lance (Swartz 1966; Roseneau and

Herter 1984). According to Roseneau and Herter (1984), few cormorants use the Chukchi Sea north of Ledyard Bay.

Kittlitz's murrelets are small diving seabirds that mainly live in Alaskan coastal waters from Point Lay to southeast Alaska (MMS 2006b; USFWS 2009b; 2010d). Most of the world population is found in Alaska with a few found in the Russian Far East (MMS 2006b). They nest on scree mountain slopes. Nests have been found at the end of the Delong Mountains near Cape Thompson (USFWS 2009b) and these birds may nest as far north as Cape Beaufort between Cape Lisburne and Point Lay (USFWS 2009b; CBD 2001).

Kittlitz's murrelets have been found to have a pelagic distribution from approximately 13 to 132 mi (21 to 213 km) offshore (Divoky 1987). Their winter distribution is not well known but they are thought to move south with the advancing ice and winter in pelagic waters over the continental shelf in the Bering Sea and Gulf of Alaska. Little is known about the Kittlitz's murrelet reproductive strategy (MMS 2006b). They appear to be paired upon arrival to breeding grounds and egg-laying occurs from mid-May to mid-June. Fledging in northern populations generally occurs during August (MMS 2006b). Spring migration in the Chukchi Sea is poorly understood, but it is assumed they follow the retreating ice front in spring where they follow offshore leads north to take advantage of under-ice plankton blooms and the large biomass of forage species associated with blooms (MMS 2006b). Fall migration is also poorly understood, but likely occurs ahead of the forming and advancing ice front (MMS 2006b).

Abundance of Cliff-nesting Birds

Common murres have a global population of 13 to 20.7 million birds, with about 2.8 million in Alaska. Thick-billed murres have a global population of 15 to 20 million birds and an Alaska population of 2.2 million (Denlinger 2006). Divoky (1987) estimated that 500,000-1,000,000 murres use the pelagic waters of the Chukchi Sea. Approximately 225,000 common and thick-billed murres nest at cliff colonies at Cape Lisburne (Table 3.6-1), and approximately 390,000 murres nest further south at Cape Thompson (Fadely et al. 1989). Murre numbers have declined about 50 percent at Cape Thompson and more than doubled at Cape Lisburne between 1976 and 1995 (Fadely et al. 1989; Roseneau 1996).

The black guillemot has a world breeding population of 0.5 to 1 million birds. The Alaska breeding population consists of about 700 birds located at 15 colonies (Denlinger 2006). However, the pelagic (offshore) population in Alaska, which includes many non-breeding individuals, is estimated to be around 70,000 (Divoky 1987).

The worldwide breeding population of puffins includes about 1,089,000 horned puffins and 2,970,000 tufted puffins. In Alaska the breeding population is about 921,000 horned puffins at 608 colonies and 2,280,000 tufted puffins in 693 colonies (Denlinger 2006). Along the shoreline of the northeastern Chukchi Sea about 1,900 puffins nest at six colonies with almost all of these being in the Cape Lisburne area (Table 3.6-1). Surveys have indicated declines in these species in Prince William Sound, Alaska; trend data do not exist for the Chukchi Sea.

Parakeet, crested, and least auklets are found in offshore waters of the northeastern Chukchi Sea (Divoky 1987), including the area of Shell's Burger Prospect, but do not nest along the Chukchi Sea coastline from Cape Lisburne northward (Denlinger 2006). Divoky estimated that as many as 40,000 parakeet auklets, a minimum of 40,000 least auklets, and about 100,000 crested auklets use the pelagic waters of the Chukchi Sea. The Alaskan population of parakeet auklet is about 1,000,000 birds at 195 colonies, and the Asian population is an additional 300,000 to 400,000 birds (Denlinger 2006). The least auklet has a North American population of 5.5 to 9.0 million and is the most abundant seabird in Alaska. The crested auklet is thought to have a global population of about six million birds, with a North American population of about two million.

The Pacific black-legged kittiwake's subspecies has a worldwide breeding population of about 2.6 million birds, with an Alaska population of approximately 1,322,000 at 371 colony sites (Denlinger 2006). Divoky (1987) reported that 400,000 kittiwakes might use the pelagic waters of the Chukchi Sea. About 18,100 kittiwakes nest along the shoreline of the northeastern Chukchi Sea at three colonies in the Cape Lisburne area (Table 3.6-1). Some colonies in Alaska have decreased significantly in recent years and others have increased. Numbers of kittiwakes at the Cape Lisburne colonies have been increasing since the 1970's (Roseneau et al. 2000).

Large numbers of shearwaters are found in the northeastern Chukchi Sea, probably peaking in August through September with most departing by late October (Roseneau and Herter 1984). Shearwaters are some of the most abundant pelagic birds in Alaska with the Bering Sea population estimated at 9 to 65 million, 90 percent of which are thought to be short-tailed shearwaters. A relatively large number, perhaps two million, are believed to use the Chukchi Sea each summer (Roseneau and Herter 1984) and are one of the more common species in the area of Shell's Burger Prospect (Divoky 1987).

The worldwide population of northern fulmars is estimated to be 10 to 12 million birds, with about 1.4 million being found at 38 nesting colonies in Alaska (Roseneau and Herter 1984). They are not known to nest along the northeastern Chukchi Sea coastline, but non-breeding birds or unsuccessful nesters are common in offshore waters including the area of Shell's prospects during late summer (Divoky 1987). As many as 45,000 fulmars might use the pelagic waters of the Chukchi Sea (Divoky 1987). Numbers of fulmars in the northern Hemisphere, including at least some Alaska colonies, are increasing in recent years (Denlinger 2006).

The worldwide population of pelagic cormorants is approximately 400,000; the Alaskan population of is thought to be about 90,000 birds, with about 43,700 nesting birds at 420 colony sites (Denlinger 2006). The Alaska population appears to be stable. As of 2000 about 238 nested along the northeastern Chukchi Sea coastline from Cape Lisburne to Ledyard Bay. They would not be expected to regularly occur in offshore waters such as those in the Burger Prospect (Divoky 1987).

In 2010, USFWS (2010d) concluded that earlier Kittlitz's murrelet estimates may have been biased low and provided a current estimate of the world-wide abundance at between 30,900 and 56,800 individuals, with perhaps 11,100 of those birds being in Russia. The Center for Biological Diversity estimated the population along the Chukchi Sea coastline (including Wrangel Island) at 450 in 1993 (van Vliet and McAllister 1994 in CBD 2001).

Divoky (1987) reported that the Kittlitz's murrelet is rare in pelagic waters of the Chukchi Sea until late August when it becomes regular but uncommon. He provided an estimated average density of <26 birds/100 mi^2 (<10 birds/100 km^2) and a maximum density of 57 birds/100 mi^2 (22 birds/100 km^2) in the central northeastern Chukchi Sea (area of Shell's Burger Prospect) in late August and September, decreasing in October. He noted that the species has not been observed during some other cruises in the area during the same season but different years, and concluded that there are annual factors affecting the species occurrence in the Chukchi Sea. Divoky estimated that 15,000 Kittlitz's murrelets are typically present in the Chukchi Sea in early fall.

3.6.2 Gulls, Terns, and Jaegers

Gull, tern, and jaeger species that commonly use the Lease Sale 193 Area and adjacent coastal areas for feeding and or nesting are listed in Table 3.6.2-1. The distribution, life history, and abundance of these species are discussed below. The black-legged kittiwake is discussed above under cliff-nesting birds.

Table 3.6.2-1 Gulls, Terns, and Jaegers Commonly Found in the NE Chukchi Sea

Common Name	Scientific Name	Chukchi Sea Status
Glaucous gull	*Larus hyperboreus*	Colonial nester along most of coastline, most common gull
Ivory gull	*Pagophila eburnean*	Not known to nest in Alaska, frequents offshore waters, associated with ice
Ross's gull	*Rhodostethia rosea*	Not known to nest in Alaska, frequents offshore waters, associated with ice
Black-legged kittiwake	*Rissa tridactyla*	Cliff nester north to Cape Lisburne, summer use of offshore northeast Chukchi Sea
Sabine's gull	*Xema sabini*	Nests in tundra & coastal marsh, summer use of northeast Chukchi Sea coastal waters
Arctic tern	*Sterna paradisaea*	Nests in small colonies along most of coastline, uses coastal & pelagic waters
Pomarine jaeger	*Stercorarius pomerinus*	Nests on tundra in years with high rodent populations, non-breeders use pelagic waters
Parasitic jaeger	*Stercorarius parasiticus*	Nests on tundra in years with high rodent populations, non-breeders use pelagic waters
Long-tailed jaeger	*Stercorarius longicaudus*	Nests on tundra in years with high rodent populations, non-breeders use pelagic waters

Distribution of Gulls, Terns, and Jaegers

The distribution of nesting colonies used by these species is indicated above in Section 3.6.1. The worldwide and Alaska distributions of gull and tern species found in and along the northeastern Chukchi Sea as described by Denlinger (2006) are summarized below in Table 3.6.2-2. Their use of offshore waters of the northeastern Chukchi Sea including the Lease Sale 193 Area and Shell's Burger Prospect is further discussed below in Section 3.6.6.

Table 3.6.2-2 Distribution of Gulls, Terns, and Jaegers Found in the NE Chukchi Sea

Common Name	Worldwide	Alaska / Northeastern Chukchi Sea
Glaucous gull	Circumpolar in holarctic, disperses in winter to open coastal waters	Nests in western Alaska to Canada, including northeastern Chukchi Sea, uses nearshore and offshore waters
Ivory gull	Nests in Siberia, Greenland, Canada, non-breeders wander Arctic Ocean south to Chukchi, winter south to Bering Sea	Doesn't nest in Alaska, uses nearshore and offshore Chukchi waters often in association with ice or ice edge
Ross's gull	Nests in restricted area north Siberia and Canada, winter range unknown, may be in Arctic year round	Doesn't nest in Alaska, uses nearshore and offshore Chukchi waters often in association with ice or ice edge
Sabine's gull	Nests circumpolar and subarctic, winters at sea in tropics/subtropics	Nests in coastal areas from AK Peninsula north to Canada, nearshore & offshore waters
Arctic tern	Nests circumpolar, winters near Antarctica and southern Africa	Nests near water across Alaska including Chukchi Sea coast, uses coastal waters
Pomarine jaeger	Nests circumpolar / holarctic, winters at sea south to Africa, S. America	Nests on tundra arctic coast & Y-K Delta, non-breeding birds use offshore Chukchi waters
Parasitic jaeger	Nests circumpolar / holarctic, winters at sea south to Africa, S. America	Nests on tundra along arctic coast and in Y-K Delta, non-breeding birds use offshore Chukchi waters
Long-tailed jaeger	Nests circumpolar / holarctic, winters at sea south to Africa, S. America	Nests on tundra along arctic coast and in Y-K Delta, non-breeding birds use offshore Chukchi waters

Y-K = Yukon-Kuskokwim

Life History of Gulls, Terns, and Jaegers

The Alaska population of glaucous gulls winters in open waters of the North Pacific near the Aleutian and Pribilof Islands, south as far as coastal Oregon. A few may overwinter in the northeastern Chukchi Sea where open water exists (Swartz 1966). Numbers found in the northeastern Chukchi Sea increase with an influx of migrants in April, which are found in the spring lead system and along the coastline (Woodby and Divoky 1982). Glaucous gulls nest either solitarily or colonially on islands and sandbars located on or near the coast, on cliffs, inland river bars, or small islands in lakes (Johnson and Herter 1989) laying 2 to 4 eggs in mid-June to early July (Roseneau and Herter 1984). Incubation takes 27 to 28 days, with the young leaving the nest in another 45 to 50 days (Denlinger 2006). Fledging is usually complete by late August (Roseneau and Herter 1984). There is also a large influx of sub-adults and non-breeding birds in late summer. Most of the fall migration occurs along the coast in September and October; however, many birds may still be present as late as early December. Glaucous gulls are scavengers and predators, feeding on marine mammal and bird carcasses, and predating bird chicks and eggs (murres), and fish such as Arctic cod, herring, and sand lance (Swartz 1966; Roseneau and Herter 1984).

The ivory gull is strongly associated with ice, even in winter when it is typically found only as far south as the ice front in the Bering Sea. In the summer it is restricted to the Arctic Basin. It does not nest along the northeastern Chukchi Sea, but non-breeders and immature birds are found in offshore waters throughout the area, seldom in sight of land (Roseneau and Herter 1984). Divoky (1987) found them to be rare in the central northeastern Chukchi throughout much of the summer, becoming common or abundant in late September and October wherever there was pack ice. They usually occur as individuals or small groups foraging over pelagic waters far from land (Roseneau and Herter 1984). Carcasses and feces of marine mammals make up much of their diet (Divoky 1976) but they also consume some fish and invertebrates (Roseneau and Herter 1984).

The Ross's gull does not nest in Alaska. They nest in very limited areas in northern Siberia and parts of Canada, colonially on tundra tussocks or on islands in lakes, sometimes with arctic terns (Johnson and Herter 1989). Their winter range is not well known, but they may be present in arctic waters throughout the winter (Roseneau and Herter 1984). Larger numbers of Ross's gull enter the Chukchi Sea area after mid-August to feed; they are often observed in nearshore waters in the fall between Wainwright and Barrow (Watson and Divoky 1972). Divoky (1987) found the species to be common in offshore waters, including the area of Shell's Burger Prospect in late September and October. Most of the world population of Ross's gull is thought to aggregate near Barrow each fall to feed prior to migration (Johnson and Herter 1989). These gulls utilize nearshore and offshore waters where they are strongly associated with ice and feed on ice-associated amphipods.

The Sabine's gull nests on the shores or islands of tundra lakes and on barrier islands (Johnson and Herter 1989). They use coastal waters during migration in the Chukchi Sea area with most observations of the species occurring landward of the 66 ft (20 m) isobath. They are also found in low numbers offshore (Divoky 1987; Roseneau and Herter 1984) where they feed on amphipods and euphausiids.

Arctic terns winter in the Southern Hemisphere near Antarctica. They arrive in the northeastern Chukchi Sea starting in May (Williamson et al. 1966), with numbers peaking in mid-June. Nesting starts in late June or early July (Lehnhausen and Quinlan 1981). In marine environments, they nest in small colonies on islands and spits. Nests consist of shallow depressions in which 1 to 3 eggs are laid. Incubation is 21 to 23 days long and the young fledge in an additional 21 to 24 days (Denlinger 2006). Terns obtain most of their food, which includes Arctic cod, sand lance, euphausiids, mysid shrimp, and amphipods, just below the water surface by plunge diving (Divoky 1983; Roseneau and Herter 1984). They primarily use coastal waters with most observations occurring within 25 mi (40 km) of shore (Divoky 1987). Fall migration out of the northeastern Chukchi Sea is abrupt with most departed by mid-September (Lehnhausen and Quinlan 1981); migration is largely restricted to coastal area with most observations of the species occurring landward of the 66 ft (20 m) isobath (Divoky 1987).

Three jaeger species (pomarine, parasitic, long-tailed) are found in the northeastern Chukchi Sea but the pomarine jaeger is by far the most abundant (Roseneau and Herter 1984). Jaegers spend most of their life at sea coming to land only to nest; all three species winter at sea in the Southern Hemisphere. They migrate into the northeastern Chukchi Sea across a broad front over land and sea in late May and early July. Jaegers nest on the tundra and the breeding birds prey on lemmings and voles (pomarine, long-tailed) or small birds and their eggs and young (parasitic). Non-breeding birds are found offshore along the ice front, where they pirate fish from other birds, or capture their own at the surface. Fall migration begins in late August and is complete by late September (Roseneau and Herter 1984).

Abundance of Gulls, Terns, and Jaegers

The worldwide population of glaucous gulls is not well known, and gross changes or trends have not been reported (Denlinger 2006). Aerial surveys indicate glaucous gull numbers on the North Slope have remained level and stable in both short and long terms (Larned et al. 2007). About 30,000 may use Alaskan waters (Sowls et al. 1978). Approximately 454 glaucous gulls nested at colonies along the northeastern Chukchi Sea coastline in 2000, but thousands more subadults and non-breeding birds use or migrate through the area. Divoky (1987) estimated that 125,000 use the pelagic waters of the Chukchi Sea.

The worldwide population of ivory gulls is unknown, but is presumed to be relatively small (Roseneau and Herter 1984). The species does not nest in Alaska. They are common in offshore waters of the central northeastern Chukchi Sea wherever ice is present (Divoky 1987).

The world population of Ross's gull is unknown but may not exceed a few tens of thousands of birds (Denlinger 2006). Divoky (1987) estimated the Alaska population, which consists of migrants from Siberian breeding colonies, at 20,000 to 40,000 birds, and estimated that 3,500 to 16,500 Ross's gull move through the Chukchi Sea during migration. Divoky (1987) reported that they are common to abundant in nearshore waters but rare offshore.

The worldwide population of Sabine's gull is not known. The Pacific wintering population has been estimated at less than 100,000. The Alaska population is probably on the order of tens of thousands of gulls (Denlinger 2006). The Sabine's gull has shown significant increases in numbers on the North Slope in the past ten years (Larned et al. 2007). Divoky (1987) reported that they are common to abundant in nearshore waters but rare offshore.

The worldwide population of arctic terns may be on the order of 1 to 2 million breeding pairs (Denlinger 2006). There may be several hundred thousand arctic tern nesting in Alaska, but there is not a reliable estimate due to the dispersed nesting (Denlinger 2006). Arctic tern numbers on the North Slope increased from 1992 to 2000, but have been more stable from 2000 to 2007 (Larned et al. 2007).

Worldwide population estimates for pomarine, parasitic, and long-tailed jaegers are 50,000 to 100,000, 500,000 to 1,000,000, and 100,000 to 500,000, respectively, with all species apparently stable (del Hoyo et al. 1996). Divoky (1987) estimated that up to 100,000 jaegers might use the offshore waters of the Chukchi Sea from late July to late August. Jaeger numbers on the North Slope are known to fluctuate widely following prey abundance, primarily brown lemmings (*Lemmus trimucronatus*) (Larned et al. 2007).

3.6.3 Loons

Loon species found in marine environments of the Lease Sale 193 Area and adjacent coastal habitats include the Pacific loon (*Gavia pacifica*), the red-throated loon (*G. stellata*), and the yellow-billed loon (*G. adamsii*). Discussions of these loons are provided below.

Distribution of Loons

The red-throated loon nests across northern North America and Eurasia. In Alaska, they nest primarily in coastal areas from southeastern Alaska to Canada. Red-throated loons tend to select small shallow wetlands, apparently due to competition with the larger and more abundant Pacific loons, and mostly within about 12 mi (20 km) of the coast (Larned et al. 2007).

Pacific loons nest in northern Canada, Alaska, and parts of Siberia. They nest throughout much of Alaska and are commonly found across the Arctic Coastal Plain including areas along the northern Chukchi Sea coastline. Pacific loons winter in marine environments along the western coast of North America from Alaska to Mexico (Schmutz 2009).

Yellow-billed loons nest across northern Russia from Novaya Zemlya east to Alaska, and across northern Alaska and Canada as far east as Hudson Bay (Earnst 2004). Within the U.S., this species breeds almost entirely within the National Petroleum Reserve-Alaska (NPR-A) (Earnst 2004). Yellow-billed loon nesting densities vary across the Arctic Coastal Plain, and offshore sightings are few. Shell's identified flight corridor for aircraft traffic supporting the exploration drilling program traverses areas identified as relatively low to medium low loon densities. Earnst (2004) reported estimates of the density of nesting yellow-billed loons on the North Slope coastal plain of about 0.01/mi^2 (0.027-0.033 loons/km^2).

Yellow-billed loons prefer large, deep, tundra lakes where they nest on low islands or near the edges of lakes to avoid terrestrial predators (Johnson and Herter 1989). They winter in ice-free marine waters primarily from southern Alaska through British Columbia and in Eurasia off the coast of Norway, Kamchatka Peninsula, Japan, North Korea, and China (Earnst 2004). Recent telemetry studies indicate that most yellow-billed loons from the North Slope winter off North Korea, Japan, and China (Schmutz 2009).

Yellow-billed loons are found in the northeastern Chukchi Sea. Aerial bird surveys conducted by the USFWS (Fischer et al. 2002; Lysne et al. 2004) have noted that nearshore areas are relatively more important to yellow-billed loons. Lysne et al. (2004) reported 43 observations of yellow-billed loons along the Chukchi Sea coast west of Barrow over four years of surveying, with the majority of these observations (86 percent) occurring between Barrow and Peard Bay. They are; however, found in offshore waters as well, including the area of Shell's Burger Prospect (Gall and Day 2011).

Life History of Loons

Pacific loons and red-throated loons winter in open water areas south of the Chukchi Sea. Spring migration through and along the Chukchi Sea begins in late May to early June and peaks in late June (Roseneau and Herter 1984). The migration occurs in offshore waters and may be concentrated in the spring lead system where relatively large numbers of loons have been observed resting (Roseneau and Herter 1984). The number of pacific and red-throated loons moving through the area in the spring is thought to be in the tens of thousands. They disperse to nest sites at low densities across the Arctic Coastal Plain. The nests made of plant debris are located at the water's edge of lakes and ponds. Two eggs are deposited in June and are incubated for about a month. The young leave the nest within a day or two and in September migrate to coastal waters where non-breeding birds tend to remain. The red-throated loon is more closely associated with the marine environment with most nests within 12 mi (19 km) of the coast (Larned et al. 2007), and is the only species that feeds the young almost exclusively on marine species (Schmutz 2008). All loons feed primarily on fish, which they obtain by diving. In the marine environment, Arctic cod is one of the more common prey species (Divoky 1978; Roseneau and Herter 1984). Fall migration begins in late August and peaks in September but continues through October (Watson and Divoky 1972). Most red-throated loons from the North Slope migrate to, and winter in East Asia.

The low population numbers, patchy distribution, and narrow habitat requirements of the yellow-billed loon could increase any effects of disturbance or habitat alteration on this species as compared to more abundant species that have greater distributions and use a wide variety of habitat (Hunter 1996). Yellow-billed loons are probably K-selected species (long-lived and dependent on high adult survival to maintain populations). On the North Slope, nesting begins as early as mid-June and the normal clutch size is two eggs (Johnson and Herter 1989). This species reaches sexual maturity at three years of age, but may not acquire breeding territories until at least four years of age (North 1994). During the breeding season, foraging habitats include lakes, rivers, and the nearshore marine environment (Earnst 2004). Young are fed entirely from the brood-rearing waterbody (Earnst 2004).

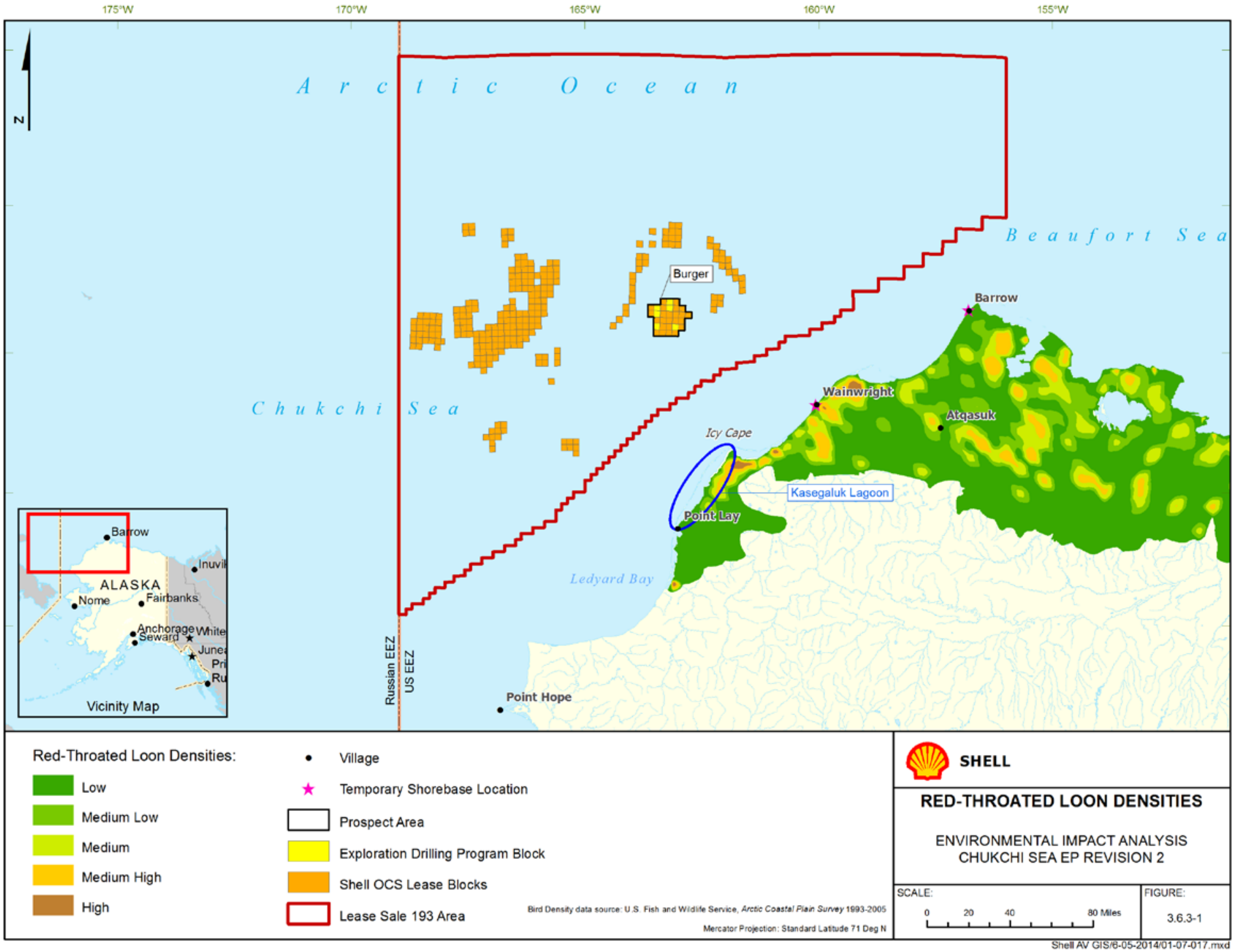
Yellow-billed loon migration routes are thought to be primarily marine, arriving along the Chukchi Sea coast in early May and leaving late-August to mid-September (Johnson and Herter 1989). Open water leads and polynyas are known to be important for staging and spring migration (Searing et al. 1975).

Sources of adult yellow-billed loon mortality include subsistence harvest, by catch in commercial and subsistence fisheries, die-offs during spring migration in years when open-water leads are not available, and disease, but the relative importance of these sources cannot be estimated with existing data (Earnst 2004). Predation on nests and young are common, but thought to be rare on adults (Earnst 2004).

Abundance of Loons

Total numbers of loons in the area are unknown but probably number in the tens of thousands with most passing through offshore to lands further north and east on the North Slope and Canadian Arctic Slope. Pacific loons are the most abundant and yellow-billed loons are the least abundant. Loons breed and nest near tundra lakes and ponds as soon as the ice and snow melt. They feed extensively on small fish species in both freshwater and marine environments.

Figure 3.6.3-1 Red-Throated Loon Densities



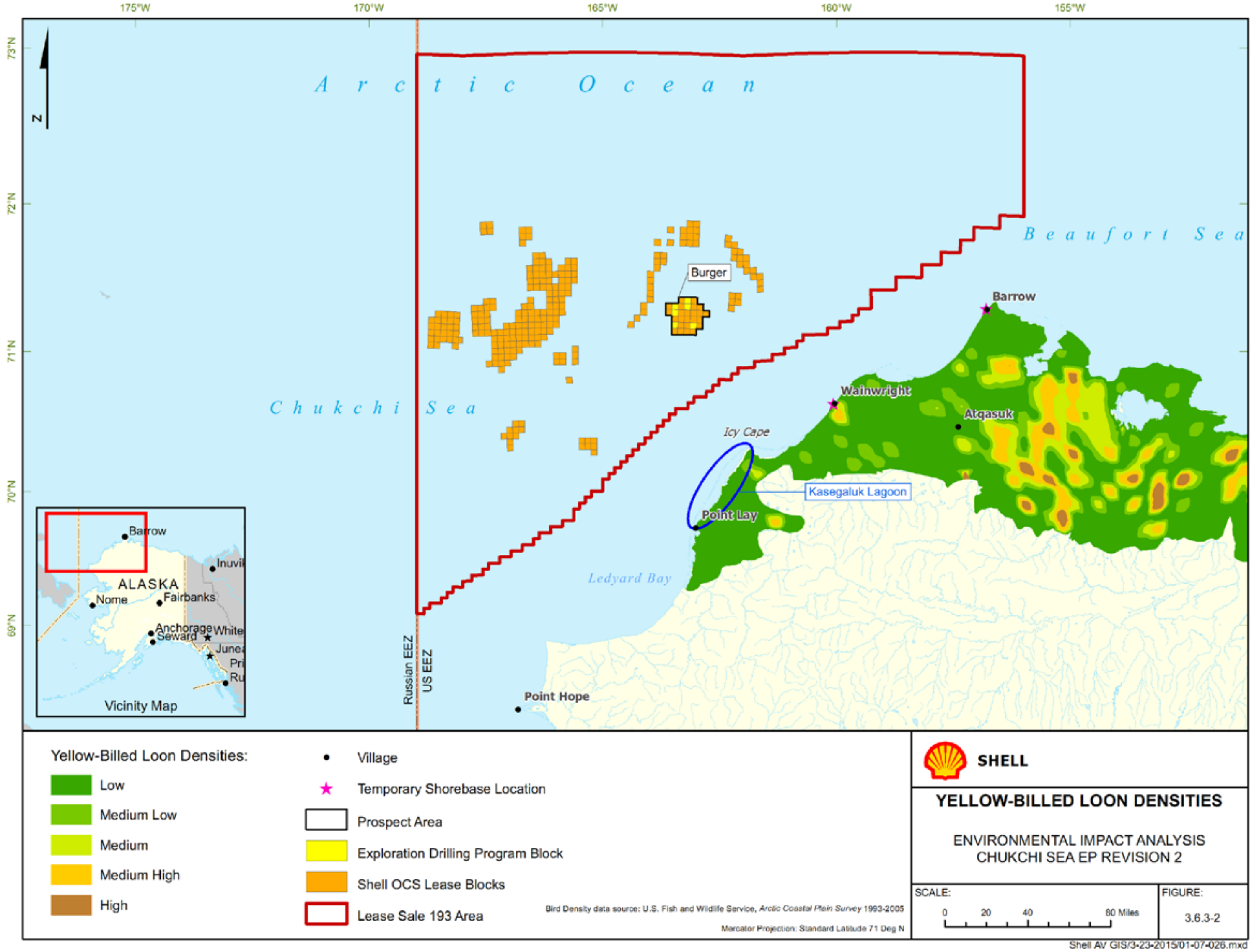
Pacific loons are commonly found nesting across the Arctic Coastal Plain. Aerial surveys on the Arctic Coastal Plain indicate that the Pacific loon population has been generally steady since 1992 (Larned et al. 2007). However, in 2007 the population index was the highest on record. Nearshore waterbird surveys have documented their common and regular occurrence along the Chukchi Sea coastline (Lysne et al. 2004; Dau and Larned 2006, 2007, 2008).

Red-throated loons tend to select small shallow wetlands, apparently due to competition with the larger and more abundant Pacific loons, and mostly within about 12 mi (20 km) off the coast (Larned et al. 2007). The density of nesting red-throated loons across the North Slope has been documented by the USFWS (Figure 3.6.3-1). These surveys indicate that the red-throated loon population has generally increased on the Arctic Coastal Plain since 1986, with a 2006 population index of 5,142 (Mallek et al. 2007). Nearshore waterbird surveys have documented their common and regular occurrence along the Chukchi Sea coastline (Lysne et al. 2004; Dau and Larned 2006, 2007, 2008).

The density of breeding yellow-billed loon varies across the Arctic Coastal Plain, with medium low densities occurring in coastal lands along the northeastern Chukchi Sea (Figure 3.6.3-1). Approximately 3,369 individuals use the breeding grounds on the North Slope, with most occurring within the NPR-A (Earnst et al. 2005). However, there are likely less than 2,000 nesting individuals on the North Slope, since not all yellow-billed loons found on the breeding grounds attempt to nest. In addition, approximately 1,500 individuals, most likely adult non-breeders and juveniles, remain at sea. In total, there are an estimated 4,892 yellow-billed loons on the North Slope breeding grounds and at sea (Earnst et al. 2005). There is no evidence of a long-term trend in the breeding population of yellow-billed loons on the Arctic Coastal Plain over the last 18 years, but this may be due to the low density in which they are found and the lack of power in statistical analysis (Earnst 2004).

Yellow-billed loons could occur in small numbers in the Burger Prospect during the planned exploration drilling program. A total of 56 yellow-billed loons were observed on transect during six years of avian surveys conducted as part of the CSESP baseline surveys, 34 were observed in the Burger Study Area (Gall et al. 2013, 2014). Almost all of these observations occurred during August to September.

Figure 3.6.3-2 Yellow-Billed Loon Densities



3.6.4 Waterfowl

The term waterfowl includes species of mergansers, ducks, geese, and swans. Species of waterfowl commonly found in marine habitats of the northeastern Chukchi Sea and adjacent coastal areas are listed in Table 3.6.4-1. The distribution and abundance of these species are summarized below. The life histories of the species most likely to be encountered in Shell's Burger Prospect during the exploration drilling season, long-tailed ducks, king eiders, and common eiders, are discussed below. Spectacled and Steller's eiders are discussed in Sections 3.8.1 and 3.8.2.

Table 3.6.4-1 Common Waterfowl Species, Northeastern Chukchi Sea and Coastal Areas

Common Name [1]	Scientific Name
Red-breasted merganser	*Mergus serrator*
Northern pintail	*Anas acuta*
Greater scaup	*Aythya marila*
Black scoter	*Melanitta nigra*
White-winged scoter	*Melanitta fusca*
Long-tailed duck	*Clangula hyemalis*
Common eider	*Somateria mollissima*
King eider	*Somateria spectabilis*
Lesser snow goose	*Chen caerulescens*
Greater white-fronted goose	*Anser albifrons*
Canada goose	*Branta Canadensis*
Pacific black brant	*Branta bernicula nigricans*
Tundra swan	*Cygnus columbianus*

[1] Spectacled and Steller's Eiders are discussed as T&E species, Section 3.8.

Distribution of Waterfowl

The worldwide and Alaska distribution of the common waterfowl species that use the waters of the northeastern Chukchi Sea are summarized below in Table 3.6.4-2.

Table 3.6.4-2 Distribution of Waterfowl Found in the NE Chukchi Sea

Common Name	Worldwide	Alaska / Northeastern Chukchi Sea
Red-breasted merganser	Resident over much of North America and Eurasia, winters in ice-free protected marine waters	Nests throughout Alaska, nests on tundra along Chukchi Sea, uses coastal waters for rearing broods, feeding, migration, winters in ice free marine waters Aleutians and south
Northern pintail	Northern North America and Eurasia, winters in Africa, Central America, and southern U.S. and Eurasia	Nests throughout Alaska, nests on tundra along Chukchi Sea, uses coastal waters for rearing broods, feeding, migration, winters in southern U.S. and Central America
Greater scaup	Holarctic, circumpolar, winters coastal waters southern U.S., Mexico, Japan, China	Nests across much of western and northern Alaska, including Chukchi Sea coastline, utilizes Chukchi Sea coastal waters for molting, staging, migration
Surf scoter	Nests in northern North America, winters in coastal waters Atlantic and Pacific	Nests mostly in boreal forest, uses coastal waters along Chukchi Sea for molting, staging, migration
Black scoter	Nests in northern Eurasia and North America, winters in coastal waters	Nests on tundra Bristol Bay to Canada, nests along Chukchi Sea coast and uses coastal waters for molting, staging, migration
White-winged scoter	Nests in northern Eurasia and North America, winters in coastal waters	Nests in forested interior, uses coastal waters along Chukchi Sea for molting, staging, migration
Long-tailed duck	Circumpolar, winter in northern marine waters. North Slope nesters winter Sea of Okhotsk/Japan.	Nest western & interior Alaska, North Slope, including northeastern Chukchi Sea coastline, uses nearshore & offshore waters molting, staging, migration, winter offshore Russian Far East
Common eider	Circumpolar, winter in northern marine waters	Nest western Alaska, North Slope, including northeastern Chukchi Sea coastline, winter in Bering Sea, Sea of Okhotsk
King eider	Circumpolar in the high arctic, winter in northern marine waters	Nests across the North Slope, uses Chukchi Sea for molting, staging, migration, winter Bering Sea, Bristol Bay, Gulf of Alaska, Sea of Okhotsk
Lesser snow goose	Breeds in northeast Siberia, northern North America, winters U.S., Japan	Nests regularly at only 2 locations, one is at Kukpowruk River delta, stages / molts along Chukchi Sea, especially Kasegaluk Lagoon
Greater white-fronted goose	Holarctic, breeds across Eurasia and North America, winters in southern U.S. / Mexico and southern Eurasia	Nests Y-K Delta, Cook Inlet, North Slope, stages / molts along Chukchi Sea.
Canada goose	Breeds northern North America, winters southern U.S.	Nests across much of Alaska, found in low numbers in Kasegaluk Lagoon, when staging
Pacific black brant	Nests in Alaska, Canada, and Siberia, winters in Baja Mexico	Nests on North Slope and Y-K Delta, up to 45% of population stages in Kasegaluk Lagoon
Tundra swan	Nests in Alaska, Canada, and northern Eurasia, winters east coast of North America	Nests on the North Slope including Chukchi Sea coast, uses Kasegaluk Lagoon and other nearshore waters for molting

Life History of Waterfowl

Telemetry studies (USGS 2008) indicate that long-tailed ducks from the North Slope winter in ice-free waters of the Sea of Japan, Sea of Okhotsk, and Kamchatka Peninsula in Asia. At least several hundred thousand migrate into or through the northeastern Chukchi Sea. Spring migration commences along the lead system in mid-May and continues through June (Roseneau and Herter 1984). They nest on the tundra near shallow water bodies across the North Slope including along the northeastern Chukchi Sea coastline (Figure 3.6.4-1). A clutch of 6 to 8 eggs takes 24 to 29 days to incubate, and the ducklings can fly within an additional 35 to 40 days (Sea Duck Joint Venture 2003). At that time they move to marine habitats where the female undergoes a molt during which she is flightless. Males and non-breeding females move to these molting areas and molt sooner. The molting, which takes place in lagoons and other shallow waters, continues through July and August, after which the birds utilize coastal waters to feed and stage for the fall migration. Known molting areas include Peard Bay, Kasegaluk Lagoon, and Ledyard Bay. Fall migration begins in early September, with few long-tailed ducks remaining in the area after mid-October

(Roseneau and Herter 1984). Fall migration is concentrated, with the birds forming large flocks. Lehnhausen and Quinlan (1981) estimated that 186,000 long-tailed ducks migrated past Icy Cape between 22 August and 20 September 1981. In the marine environment they feed primarily on invertebrates, with key food items being mysid shrimp, gammarid amphipods, isopods, and mollusks (Johnson and Richardson 1981).

King eiders that nest in Alaska winter in the Bering Sea, Bristol Bay and the Gulf of Alaska, and the Sea of Okhotsk in eastern Asia. They migrate to and through the Chukchi Sea following the spring lead system, generally reaching the northeastern Chukchi Sea by mid-May, but sometimes as early as April (Roseneau and Herter 1984). As many as a million king eiders may transit through the Chukchi at this time (Woodby and Divoky 1982). A relatively small proportion of this population remains in the northeastern Chukchi Sea or nests along the coastline (Figure 3.6.4-2). Others nest along the Beaufort Sea and on islands in high arctic Canada. They commonly nest on the tundra near lakeshores (Powell et al. 2005). Eggs (3-4 per nest) are laid mid-June to mid-August, and hatch mid-July to early August (Roseneau and Herter 1984). The males depart these nesting areas at the on-set of incubation and migrate to the molting areas; breeding females and their young move to the sea when they fledge. Primary molting areas are located along the Chukotka Peninsula in Russia (Sea Duck Joint Venture 2004a) but molting also occurs in Peard Bay, northern Kasegaluk Lagoon so there is a large westward migration in coastal waters. The molt migration occurs through the Chukchi Sea starting in early July with the males, and increasing in August with the females (Roseneau and Herter 1984). At this time king eiders are found in nearshore and offshore waters of the northeastern Chukchi Sea. Springer et al. (1982) estimated that 50,000 eiders passed Cape Lisburne each day in late July of 1980. These large scale movements continue until early October and some birds remain as long as there is open water, sometimes as late as mid-November (Bailey 1948). Divoky (1987) reported that eiders were common along the 66 ft (20 m) depth contour, where migration is concentrated, through the summer, but small numbers were observed much further offshore after 22 September. The diet of king eiders consists primarily of mollusks, gammarid amphipods, and isopods (Roseneau and Herter 1984), they obtain by diving to depths of 180 to 200 ft (55 to 60 m) or more (Suydam 2000).

Most common eiders tagged on the North Slope have been found to winter in the Bering Sea and Sea of Okhotsk along the Kamchatka Peninsula (USGS 2009). They migrate to and through the Chukchi Sea following the spring lead system, generally reaching the northeastern Chukchi Sea by mid-May, but sometimes as early as April (Roseneau and Herter 1984). A relatively small proportion of this population remains in the northeastern Chukchi Sea or nests along the coastline (Table 3.6-1); most nest along the Beaufort Sea and arctic Canada. The females typically return to their natal areas and often reuse the same nest site (Sea Duck Joint Venture 2004b). They commonly nest in dense colonies along the coast on sand spits and barrier islands in May or June. Eggs (3 to 4 per nest) are laid May or June, hatching 24 to 26 days later (Sea Duck Joint Venture 2004b). The young, which are typically reared in marine waters near the nesting sites, are fledged in 60 to 65 days. Most males and non-breeding females migrate to molting sites in coastal waters in June or July; the breeding females follow in August and September (Sea Duck Joint Venture 2004b). The birds are flightless during this 3 to 4 week molting period. Females nesting on the North Slope molt in coastal waters near the nesting colonies (Peterson and Flint 2002). After molting and staging (grouping), the eiders begin their fall migration to wintering areas. Divoky (1987) reported that eiders were common along the 66 ft (20 m) depth contour, where migration is concentrated, through the summer, but small numbers were observed much further offshore in the central northeastern Chukchi Sea after 22 September. Large scale movements of eiders along through the northeastern Chukchi Sea occur through October, with some birds remaining as late as mid-November (Bailey 1948) depending on availability of open water. The diet of common eiders consists primarily of mussels, clams, sea urchins, starfish, and crabs, which are obtained by diving. The birds typically feed in water depths of 10 to 66 ft (3 to 20 m) (Sea Duck Joint Venture 2004b).

Figure 3.6.4-1 Long-tailed Duck Densities

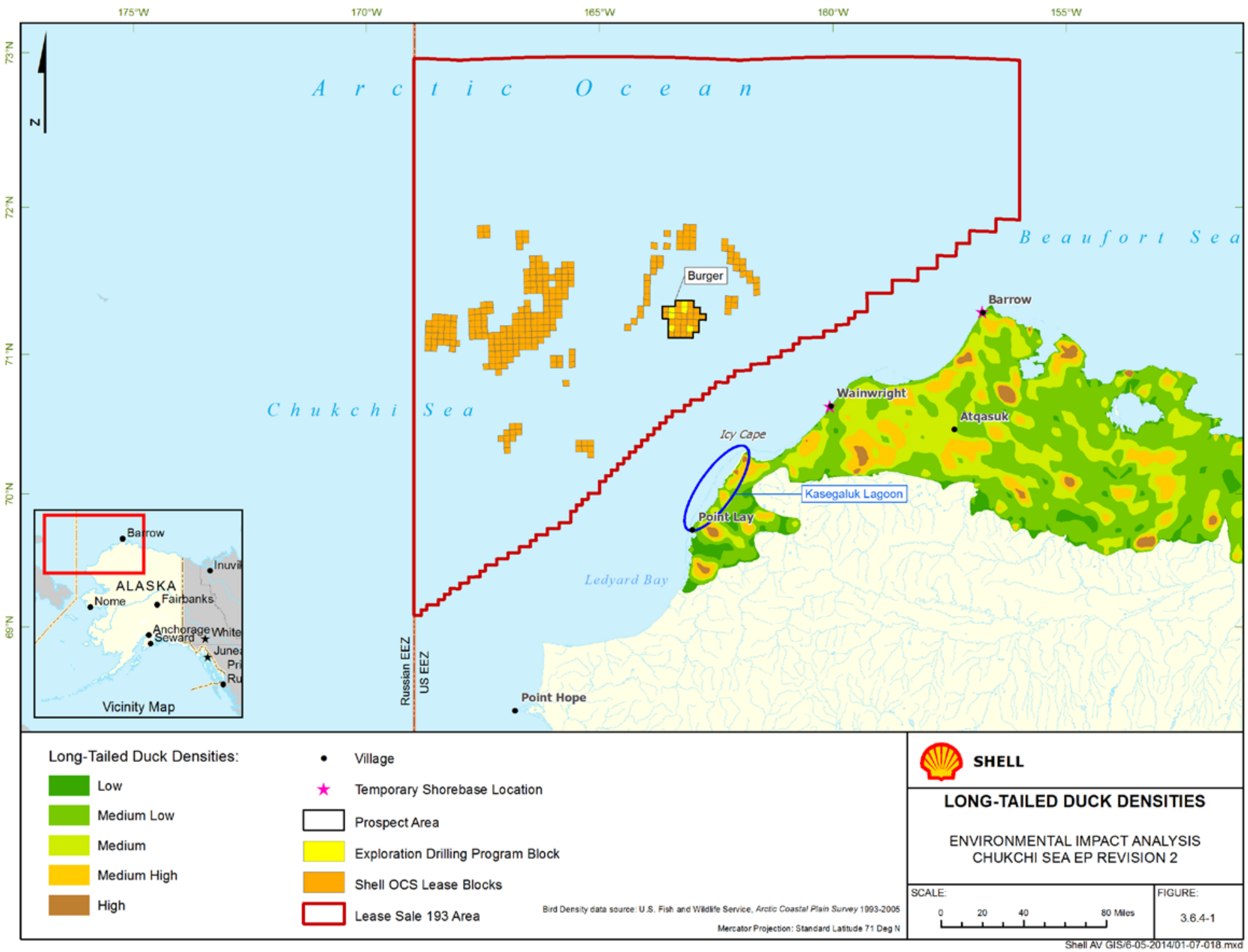
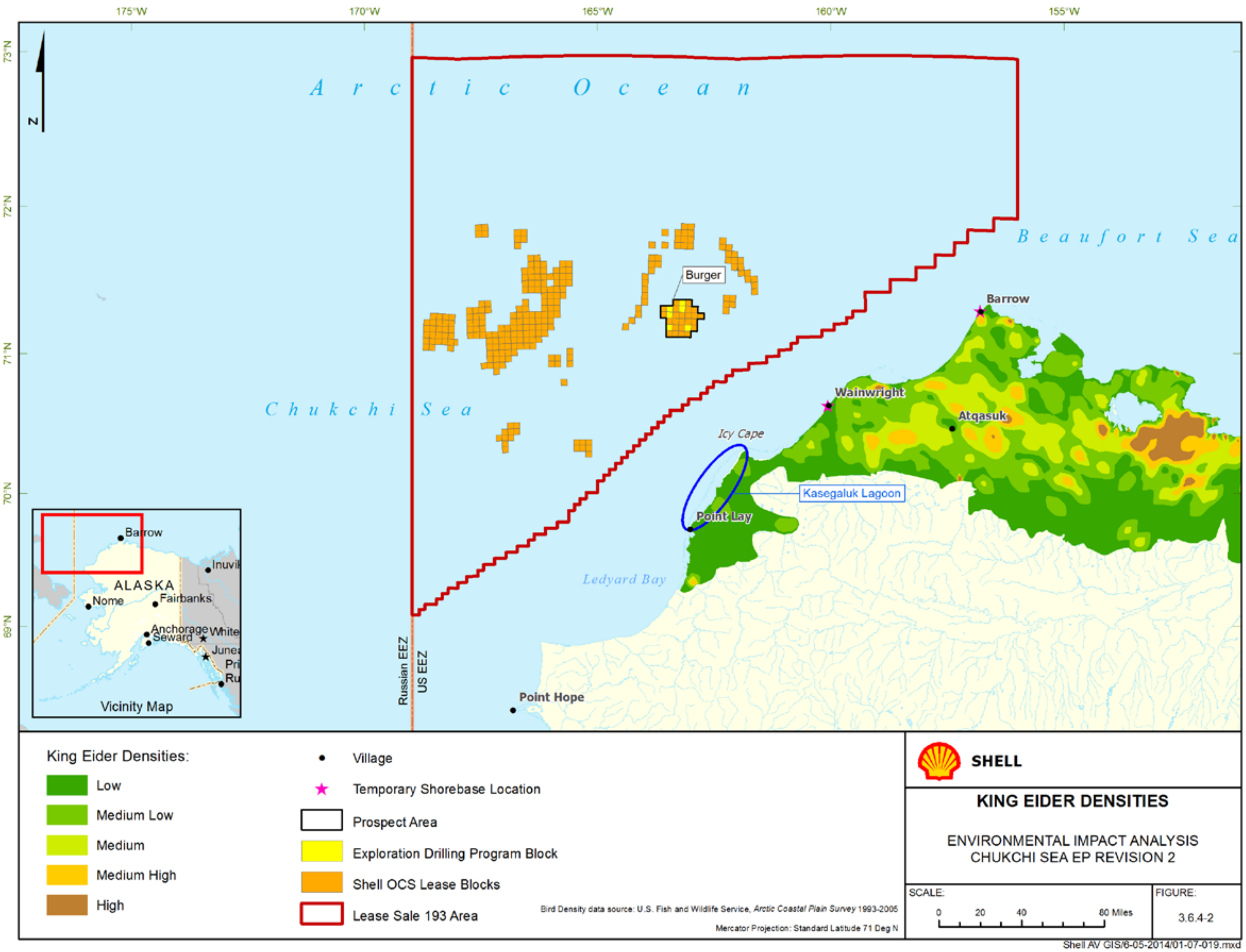


Figure 3.6.4-2 King Eider Densities



Abundance of Waterfowl

The worldwide population of long-tailed ducks is unknown. However, over one million are estimated to nest in North America, with about 200,000 in Alaska and the rest in Canada (Sea Duck Joint Venture 2003). Long-tailed ducks are one of the most abundant nesting ducks on the North Slope, second in numbers only to the pintail. Survey data indicate that the U.S. and Canadian breeding population of long-tailed ducks has declined by about 80 percent since 1957; however, the population seems to have stabilized since the 1990s (Sea Duck Joint Venture 2003). Over the past 16 years (1992 to 2007), aerial surveys of the North Slope have shown that the population of long-tailed ducks has been declining significantly (Larned et al. 2007).

Common eider production can fluctuate with ice conditions (Dau and Larned 2005) and predation rates from arctic fox (*Alopex lagopus*) and glaucous gulls (Noel et al. 2002). The common eider population declined dramatically by 53 percent from approximately 156,081 in 1976 to about 72,606 in 1996 (Suydam et al. 2000).

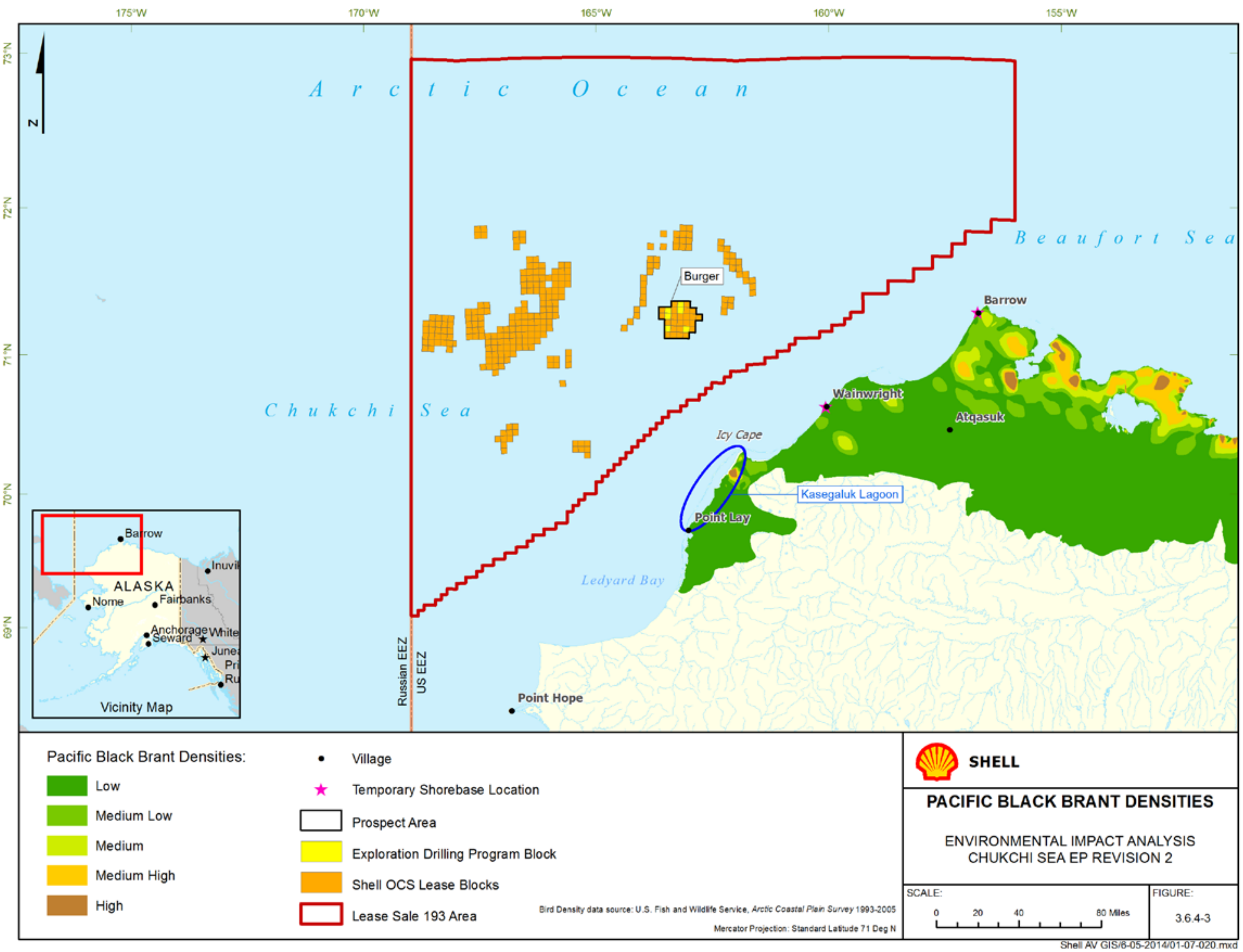
The population of king eiders has dramatically declined in recent times: from 1953 to 1976 the population appeared to be stable but declined by 56 percent from approximately 802,556 birds in 1976 to about 350,835 birds in 1996 (Suydam et al. 2000).

Pacific black brant are colonial nesters and prefer to nest in scattered locations on offshore spits and barrier islands, or on islands in river deltas away from terrestrial predators (Johnson and Herter 1989). Brant densities across the Chukchi Sea coast are surveyed annually by the USFWS (Figure 3.6.4-3). They are not known to nest in large numbers near the Chukchi Sea coastline, but use adjacent coastal wasters heavily during migration and staging, with as much as 45 percent of the entire Pacific Flyway population being found in Kasegaluk Lagoon (Johnson et al. 1993). Aerial surveys have indicated positive growth on the North Slope over the past 16 years (1992-1997) (Larned et al. 2007). However, this trend is suspect as surveys may include non-breeders or failed breeders from western Alaska.

One of the two regularly used nesting sites in the U.S. for the colonially-nesting lesser snow geese is located along the coastline of the northeast Chukchi Sea in the delta of the Kukpowruk River (MMS 2007b). They nest on the tundra and use coastal waters such as Kasegaluk Lagoon for molting and staging. Greater white-fronted geese are more common in the region and nest within 19 mi (30 km) of the coastline. As many as 4,200 white-fronted geese have been observed in Kasegaluk Lagoon.

Tundra swans are known to nest in Kasegaluk Lagoon. The North Slope population index for this species was 10,174 in 2006, which was two percent over the 20-year mean. The North Slope population has undergone a significant increase (Mallek et al. 2007).

Figure 3.6.4-3 Pacific Black Brant Densities



3.6.5 Shorebirds

Shorebird species include sandpipers, phalaropes, and allies, which are part of the Scolopacidae family. Most of the shorebird species found on the North Slope of Alaska nest on the tundra and utilize littoral or intertidal habitats along the coast for feeding and staging during migration. Only two species, the red phalarope and red-necked phalarope routinely utilize offshore waters of the northeastern Chukchi Sea, including the area of Shell's Burger Prospect. The distribution and abundance of these species are discussed below. Detailed life history information is provided for the phalaropes.

Distribution of Shorebirds

Troy (2000) listed 16 shorebird species that routinely use the North Slope and another 20 that occur as migrants, vagrants, or rare breeders (Troy 2000). A 1998-2004 North Slope-wide study (Johnson et al. 2007a) of the distribution of shorebirds documented a total of 19 species breeding in the area. Generally, shorebirds are present on the North Slope from May to mid-August. These species nest on the tundra, but many move to the Chukchi Sea coastline to use intertidal habitats for feeding and staging prior to and during migration. These shores provide productive shorebird habitat that is used for foraging and replenishing fat reserves after breeding and prior to southward migration. Information on the worldwide and Alaska distribution of shorebirds found on the Alaska North Slope is summarized below in Table 3.6.5-1.

Table 3.6.5-1 Distribution of Shorebirds that Commonly Nest on the Alaska North Slope

Common Name[1]	Worldwide Distribution[2]	Alaska Distribution[3]
Black-bellied plover	Pan-arctic breeding, winters in South America & Pacific islands	Nesting common in the Y-K Delta, uncommon on the Arctic Coastal Plain, Rare in the Southwest and Northwest
American golden plover	Nests North America, winters in South America	Nesting common in the Northwest and Arctic Coastal Plain, Uncommon in the Y-K Delta
Semipalmated plover	Nests northern Alaska and northern Canada, winters along coasts North & South America	Nesting common in the southwest, Uncommon in the Northwest and on the Arctic Coastal Plain
Whimbrel	Nests N Eurasia, north and coast Alaska & Canada, winters India, Africa, southern U.S., northern South America	Nesting uncommon in the Northwest, Rare in the Southwest, Y-K Delta, and Arctic Coastal Plain
Bar-tailed godwit	Nests northern Eurasia, western North Alaska, winters tropical Asia, Africa, Australia	Nesting common in the Y-K Delta, Uncommon in the Northwest, and rare on the Arctic Coastal Plain
Ruddy turnstone	Nests northern Eurasia, northern Alaska & Canada, winters Africa, Australia, southern U.S. South America	Nesting uncommon in the Y-K Delta, Northwest, and Arctic Coastal Plain
Sanderling	Nests northern North America, Eurasia, winters coasts to Africa, South America, Australia	Nesting uncommon on the Arctic Coastal Plain[4]
Semipalmated sandpiper	Nests northeastern Siberia, arctic North America, winters Pacific/Atlantic coasts to South America	Nesting abundant in the Y-K Delta and on the Arctic Coastal Plain, common in the Northwest
Western sandpiper	Nests in northeastern Asia and northwestern North America, winters Pacific/Atlantic coasts	Nesting Abundant in the Y-K Delta, common in the Northwest, uncommon in the Southwest, and rare on the Arctic Coastal Plain
White-rumped sandpiper	Nests in northern Alaska, Canada, winters in South America	Nesting uncommon on the Arctic Coastal Plain
Baird's sandpiper	Nests northeastern Asia and northern North America, winters in South America	Nesting uncommon on the Arctic Coastal Plain, rare in the Y-K Delta

Table 3.6.5-1 Distribution of Shorebirds that Commonly Nest on the Alaska North Slope

Common Name[1]	Worldwide Distribution[2]	Alaska Distribution[3]
Pectoral sandpiper	Nests eastern Siberia, northern Alaska and Canada, winters South America, Australia	Nesting abundant on the Arctic Coastal Plain, uncommon in the Northwest, and rare in the Y-K Delta and in the Southwest
Dunlin	Circumpolar in holarctic, winters in southern U.S, Mexico, Europe, southern Asia, northern Africa	Nesting abundant in the Y-K Delta and on the Arctic Coastal Plain, and common in the Southwest and Northwest
Stilt sandpiper	Nests from northern Alaska to Hudson Bay, winters in South America	Nesting common on the Arctic Coastal Plain
Buff-breasted sandpiper	Nests northeastern Siberia, northern Alaska and Canada, winters in southern South America, Australia	Nesting uncommon on the Arctic Coastal Plain
Long-billed dowitcher	Nests northeastern Asia, north central North America, winters western/southern U.S., Central America	Nesting uncommon in all areas in Alaska
Wilson's snipe	Nests northern North America, winters northwestern/central U.S. to northern South America	Nesting common in the Southwest, Y-K Delta, and Northwest U.S. Rare on the Arctic Coastal Plain
Red-necked phalarope	Circumpolar in holarctic, winters at sea off South America, Africa, Australia	Nesting abundant in the Y-K Delta, common in the Southwest, Northwest, and on the Arctic Coastal Plain
Red phalarope	Circumpolar in holarctic, winters at sea off South America and Africa	Nesting abundant on the Arctic Coastal Plain, common in the Y-K Delta, and uncommon in the Northwest U.S.

[1] Species list based on results of 1998-2004 surveys reported by Johnson et al. (2007a)
[2] Worldwide distribution summarized from World Bird Guide (2009)
[3] Alaska nesting distribution summarized from Bowman 2004
[4] Sanderling nesting distribution summarized from USFWS (2008a)

Life History of Shorebird

Both the red and red-necked phalaropes spend most of their life in pelagic waters off the coasts of South America and Africa. Red-necked phalaropes breed throughout Alaska, wherever there is suitable habitat. Red phalaropes nest in coastal areas of Alaska from the Y-K Delta north to the Canadian boundary. Both species nest in wet habitats along the coastline of the northeastern Chukchi Sea, but the red phalarope is the more plentiful species north of Point Lay (Roseneau and Herter 1984). Both species migrate into the area in late May and early June (Lehnhausen and Quinlan 1981). Use of shoreline habitats is light (Roseneau and Herter 1984). However, large numbers of migrating and staging phalaropes are common along the shoreline and nearshore waters during July, August and September. Divoky (1987) reported that such changes in abundance are not observed offshore where phalaropes are common throughout the summer and into October. Phalaropes gather in large concentrations in late August on lagoons. Fall and spring migration for red phalaropes occurs along routes well out at sea where flocks concentrate at ice edges and oceanic fronts and where invertebrate prey is plentiful (Johnson and Herter 1989). In the marine environment, primary food items consist of zooplankton such as euphausiids, copepods, and amphipods.

Abundance of Shorebirds

Estimates of the North American population of the common shorebird species on the North Slope are provided below in Table 3.6.5-2. The most common shorebird species breeding on the North Slope are dunlin, semipalmated sandpiper, pectoral sandpiper, and red phalarope (Alaska Shorebird Working Group 2008). Johnson et al. (2007a) conducted shorebird surveys across the North Slope; the frequency of occurrence of shorebird species in their study (Table 3.6.5-3) provides a measure of their relative abundance.

Table 3.6.5-2 Shorebird Populations Nesting Across Alaska North Slope

Common Name	North American Population [1]	Percent of Population in Alaska [1]		
		Breeding	Migration	Winter
Black-bellied plover	50,000	100	100	<5
American golden plover	200,000	25-50	25-50	0
Semipalmated plover	150,000	>25	>25	0
Whimbrel	26,000	>80	>80	0
Bar-tailed godwit	80,000-120,000	100	100	0
Ruddy turnstone	65,000	>35	35	<1
Sanderling	300,000	<10	<10	<5
Semipalmated sandpiper	2,000,000	>25	>25	0
Western sandpiper	3,500,000	>95	100	0
White-rumped sandpiper	1,120,000	<5	<5	0
Baird's sandpiper	300,000	5-15	5-15	0
Pectoral sandpiper	500,000	30-50	>70	0
Dunlin	750,000- 1,300,000	100	100	<5
Stilt sandpiper	820,000	5-10	5-10	0
Buff-breasted sandpiper	30,000	<25	<30	0
Long-billed dowitcher	400,000	>80	>90	0
Wilson's snipe	2,000,000	25-50	25-50	0
Red-necked phalarope	2,500,000	20-40	20-40	0
Red phalarope	1,250,000	60	60	0

[1] Source: Alaska Shorebird Conservation Plan (Alaska Shorebird Group 2008)

Table 3.6.5-3 Shorebird Frequency of Occurrence, Alaska North Slope 1998 to 2004

Common Name	Scientific Name	Frequency of Occurrence by Region [1,2,3]				
		Icy-Nal	Nal-Ikp	Ikp-Col	Col-Can	Can-Aic
Black-bellied plover	*Pluvialis squatarola*	20.0	44.5	22.6	22.2	1.5
American golden plover	*Pluvialis dominica*	5.0	21.8	28.1	36.1	34.8
Semipalmated plover	*Charadrius semipalmatus*	-	-	-	-	4.4
Whimbrel	*Numenius phaeopus*	-	-	-	-	1.5
Bar-tailed godwit	*Limosa lapponica*	25.0	14.9	8.7	8.3	-
Ruddy turnstone	*Arenaria interpres*	-	3.3	6.0	-	4.4
Sanderling	*Calidris alba*	-	-	-	-	0.7
Semipalmated sandpiper	*Calidris pusilla*	70.0	80.8	69.7	66.7	47.4
Western sandpiper	*Calidris mauri*	60.0	16.8	-	-	0.7
White-rumped sandpiper	*Calidris fusicollis*	-	2.4	14.2	-	0.7
Baird's sandpiper	*Calidris bairdii*	-	7.2	2.8	5.6	2.2
Pectoral sandpiper	*Calidris melanotos*	90.0	83.6	82.4	80.6	52.6
Dunlin	*Calidris alpina*	50.0	73.1	60.7	33.3	14.1
Stilt sandpiper	*Calidris himantopus*	-	23.2	13.0	27.8	15.6
Buff-breasted sandpiper	*Tryngites subruficollis*	-	11.9	5.7	19.4	8.1
Long-billed dowitcher	*Limnodromus scolopaceus*	70.0	59.2	48.4	52.8	12.6
Wilson's snipe	*Galinago delicate*	-	-	0.4	2.8	-
Red-necked phalarope	*Phalaropus lobatus*	55.0	46.2	23.9	33.3	40.7
Red phalarope	*Phalaropus fulicaria*	70.0	67.3	53.2	38.9	20.0

[1] Source: Alaska Shorebird Conservation Plan (Alaska Shorebird Group 2008)

[2] Frequency of occurrence is the percent transects with the region along which birds of that species were observed

[3] Region: Icy-Nal = Icy Cape Nalimiut Point, Nal-Ikp = Nalimiut Point to Ikpikpuk River, Ikp-Col = Ikpikpuk River to Colville River, Col-Can = Colville River to Canning River, Can-Aic = Canning River to Aichilik River

3.6.6 Bird Use of the Burger Prospect Area

Oceanographic expeditions in the Beaufort and Chukchi Seas have found gulls, kittiwakes, jaegers, and terns far from shore and among pack ice (Harwood et al. 2005). In the northernmost sighting, black-legged kittiwakes and ivory gulls were spotted 460 mi (740 km) from shore in an area of pack ice. Sightings of gulls, kittiwakes, and fulmars were numerous between 37 to 62 mi (60 to 100 km) northwest of Barrow at the Northwind Ridge area and near Barrow Canyon. Likewise, gulls and kittiwakes were often found along the Chukchi Shelf break. Waterfowl (mostly eiders) were observed 12 to 25 mi (20 to 40 km) from shore. Bird distributions were clumped, with birds tending to be found in areas where productivity was enhanced due to oceanographic features such as canyons, upwellings, and shelf breaks. The distribution of seabirds, particularly the planktivorous species were found to be strongly influenced by advective processes that transport oceanic species of zooplankton from the Bering Sea to the Chukchi Sea (Gall et al. 2013). This movement of water influences the patterns of productivity throughout the Chukchi Sea (Grebmeier et al. 2006a). In-situ primary productivity in the northern Chukchi Sea generally is not very high, whereas productivity in the Bering Shelf Water that is transported from farther south may be greater (Gall and Day 2011).

Satellite transmitters implanted in common murres and thick-billed murres at the Cape Thompson and Cape Lisburne colonies revealed distributions throughout the Chukchi Sea (Hatch et al. 2000). Birds from Cape Thompson foraged southwest to southeast and north to Point Hope, while birds from Cape Lisburne foraged northwest to northeast of the colony. Murres were found to regularly forage up to 62 mi (100 km) from their colonies. Male murres with flightless chicks appeared to drift toward Siberia with prevailing currents, further increasing their use of the Chukchi Sea to the north and west (Hatch et al. 2000). The flightless period lasts from early September through mid-November; therefore, attendant adult males with young do not leave the Chukchi Sea for the Bering Sea until early winter.

The most extensive surveys of bird use of the OCS waters in the northeastern Chukchi Sea were those reported by Divoky (1987). These surveys were conducted throughout the Chukchi Sea from mid-July through mid-October in multiple years in the 1970s and 1980s (Divoky 1987). Densities of birds observed in the central northeastern Chukchi Sea (North of Cape Lisburne or 68° 55’N latitude and south of 71° 55’N latitude), which includes the entire Lease Sale 193 Area, are provided in Table 3.6.6-2.

Loons have been found to be uncommon in the pelagic Chukchi Sea until late August (Divoky 1987). Loons were observed more regularly in nearshore waters in September when the bulk of fall migrations occur. None were observed as far offshore as Shell’s prospect.

Divoky (1987) reported that sea ducks were encountered mostly in nearshore waters. Large flocks of eiders comprised of king, common, and spectacled eiders, were encountered adjacent to the 66 ft (20 m) isobath. After 22 September, eiders were observed further offshore where small numbers were regularly encountered, but even after that date, eiders were most common nearshore. Offshore migration distances for common eiders are poorly understood in the Chukchi Sea; however, in the Beaufort Sea they are usually found within 29 mi (47 km) of shore (MMS 2007b). Long-tailed ducks were found to be uncommon in the central Chukchi Sea until late September when they were common to abundant within 29 mi (47 km) of shore (Divoky 1987). Although long-tailed ducks were sighted as early as 17 July, 93 percent of sightings of this species were made after 18 September. Long-tailed ducks may move offshore to the pelagic waters of the Chukchi Sea in late September as a result of freezing of the nearshore waters.

The majority of phalaropes were not identified by species (red and red-necked phalaropes) during vessel surveys, but the majority were assumed to be red phalaropes as red-necked phalaropes are known to be more abundant north of Point Lay (Divoky 1987). Phalaropes were found during all time periods with no obvious change in density. Phalaropes were observed throughout the central northeastern Chukchi Sea including the area of Shell’s Burger Prospect.

All three species of jaegers were found to be common in the Chukchi Sea until late September. The last documented sighting was September 29, which indicates that they are rare by October. Jaegers were well dispersed over all areas surveyed, including the area of Shell’s Burger Prospect.

Encounters with gulls varied by species and time throughout the July-October time frame of the surveys (Divoky 1987). Glaucous gulls were found to be present in all areas of the pelagic Chukchi Sea, including the area of Shell’s Burger Prospect. From late July to late September, they were most common in the eastern central Chukchi Sea from Icy Cape to Barrow within 44 mi (70 km) of shore. After late

September, densities increased in all areas, presumably due to the end of the breeding season and freezing of nearshore waters. Single ivory gulls were observed as early as July 18 and were considered rare until 22 September. They were common to abundant in areas where ice was present, including the area of Shell's Burger Prospect from late September till the end of the observations on 12 October. The lack of ice during the surveys likely had an effect on the number of ivory gull sightings. Ross's gulls were not found to be common until late September. Most were found at the ice edge although small numbers were seen well south of the ice, but they were found over most of the survey area and would be expected in the area of Shell's Burger Prospect. Black-legged kittiwakes were common throughout most of the survey area, including the area of Shell's Burger Prospect, from mid-July until late September. Densities increased from 1 to more than 2 birds/mi^2 (0.4 to > 0.8 birds/km^2), from late August to early September and decreased after as they left the Chukchi Sea. Sabine's gulls and arctic terns were rarely found in the pelagic Chukchi Sea; most observations were within 29 mi (46 km) from shore. The lack of sightings well offshore indicates that migration likely occurs landward of the 66 ft (20 m) isobath.

Alcids were commonly encountered throughout the July-October period of the survey, but densities varied by species and time throughout this period (Divoky 1987). Murres were most abundant in the southern and south central areas of the Chukchi, south of the Lease Sale 193 Area. Sightings decreased after 20 August. Murres began to depart the Chukchi Sea as early as late August. Black guillemots were regularly found in low densities in the central and northern Chukchi Sea when ice was present. Both murres and black guillemots were common in offshore areas, including the area of Shell's Burger Prospect, during July and August. Parakeet auklets were found to be uncommon in the Chukchi Sea until late August when they became common in the southern Chukchi Sea. By late September, they were again uncommon. Small numbers of least auklets were found in the central Chukchi Sea after late September and few were found after 1 October. Crested auklets move from the Bering Sea into the central Chukchi Sea in late August and early September; they were regularly encountered from 27 August into the first half of October. However, crested auklets were encountered in patches, likely reflecting the availability of zooplankton. Least and crested auklets were observed in the area of Shell's Burger Prospect. Small numbers of tufted puffins were found in the central and southern Chukchi Sea. They were only regularly found in the southern Chukchi Sea. Few horned puffins were found in the central Chukchi Sea in August and numbers increased in September after the breeding season. Most horned puffins found in the central Chukchi Sea were observed near the Cape Lisburne area. Puffins were not observed in the area of Shell's Burger Prospect.

Northern fulmars do not breed in the Chukchi Sea, but non-breeders or failed breeders have been found in pelagic waters (Divoky 1987). Although present in the central Chukchi Sea before late August, northern fulmars become more common from late August to mid-September and absent after late September. Shearwaters were found to be common to abundant in the Chukchi Sea during periods of maximum ice retreat from late August to late September and their distribution can be expected to follow zooplankton prey abundance. Both the northern fulmar and shearwater were observed in the area of Shell's Burger Prospect.

Based on the available literature, northern fulmars, short-tailed shearwaters, red and red-necked phalaropes, glaucous, ivory, and Ross's gulls, kittiwakes, pomarine, parasitic, and long-tailed jaegers, common and thick-billed murres, black guillemots, and least and crested auklets would be expected to occur in the vicinity of the Shell's prospect during the July-October time frame when Shell's exploration drilling would take place. These groups of species are often found foraging in the pelagic Chukchi Sea. Loons and sea ducks might occasionally be found within the lease area, but most are found in nearshore waters where depths are shallower for foraging. Overall, bird use (densities) of the offshore waters in the Lease Sale 193 Area is lower than in the nearshore waters where high bird densities have been observed.

Bird surveys were conducted annually during six open-water seasons in 2008-2013 along transects within four study areas in the northeastern Chukchi Sea as part of the CSESP. The final report for data collected in 2013 was not yet available at the time of this analysis. Similar studies were also conducted 2014 in a reduced survey encompassing the Burger prospect and shoreward locations. The Burger Study Area (Figure 3.0-1) is a 30 x 30 nmi (55 x 55 km) area surrounding Shell's Burger Prospect. Data was collected during three time periods each year: late summer (July-August), early fall (August-September), and late fall (September-October). Over 34 species were observed during the study (Table 3.6.6-1): 31 species were recorded in 2008, 23 species in 2009, 29 in 2010 and 30 in 2011, and 23 species in 2013. Bird species observed during these surveys in the Burger Prospect study area are listed below in Table 3.6.6-1. Marine bird density in the study area was significantly greater in 2009 than in 2008 or 2010 (Table 3.6.6-2).

The abundance of birds in the CSESP study areas was found to vary greatly across the years (Table 3.6.6-4). Total abundance of seabirds within the individual study areas varied by more than 2 orders of magnitude during the six years of the study (Gall et al. 2014) Seabirds were most abundant in the Burger Study Area in 2009 and 2012 and least abundant in 2008 and 2013; abundance was similar in 2010 and 2011, but generally lower than that in 2009 and higher than in 2008 and 2013 (Gall et al. 2014). Abundance also varied across season, but with no consistent pattern over the five survey years. The crested auklet was the most abundant bird during each of the six survey years (Gall et al. 2014). The investigators (Gall et al. 2013) reported the western portion of the Greater Hanna Shoal Study Area (Figure 3.0-1) including the Klondike Study Area appears to be a more pelagically-dominated system with a greater abundance of diving alcids and short-tailed shearwaters and higher biomass of copepods (in 2008–2010), while the northeastern half of Greater Hanna Shoal Study Area, including the Burger Study Area, appears to be a benthically-dominated system with a greater abundance of surface-feeding larids and higher abundance, biomass, and number of benthic taxa than seen to the south and west (Gall et al. 2013).

Gall and Day (2012, 2013) compared the CSESP bird survey data from 2008-2010 was compared to historical data from the same area collected in 1975–1981 (Gall and Day 2012; Gall et al. 2013). Eight of the 10 most abundant species were shared between the two data sets. However, eight species recorded during the 2008-2011 surveys (king eider, common eider, white-winged scoter, red-throated loon, yellow-billed loon, red-necked phalarope, and pigeon guillemot) were not recorded on the historical surveys. The greater species richness recorded in the recent surveys is likely due to more intensive nature of the recent surveys (Gall and Day 2012). Total seabird abundance was found to have declined over this time period (37 years), with the abundance of omnivorous and piscivorous species declining and the abundance of planktivorous species generally increasing (Gall et al. 2013).

Table 3.6.6-1 Bird Species Observed in the Burger Study Area CSESP Surveys 2008-2013

Species	Year/Season Observed[1]		
	August	**September**	**September-October**
Waterfowl			
Spectacled eider	-	2009	2010
King eider	-	2008, 2010, 2012	2008, 2010
Common eider	2012	2008	2010
White-winged Scoter	-	-	2008, 2010
Long-tailed Duck	-	2008, 2009, 2010, 2012, 2013	2008, 2010
Loons			
Red-throated Loon	-	2008, 2011	-
Pacific loon	-	2008, 2009, 2010, 2011, 2012, 2013	2008, 2009, 2010
Yellow-billed Loon	-	2008, 2009, 2010, 2011	2009
Tubenoses			
Northern fulmar	2008, 2009, 2010, 2011, 2012	2008, 2009, 2010, 2012, 2013	2008, 2009, 2010
Short-tailed Shearwater	2009, 2010, 2011, 2012, 2013	2008, 2009, 2010, 2011, 2012, 2013	2008, 2009, 2010
Phalaropes			

Table 3.6.6-1 Bird Species Observed in the Burger Study Area CSESP Surveys 2008-2013

Species	Year/Season Observed[1]		
	August	September	September-October
Red phalarope	2009, 2010, 2011, 2012, 2013	2008, 2009, 2010, 2012, 2013	2009, 2010
Red-necked Phalarope	2009, 2010, 2011, 2012	2008, 2009, 2010, 2011, 2013	2009
Larids			
Black-legged Kittiwake	2008, 2009, 2010, 2011, 2012, 2013	2008, 2009, 2010, 2011, 2012, 2013	2008, 2009, 2010
Ivory gull	-	2012	2008
Sabine's gull	2008, 2009, 2010, 2011, 2012, 2013	2008, 2010, 2012, 2013	2009
Ross's gull	-	2009, 2011, 2013	2008, 2009, 2010
Herring gull	2009	2009, 2010	2008
Glaucous gull	2008, 2009, 2010, 2011, 2013	2008, 2009, 2010, 2011, 2012, 2013	2008, 2009, 2010
Arctic tern	2009, 2010, 2012	2008, 2009	-
Pomarine jaeger	2008, 2009, 2010, 2011, 2013	2008, 2009, 2010, 2011, 2012	-
Long-tailed Jaeger	2009	2008, 2010	-
Parasitic jaeger	2008, 2012, 2013	2010	-
Alcids			
Dovekie	-	-	2008, 2010
Common murre	2011, 2012	2009, 2010, 2011, 2012, 2013	2009
Thick-billed Murre	2008, 2009, 2010, 2011, 2013	2009, 2010, 2011, 2012, 2013	2008, 2009, 2010
Black guillemot	2008, 2010, 2011	2012	2008, 2010
Pigeon Guillemot	2008	-	-
Kittlitz's Murrelet	-	2010, 2011, 2012	2009
Parakeet Auklet	-	2010, 2012, 2013	2008, 2010
Least Auklet	2009, 2010, 2011, 2012, 2013	2008, 2009, 2010, 2011, 2012, 2013	2008, 2009, 2010
Crested Auklet	2009, 2010, 2011, 2013	2008, 2009, 2010,2011, 2012, 2013	2008, 2009, 2010
Ancient Murrelet	2013	2010, 2011, 2012, 2013	2010
Horned Puffin	2008, 2009, 2010, 2012	2010	-
Tufted Puffin	2012	2010	-

[1] Source: Gall et al. 2013, includes on-transect and off-transect observations within the study area

Table 3.6.6-2 Densities of the Common Birds in the CSESP Burger Study Area

Species	Year	Season Observed [1,2,3]					
		August		September		September-October	
		birds/km^2	birds/mi^2	birds/km^2	birds/mi^2	birds/km^2	birds/mi^2
Phalaropes	2008	0.00	0.00	0.71	1.84	0.00	0.00
	2009	3.01	7.80	1.44	3.73	0.10	0.26
	2010	0.05	0.13	0.66	1.71	0.03	0.08
	2011	0.54	1.40	0.29	0.75	NS	NS
	2012	0.83	2.15	0.03	0.08	NS	NS
	2013	1.12	2.90	1.27	3.29	NS	NS
Northern Fulmar	2008	0.04	0.10	0.04	0.10	0.06	0.16
	2009	1.04	2.69	0.20	0.52	0.15	0.39
	2010	0.16	0.41	0.05	0.13	0.01	0.03
	2011	0.21	0.54	0.00	0.00	NS	NS
	2012	0.47	1.22	0.05	0.13	NS	NS
	2013	0.00	0.00	0.10	0.26	NS	NS
Shearwaters	2008	0.00	0.00	1.36	3.52	0.29	0.75
	2009	1.45	3.76	1.63	4.22	0.29	0.75
	2010	0.03	0.08	1.63	4.22	0.02	0.05

Table 3.6.6-2 Densities of the Common Birds in the CSESP Burger Study Area

Species	Year	Season Observed [1,2,3]					
		August		September		September-October	
		birds/km^2	birds/mi^2	birds/km^2	birds/mi^2	birds/km^2	birds/mi^2
	2011	1.64	4.25	1.82	4.71	NS	NS
	2012	2.73	7.07	0.60	1.55	NS	NS
	2013	0.03	0.08	0.15	0.39	NS	NS
Black-legged Kittiwake	2008	0.09	0.23	0.63	1.63	0.10	0.26
	2009	0.13	0.34	1.66	4.30	0.15	0.39
	2010	0.10	0.26	0.27	0.70	0.00	0.00
	2011	0.05	0.13	1.15	2.98	NS	NS
	2012	0.09	0.23	0.52	1.35	NS	NS
	2013	0.62	1.76	0.16	0.42	NS	NS
Glaucous Gull	2008	0.04	0.10	0.16	0.41	0.12	0.31
	2009	0.06	0.16	0.39	1.01	0.37	0.96
	2010	0.04	0.10	0.06	0.16	0.07	0.18
	2011	0.01	0.03	0.10	0.26	NS	NS
	2012	0.00	0.00	0.33	0.85	NS	NS
	2013	0.05	0.13	0.31	0.80	NS	NS
Thick-billed Murre	2008	0.02	0.05	0.16	0.41	0.01	0.03
	2009	0.12	0.31	0.11	0.28	0.09	0.23
	2010	0.15	0.39	0.05	0.13	0.01	0.03
	2011	0.30	0.78	0.21	0.54	NS	NS
	2012	0.09	0.23	0.52	1.35	NS	NS
	2013	0.01	0.03	0.02	0.05	NS	NS
Least Auklet	2008	0.00	0.00	0.01	0.03	0.03	0.08
	2009	1.66	4.30	0.83	2.15	0.34	0.88
	2010	0.24	0.62	1.88	4.87	0.50	1.29
	2011	0.00	0.00	0.13	0.34	NS	NS
	2012	2.05	5.31	1.01	2.62	NS	NS
	2013	0.11	0.28	0.19	0.49	NS	NS
Crested Auklet	2008	0.00	0.00	0.01	0.03	0.17	0.44
	2009	30.16	78.11	26.57	68.82	0.13	0.34
	2010	4.66	12.07	3.74	9.69	5.16	13.36
	2011	1.73	4.48	9.48	24.55	NS	NS
	2012	24.83	64.31	3.46	8.96	NS	NS
	2013	0.49	1.27	2.12	5.49	NS	NS

[1] Source: Gall et al. 2013, 2014

[2] Densities observed in the CSESP Burger Study Area, which encompasses Shell's Burger Prospect

[3] NS = no survey, ND = no data provided in cited report

Table 3.6.6-3 Species Composition of Seabirds in the CSESP Burger Study Area[1,2]

Bird Species Group	Percent of Observed Birds											
	Jul-Aug				Aug-Sep				Sep-Oct			
	2008	2009	2010	2011	2008	2009	2010	2011	2008	2009	2010	2011
Waterfowl	0	0	5	0	14	1	1	0	2	1	8	0
Loons	0	0	0	0	7	4	1	12	1	<1	0	0
Tubenoses	15	7	28	66	38	6	36	38	19	25	3	0
Phalaropes	0	5	4	15	11	3	8	4	0	3	2	0
Larids	65	1	18	3	30	5	6	27	51	40	18	0
Alcids	20	87	45	16	0	82	48	19	28	30	69	0
All	100	100	100	100	100	100	100	100	100	100	100	0

[1] Source: Gall and Day 2009, 2010, 2011, 2012

[2] Similar data was not presented in Gall et al. 2013,2014

Table 3.6.6-4 Abundance of Marine Birds in the CSESP Burger Study Area[1]

Season	Estimate of Total Bird Abundance in CSESP Burger Study Area (birds/study area)					
	2008	2009	2010	2011 [2]	2012 [2]	2013[2]
August	800	116,800	17,300	14,000	98,900	7,700
September	11,500	106,600	26,800	45,000	24,400	14,000
September/October	7,000	7,400	19,400	--	--	--

[1] Source: Gall et al. 2013,2014

[2] Surveys not conducted in September/October

3.6.7 Important Coastal Avian Habitats in the Chukchi Sea

Some areas along the Chukchi Sea coast are particularly important habitat for a number of species. These include nesting colony sites and locations where large numbers of birds congregate for staging, foraging, or molting, as well as migration routes. Distances between Shell's Burger Prospect and known coastal nesting colonies are shown in Table 3.6.7-1.

Kasegaluk Lagoon contains important avian habitats. The richness and diversity of birds in the Kasegaluk Lagoon system are distinctly greater than in other arctic Alaska lagoons (Johnson et al. 1992). Pacific black brant was the most abundant species of bird recorded during aerial surveys of the Kasegaluk Lagoon by Johnson et al. (1992). Large quantities of green algae are believed to have attracted brant to feed in the area. Shorebirds also extensively use lagoons such as Kasegaluk Lagoon during fall migration (Alaska Shorebird Working Group 2008).

In the Chukchi Sea, common eiders molt in areas near Point Lay, Icy Cape, and Cape Lisburne (Johnson and Herter 1989). Peard Bay may be particularly important to molting common eiders (Kinney 1985). After molting, most common eiders stay close to shore, but some move offshore into pelagic waters (Divoky 1987). Most males move out of the Chukchi Sea by late August and early September, and most females move out by late October or early November. Most common eiders winter near the Bering Sea pack ice or near the Aleutian Islands, but some remain within open leads in the Chukchi Sea until early winter (Johnson and Herter 1989).

Other species of sea ducks also use the Chukchi Sea extensively, particularly close to shore. King eiders have been found close to shore two weeks prior to and during wing molt, suggesting that the sea is an important migration flyway and staging area (Phillips 2005; Powell et al. 2005). By late June, flocks of long-tailed ducks begin to move westward to protected coastal areas such as lagoons, leeward beaches within barrier islands, and large lakes where they gather to form massive molting flocks (Johnson and Herter 1989). While molting, they take advantage of abundant supplies of invertebrate foods (Johnson and Herter 1989). In spring, loons migrate along the coast and use inland routes (Johnson and Herter 1989). However, in the fall, loons migrate along the coast and then out to sea once they reach the Lisburne Peninsula (Divoky 1987). Shorebirds extensively use the shorelines, particularly during fall migration (Johnson and Herter 1989). Kasegaluk Lagoon and Peard Bay have been identified as two of the most important shorebird sites in the U.S. (Brown et al. 2001b).

Table 3.6.7-1 Distances from Drill Sites to Important Avian Habitats along the Chukchi Sea

Prospect [1]	Ledyard Bay LBCHU	Kasegaluk Lagoon SA[2]	Peard Bay SA	Alaska Maritime NWR	HSWUA	Cape Lisburne Bird Colony
Burger	58 mi (93 km)	65 mi (104 km)	86 mi (138 km)	65 mi (104 km)	7 mi (12 km)	172 mi (277 km)

[1] Distance from sensitive area per Figure 3.9-1 to nearest drill site within the Burger Prospect

[2] SA = Sensitive Area

3.7 Mammals

This section discusses both marine mammals that could be present in the Chukchi Sea near the project area, and terrestrial mammals using the Chukchi coastal areas during Shell's exploration drilling activities. Marine mammals found in the Chukchi Sea are listed below in Table 3.7-1. The most common marine mammals in the Lease Sale 193 Area are Pacific walruses, ringed seals, spotted seals, bearded seals, polar bears, bowhead whales, gray whales, beluga whales, and harbor porpoises. Small numbers of narwhals, killer whales, minke whales, fin whales, humpback whales, and ribbon seals may be present in the Lease Sale 193 Area but not necessarily in the vicinity of the planned exploration drilling operations. All marine mammals are federally protected species under the MMPA. There are no state-listed marine mammal species of special concern within the Lease Sale 193 Area. Discussions of the bowhead whale, humpback whale, fin whale, ringed seal, bearded seal, and polar bear are presented in Section 3.8 as they are T&E species. The Pacific walrus is also discussed in Section 3.8 as a candidate species; listing of the Pacific walrus was determined to be warranted but precluded by higher priorities. Because Steller sea lions and North Pacific right whales do not occur in or near the Burger Prospect or project area, Shell does not include a discussion of these mammals in Section 3.8.

Table 3.7-1 Marine Mammal Species Present in the Northeastern Chukchi Sea

Common Name	Scientific Name	ESA Status	MMPA Stock Status	Extralimital (Yes/No)
Ringed seal	*Phoca hispida*	Threatened	depleted	No
Spotted seal	*Phoca largha*	Not listed	Not depleted	No
Ribbon seal	*Phoca fasciata*	Not listed	Not depleted	No
Bearded seal	*Erignathus barbatus*	Candidate	Not depleted	No
Pacific walrus	*Odobenus rosmarus divergens*	Candidate	Not depleted	No
Polar bear	*Ursus maritimus*	Threatened	Depleted	No
Bowhead whale	*Balaena mysticetus*	Endangered	Depleted	No
Gray whale	*Eshchrichtius robustus*	Not Listed	Not depleted	No
Fin whale	*Balaenoptera physalus*	Endangered	Depleted	Yes
Minke whale	*Balaenoptera acutorostrata*	Not listed	Not depleted	No
Humpback whale	*Megaptera novaengliae*	Endangered	Depleted	Yes
Killer whale	*Orcinus orca*	Not listed	Not depleted	Yes
Harbor porpoise	*Phocoena phocoena*	Not listed	Not depleted	No
Beluga whale	*Delphinapterus leucas*	Not listed	Not depleted	No
Narwhal	*Monodon monoceros*	Not listed	Not depleted	Yes

The presence and abundance of each species of marine mammals within the Lease Sale 193 Area depend upon environmental factors such as water depth, time of year, prey density and availability, and the local presence of sea ice. Depth preference varies between marine mammal species. The presence of ice in the prospect areas has varied greatly in past years, and the prevalence of ice in the prospect during Shell's planned exploration drilling program will have bearing on the number of ice-associated marine mammals (e.g., polar bears, walruses, ringed seals, spotted seals, bearded seals) present in the vicinity or near the operations.

BOEM conducted the Bowhead Whale Aerial Survey Project (BWASP) and Chukchi Offshore Monitoring in Drilling Area (COMIDA) aerial surveys between 1987 and 2007 to investigate the use of the Chukchi Sea by bowhead whales during fall migration (Clarke and Ferguson, 2010; Clarke et al. 2011). Starting in 2007, the surveys were supported by BOEM but conducted by NMFS. These surveys have are now referred to as the Aerial Surveys of Arctic Marine Mammals (ASAMM) project (Clarke et al. 2012). While the survey programs have been focused on the bowhead whale, distribution data is collected on all observed marine mammals. Data from these surveys thru 2012 are available via a NMFS web portal (http://www.afsc.noaa.gov/NMML/software/bwasp-comida.php) and are utilized in the following discussions of the distribution of marine mammals in the Lease Sale 193 Area. Variation in survey effort across the Chukchi Sea should be taken into consideration when interpreting figures created using BWASP/COMIDA/ASAMM data; equal levels of survey effort were not given to all areas in the Chukchi Sea. Coastal areas between Wainwright and Barrow were surveyed more than water further from the coast in the Lease Sale 193 Area.

Shell and other industry participants have also supported aerial surveys in the nearshore waters of the Chukchi Sea. Surveys were flown once to twice weekly in a sawtooth pattern from shore out to a distance of 23 mi (37 km) along the Chukchi Sea coastline from Barrow to Point Hope from July through October in 2006, 2007, 2008, 2010, and 2012 (Funk et. al. 2011b; Bisson et al. 2013). In 2012, Shell supported an offshore aerial survey effort over the Burger Prospect utilizing high definition cameras (Bisson et al. 2013).

Marine mammal monitoring programs were conducted during past exploration drilling efforts in the same general area as the Burger Prospect, and monitoring studies or more recent seismic surveys over much of the northeastern Chukchi Sea. Marine mammals observed in the area from vessels and aircraft during the drilling of the historic Burger, Crackerjack, Popcorn, and Klondike exploration wells in 1989 and 1990 are summarized in Table 3.7-2.

Table 3.7-2 Marine Mammals Observed during Historic Drilling in the Chukchi Sea

Marine Mammal	Klondike [1,2,3]		Burger [1,2,3]	Popcorn [1,2,3]		Crackerjack [1,2,3]		Diamond [1,2,3]
	1989	1989	1990	1989	1990	1990	1991	1991
Pacific walrus	4,858	19	534	85	33	22	14,593	34,097
Bearded seal	1	2	11	0	12	4	85	57
Ringed seal	0	0	8	1	22	8	402	141
Spotted seal	43	6	3	0	1	0	0	0
Bowhead whale	0	0	0	0	0	0	0	9
Gray whale	6	0	0	0	0	0	4	16
Beluga whale	1	0	0	0	0	0	2	24
Minke whale	0	0	0	0	1	0	0	0
Polar bear	2	0	6	14	1	0	36	33
Unid pinniped	31	26	8	0	6	0	160	120
Unid cetacean	3	4	0	0	1	0	0	4
Total	4,945	57	570	100	77	34	15,285	34,501

[1]Prospects were defined in 1989 as the aerial survey grid, and in 1990-1991 as the area within 11.5 miles of the drill site.
[2] Brueggeman et al. 1990, 1991a, 1991b, 1992a, 1992b
[3] Number of individuals observed from vessels and aircraft

Since 2007, Shell has used acoustic recorders (ocean bottom hydrophones [OBHs]) to conduct a large-scale underwater acoustic monitoring program (Funk et al. 2011b; Delarue et al. 2012a; Bisson et al. 2013). The ongoing study has provided information on the characteristics of sounds produced by exploration operations of various types, at various locations within the Chukchi Sea, and marine mammal vocalization detections to examine the spatial and temporal distributions of marine mammal paths in the Chukchi Sea. The study was also designed to help understand the impacts of in-water sounds from oil and gas exploration on marine mammal behavior. The systems suffered failures in 2007 and 2008 that resulted in partial data sets being collected during each of these two seasons, but in October 2008 the recorders were redeployed over the winter to collect additional data. Complete data sets have been successfully collected since 2009.

Marine mammal observations from monitoring efforts associated with seismic surveys, development surveys and exploratory drilling activities in July-October, 2006-2010, and 2012, in the Lease Sale 193 Area and near Shell's Burger Prospect are summarized in Table 3.7-3. Marine mammals observed during the monitoring of 3D seismic surveys conducted for Statoil in a large area just north of the Burger Prospect, and a 2D survey partly within the Burger Prospect, are indicated in Table 3.7-4. Marine mammals observed during the monitoring of geophysical site surveys and geotechnical soil investigations conducted for Statoil in an area north of the Burger Prospect, are indicated in Table 3.7-5.

Vessel-based marine mammal surveys were conducted along transects during the CSESP in survey areas encompassing the Burger Prospect and ConocoPhillips Klondike Prospect in July-October 2008 and 2009 (Brueggeman 2009a, 2010). The study area was expanded to included Statoil's prospect in 2010 and the Greater Hanna Shoal Study Area in 2011-2013 (Aerts et al. 2012, 2013, 2014). Results of these surveys are summarized in Table 3.7-6 and 3.7-7. Sea ice most likely influenced the differences in numbers of seals and walruses in the prospects (Brueggeman 2009a). A similar survey was conducted in 2014 in a survey area encompassing the Burger prospect and shoreward locations; however final peer reviewed data was not available at the time this analysis was prepared.

Table 3.7-3 Marine Mammals Observed from Seismic & Drilling Support Vessels, Chukchi Sea 2006-2012

Species	Marine Mammal Sightings (Individuals) [1,2,3]							
	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**Total**
Ringed seal	718 (807)	117 (132)	228 (248)	38 (40)	69 (72)	20 (20)	79 (85)	1,269 (1,404)
Spotted seal	189 (228)	28 (44)	51 (57)	2 (2)	18 (24)	1 (1)	68 (79)	357 (435)
Bearded seal	265 (306)	56 (73)	124 (142)	17 (17)	178 (184)	59 (61)	149 (162)	848 (945)
Ribbon Seal	2 (2)	1 (1)	1 (1)	0	3 (5)	0	0	7 (9)
Pacific walrus	187 (1,275)	490 (3,421)	105 (791)	70 (131)	513 (1,572)	81 (147)	338 (8,678)	1,784 (16,015)
Harbor porpoise	22 (38)	11 (28)	18 (30)	3 (10)	5 (13)	0	1 (6)	60 (125)
Dall's porpoise	0	0	1 (5)	0	0	0	1 (4)	2 (9)
Killer whale	2 (7)	1 (1)	2 (2)	0	1 (2)	0	2 (5)	8 (17)
Beluga	4 (42)	0	1 (2)	0	0	1 (2)	1 (2)	7 (48)
Bowhead whale	27 (50)	7 (10)	18 (60)	1(2)	19 (27)	0	117 (319)	189 (468)
Fin Whale	0	0	3 (6)	0	0	0	1 (1)	4 (7)
Gray whale	36 (91)	39 (75)	103 (226)	3 (3)	33 (103)	128 (256)	128 (256)	350 (787)
Humpback whale	0	4 (6)	2 (4)	0	1 (1)	0	2 (6)	9 (17)
Minke whale	8 (8)	5 (6)	26 (34)	0	9 (11)	0	10 (12)	58 (71)

[1] Source: Funk et al. 2011b for 2006-2010, 2011 data from Hartin et al. 2011, 2012 data from Bisson et al. 2013
[2] The number of times marine mammals of that taxon were observed (the total number of individuals of that taxon summed across all sightings) by the PSOs on seismic vessels, drilling units, and support vessels during industry surveys in the open water season
[3] Some values have changed since EIA for EP Revision 1 due to different cited sources or inclusion of mammals on ice

Table 3.7-4 Marine Mammals Observed during Statoil's 2010 Seismic Surveys, Chukchi Sea

Species	Marine Mammal Sightings (Individuals) [1,2]		
	Seismic Vessel [3]	**Monitoring Vessel [4]**	**Total**
Ringed seal	17 (18)	16 (17)	33 (35)
Spotted seal	1 (1)	4 (4)	5 (5)
Bearded seal	53 (56)	69 (72)	122 (128)
Ribbon Seal	0	1 (1)	1 (1)
Unidentified seal	57 (63)	97 (98)	154 (161)
Pacific walrus	--	--	346 (1,042)
Bowhead whale	0	5 (6)	5 (6)
Gray whale	1 (1)	4 (9)	5 (10)
Minke whale	4 (5)	0	4 (5)

[1] Source: Blees et al. 2010
[2] The number of times marine mammals of that taxon observed by PSOs (total number of individuals in those sightings) while monitoring Statoil 2D and 3D seismic surveys 20 August - 1 October 2010
[3] Observations recorded by PSOs on the seismic vessel Geo Celtic along 6,510 mi (10,477 km) of survey lines over 1,223 hr
[4] Observations recorded by PSOs on the monitoring vessels Norseman I along 5,748 mi (9,250 km) over 784 hr and Tanux I along 5,190 mi (8,535 km) of survey lines over 734 hr

Table 3.7-5 Marine Mammals Observed in Statoil Geophysical / Geotechnical Surveys, Chukchi Sea

Species	Marine Mammal Sightings (Individuals) [1,2]		
	Geophysical Vessel [3]	Geotechnical Vessel [4]	Total
Ringed seal	18 (18)	2 (2)	20 (20)
Spotted seal	1 (1)	0	1 (1)
Bearded seal	59 (61)	0	59 (61)
Ribbon Seal	0	0	0
Unidentified seal/pinniped	33 (33)	10 (10)	43 (43)
Pacific walrus	61 (98)	20 (49)	81 (147)
Bowhead whale	0	0	0
Gray whale	6 (29)	2 (4)	8 (33)
Minke whale	0	0	0
Unidentified whale	5 (6)	3 (4)	8 (10)

[1] Source: Hartin et al. 2011

[2] The number of times marine mammals of that taxon observed by PSOs (total number of individuals in those sightings) from vessels during geophysical and geotechnical surveys in September-October 2011

[3] Observations recorded by PSOs on the geophysical vessel Duke along 5,779 mi (9,301 km) of survey lines

[4] Observations recorded by PSOs on the geotechnical vessel Synergy along 1,147 mi (1,846 km)

Table 3.7-6 Marine Mammal Sightings during CSESP Surveys July-October 2008-2013

Common Name		Marine Mammal Sightings (Individuals) by Year [1,2]					
	2008	2009	2010	2011	2012	2013	Total
Ringed/spotted seal	161 (178)	67 (72)	67 (68)	127 (139)	280 (299)	163 (165)	865 (921)
Ringed seal	101 (116)	19 (19)	14 (14)	74 (74)	76 (88)	68 (70)	352 (381)
Spotted seal	55 (60)	16 (17)	24 (24)	53 (54)	53 (62)	40 (41)	241 (258)
Bearded seal	111 (116)	32 (33)	112 (114)	186 (188)	257 (263)	213 (229)	911 (943)
Ribbon seal	6 (6)	0	0	2 (2)	0	0	8 (8)
Unidentified seal	333 (467)	49 (49)	63 (65)	143 (150)	186 (191)	174 (179)	948 (1,101)
Pacific walrus	51 (967)	128 (314)	56 (133)	153 (289)	603 (4,709)	211 (5,325)	1,202 (11,737)
Unidentified pinniped	28 (32)	12 (12)	14 (14)	16 (16)	0	27 (28)	90 (102)
Unid. marine mammal	0	0	0	3 (3)	0	2 (2)	5 (5)
Harbor porpoise	3 (7)	2 (3)	1 (3)	2 (3)	6 (13)	5 (5)	19 (34)
Dall’s porpoise	1 (1)	2 (5)	0	0	0	0	3 (6)
Killer whale	2 (9)	0	0	6 (7)	3 (41)	0	11 (57)
Beluga whale	0	0	0	0	0	1 (4)	1 (4)
Bowhead whale	2 (2)	2 (3)	36 (54)	15 (21)	75 (105)	28 (35)	158 (220)
Gray whale	15 (22)	42 (96)	14 (19)	8 (10)	79 (120)	19 (34)	177 (301)
Fin whale	0	1 (3)	0	0	6 (11)	2 (2)	9 (16)
Minke whale	1 (1)	3 (3)	0	3 (5)	3 (3)	1 (1)	11 (13)
Unidentified whale	9 (11)	3 (3)	3 (3)	6 (8)	108 (128)	14 (25)	143 (178)
Polar bear	7 (9)	3 (4)	3 (3)	0	14 (18)	6 (7)	33 (41)
Survey Effort	8,231 km	7,104 km	7,938 km	7,103 km	9,690 km	6,934 km	40,066 km
	5,115 mi	4,414 mi	4,932 mi	4,414 mi	6,020 mi	4,309 mi	24,895 mi

[1] Source: Aerts et al. 2013, 2014

[2] Includes all observations, on-transect and off, in study areas and out

Table 3.7-7 Seal and Cetacean Sighting Rates in the CSESP Burger Study Area 2008-2012

Common Name	Units	Sighting Rates by Year in July-October [1,2]				
		2008	2009	2010	2011	2012
Ringed/spotted seal	Sightings/1,000 km	8.0	9.0	4.0	4.0	23.0
	Sightings/1,000 mi	12.9	14.5	6.4	6.4	37.0
Ringed seal	Sightings/1,000 km	4.0	4.0	0.0	1.0	10.0
	Sightings/1,000 mi	6.4	6.4	0.0	1.6	16.1
Spotted seal	Sightings/1,000 km	5.0	1.0	1.0	2.0	3.0
	Sightings/1,000 mi	8.0	1.6	1.6	3.2	4.8
Bearded seal	Sightings/1,000 km	16.0	7.0	13.0	7.0	36.0
	Sightings/1,000 mi	25.7	11.3	20.9	11.3	57.9
Ribbon seal	Sightings/1,000 km	1.0	0.0	0.0	0.0	0.0
	Sightings/1,000 mi	1.6	0.0	0.0	0.0	0.0
Unidentified seal	Sightings/1,000 km	15.0	6.0	8.0	9.0	33.0
	Sightings/1,000 mi	24.1	9.7	12.9	14.5	53.1
Harbor porpoise	Sightings/1,000 km	0	0	0	0	0
	Sightings/1,000 mi	0	0	0	0	0
Dall’s porpoise	Sightings/1,000 km	0	0	0	0	0
	Sightings/1,000 mi	0	0	0	0	0
Killer whale	Sightings/1,000 km	0	0	0	0	0
	Sightings/1,000 mi	0	0	0	0	0
Bowhead whale	Sightings/1,000 km	0.72	0.73	6.79	4.14	11.36
	Sightings/1,000 mi	1.16	1.17	10.93	6.66	18.28
Gray whale	Sightings/1,000 km	0.36	0.37	0.36	0	0.87
	Sightings/1,000 mi	0.58	0.60	0.58	0.00	1.40
Fin whale	Sightings/1,000 km	0	0	0	0	0
	Sightings/1,000 mi	0.	0	0	0	
Minke whale	Sightings/1,000 km	0	0	0	0	0.87
	Sightings/1,000 mi	0	0	0.	0	1.40
Unidentified whale	Sightings/1,000 km	0	0.37	0.71	1.66	9.61
	Sightings/1,000 mi	0.00	0.60	1.14	2.67	15.47
Survey Effort	Sightings/1,000 km	2,500 km	2,686 km	2,714 km	1,031 km	1,144 km
	Sightings/1,000 mi	1,553 mi	1,669 mi	1,686 mi	641 mi	711 mi

[1] Source: Aerts et al. 2013

[2] Sighting rates in the Burger study area were not presented in Aerts et al. 2014

3.7.1 Spotted Seal

The Alaska stock of spotted seals is not considered depleted by the MMPA; nor are they listed as threatened or endangered by the ESA. NMFS initiated a status review of the spotted seal on 28 March 2008, and was petitioned on 28 May 2008 to list the spotted seal as T&E species primarily due to concerns regarding threats to the species from climate change. NMFS status review (Boveng et al. 2009) determined there are three distinct population segments (DPSs) of spotted seals, the Bering Sea DPS, which includes all of the Alaska stock, the Sea of Okhotsk DPS found in the Sea of Okhotsk, and the Southern DPS composed of spotted seals that breed in Peter the Great Bay, the Sea of Japan, and the Yellow Sea offshore of China. On 22 October 2010, NMFS listed the Southern DPS as a threatened species under the ESA but found that listing of the remaining stocks was not warranted.

<u>Distribution of the Spotted Seal</u>

In winter, the Alaska stock of spotted seals is found in the Bering Sea, where it is strongly associated with drifting ice floes (Boveng et al. 2009). As spring approaches, they shift toward, and are mainly found along the southern ice front of the Bering Sea where they breed and whelp their pups (Rugh et al. 1995; Lowry et al. 2000). A portion of the population migrates northward in the spring with the diminishing ice forming small herds on remnant ice floes where they molt and wean their pups (Boveng et al. 2009).

In summer, after molting is complete and most of the ice is gone, spotted seals move towards the coast where they use coastal (terrestrial) haulout sites but make long foraging trips to coastal and offshore waters. The summer distribution of the Alaska stock of spotted seals includes the Bering, Chukchi, and Beaufort Seas, where they occur in coastal waters and in open water far offshore (BPXA 2004). Important haulout sites along the northeastern Chukchi Sea are found at Kasegaluk Lagoon, Icy Cape, and Peard Bay (Davis and Thomson 1984; Quakenbush 1988). Spotted seals leave the Beaufort and Chukchi Seas in October and November before ice formation occurs in the fall to overwinter at the southern edge of the pack ice in the Bering Sea until spring (Allen and Angliss 2012).

Spotted seals are common in the northeastern Chukchi Sea during summer-fall, and would be expected to be encountered in small numbers in the Burger Prospect during the drilling season. BWASP/COMIDA/ASAMM survey data does not show broad distribution across the Lease Sale 193 Area but this may be due to survey timing and protocols (Figure 3.7.1-1). Spotted seals have been observed in the Burger Prospect area during several studies. Brueggeman et al. (1990) observed spotted seals in or near the Burger Prospect area during exploration drilling in 1989 and 1990 (Table 3.7-2). They have more recently been observed there during monitoring surveys conducted by Shell in 2006-2012 (Table 3.7-3), and during baseline surveys conducted in the Burger Prospect study area in July-October of 2008-2013 (Brueggeman 2009a, 2010; Aerts et al. 2013).

Life History of the Spotted Seal

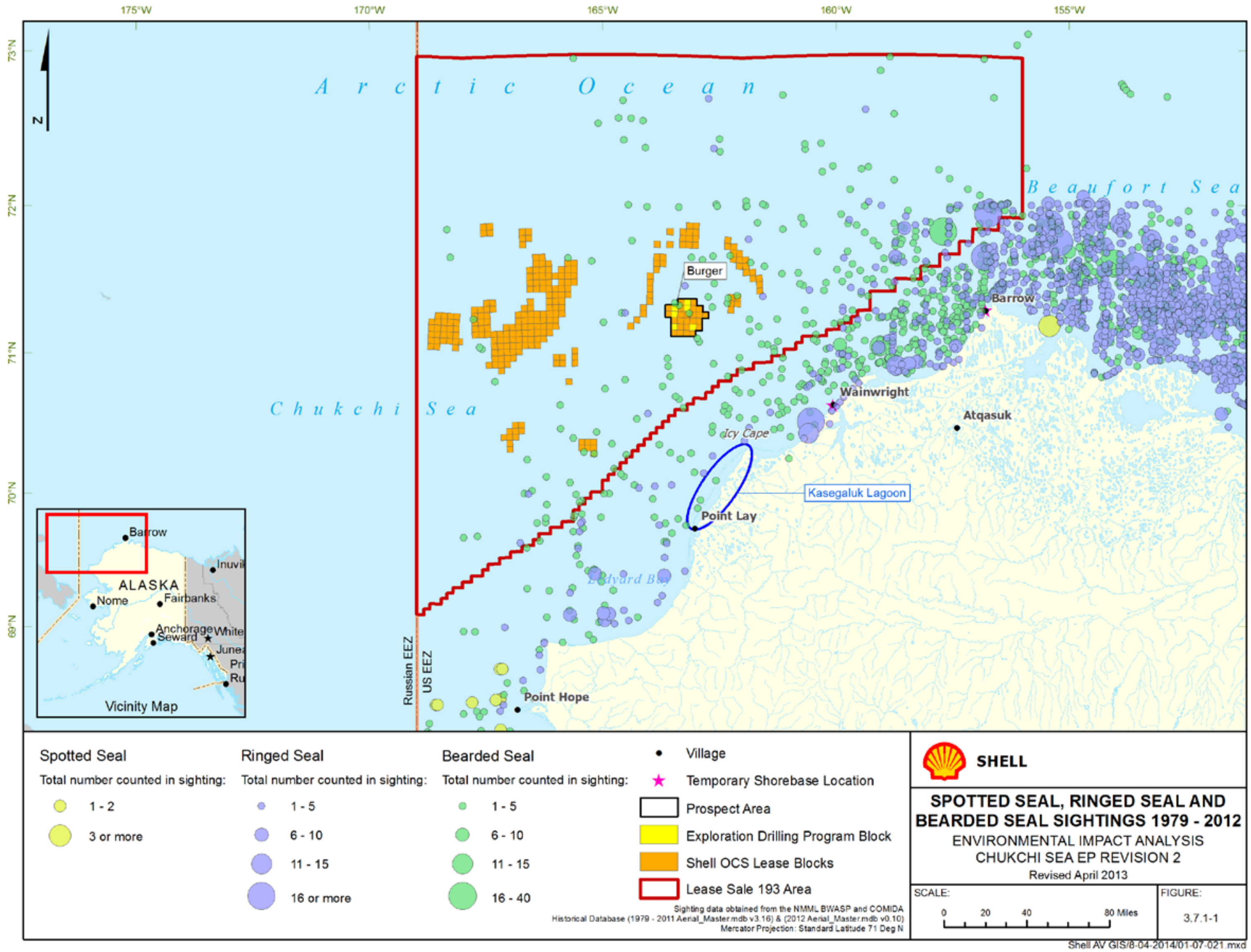
The spotted seal is an intermediate-sized seal, weighing on average, 180 to 240 lb. (80 to 110 kg) (Burns 1994a). They are covered with dark spots that are sometimes encircled by a faint ring. The diet of spotted seals is similar to that of ringed seals. Spotted seals have also been known to eat sand lance, sculpins, flatfish, and octopus, while juveniles eat mostly shrimp (Burns 1994a). Spotted seals can become prey for polar bears, killer whales, and occasionally walruses as well as grizzly bears when they are on land haulouts. Spotted seals are presumed to be monogamous and territorial (Rugh et al. 1997). Females tend to reach sexual maturity around three to four years of age and males around four to five years of age (Burns 1994a). Pups are typically born near the ice edge in early April nursed for three to four weeks before they are weaned. Mating occurs between April and May when sexually immature seals are molting. Mature seals molt later in May and June (Rugh et al. 1997).

Abundance of the Spotted Seal

Burns (1973) estimated the Bering Sea population, which includes spotted seals in Russian waters, to be between 200,000 and 250,000 in 1973. More recently the NMFS conducted surveys in the Bering Sea in 2007 and developed a population estimate of 141,479 (95% CI 92,769-321,882) in the eastern and central Bering Sea (Allen and Angliss 2012).

Spotted seals have been observed to be common, but in relatively low numbers in the Burger Prospect area during July-October. (Table 3.7-3). Annual variation in the number of animals seen was primarily due to differences in the amount of effort among years. Estimated spotted seal densities of 0 to 80 seals/1000 km^2 were calculated based on these surveys for 2006 to 2010 (Funk et al. 2011b). Some spotted seals would be expected to be encountered in the Burger Prospect during the planned exploration drilling program.

Figure 3.7.1-1 Spotted Seal, Ringed Seal, and Bearded Seal Sightings 1979-2012



3.7.2 Ribbon Seal

Ribbon seals are not listed as depleted under the MMPA, and they are not considered threatened or endangered by the ESA. NMFS was petitioned on 20 December 2007 to list the ribbon seal as an endangered species. As a result of the petition, NMFS conducted a status review (Boveng et al. 2008), and issued a finding on 30 December 2008 that after a formal review of the best scientific data available they concluded that listing of the species under the ESA is not warranted.

Distribution of the Ribbon Seal

The Alaska stock of ribbon seals is the only stock found within U.S. waters, where they range from Bristol Bay, across the Bering Sea, to and throughout the Chukchi Sea. Ribbon seals haul out on the northern pack ice in the Bering Sea from late March to early May until the ice begins receding (Burns 1981a, 1994c; Braham 1984). Recent literature indicates that the seals move into the Chukchi Sea in the summer (Kelly 1988b). Ribbon seals are rarely seen on shorefast ice (Kelly 1988b). Little is known about the distribution of ribbon seals in the summer, but they have been documented to occur in low numbers in the Burger Prospect area during July to October (Tables 3.7-3, 3.7-4, and 3.7-6).

Life History of the Ribbon Seal

Size of the ribbon seal is intermediate relative to other seals in the Alaskan Arctic. They mainly prey on fish. They reach sexual maturity between the ages of two and six. Pups are born on the ice between April and May with a thick coat of white fur called lanugo. Adults have dark fur with light-colored “ribbons” encircling the head, tail, and flippers. Nursing lasts between three and four weeks, during which time mating is also occurring.

Abundance of the Ribbon Seal

A current reliable abundance estimate is not available for the Alaska stock of ribbon seals. In the 1970s, Burns (1994c) estimated 240,000 ribbon seals worldwide and 90,000 to 100,000 for the Bearing Sea. More recently the NMFS conducted aerial surveys in the Bering Sea in 2003, 2007 and 2008 that resulted in a provisional estimate of 49,000 ribbon seals in the eastern and central Bering Sea (Allen and Angliss 2012).

Ribbon seals are not common in the northeastern Chukchi Sea, but they are found there in small numbers in the summer-fall. Eight were observed over a period of seven years (2006 to 2012) during monitoring from seismic and drilling support vessels in a large area of the northeastern Chukchi Sea (Table 3.7-3), and one was observed during a seismic survey conducted near the Burger Prospect in 2010 (Table 3.7-4). None were identified during drilling conducted in this area of the Chukchi Sea in 1989-1991 (Table 3.7-2). These observations indicate that they may be encountered in the Burger Prospect in very small numbers during the planned exploration drilling program.

3.7.3 Beluga Whale

Beluga whales are harvested by North Slope Alaska Natives as a subsistence resource. Beluga whale stocks found in the Chukchi Sea are not listed as depleted under the MMPA (Allen and Angliss 2012) or listed as threatened or endangered by the ESA.

Distribution of the Beluga Whale

Five stocks of beluga whales occur in Alaska (Allen and Angliss 2012), but only the eastern Chukchi Sea and Beaufort Sea stocks occur in the Lease Sale 193 Area. Both stocks overlap in the Chukchi Sea and winter in the Bering Sea (Suydam et al. 2001, Miller et al. 1998). Much of the Chukchi Sea stock congregates in Kasegaluk Lagoon in June and July, at which time the village of Point Lay conducts a subsistence hunt. In the spring, beluga whales migrate along open leads north from their wintering grounds in the Bering Sea, often near the coast. Fall migrant beluga whales from the Canadian Beaufort Sea transit the Alaskan Beaufort Sea in a more dispersed pattern, but often along the southern edge of the pack ice, to reach western Chukchi Sea waters primarily during September (Richard et al. 1998). During this time, pods can exceed 1,000 individuals (Citta and Lowry 2008). Evidence indicates that beluga whales occupy areas near or beyond the continental shelf break during summer in the eastern Chukchi Sea, often near the pack ice margin or in areas of dense ice (Suydam et al. 2005a). These preferred summer habitats are well north of the revised Chukchi Sea EP drill sites. Belugas are found throughout the Lease Sale 193 Area including Shell's Burger Prospect (Figure 3.7.3-1).

Life History of the Beluga Whale

Beluga whales feed primarily on schooling fish, but they also feed on marine invertebrates within the OCS and in estuarine and riverine waters (Citta and Lowry 2008). Fall migrant beluga whales in Alaskan waters are known to routinely dive to depths greater than 1,300 ft (400 m) while foraging in the OCS. Pod structure revolves around matrilineal lines where males form separate aggregations. Male belugas typically leave the maternal pod when around 4-5 years of age, while females stay with the pod their whole life (Krasnova et al. 2005).

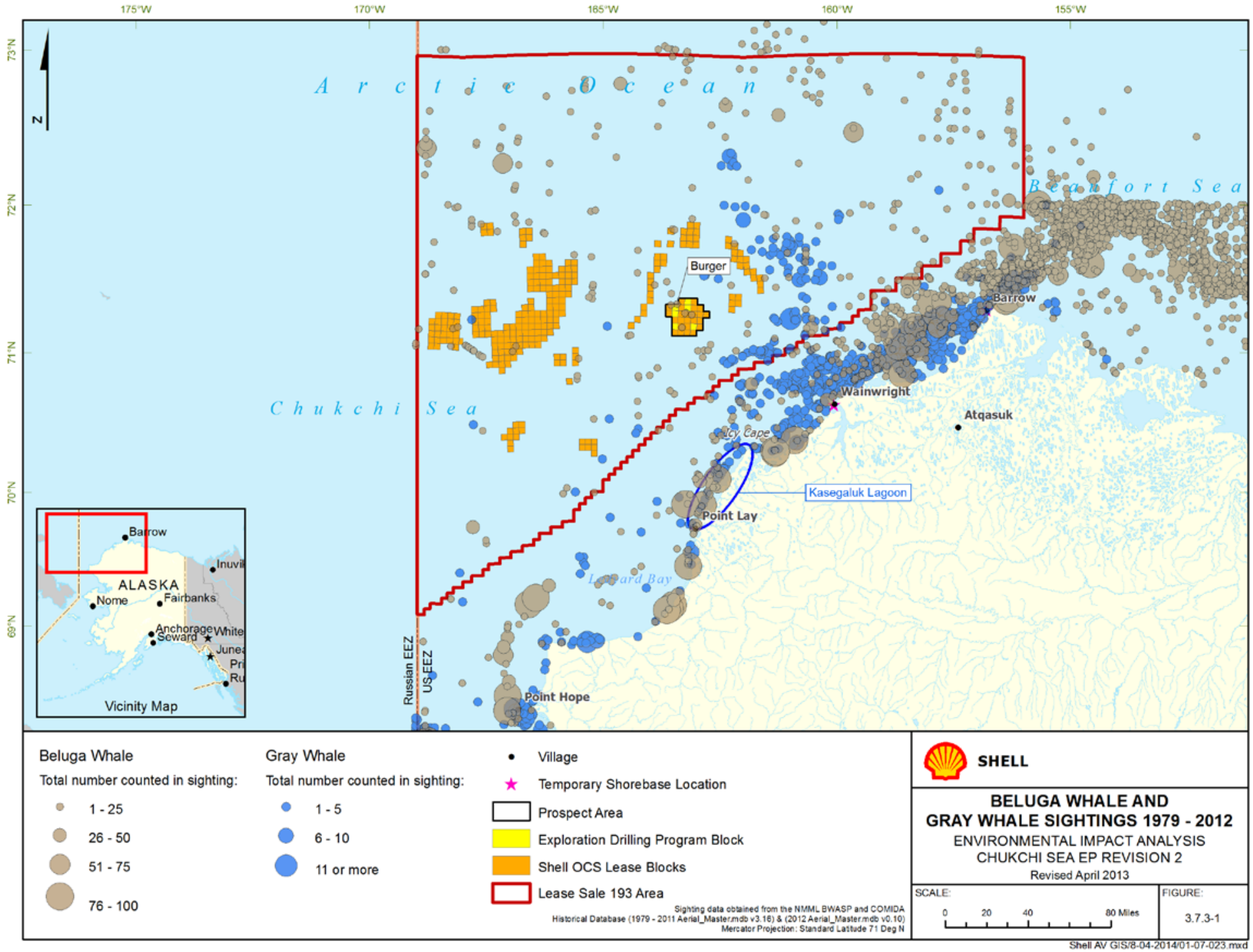
Beluga whale mating season occurs during early spring (Richard et al. 1998) and calves are born in summering areas between May and July. Calves are dark in color and about one-fourth the length of the mother (Krasnova et al. 2005). They stay very close to their mother for at least a month after birth, and they are not weaned until they are at least three years of age (Krasnova et al. 2005).

Abundance of the Beluga Whale

The most reliable estimate of the number of beluga whales in the eastern Chukchi stock is 3,710 individuals based on 1989-1991 aerial surveys (Frost et al. 1993, Allen and Angliss 2012). Subsequent surveys were conducted in 1998 (DeMaster et al. 1998) and in July 2002 (Lowry and Frost 2002), but both were partial surveys; therefore, a more recent complete abundance estimate for this stock is not available. Beluga whale stocks found in the Chukchi Sea are not listed as depleted under the MMPA (Allen and Angliss 2012) or listed as threatened or endangered by the ESA.

Belugas are not commonly observed in the area of the Burger Prospect but may be encountered there in small numbers during the drilling season. They have been observed there during BWASP/COMIDA/ASAMM surveys (Figure 3.7.3-1). PSOs monitoring marine mammal occurrence from vessels during seismic surveys in offshore waters of the northeastern Chukchi Sea reported 46 beluga whales from marine vessels in 2006-2012 (Table 3.7.3), but many more were observed during aerial surveys in more coastal waters. Belugas were not observed in the Burger Prospect area during past exploration efforts in 1989-1990 (Table 3.7-2). None were observed around the Burger Prospect during Shell's July-October 2008-2012 CSESP surveys; however four were observed in 2013 (Aerts et al. 2014) (Table 3.7-6).

Figure 3.7.3-1 Beluga Whale and Gray Whale Sightings 1979-2012



3.7.4 Harbor Porpoise

Harbor porpoise stocks found in the Chukchi Sea are not listed as depleted under the MMPA or listed as threatened or endangered by the ESA.

Distribution of the Harbor Porpoise

Harbor porpoises are found in relatively shallow costal and shelf waters throughout much of the northern hemisphere (Read 1999), where they are generally found in shallow coastal waters less than 330 ft (100 m) in depth (Allen and Angliss 2012). Offshore of Alaska they are found from southeast Alaska throughout the Chukchi Sea shelf (Allen and Angliss 2012) and have been observed as far north as the Barrow area (Suydam and George 1992) and as far east as Harrison Bay in the Beaufort Sea (Funk et al. 2010). Although there is no official designation of separate stocks of harbor porpoises in Alaska, three stocks have generally been recognized, with harbor porpoises found in the Chukchi Sea being considered part of the Bering Sea group. They would be expected to occur over much of the Lease Sale 193 area in summer and fall, and have been observed by Shell in the northeastern Chukchi Sea (Table 3.7-3).

Life History of the Harbor Porpoise

Harbor porpoises feed mainly on non-spiny fish, cephalopods such as squid and octopus, and crustaceans such as shrimp. They use echolocation to find prey while foraging (Nowak 1999). Harbor porpoises normally travel in small groups consisting of a few individuals, but form larger groups for feeding and mating purposes. Calving occurs between spring and early summer, and calves are generally weaned within one year (Read 1999).

Abundance of the Harbor Porpoise

Allen and Angliss (2012) provided a minimum population estimated of 40,039 for the Bering Sea stock of harbor porpoise based on aerial surveys conducted in Bristol Bay in 1999.

Harbor porpoises are common cetaceans in the northeastern Chukchi Sea. They were the second most commonly observed cetacean by PSOs monitoring Shell's activities in the area, with a total of 125 observed in 2006-2012 (Table 3.7-3). An average density of 0.00128/km^2 has been calculated harbor porpoises based on these industrial surveys. They were not observed during exploration drilling efforts conducted in 1989-1991 (Table 3.7-2). None were observed within the Burger Prospect study area during the CSESP in 2008-2013, but 35 were observed elsewhere during the studies (Aerts et al. 2013, 2014). These data indicate that harbor porpoises may be encountered in the prospect area, or in transit to the prospect, in small numbers during the drilling season.

3.7.5 Narwhal

Narwhals are not listed as depleted under the MMPA (Allen and Angliss 2012) or listed as threatened or endangered by the ESA.

Distribution of the Narwhal

There are scattered records of narwhal in Alaskan waters where the species is considered extralimital (Reeves 2002). Thus, it is possible, but very unlikely, that individuals could be encountered in the area of the planned exploration drilling activities. Narwhals have a discontinuous arctic distribution (Hay and Mansfield 1989; Reeves et al. 2002).

Life History of the Narwhal

Male narwhals are distinguishable due to a long helical tusk that protrudes from their upper left jaw. This tusk is rarely used for fighting and is thought to be a specialized trait for sexual selection and possibly a sensory organ (Nweeia et al. 2005). They mainly feed on flatfish and other benthic organisms. They are thought to use echolocation to locate prey. These whales can live to be 50 years old. The gestation period is between 10 and 16 months. Calves are nursed for about 4 months.

Abundance of the Narwhal

A large population inhabits Baffin Bay, West Greenland, and the eastern part of the Canadian Arctic archipelago, and much smaller numbers inhabit the Northeast Atlantic/East Greenland area. Population estimates for the narwhal are scarce, and the International Union for the Conservation of Nature (IUCN) lists the species as Near Threatened (IUCN Red List of Threatened Species 2014). Narwhals are observed so seldom in the Lease Sale 193 Area, they would not be expected to be encountered during Shell's planned exploration drilling program. None have been reported as observed during previous industrial monitoring (Table 3.7-2, 3.7-3, 3.7-4, and 3.7-5) or during baseline marine mammal surveys (Table 3.7-6).

3.7.6 Killer Whale

Killer whale stocks found in the Chukchi Sea are not listed as depleted under the MMPA or listed as threatened or endangered by the ESA.

Distribution of the Killer Whale

Killer whales are found throughout the world's oceans and seas, from the equator's more tropical waters to the cooler waters in the high latitudes. They are most common in cooler coastal waters of both hemispheres, but appear in greatest numbers within 800 km (432 nmi) from continental coasts (Mitchell 1975). Killer whales can be found in all Alaskan waters, although they are considered rare in the Chukchi Sea. Of the eight killer whale stocks recognized in the Pacific, the trans-boundary Alaska Resident stock, found from southeastern Alaska to the Chukchi Sea (Allen and Angliss 2012) is the only stock that could possibly be encountered in the area of Shell's planned exploration drilling operations.

Life History of the Killer Whale

Adult killer whales generally grow to reach 27 ft (8.2 m). They are the largest members of the delphinidae family. Transient killer whales prey on marine mammals while resident animals feed on fish and invertebrates. They are long-lived and reproduce slowly. Gestation typically lasts between 15 and 16 months. Calving usually occurs during the spring and fall.

Abundance of the Killer Whale

The National Marine Mammal Laboratory (NMML) began killer whale studies in 2001 in Alaskan waters west of Kodiak Island, including the Aleutian Islands and Bering Sea. Line-transect surveys were conducted in July and August in 2001-2003. Based on surveys conducted by the NMML, a minimum estimate of 1,123 killer whales comprises the Alaska Resident stock (Allen and Angliss 2012). The eastern North Pacific Alaska resident stock of killer whales is not classified as a strategic stock.

PSOs recorded observations of 17 killer whales (in eight groups) from vessels while conducting monitoring surveys for seismic surveys and drilling in the northeastern Chukchi Sea in 2006-2012 (Table 3.7-3). None were observed in the prospect during historical drilling in 1989-1991 (Table 3.7-2), and none were observed in the Burger Prospect area during 2008-2013 CSESP marine mammal surveys (Table 3.7-6), but 57 were observed elsewhere in the Lease Sale 193 Area during the surveys (41 in 2012 alone) (Brueggeman 2009a,b; Aerts et al. 2013). Although unlikely, they could possibly be encountered in the prospect in small numbers during the planned exploration drilling program.

3.7.7 Gray Whale

Gray whales found in the Chukchi Sea are not listed as depleted under the MMPA or listed as threatened or endangered by the ESA.

Distribution of the Gray Whale

The eastern North Pacific population of gray whales ranges from the Bering, Chukchi, and Beaufort Seas in summer to the Gulf of California in winter (Rice 1998). Most of the eastern North Pacific population makes a round-trip annual migration of more than 5,000 mi (8,000 km) from Alaska waters to Baja California and Mexico. From late-May to early-October, the majority of the population is concentrated in the northern and western regions of the Bering Sea and in the Chukchi Sea.

Gray whales are considered common summer residents in the nearshore waters of the eastern Chukchi Sea. They are occasionally seen east of Point Barrow in late spring and summer, and as far east as Smith Bay (Green et al. 2007). In wintering grounds, mainly along the west coast of Baja California, gray whales use shallow, nearly land-locked lagoons and bays (Rice et al. 1981). From late February to June, the population migrates back to arctic and subarctic seas (Rice and Wolman 1971). Gray whales prefer areas with little or no ice cover and spend most of their time in water less than 200 ft (60 m) deep (Moore and DeMaster 1997). They are found in waters of the northeastern Chukchi Sea during these seasons, including the area of Shell's Burger Prospect. They are often observed in the area of Hanna Shoal, a feeding area, located about 60 mi (96 km) northeast of Burger (Figure 3.7.3-1).

Life History of the Gray Whale

Most gray whales feed in the northern Bering and Chukchi Seas (Braham 1984). They are primarily benthic feeders specializing in straining prey items from seafloor sediments. Amplescids (benthic infauna) form the bulk of their diet in the Chukchi Sea (Moore et al. 2003). The most well-known feeding area is in the Chukchi Sea, southwest of Barrow (Clarke et al. 1989). Hanna Shoal is another area where they are commonly observed. These areas can be seen on Figure 3.7.3-1 as clusters of the blue dots representing gray whale sightings. Gray whales are subject to killer whale predation (Weller et al. 2002). Gray whales are rarely taken by Native subsistence hunters (IWC 1997).

Gray whales have a two-year reproductive cycle with one calf being born every other year (Rice and Wolman 1971). Female gray whale oestrus is highly synchronized and occurs within a three-week period between November and December. If conception does not occur during the first oestrus, females may enter into a second oestrus approximately 40 days later (Rice and Wolman 1971). Although the possibility for conception is restricted to a short time period, gray whales have been seen mating throughout the year (Jones and Swartz 1984). Calving usually occurs in the middle of January following a 13-month gestation (Swartz et al. 2006) during the southbound migration or when they reach the Gulf of California (MMS 2006a). Calves stay with their mothers for six to seven months and are weaned by the time the whales reach their summer grounds. After the calf is weaned, the female will remain anoestrus for a few months before beginning the oestrus cycle again (Rice and Wolman 1971).

Abundance of the Gray Whale

Gray whales summering in the northeastern Chukchi Sea tend to use recurring feeding areas, which include an offshore area southwest of Point Barrow and coastal waters between point Barrow and Wainwright. These areas are evident in the BWASP/COMIDA/ASAMM survey data (Figure 3.7.3-1). Rugh et al. (2005) estimated the Eastern North Pacific stock of gray whales at 18,178 whales, based on surveys conducted in 2001 and 2002 off the coast of central California coast during the south-bound migration. Using 2006/2007 abundance data Allen and Angliss (2011) calculated a minimum population estimate of 18,017. Gray whales originally inhabited both the North Atlantic and North Pacific Oceans. The Atlantic populations are believed to have become extinct due to industrial whaling by the early

1700s, while a relic population survived in the western North Pacific. The gray whale population has recovered from commercial whaling. The eastern North Pacific stock has recovered and was removed from the Endangered Species List in 1994.

Gray whales are commonly found over much of the continental shelf of the northeastern Chukchi Sea. The gray whale was the most commonly observed cetacean during marine mammal monitoring conducted in association with exploration activities in 2006-2012, during which a total of 787 gray whales were observed by PSOs on vessels (Table 3.7-3). They were also one of the most commonly observed cetaceans during the July-October 2008-2013 CSESP surveys (Table 3.7-6) (Aerts et al. 2013, 2014). No gray whale observations were reported for the surveys conducted in and near Burger, Crackerjack, and Popcorn Prospects in 1989 and 1990, but the more recent data indicate that gray whales will likely occur in the prospect area during Shell's exploration drilling activities.

3.7.8 Minke Whale

Minke whales found in the Chukchi Sea are not listed as depleted under the MMPA or listed as threatened or endangered by the ESA.

Distribution of the Minke Whale

In the North Pacific, minke whales are found from near the equator north to and across the Bering and Chukchi Seas (Leatherwood et al. 1982) where they have been observed penetrating loose ice in the summer (Leatherwood et al. 1982). Minke whales found in the Chukchi Sea are believed to be migratory and travel along the coast to California (Dorsey et al. 1990). These whales are a separate stock from the minke whales that inhabit the coast of Washington and California year-round. Minke whales have been observed in small numbers throughout the northeastern Chukchi Sea (Table 3.7-3 and Table 3.7-4) and in the Burger Prospect area (Table 3.7-5).

Life History of the Minke Whale

Small schooling fish and zooplankton are the main prey for minke whales. These whales exhibit reverse sexual dimorphism with the females being, on average, slightly larger than the males. The average adult female weighs eight tons (7,300 kg), and the average male weighs six tons (5,400 kg). Sexual maturity typically occurs around age six. A single calf is born every one to two years, and gestation lasts 10 months. Calves are nursed for six months before being weaned (Wynne 1992).

Abundance of the Minke Whale

No population estimates are available for the Alaska stock of minke whales (Allen and Angliss 2012). Moore et al. (2002) conducted vessel-based surveys across portions of the Bering Sea in 1999 and 2000 and reported an average estimate of 1,813 whales in the central eastern and southeastern Bering Sea (Moore et al. 2002). However, this estimate did not take into consideration a correction factor for whales not visible during the survey. The Alaska stock of minke whales is not considered depleted under the MMPA, and they are not listed as threatened or endangered under the ESA.

Minke whales appear to be uncommon but regular inhabitants of the northeastern Chukchi Sea. A total of 71 minke whales were observed by PSOs on vessels monitoring seismic surveys and drilling activities in the northeastern Chukchi Sea over seven years (2006-2012), but they were less common than gray and bowhead whales (Table 3.7-3). They were observed at about the same frequency as gray whales and bowheads during 2010 seismic surveys near the Burger Prospect (Table 3.7-4). One minke whale was observed during surveys associated with drilling in the historical Popcorn Prospect in 1990; none were observed at the historical Burger, Crackerjack, or Klondike Prospects in 1989 or 1990 (Table 3.7-2). Thirteen were observed in the CSESP survey area during baseline studies from 2008-2013 (Table 3.7-6); (Aerts et al. 2013, 2014). In addition, autonomous acoustic recorders deployed in the Chukchi Sea detected minke whale vocalizations in the fall of 2009 and summer of 2011 (Delarue et al. 2012a). These data indicate that minke whales may occur in the vicinity of the Burger Prospect during planned exploration drilling.

3.7.9 Terrestrial Mammals

Caribou (Rangifer tarandus), moose (Alces alces), and brown bears (Ursus arctos) have been the subject of extensive research on the North Slope. Caribou are an important subsistence species and all are prized big game. Caribou regularly use coastal areas of the Chukchi Sea in summer. For this reason, caribou are the most likely large mammal species that may be potentially impacted. The other large terrestrial mammals of the North Slope are considered uncommon along the Beaufort Sea and Chukchi Sea coastal habitats because they are at the limits of their range.

Caribou

Two different caribou herds occur on the North Slope bordering the Chukchi Sea; the Teshekpuk Herd and Western Arctic Herd. These herds serve as an important subsistence resource for surrounding communities.

Distribution of Caribou

On the North Slope, caribou are the predominant large herbivores and are widely distributed (Manville and Young 1965; Miller 1982; Valkenburg 1999). Distinct caribou herds are distinguished by their traditional calving grounds (Cameron and Whitten 1979). However, caribou herds often overlap each other, such as is the case for many of the caribou herds on the North Slope. Much of the overlap occurs while caribou are on their wintering ranges (Valkenburg 1999).

The Teshekpuk herd has a range that is centered around Teshekpuk Lake. Wintering areas can be variable as most winter just south of Teshekpuk Lake and some winter near the Brooks Range foothills from the Seward Peninsula to the Arctic National Wildlife Refuge (Carroll 2007). Calving occurs on the eastern portion of Teshekpuk Lake.

The Western Arctic herd calves in the Utukok Hills (Dau 2007). Wintering occurs on the eastern half of the Seward Peninsula and the summer range includes the western North Slope and Brooks Range.

On the North Slope, coinciding with the decline of biting insects, caribou breed and begin migrating inland during the fall. Most caribou spend the winter inland near the foothills of the Brooks Range and migrate north to the Arctic Coastal Plain in the spring. Calving occurs on the open tundra from late April to early June (Whitten and Cameron 1985). In winter, caribou occur at very low densities near coastal areas. Although most caribou migrate into the northern and southern foothills of the Brooks Range during the fall and winter (Lenart 2003; BLM 2002), several hundred caribou may remain on the Arctic Coastal Plain during this time (BLM 2002).

Migration routes used for many years may suddenly be abandoned in favor of movements to new areas with more food (Valkenburg 1999). Therefore, caribou distributions change periodically.

Life History of Caribou

Caribou have distinct phases of activities that include: spring migration, calving, post-calving aggregation, fall migration, rutting, and wintering.

Spring migration of parturient females to calving grounds begins in late March (Hemming 1971). Bulls and non-parturient females migrate later. Calving occurs in early June for North Slope caribou where females typically have one calf per year (Valkenburg 1999). After calving, caribou collect in large post-calving aggregations to avoid predators (Valkenburg 1999). Caribou use coastal areas to escape inland predators and avoid biting insects and summer heat (Cameron and Smith 1992; Lawhead 1997; Pollard and Noel 1994; Valkenburg 1999). In late August and early September, males come into rut for the breeding season, the time that caribou again begin to migrate (Valkenburg 1999). By winter, most caribou have migrated inland from the Chukchi Sea coast for the winter.

Abundance of Caribou

The Teshekpuk herd was estimated at 3,000 to 4,000 in 1978 to 1982 and increased to 45,166 in 2002, (Carroll 2007), and to at least 64,000 in 2008 (Parrett 2009). The Western Arctic herd is the largest in the state with an estimated population of 377,000 in 2007 and distribution over 140,000 mi^2 (362,894 km^2) (Dau 2007). Emigration and immigration between herds can occur and change population estimates.

Moose

Distribution of Moose

On the North Slope, moose are at the limit of their range due to food availability (Hicks 1998) and are generally found in forested habitats and river valleys (Rausch and Gassaway 1994). Nearly all moose on the North Slope are confined to riparian areas (Carroll 2010). During summer, moose disperse to small tributaries near the Brooks Range Foothills and across the coastal plain (Carroll 2010). In winter, moose use river valleys containing shrub riparian vegetation (Rausch and Gassaway 1994) such as the inland portions of the Colville River drainage, where the largest concentrations of moose on the North Slope are found (Carroll 2010).

Abundance of Moose

Moose populations in Unit 26A have fluctuated from 1,535 in 1991 to 326 in 1999. In 2010, the population was estimated at 1,180 (Carroll 2010). Unit 26A is a large game management unit west of the Itkillik River drainage and west of the Colville River between the mouth of the Itkillik River and the Arctic Ocean all the way east to Cape Lisburne. Surveys for moose occur in the western portion of Unit 26A, where there are many more riparian areas.

Life History of Moose

The life history of moose involves breeding during the rut, wintering, and calving where moose make seasonal migrations up to 60 mi (97 km) between rutting, calving, and wintering areas (Rausch and Gassaway 1994). Moose breed during the fall and the peak of the rut occurs at the end of September and early October. By the time the rut is over, males have depleted much of their fat reserves and resume feeding in late fall. Calves develop during the winter and are born in the spring, from mid-May to early June.

Maternal moose become solitary in early spring and find secluded areas for giving birth (Cederlund et al. 1987; MacCracken et al. 1997). Twinning may occur when habitat conditions provide adequate forage and the cow is nutritionally fit. When cows are nutritionally stressed, single calves are more common (Franzman and Schwartz 1985). When selecting birth sites, cow moose may select for forage, visibility, southerly exposures, and relatively high elevations in an attempt to have adequate forage nearby and avoid predators (Bowyer et al. 1999). After birth, cow moose remain at or near the birth site for several weeks (Addison et al. 1990).

Winter use concentration areas may be sensitive habitat since moose condition can be low and forage few. Moose lose body mass during winter (Schwartz 1997) and experience more starvation and predator-related mortality than other parts of the year, which often is related to winter severity (Ballard et al. 1991). Moose are restrictive in their movements, particularly during late winter when snow can be deep (Peek 1997).

Brown Bear

Distribution of Brown Bears

Brown bear (Ursus arctos) distributions are influenced by a combination of factors, which includes patterns of calving caribou (Young et al. 2002). Home range sizes are large, ranging from approximately 1,000-2,000 mi² (2,600-5,200 km^2) in the Prudhoe Bay region (MMS 2002b).

On the North Slope, brown bears are at the northern extent of their distribution and typically occur at relatively low densities. Brown bears, in general, are most abundant in the foothills and mountains of the arctic coastal plain (Young et al. 2002; Carroll 2009).

Life History of Brown Bears

Brown bears consume a wide variety of food that includes vegetation, salmon, moose, and caribou (Eide and Miller 1994). In the winter, most brown bears enter dens and hibernate. In northern climates, brown bears may spend 5-7 ½ months in dens (Eide and Miller 1994).

In arctic environments, denning typically begins in October with emergence in April and May (Craighead and Mitchell 1982; MMS 2002b). Denning frequently occurs in snow-accumulating areas of moderate to high relief such as pingos, riverbanks, lake basins, dunes, and gullies, often with southern exposures (MMS 2002b).

Abundance of Brown Bears

In the presence of anthropogenic food sources, brown bear density in the Prudhoe Bay area increased to 15 bears/1,000 mi² (6 bears/1,000 km^2) (Stephenson 2003). Overall in unit 26A, there are an estimated 900-1,120 bears (Reynolds 1989) with an estimated density at 76.4 bears/1,000 mi^2 (29.5 bears/1,000 km^2) (Reynolds, personnel communication cited in Carroll 2009). Densities by habitat zone are estimated at 1.3 to 5.18 bears/1,000 mi^2 (0.5 to 2 bears/1000 km^2) on the coastal plain, 25.9 to 77.7 bears/1,000 mi^2 (10 to 30 bears/1,000 km^2) in the foothills, and 25.9 to 51.8 bears/1,000 mi^2 (10 to 20 bears/1,000 km^2) in the mountains (Carroll 2009). Using these densities, bear populations are estimated at 1,007, with 81 in the coastal plain, 666 in the foothills, and 260 in the mountains (Carroll 2009).

3.8 Threatened and Endangered Species

Species known to occur in the Lease Sale 193 Area and listed as threatened endangered, or candidate species under the ESA, are listed below in Table 3.8-1, and discussed in the following section. Effective 26 February 2013, the Arctic subspecies of ringed seal, and the Beringia DPS of bearded seals, both of which occur in the Chukchi Sea, were listed as threatened under the ESA.

On 25 July 2014 the U.S. District Court for the District of Alaska court determined that NMFS' action listing the bearded seal was "arbitrary, capricious, an abuse of discretion, or otherwise not in accordance with law." It further explained in its decision that it does not appear from the Listing Rule that any serious threat of a reduction in the population of the Beringia DPS, let alone extinction, exists prior to the end of the 21st century. The court referenced information in the Listing Rule that at least through mid-21st century, there will be sufficient sea-ice to sustain the Beringia DPS at or near its current population levels. The court thereby vacated the rule to list the Beringia DPS of bearded seals as a threatened species and remanded the rule back to NMFS. Therefore, Shell will treat the bearded seal as a candidate species for listing under the ESA.

On 3 October 2013, USFWS announced a 12-month finding on a petition to list the Kittlitz's murrelet; USFWS determined that the listing of the species is not warranted at this time (78 FR 61764-61801).

In NMFS' (2013b) BO for oil and gas exploration activities in the Chukchi and Beaufort Seas, the agency analyzed potential effects of an expanded project area that included portions of the Bering Sea where Steller sea lions and North Pacific right whales may be affected. In turn, NMFS analyzed the effects of oil and gas exploration activities on those species. Although transiting vessels in the Bering Sea could encounter both species, transit to the Chukchi Sea is not analyzed as part of the exploration drilling project activities. Because Steller sea lions and North Pacific right whales do not occur in or near the Burger Prospect or project area, Shell does not include a discussion of these mammals in this section.

Table 3.8-1 ESA Designation of Species Present in the Chukchi Sea 2013

Common Name	Scientific Name	ESA Status
Spectacled eider	*Somateria fischeri*	Threatened
Steller's eider	*Polysticta stelleri*	Threatened
Ringed seal	*Phoca hispida*	Threatened
Bearded seal	*Erignathus barbatus*	Candidate
Pacific walrus	*Odobenus rosmarus divergens*	Candidate
Polar bear	*Ursus maritimus*	Threatened
Bowhead whale	*Balaena mysticetus*	Endangered
Fin whale	*Balaenoptera physalus*	Endangered
Humpback whale	*Megaptera novaeangliae*	Endangered

3.8.1 Spectacled Eider

The spectacled eider was listed as a threatened species on May 10, 1993. The spectacled eider, which was listed as a threatened species under the ESA of 1973, as amended (PL 93-205; 16 USC §1531), breeds on the Arctic Coastal Plain of Alaska and Russia and winters in the Bering Sea (Figure 3.8.1-1).

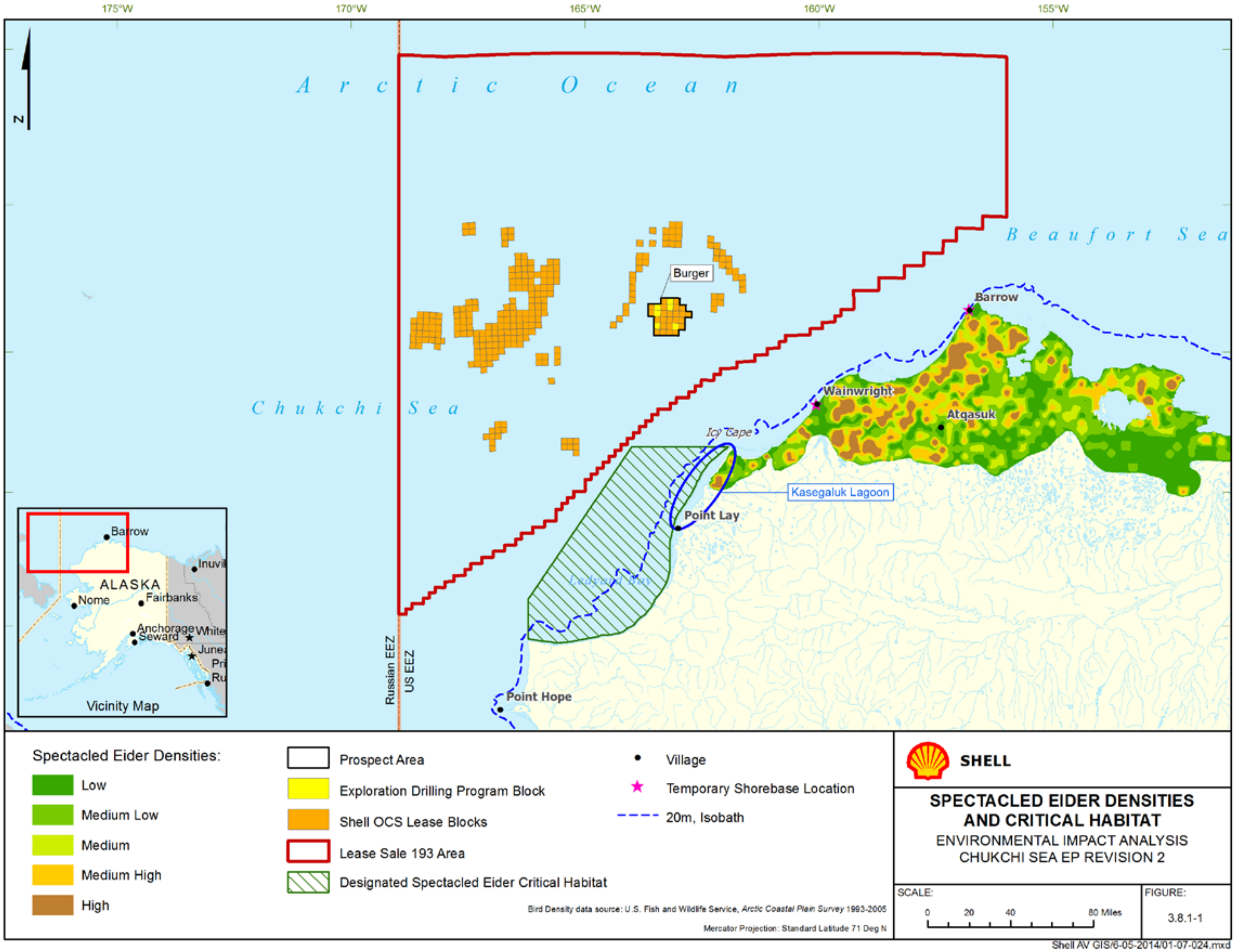
<u>Distribution of the Spectacled Eider</u>

Historically, spectacled eiders nested in Russia and along much of the Alaskan coast from the Nushagak Peninsula north to Barrow and east nearly to the Canadian border (USFWS 2005), but the nesting range has contracted in recent years. Currently the breeding distribution includes the central coast of the Y-K Delta, the Arctic Coastal Plain of Alaska, and the Arctic Coastal Plain of Russia (USFWS 2005). The worldwide population is composed of three breeding populations: one in Russia and two (Western and Northern) in Alaska (Petersen et al. 2000). The Northern Alaska population, nests on the Arctic Coastal Plain from south of Icy Cape north and east to the Shaviovik River; within this area, most of the nesting occurs between Cape Simpson and the Sagavanirktok River (USFWS 1996, 2001). Densities of spectacled eiders vary across the North Slope along the Chukchi Sea coast as indicated in Figure 3.8.1-1. The area from Dease Inlet south and west to Wainwright and up to Barrow contains some of the highest densities on the North Slope (Larned et al. 2005).

Spectacled eiders from the Northern Alaska population leave their wintering grounds south of St. Lawrence Island between March and April and fly north, reaching their nesting grounds between late May and early June (Petersen et al. 1999). After nesting, spectacled eiders move to coastal waters where they migrate to molting areas along the coast where they congregate and molt in large flocks in shallow coastal waters up to 120 ft (65 m) deep (MMS 2006b). Males move to the marine environment by mid-to-late June (Troy 2003), followed by females that are unsuccessful nesters in mid-to-late July. Successful females and their broods move to coastal waters between 26 August and 4 September (Petersen et al. 1999).

There are three principal molting areas, Mechigmensky Bay in Russia, Norton Sound in the Bering Sea, and Ledyard Bay in the Chukchi Sea (Peterson et al. 1999). As many as 33,000 spectacled eiders molt in Ledyard Bay (Larned et al. 1995). Approximately 5,390 mi^2 (13,960 km^2) of coastal waters in and offshore of Ledyard Bay have been designated critical habitat for the species (Figure 3.8.1-1). The critical habitat includes marine waters greater than 16.4 ft (5.0 m) deep and less than 82 ft (25 m). Other important molting and staging areas in the Chukchi Sea include Peard Bay and Kasegaluk Lagoon (Petersen et al. 1999).

Figure 3.8.1-1 Spectacled Eider Densities and Critical Habitat



The distribution of non-breeding eiders in the summer is not well known, but they are thought to be present in small flocks in coastal waters throughout their range, including the Chukchi Sea (USFWS 2002b). Small numbers are observed in nearshore waters along the Chukchi coastline during annual USFWS waterbird surveys (Dau and Larned 2006, 2007, 2008).

Divoky (1987) reported that eiders (including spectacled eiders) were commonly observed along the 20 m isobath of the northeastern Chukchi Sea during the summer but only after 22 September did they move to more offshore waters; even then they were much more common in nearshore waters. Spectacled eider use of offshore waters near Shell's Burger Prospect low. In six years (2008-2013) of intensive surveys conducted as part of the CSESP in a 35 x 35 mi (56 x 56 km) area around the Burger Prospect during July – October, no spectacled eiders were observed in 2008, 2010, and 2011; a single spectacled eider was 2009 (Gall et al. 2013, 2014). Surveys were conducted in 2014; however the final report was not available at the time this analysis was prepared.

In winter, most of the world's population of spectacled eiders winters south of St. Lawrence Island in the Bering Sea, where they forage in open leads. The only known area is located in 165 to 200 ft (50 to 61 m) of water about 65 mi (105 km) south of Saint Lawrence Island (Peterson et al. 1999; USFWS 2002b). Such wintering areas are thought to be kept open partly due to the sheer numbers of eiders in these large flocks (MMS 2006a).

Life History of the Spectacled Eider

The typical age at which females start breeding is not well known but probably occurs at age three. Nesting starts in late May and continues through mid-to-late June. Female spectacled eiders have a strong fidelity to nesting areas, often returning to within 1 mi (0.6 km) of the same nesting site from the previous year (MMS 2006b). They nest on the tundra in sedge meadow habitats, often on islands or peninsulas near lakes. Incubation lasts 20 to 25 days with reported clutch sizes ranging from one to eight eggs with an average of five. Fledging occurs approximately 50 days after hatching. Females with broods may disperse up to 8.7 mi (14 km) but most use freshwater lakes within 3.1 mi (5 km) of the nest site (MMS 2006b). Predation is thought to be the principal cause for nesting failures. The diet of spectacled eiders in the marine environment consists of benthic mollusks and crustaceans. Dau and Kistchinski (1977) reported that they feed out to depths of about 100 ft (30.5 m). Wintering spectacled eiders feed on clams (Peterson et al. 1999) such as *Macoma spp.*, *Yoldia spp*., and *Nuculana* radiate, out to depths of 130 to 230 ft (40 to 70 m).

Abundance of the Spectacled Eider

The threatened spectacled eider population is currently estimated to be about 360,000 worldwide, (USFWS 2005). Spectacled eider populations on the Y-K Delta are down to approximately 4 percent of the numbers estimated in the early 1970s (Stehn et al. 1993). An estimated 4,399 pairs nested on the Y-K Delta in 2007 (Fischer et al. 2007). Biologists do not know if numbers on the North Slope or Russia ever declined (USFWS 2005). Spectacled eider numbers on the North Slope counted during annual aerial surveys has indicated a relatively stable population from 1992 to 2011 with an estimated 2011 population index of 7,952 (Larned et al. 2012).

They are not common or abundant in the offshore waters of the northeastern Chukchi Sea but are found there. Avian surveys conducted as part of the CSESP at the Burger Prospect recorded one spectacled eider in the Burger study area in the fall of 2009 (Table 3.6.6-1, Gall et al. 2013).

3.8.2 Steller's Eider

The Alaska breeding population of the Steller's eider was listed as a threatened species under the ESA on 11 June 1997, due to an apparent long-term decline in numbers and a restriction in breeding range. Causes of the decline are unknown but may include predation, over hunting, ingestion of spent lead shot in wetlands, and habitat loss from development (USFWS 2012). Bustnes and Systad (2001) also suggested that Steller's eiders might have specialized feeding behavior that may limit the availability of winter foraging habitat. Steller's eiders could be affected by climate regime shifts that cause changes in prey communities. Critical habitat has been designated for the Steller's eider in breeding areas on the Y-K Delta, staging areas in the Kuskokwim Shoals, and molting areas in waters associated with the Seal Islands, Nelson Lagoon, and Izembek Lagoon in Southwestern Alaska. No critical habitat areas have been designated on the North Slope or in the Chukchi Sea.

Distribution of Steller's Eider

Coastal and offshore areas provide habitat for Steller's eiders. The Alaska-breeding population is primarily confined to the Arctic Coastal Plain of Alaska's North Slope, with a distinguished concentration around Barrow (USFWS 2002c) (Figure 3.8.2-1). The Colville River roughly marks the easternmost limit of the Steller's eider, with the exception of a few individuals observed in the vicinity of Prudhoe Bay (USFWS 2002c; Anderson et al. 2004). Historically, Steller's eiders nested throughout the coastal areas of western and northern Alaska (USFWS 2005).

Important habitat for Steller's eiders includes the Y-K Delta nesting areas and the Kuskokwim Shoals fall molting and spring staging areas (USFWS 2005). On the North Slope, no areas have been designated as critical habitat (USFWS 2005). Nevertheless, the habitat on the North Slope is used for nesting, particularly near the Barrow area (USFWS 2005).

Steller's eiders also use marine waters in the Cape Thompson area where they were documented occupying coastal waters that extended 2.0 mi (3.2 km) from shore (Williamson et al. 1966). Telemetry studies have shown Steller's eiders leaving the Arctic Coastal Plain nesting areas near Barrow on 23 June and moving to coastal marine waters between Wainwright and Dease Inlet between Cape Lisburne and Point Lay (MMS 2006b). Their use of areas as far offshore as the Burger Prospect is probably light to non-existent. Eight individuals were tracked from Barrow across the Chukchi Sea to Siberia and back to Alaska (MMS 2006b). None were observed during six seasons (2008 to 2014) of intensive avian surveys (21,656 mi / 34,851 km of survey transects) conducted as part of the CSESP studies in and around Shell's prospect (Gall and Day 2010, 2011, 2012; Gall et al. 2013).

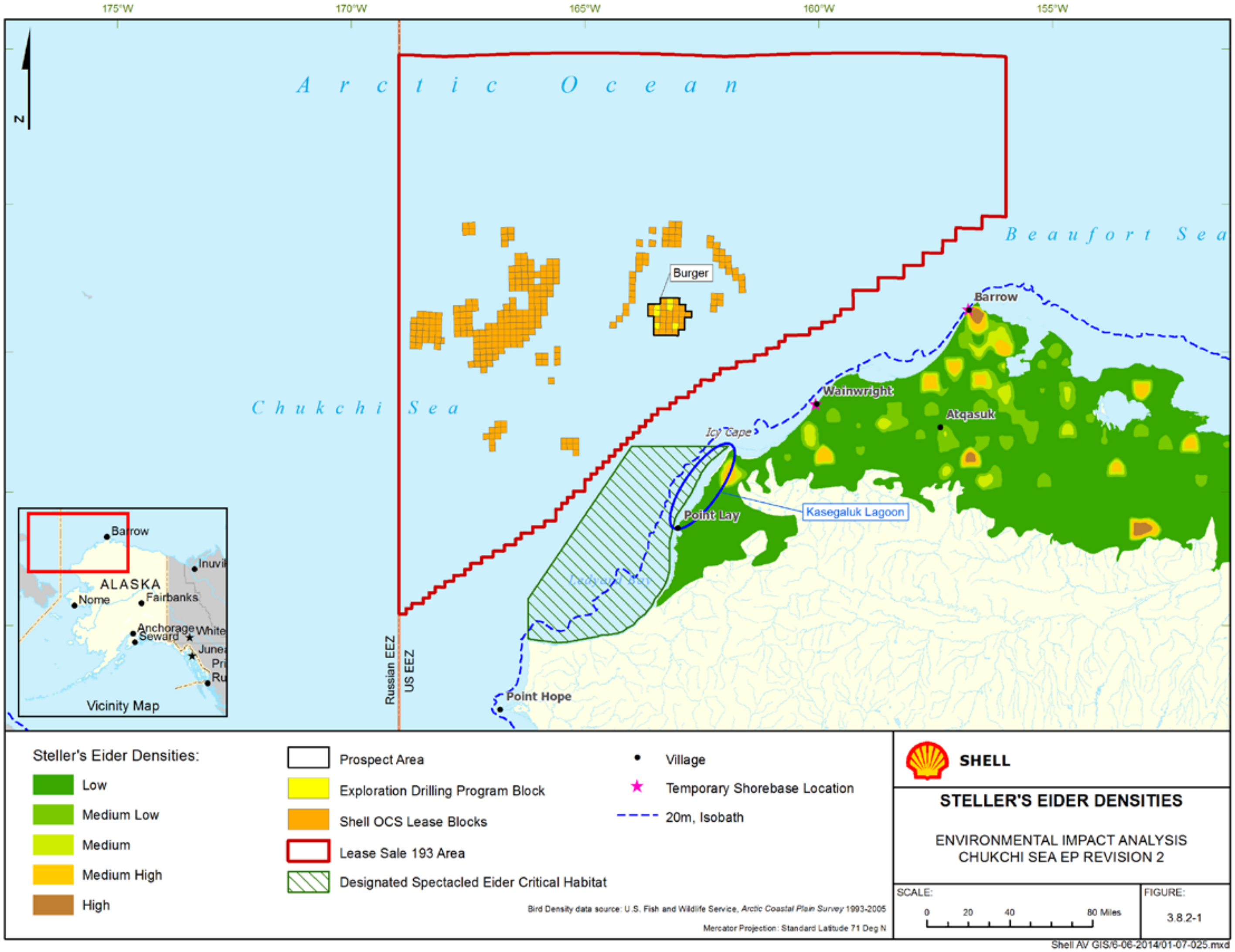
Life History of Steller's Eider

The smallest of the four eider species, Steller's eiders are diving ducks that spend most of their time in shallow, near-shore marine waters where they can reach mollusks and crustaceans (USFWS 2005). Steller's eiders arrive on the nesting areas in Alaska as early as 5 June (Bent 1987 cited in MMS 2006b). Nesting sites include coastal wetland tundra or shallow ponds and lakes well inland (MMS 2006b). Clutch sizes range from 2 to 10 eggs with an average of 5 eggs (Quakenbush et al. 1995 cited in MMS 2006b) and incubation takes about three weeks (Johnson and Herter 1989).

Abundance of Steller's Eider

The threatened Alaska-breeding population is thought to be in the hundreds or low thousands on the Arctic Coastal Plain and in the dozens on the Y-K Delta (USFWS 2002c). Steller's eider numbers have declined in the 1960s-1980s (Kertell 1991 cited in MMS 2006b). Mallek et al. (2007) reported a mean Arctic Coastal Plain population of 780 from 1986 to 2005, with some annual estimates as high as 2,636. Larned et al. (2012) reported that the population was relatively stable from 1992 to 2011 but cautioned the analysis was imprecise due to the low density of observed birds. A low density (0.10/mi^2 [0.04/km^2]) of Steller's eiders was documented using Kasegaluk Lagoon in 1991, but not in 1989 and 1990 (Johnson et al. 1993).

Figure 3.8.2-1 Steller's Eider Densities and Critical Habitat



3.8.3 Polar Bear

The polar bear was listed by USFWS as a threatened species under the ESA on 14 May 2008 (73 FR 28212-2833). The determination, based on the best available science, was that an observed and continuing decline of habitat (sea ice) threatens the polar bear. Polar bears are also protected under the MMPA. Requirements of this act generally prohibit the take or import of marine mammals and their parts or products. They are also protected by international treaties involving countries of the specie's range. Congress passed the United States-Russia Polar Bear Conservation and Management Act of 2006, implementing a treaty with Russia designed to conserve polar bears shared between the two countries.

Distribution of the Polar Bear

Polar bears have a circumpolar range in the Northern Hemisphere. Polar bear distribution is determined largely by seasonal ice that is inhabited by ringed seals, the primary prey of polar bears (Smith 1980), and is therefore highly contingent on the season. Polar bears are found throughout the Lease Sale 193 Area when ice conditions are met as indicated by BWASP/COMIDA/ASAMM survey data (Figure 3.8.3-1). They are found in the area of Shell's Burger Prospect year-round whenever some ice exists. Small numbers of polar bears have been observed during the drilling of most of the past exploration wells in the Chukchi Sea (Table 3.7-2) and when conducting baseline marine mammal surveys near the Burger Prospect (Table 3.7-6).

Life History of the Polar Bear

As ice forms and spreads from the polar pack ice in the fall, polar bears move with it and start to appear along the coast in October (Lentfer 1972). In the winter, polar bears prefer the ice lead system found in the shear zone that occurs between shore-fast ice and active offshore ice. Polynyas are another habitat type that is important to polar bears where these openings are often preferred by seals (Stirling 1997). Polar bears are typically on land only during the winter denning season.

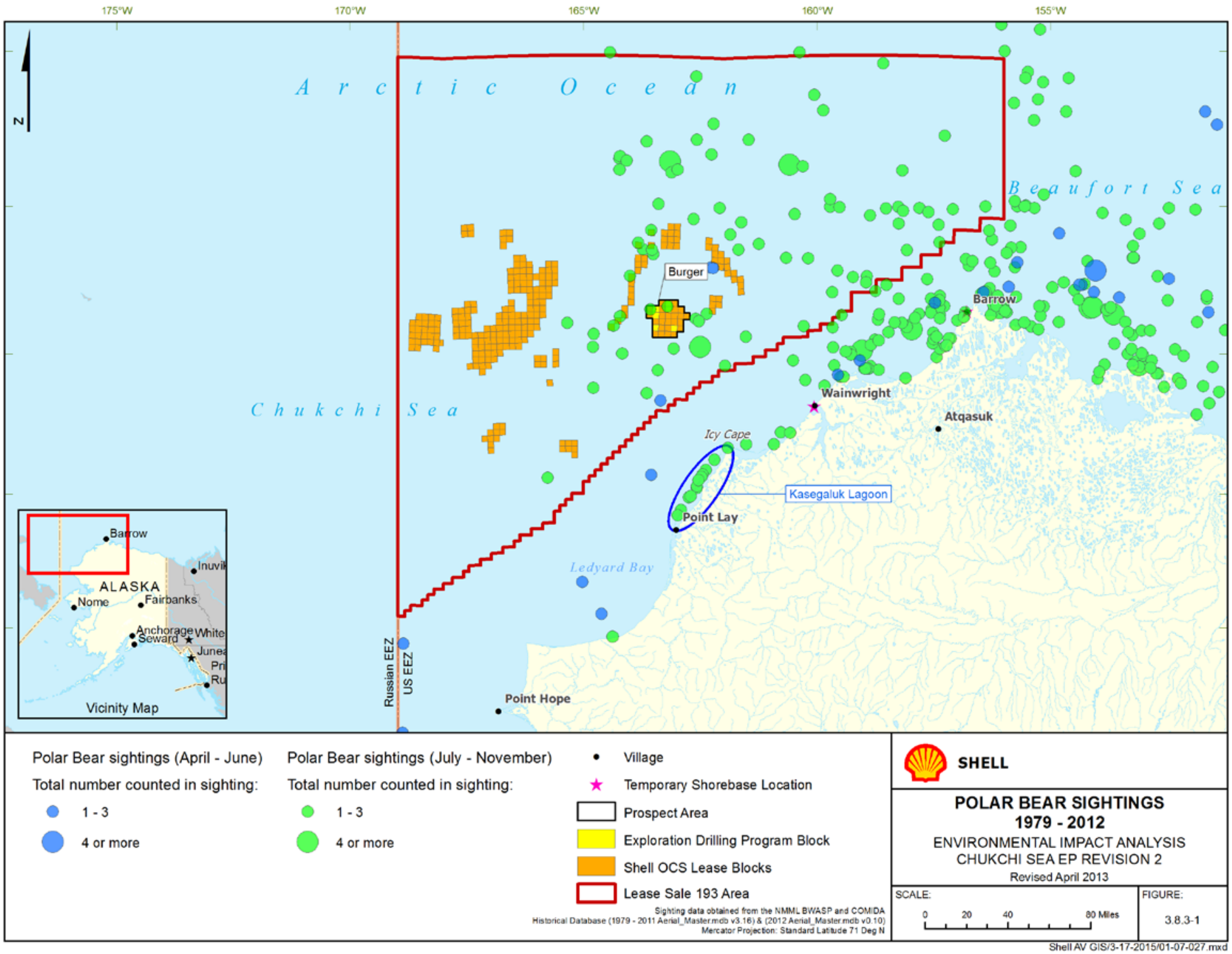
Polar bears require sea ice habitats and use offshore pack ice during the summer; they range more widely in other seasons when they may come ashore, use landfast ice, and hunt along the active flaw zone (Durner et al. 2004). Polar bears select areas of high ice concentration in spring and summer and, generally, are found far offshore as nearshore ice melts, but they return shoreward with rapid ice formation in the fall (Durner et al. 2004). Few polar bears are found on land during summer; most are found along the edge of the permanent pack ice (Frame 1972; Moore and Quimby 1975; Eley and Lowry 1978).

Pregnant females enter dens in October or November to give birth in December or January and emerge in late March or April (Lentfer and Hensel 1980; Amstrup and Gardner 1994). Adult males and non-pregnant females are active year-round and do not use dens (temporary shelters are used during harsh weather). Each year, females tend to return to the same general area to den (Amstrup and Gardner 1994).

Polar bears are the apex predators of the arctic marine ecosystem and specialize in phocid seals (mainly ringed seals). Ringed seal populations have been found to be tied to the natality of polar bears and the survival of subadults (Stirling 2002). When populations of ringed seals declined, polar bear production and subadult survival also declined.

Polar bears have delayed maturation, small litter sizes, and high adult survival rates. Thus, their ability to compete for limited resources is necessary for survival and they rely on a high survival rate to maintain population levels. A female may produce 8-10 cubs in her lifetime, and only half will likely survive (Amstrup 2003). This means that polar bear populations will take time to recover from adverse effects that reduce their numbers.

Figure 3.8.3-1 Polar Bear Sightings 1979-2012



Warming of the climate and associated declines in Arctic sea ice have raised concerns about the conservation of polar bears. A study on polar bears in the southern Beaufort Sea has predicted a high probability of serious declines unless the frequency of bad ice years is less than its recent average. Models have predicted a crash in the population within the next century (Hunter et al. 2007).

Predictions of polar bear habitat distribution were developed to help forecast the consequences of anticipated sea-ice reductions on polar bear populations. Although models predicted net habitat losses in the Polar Basin during the 21st century, losses of polar bear habitat were more modest for the 21st century compared to the period 1985 to 1995. Simulated and projected rates of habitat loss during the late 20th and early 21st centuries tended to be less than observed rates of loss during the past two decades. Although less available habitat will likely reduce polar bear populations, exact relationships between habitat losses and population demographics remain unknown (Durner et al. 2007).

On a range-wide scale, a prototype study forecasted that polar bear populations would decline throughout all of their range during the 21st century. Using projections based on minimal and maximal ice levels, extinction of polar bears in the Polar Basin could occur in 45 to 100 years. Again, declines in ice habitat were the overriding factors that determined all model outcomes. Sea-ice conditions would have to be substantially better than even the most conservative projections to result in a different outcome. A mean loss of about two-thirds of the world's current polar bear population is projected to occur by mid-century (Amstrup et al. 2007).

In 2001 and 2002, survival of adult female polar bears was high when the ice-free periods were relatively short (Regehr et al. 2007). In 2004 and 2005, survival of adult female polar bears was lower during long ice-free periods. In addition, cub-of-the-year survival declined from high rates in the early years of the study to lower rates in the later years of the study (Regehr et al. 2007).

Changes in stature and body mass can affect reproduction and survival and have been shown to be early indicators of changes in status and trends of polar bear populations. Capture-recapture studies between 1982 and 2006 have shown that individual stature and body mass were positively related to the percent of days in which sea ice covered the offshore continental shelf (Rode et al. 2007). The mass, length, skull size, and body condition index of growing males (aged 3 to 10); the mass and skull size of cubs-of-the-year; and the number of yearlings per female in the spring and fall were all related to the number of days the sea-ice cover occurred. These data suggest that polar bears of the southern Beaufort Sea have experienced a declining trend in nutritional status, which may be associated with changing sea-ice conditions (Rode et al. 2007). Changes in sea-ice conditions in the Chukchi Sea are also declining; therefore, declines in nutritional status for the Chukchi/Bering Sea stock of polar bears may be similar to the Beaufort Sea stock.

Nutritional status may also be associated with the increased distances polar bears are traveling to denning areas. Polar bear females returning to Alaska to den have experienced an annual increase in travel, likely due to a reduction in summer sea-ice extent throughout the Arctic (Bergen et al. 2007). Increased travel will likely increase energetic demands on the polar bears.

Abundance of Polar Bears

Lunn et al. (2002) estimated the polar bear worldwide population to be 21,500 to 25,000. The polar bear population in Alaska is considered to consist of two stocks, the Chukchi/Bering Sea stock and the southern Beaufort Sea stock, although there is considerable overlap between the two stocks (Amstrup et al. 2005). The two populations overlap between Point Hope and Point Barrow (Amstrup 1995). In 2001, the southern Beaufort Sea stock was estimated at 2,200 bears (USFWS 2010c). There currently is no reliable estimate for the Chukchi/Bering Sea stock, but it is thought to contain at least 2,000 animals (Aars et al. 2006; USFWS 2010b).

Past observations indicate that small number of polar bears may be found in the Burger Prospect area when sea ice is present. Small numbers of polar bears were observed in the area during the drilling of most of the past exploration wells in the Chukchi (Table 3.7-2).

A total of 41 polar bears have been observed in all study areas (not only the Burger Prospect) over the six seasons of marine mammals surveys conducted for CSESP (Brueggeman 2009a,b, 2010; Aerts et al. 2011, 2012, 2013, 2014). Thirty-two of the observed polar bears were on ice and the remaining nine were sighted in the water; all of these observations occurred when sea ice was present (Aerts et al. 2013,2014). In 2013 five polar bears were observed in the Burger study area (Aerts et al. 2014).

Polar Bear Critical Habitat

USFWS published a final rule on 7 December 2010 designating critical habitat for the threatened polar bear, effective 6 January 2011 (75 FR 76086-76137); however, on 10 January 2013 the U.S. District Court for the District of Alaska, vacated and remanded the Final Rule to USFWS. There is currently no designated critical habitat for polar bears.

3.8.4 Bowhead Whale

The bowhead whale is federally designated as endangered and is an Alaska Species of Special Concern.

Distribution of Bowhead Whales

Of the five designated stocks of bowhead whales in the world, only the Western Arctic stock is found within U.S. waters where it is distributed seasonally in ice-covered waters of the Arctic and near-Arctic, generally between 60° and 75° north latitude (Moore and Reeves 1993). The majority of these whales winter in the central and northwestern Bering Sea (November to March), migrate (Figure 3.8.4-1) through the Chukchi Sea in the spring (March to June) following offshore ice leads, and summer in the Canadian Beaufort Sea (mid-May through September) (Braham et al. 1980; Moore and Reeves 1993). All of the planned drill sites in Shell’s Burger Prospect are located seaward of the generalized spring migration route (Figure 3.8.4-1).

In the fall bowheads migrate westward along the U.S. Beaufort Sea coast across the Chukchi Sea to Russian waters and then south through the Bering Strait to the Bering Sea (Figure 3.8.4-1) (Citta et al. 2012). The EP lease blocks in Shell’s Burger Prospect are located within the generalized fall migration route (Quakenbush et al. 2010). Bowhead whales typically reach the Barrow area following their westward migration in mid-September to late-October. The start of migration into and through the Chukchi Sea is about 25 September (LGL 2007). In 2006, the main part of the bowhead migration at Point Barrow ended by 25 October (LGL 2007). During migration, pods travel in pulses (Ljungblad et al. 1986). Traditional Knowledge of Iñupiat residents indicates that these migration pods are segregated by sex and age (Braham et al. 1980). Most bowheads migrate west in water ranging from 49 to 660 ft (15 to 200 m) deep (Miller et al. 2002); some individuals enter shallower water, particularly in light ice years, but very few whales are ever seen shoreward of the barrier islands. Ice cover influences the timing, duration, and path that the whales follow (Treacy 2002). During years with higher-than-average ice coverage, bowheads tend to migrate in deeper water farther offshore (Moore 2000).

Figure 3.8.4-1 Bowhead Whale Seasonal Movements

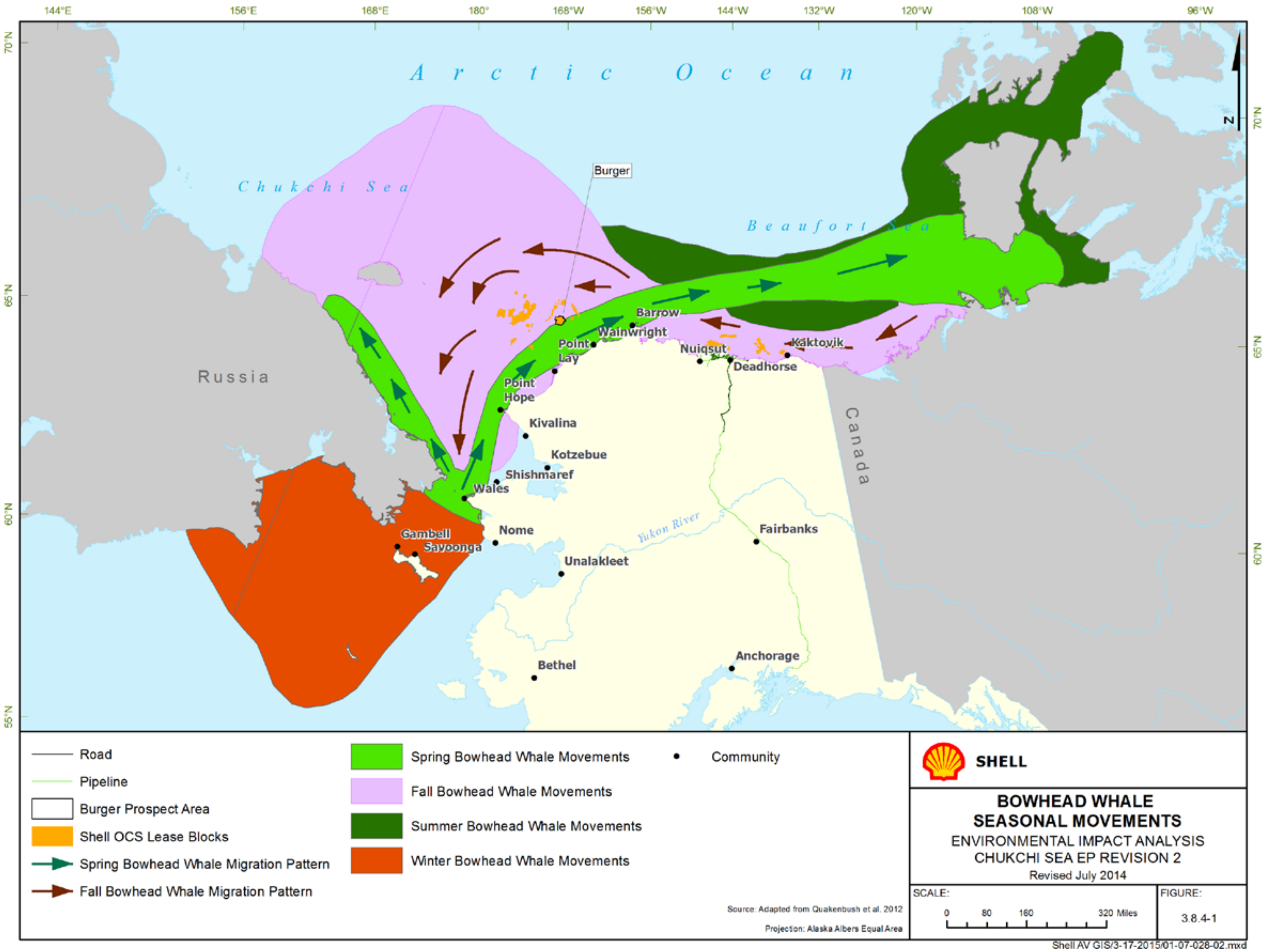


Figure 3.8.4-2 Bowhead Whale Sightings 1979-2012

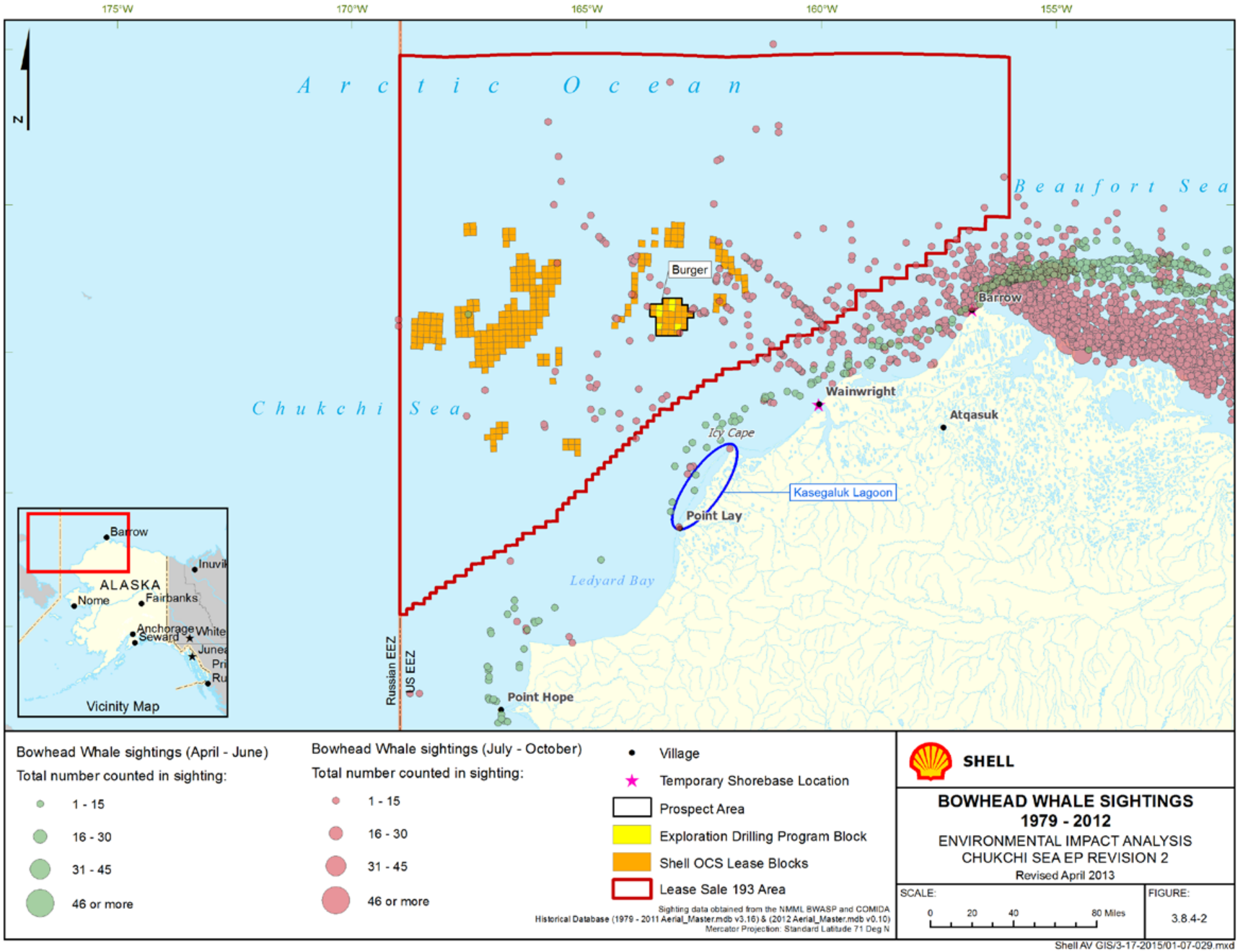
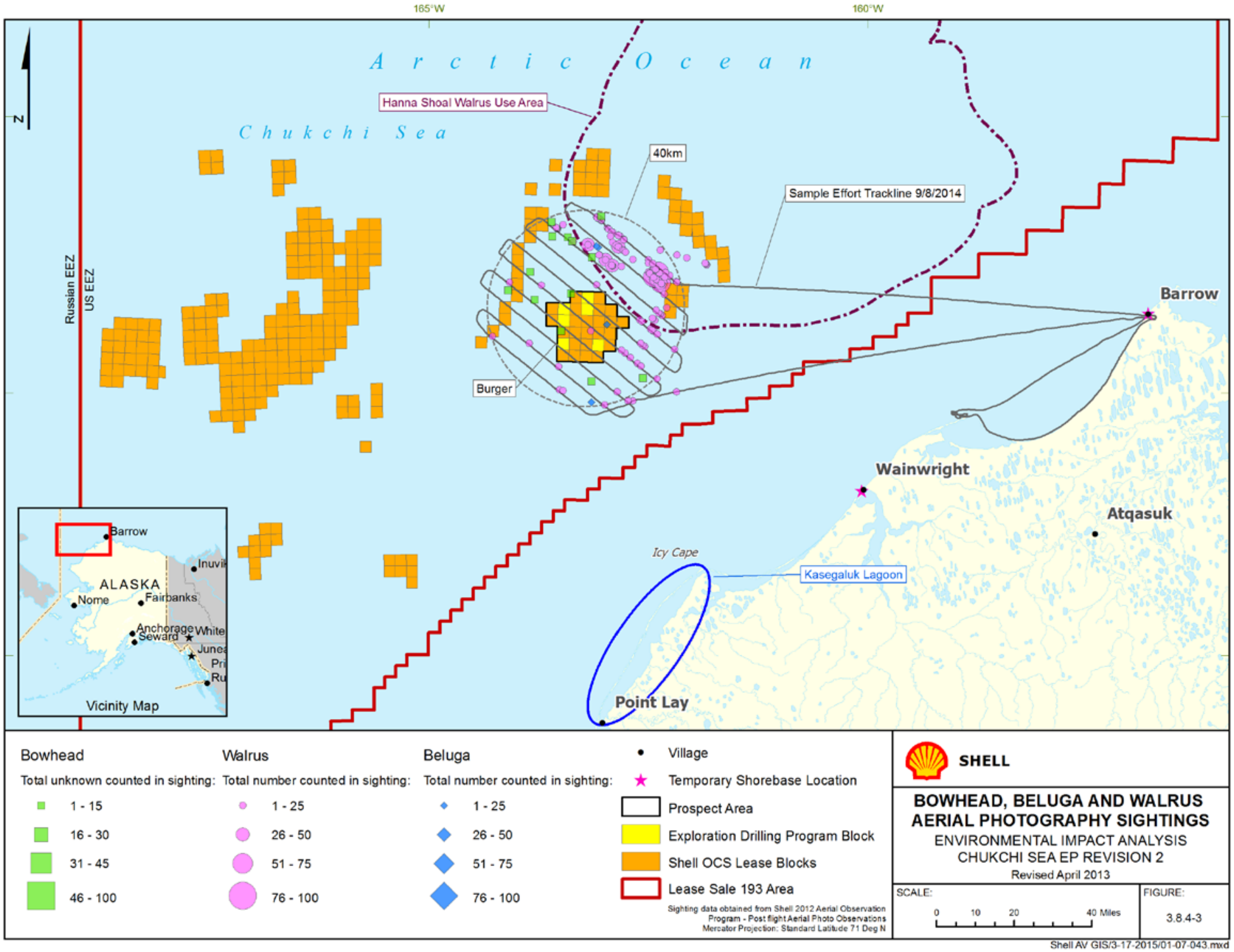


Figure 3.8.4-3 Bowhead ,Beluga and Walrus Aerial Sightings



BWASP/COMIDA/ASAMM survey data indicate the bowhead is found throughout the Lease Sale 193 Area, including the areas near Shell's Burger Prospect, at certain times (Figure 3.8.4-2). Depending on ice conditions and the date, bowheads may be found within the prospect. Funk et al. (2011b) and Bisson et al. (2013) observed very small numbers of bowheads in this portion of the Chukchi as early as July during dedicated vessel marine mammal surveys associated with Shell's seismic and drilling programs (Table 3.7-3). Bowheads were also observed in the Burger Prospect during baseline marine mammal surveys conducted as part of the CSESP in 2008-2012 (Brueggeman 2009a and 2010; Aerts et al. 2013). Results from the survey conducted in 2013 were not final at the time this analysis was prepared. Similar studies are planned for 2014 in a reduced study area encompassing the Burger prospect and shoreward locations. In 2012, Shell also conducted an offshore aerial survey over the Burger Prospect utilizing high definition cameras (Bisson et al. 2012). Figure 3.8.4-3 presents sightings from the aerial survey.

Life History of Bowhead Whales

Bowhead whales are large baleen whales that feed primarily on copepods and euphausiids (Lowry 1993; Lowry and Sheffield 2002). In order to satisfy energy requirements, it is likely that bowheads must find areas with above-average concentrations of zooplankton (Lowry 1993). Bowhead whales are long-lived, slow-growing, late-maturing, and reproduce infrequently (Koski et al. 1993). Females become sexually mature at approximately 46 ft (14 m) in length; although a few become sexually mature by the time they are 43 ft (13 m) long. It is believed that males become sexually mature when they reach 39-43 ft (12-3 m) in length, although this needs to be confirmed (Koski et al. 1993). Bowheads mate and calve during spring migration (Nerini et al. 1984). Calving occurs every three to four years (Koski et al. 1993). The majority of bowhead whale mating occurs in March and April (IWC 2004). Gestation lasts between 12 and 16 months (Nerini et al. 1984) and most calving occurs between March and August (Koski et al. 1993).

Abundance of Bowhead Whales

In the late 19th and early 20th Centuries, the Western Arctic stock of bowhead whales was greatly reduced by commercial whaling from an estimated population of 10,400 to 23,000 in 1848 to 1,000 to 3,000 near the end of commercial whaling (Woodby and Botkin 1993). The 1993 population was estimated at 8,200, with a 95 percent probability that the population was between 7,200 and 9,400 (Zeh et al. 1995, IWC 1996). The Western Arctic stock is by far the largest of the five remnant populations worldwide but is classified as depleted under the MMPA (Allen and Angliss 2012). The Western Arctic stock numbered an estimated 10,470 in 2001 (George et al. 2004). Allen and Angliss (2012) provided a minimum population estimate for this stock bowhead whales of 9,472. Despite regulated harvest by subsistence hunters, the population slowly increased at an annual rate of 3.4 percent between 1978 and 2001 (George et al. 2004). Calf counts in 2001 were the highest on record at 121 individuals, lending evidence of a growing population (George et al. 2004). The most recent abundance estimate accepted by the International Whaling Commission is 12,631 and is the result of a photographic survey completed in 2003-2004. (Koski et al. 2010; IWC 2010). Most recently, Givens et al. (2013) estimated the population to be 16,892 individuals in 2011. Assuming a continuing annual population growth of 3.7 percent (Givens et al. 2013), the 2015 Bering-Chukchi-Beaufort Sea bowhead population may number around 19,534 animals.

Some reports (Shelden et al. 2001; IWC 2004; IWC 2005) suggest the Western Arctic stock of bowhead whales are now approaching the lower limit of the historical (pre-industry whaling) population size, and some have suggested removing Bering-Chukchi-Beaufort Sea bowhead whales from the T&E species list (Gerber et al. 2007).

Bowheads are fairly common in the area of Shell's Burger Prospect, but found in small numbers. They were the second most commonly observed cetacean, second to the gray whale, in this area of the northeastern Chukchi Sea during marine mammal monitoring associated with seismic surveys in 2006-2013 (Table 3.7-3). No bowhead whales were observed during monitoring surveys (Brueggeman et al.

1990, 1991b) conducted near exploration drilling in the Burger, Crackerjack, Klondike, and Popcorn Prospects in 1989 and 1990 (Table 3.7-2). During six seasons (2008-2012) of vessel-based marine mammal surveys conducted for the CSESP, two were observed in the Burger Prospect study area in 2008, three in 2009, 28 in 2010, eight in 2011, 14 in 2012, and 8 in 2013 (Aerts et al. 2013, 2014). A total of 220 bowheads were observed over the six seasons in the larger CSESP study area (Aerts et al. 2013, 2014) (Table 3.7-6). Small numbers of bowheads may be found in the Burger Prospect during Shell's planned exploration drilling program. Shell's Burger Prospect is located seaward of most of the generalized spring migration route for the Western Arctic stock of bowhead whales. Figure 3.8.4-1 shows bowhead whale seasonal movements. In the fall bowheads migrate westward along the U.S. Beaufort Sea coast across the Chukchi Sea to Russian waters and then south through the Bering Strait to the Bering Sea (Figure 3.8.4-1) (Citta et al. 2012). The EP lease blocks in Shell's Burger Prospect are located within the generalized fall migration route (Quakenbush et al. 2010).

Bowheads were the second most commonly observed cetacean (second to the gray whale) in this area of the northeastern Chukchi Sea during marine mammal monitoring associated with exploration activities in 2006-2012 (Table 3.7-3 above). A total of 220 bowheads were observed over all CSESP study areas during the six seasons of vessel-based marine mammal surveys, 63 in the Burger Study Area, which encompasses the Burger Prospect (Table 3.8.4-1). Bowhead whales were only sighted twice in the Burger Study Area in 2008 and 2009, but were the most commonly observed cetaceans in 2010-2013. In 2008–2010, bowhead whales were only observed during their fall migration (late September or October), but bowheads were observed throughout the months of August and September in 2011 and 2012. These data indicate that small numbers of bowheads may be found in the Burger Prospect during Shell's planned exploration drilling program.

Table 3.8.4-1 Bowhead Whale Sightings in the CSESP Burger Study Area

Year	Sightings and Sighting Rates in the CSESP Burger Study Area [1,2]			
	Sightings	**Individuals**	**Sightings/100 mi**	**Sightings/100 km**
2008	2	2	0.116	0.072
2009	2	3	0.117	0.073
2010	19	28	1.093	0.679
2011	5	8	0.666	0.414
2012	13	14	1.83	1.136
2013	7	8	0.823	0.51

[1] Source: Aerts et al. 2013, 2014
[2] Includes only whales observed on transects

3.8.5 Fin Whale

The fin whale is listed as endangered under the ESA of 1973, and therefore designated as depleted under the MMPA.

<u>Distribution of the Fin Whale</u>

Published range maps indicate the Alaska stock of fin whales is restricted to the Gulf of Alaska and the Bering Sea in U.S. waters, and the southwestern Chukchi along the Russian coast (Allen and Angliss 2012). They are therefore considered to be extralimital in the Lease Sale 193 Area. However, they have recently been observed in the Lease Sale 193 area (Funk et al. 2011b), and their range may be expanding.

One fin whale was observed in the Lease Sale 193 Area while monitoring from a project support vessel during 2012 exploration drilling operations. Four groups totaling seven fin whales were observed during the monitoring program for recent seismic surveys (Table 3.7-3 above), and they have been detected acoustically in the area in 2007 and 2009 (Hannay et al. 2009; Martin et al. 2008; Delarue and Martin 2009). While no confirmed fin whale calls were detected during summer 2012, several low-frequency sounds were believed to be from fin whales. Seven sightings of fourteen fin whales were recorded in off-transect areas (Figure 3.0-1) while conducting the CSESP vessel-based marine mammal surveys during August through October 2008-2012 (Aerts et al. 2013). All fin whale sightings during CSESP were recorded during transit between Nome and the study areas. Fin whales could potentially occur in the Burger Prospect during the planned exploration drilling program but would not be expected.

Life History of the Fin Whale

Fin whales are baleen whales that feed on euphausiids and other small schooling organisms. They are dark gray on their dorsal side and light-colored on their ventral side. Fin whales become sexually mature between the ages of six and twelve. Breeding occurs in the winter, and a single calf is born approximately every two years. Weaning occurs after six months.

Abundance of the Fin Whale

There is currently no reliable estimate of abundance for the northeast Pacific stock of fin whales. In 1994, a survey of fin whales was conducted south of the Aleutian Islands (Forney and Brownell 1996). A 1999-2000 survey (Moore et al. 2002) provided a provisional estimate of 3,368 fin whales in the central and southeastern Bering Sea. A population estimate could not be made, because the entire extent of their range was not surveyed. In another estimate, it is thought that there are at least 5,700 fin whales in Alaska waters west of the Kenai Peninsula, including the Bering Sea (Allen and Angliss 2012).

Fin whales could occur in the Burger Prospect during the planned exploration drilling program but would not be expected. No fin whales were sighted in the area (Table 3.7-2) during marine mammal monitoring surveys (Brueggeman et al. 1990, 1991b) conducted near the Burger Prospect when exploration wells were drilled in 1989 and 1990. No fin whales were observed while conducting baseline marine mammal surveys for the CSESP near the Burger Prospect during August and October 2008-2013 (Brueggeman 2009a, 2010; Aerts et al. 2011, 2012, 2013, 2014).

3.8.6 Humpback Whale

The humpback whale is listed as endangered under the ESA and designated as depleted under the MMPA.

Distribution of Humpback Whales

Humpback whales are migratory. Most of the humpback whales that are found in Alaska are thought to winter in Hawaii or along the coast of Mexico (Allen and Angliss 2012). In Alaska, their range includes the Gulf of Alaska, the Aleutians, the Bering Sea, and the southwestern Chukchi Sea (Allen and Angliss 2012), but recent observations of humpbacks have been reported in the northeastern Chukchi Sea and the Beaufort Sea. A few have been observed in the northeastern Chukchi Sea during monitoring for seismic surveys (Funk et al. 2011b; Bisson et al. 2013), during COMIDA aerial surveys in the Chukchi Sea, and (Clarke et al. 2011; Clarke et al. 2013; Clarke et al. 2014; Green et al. 2007) documented an occurrence in the Beaufort Sea.

Life History of Humpback Whales

Humpback whales feed mainly on euphausiids and other small schooling organisms. They use baleen to capture large amounts of prey, and they also cooperate with other individuals in a process called “bubble netting” in order to maximize their prey capture. Humpback whales are black with some white markings on their ventral surface. They have several fleshy knobs located on the rostrum, and their flippers are as long as one third of their body length.

Abundance of Humpback Whales

Currently, there is not a reliable abundance estimate of the north Pacific stock of humpback whales, because surveys conducted to date are incomplete in their coverage (Angliss and Outlaw 2008; Allen and Angliss 2012). Recent estimates of 9,000-14,000 have been suggested for humpbacks in the Bering Sea, Aleutians, and Gulf of Alaska. Few humpbacks are probably found in the northeastern Chukchi Sea, where they seem to be extending their range. Seventeen humpback whales were observed over a seven-year period of conducting vessel-based marine mammal monitoring for seismic surveys and drilling activities in the northeastern Chukchi Sea (Table 3.7-3; Funk et al. 2011b, Bisson et al. 2013). No humpback whales were sighted in the area during marine mammal surveys conducted during drilling of the historic Burger Prospect in 1989 and 1990 (Brueggeman et al. 1990, 1991b), and no humpback whales were observed in the CSESP study areas while conducting baseline marine mammal surveys for the CSESP during August and October 2008-2013 (Aerts et al. 2013, 2014).

These data indicate that while it is possible that one or two humpback whales could occur in the Burger Prospect during the planned exploration drilling program, that event is unlikely. A few humpback whales have been observed in the northeastern Chukchi Sea during monitoring for seismic surveys (Funk et al. 2011b; Bisson et al. 2013), and during COMIDA aerial surveys in the Chukchi Sea (Clark et al. 2011). Humpback whales could potentially occur in the Burger Prospect during the planned exploration drilling program but would not be expected.

3.8.7 Ringed Seal

The range of the ringed seal is circumpolar with five subspecies being recognized, the Arctic ringed seal (*Phoca hispida hispida*), the Baltic ringed seal (*Phoca hispida botnica*), the Okhotsk ringed seal (*Phoca hispida ochotensis)*, the Ladoga ringed seal (*Phoca hispida ladogensis*), and the Saimaa ringed seal (*Phoca hispida saimensis*).

On 28 December 2012, NMFS published a final rule listing the Arctic, Okhotsk, and Baltic subspecies as threatened and the Ladoga subspecies as endangered under the ESA (77 FR 76706-76738 December 28, 2012). The only subspecies that occurs in the northeastern Chukchi Sea is the Arctic subspecies. NMFS proposed critical habitat for the Arctic ringed seal in the northern Bering, Chukchi, and Beaufort Seas off of Alaska in December 2014.

A detailed comprehensive description of the distribution, life history, and abundance of ringed seals is included in the status review of the ringed seal recently published by the NMFS (Kelly et al. 2010). In 2000, the annual estimated subsistence take from Alaska of ringed seals was 9,567 (ADF&G 2000).

Distribution of Ringed Seals

The ringed seal is the most common and widespread seal in the Arctic Ocean and adjacent seas. Observations of ringed seals made incidental to BWASP/COMIDA/ASAMM surveys (Figure 3.7.1-1) indicate the ringed seal is found throughout the Lease Sale 193 Area, including the Burger Prospect. Throughout their range, ringed seals have an affinity for ice-covered waters and are well adapted to occupying seasonal and permanent ice. They are year-round residents throughout the Beaufort, Chukchi, and Bering Seas, and range as far south as Bristol Bay in years of extensive ice coverage. Ringed seals prefer shore fast ice until it disappears for the summer. They tend to prefer large floes greater than 160 ft (48 m) in diameter and are often found on the interior ice pack where the sea ice coverage is greater than 90 percent (Simpkins et al. 2003). Ringed seals are known to follow the advance and retreat of the pack ice edge (Burns 1970), but little else is known about their migration (Allen and Angliss 2012).

History of Ringed Seals

The ringed seal is the smallest pinniped present off the coast of Alaska, weighing up to 150 lb (68 kg) and reaching 5 ft (1.5 m) in length. Ringed seals give birth between mid-March and April and nurse for five to eight weeks in subnivean lairs. These lairs are excavated in the snow around breathing holes on landfast ice or the ice pack and have been known to have multiple chambers that are used for thermal regulation and as a physical barrier between pups and predators (Smith et al. 1991). Polar bear predation is high during the time females and pups are in the lairs (Smith 1980). The breathing holes are spaced about 0.62 to 1.2 mi (1 to 2 km) from each other, limiting the seals' range. Approximately four weeks after pupping, mating occurs. Ringed seals exhibit delayed implantation of the embryo until later in the summer.

The primary food sources for ringed seals are Arctic cod, saffron cod, shrimp, amphipods, and euphausiids (Reeves et al. 1992). Ringed seals are a primary prey for both polar bear and arctic fox. It has been speculated that higher seal densities on smooth ice could come from the relative ease of predator detection there compared to ice with greater deformities (Frost et al. 2002). There is a positive correlation between lack of maternal experience and increased predation by polar bears (Eley 1994a).

Abundance of Ringed Seals

Between 1996 and 1999, Frost et al. (2004) conducted aerial surveys to assess the effects that environmental covariates (water depth, relative distance from the fast ice edge, and quality of the ice) had on ringed seal counts. They determined that the densities were highest in intermediate water depth of 16 to 115 ft (5-35 m) and areas of smooth ice nearest to the edge of the fast ice (Frost et al. 2004). Seals tend to be widely distributed over the ice during the winter months, but as the spring breakup period begins, densities increase toward the ice edge and decrease inshore from the ice edge (Moulton et al. 2002). This could be strictly due to seals moving outward toward the ice edge or it could be due to the added effect of an influx of seals looking for new haulout areas during this time. Marine mammal monitoring while drilling historical exploration wells in the Chukchi Sea have shown up to 22 ringed seals in the area of a single well site (Table 3.7-2). The distribution of ringed seal sightings that occurred during BOEM's BWASP/COMIDA/ASAMM survey are presented in Figure 3.7.1-1.

A reliable estimate of the number of ringed seals in Alaska does not exist (Allen and Angliss 2012) partly because there is variability in the proportion of seals hauled out and visible compared to those not visible across survey efforts (Frost et al. 2002). Bengston et al. (2005) reported an average estimate of 230,673 for ringed seals in the Chukchi Sea in 1999 and 2000. This estimate incorporated a correction factor for seals that were not hauled out during the survey. Kelly et al. (2010) reviewed available information on the abundance of ringed seals and concluded that 1,000,000 is a reasonable estimate of the total population in the Beaufort and Chukchi Seas.

Observers aboard Shell vessels in 2006-2012 recorded a total of 1,404 ringed seals in the northeastern Chukchi Sea while monitoring seismic surveys and drilling activities (Table 3.7-3), and 55 were observed during seismic, geophysical, and geotechnical surveys conducted just north of the Burger Prospect in 2010 and 2011 (Tables 3.7-4 and 3.7-5). A total of 311 were observed in July-October 2008-2012 during the CSESP baseline marine mammal surveys (Table 3.7-6) (Aerts et al. 2013). Eight ringed seals were observed within the monitoring area when the historic Burger well was drilled in 1989-1990 (Table 3.7-2). It is likely that some ringed seals will occur in the Burger Prospect during the planned exploration drilling program.

Densities of seals in the prospect area calculated from CSESP marine mammal surveys for 2008-2013 are provided in Table 3.8.7-1. It is likely that some ringed seals will occur in the Burger Prospect during the planned exploration drilling program. Sighting rates in the CSESP study areas are provided above in Table 3.7-7; ringed seal sighting rates varied from 0.0 to 0.01 ringed seals/km.

Table 3.8.7-1 Seal Densities in the CSESP Burger Study Area 2008-2011 [1,2,3]

Study Area	Year	Ringed/Spotted Seal		Bearded Seal		Ratio	
		Seals/mi^2	Seals/km^2	Seals/mi^2	Seals/km^2	Ringed/Spotted	Bearded
Burger	2008	0.127	0.049	0.096	0.037	57%	43%
	2009	0.083	0.032	0.036	0.014	70%	30%
	2010	0.041	0.016	0.083	0.032	33%	67%
	2011	0.070	0.027	0.060	0.023	55%	45%
	2012	ND	ND	ND	ND	ND	ND

[1] Source: Aerts et al. 2012 for 2008-2011 data
[2] Densities for ringed and spotted seals are combined as in many observations the species cannot be determined
[3] ND = similar data presentation was not provided in 2012 or 2013 annual report

3.8.8 Bearded Seal

The bearded seal (*Erignathus barbatus*) is a circumpolar ice-associated seal, with two widely recognized subspecies, one (*Erignathus barbatus barbatus*) inhabiting the Atlantic sector of the species range, and the other (*Erignathus barbatus nauticus*) occupying the Pacific sector (Rice 1998). NMFS (Cameron et al. 2010) conducted a status review of the bearded seal, in which the Biological Review Team further delineated the subspecies found in the Pacific sector into an Okhotsk DPS and a Beringia DPS, the Okhotsk DPS being found in the Sea of Okhotsk and the Beringia DPS being found in the Bering, Chukchi, and Beaufort Seas. NMFS subsequently promulgated a final rule to list the Beringia DPS and the Okhotsk DPS of bearded seals as threatened throughout their ranges under the ESA on 28 December 2012 (77 FR 76739-76768), but that decision was recently vacated and remanded to the agency in a judicial decision (*Alaska Oil and Gas Association v. Frank Pritzker, et al.*, 4:13-cv-00018-RRB – 1). For the purposes of this analysis, the bearded seal is treated as a candidate species for listing under the ESA.

<u>Distribution of Bearded Seals</u>

The range of the bearded seal in Alaska extends from the Bering Sea north through the Chukchi and Beaufort Seas (Burns 1981b). They are strongly associated with the pack ice edge near the continental shelf, staying near mobile pack ice (Burns 1967), and migratory following the retreat and advance of the seasonal pack ice north and south across the Chukchi Sea and northern Bering Sea (Nelson et al. 1985). However, they generally avoid regions of continuous thick shorefast ice (Burns and Frost 1979). The distribution of bearded seals is dictated by the presence of ice, and they prefer water depths of less than 660 ft (200 m) (Burns 1981b). They are found throughout the Lease Sale 193 Area as indicated by BWASP/COMIDA/ASAMM survey data (Figure 3.7.1-1).

<u>Life History of Bearded Seals</u>

The bearded seal is the largest of the northern seals, weighing up to 750 lb (340 kg). The average length of adults is about 7.9 ft (2.4 m) (Eley 1994b). They feed mainly on benthic invertebrates, including crabs, shrimp, clams, and snails (Burns 1994b).

Similar to ringed seals, bearded seals sometimes create and maintain breathing holes (Burns and Frost 1979). Males defend aquatic territories and have shown a high degree of site fidelity, where they return to the same territories from year to year (Van Parijs and Clark 2006). Males also put on displays of diving and individually unique vocalizations to attract females (Van Parijs and Clark 2006).

Bearded seals give birth to a single pup on drifting ice floes near the pack ice edge between mid-April and mid-May (Burns 1981b). Pups weigh an average of 75 lb. (34 kg) at birth (Eley 1994b) and are born in an advanced developmental state and often enter the water shortly after being born (Watanabe et al. 2009; Lydersen et al. 2002). Pups have been reported entering the water within 24 hr of being born, and begin foraging within their first or second week of life. Unlike other ice seals in the Arctic, bearded seal pups shed their lanugo coat in utero and only remain on the ice for a day or so after being born (Burns 2009).

Mother bearded seals usually abandon their young after a 12 to 24 day nursing period (Burns 1981b, 2009; Kovacs et al. 1996) leaving their offspring to fend for themselves. The female mates soon after the pup is weaned (usually at two months) (Eley 1994b). Bearded seals utilize delayed implantation, where embryo development is put on hold for approximately two and a half months (Eley 1994b).

Abundance of Bearded Seals

A reliable estimate of the Alaska stock of bearded seals is not available (Allen and Angliss 2012). Recent surveys conducted from May to June of 1999 and 2000 found densities of 0.03 and 0.05 seals/mi^2 (0.07 and 0.14 seals/km^2), respectively (Bengston et al. 2005). However, these density estimates cannot be used to calculate a population estimate, because no correction factor is available. Earlier estimates of the Bering Sea and Chukchi Sea population ranged from 250,000 to 300,000 bearded seals (Burns 1981b). More recent estimates of the Beringia DPS are approximately 155,000 bearded seals (Cameron et al. 2010).

The occurrence of bearded seals is common and regular throughout the Chukchi Sea, including the area of Shell's Burger Prospect. PSOs aboard industry vessels recorded a total of 945 bearded seals in the northeastern Chukchi Sea while monitoring seismic surveys and drilling activities in 2006-2012 (Table 3.7-3 above), and 189 bearded seals were observed during 2010 and 2011 seismic, geophysical and, geotechnical surveys just north of the Burger Prospect (Tables 3.7-4 and 3.7-5). A total of 943 were observed in July-October 2008-2013 during the CSESP baseline marine mammal surveys in the Chukchi Sea (Table 3.7-6 above) (Aerts et al. 2013, 2014). Calculated bearded seal densities in the Burger Study Area were 0.036-0.096 / mi^2 (0.014-0.037 / km^2) during the 2008-2012 CSESP surveys (Table 3.8.8-1); sighting rates from those surveys are provided below in Table 3.8.8-1. Eleven bearded seals were observed within the monitoring area when the historic Burger well was drilled in 1989-1990 (Table 3.7-2). These data indicate that is likely that some bearded seals will occur in the Burger Prospect area during the planned exploration drilling program.

Table 3.8.8-1 Bearded Seal Sightings in the CSESP Burger Study Area 2008-2013

Year	Sightings and Sighting Rates in the Burger Study Area [1]			
	Sightings	Individuals	Sightings/1,000 mi	Sightings/1,000 km
2008	44	45	25.7	16.0
2009	25	26	11.3	7.0
2010	37	37	20.9	13.0
2011	9	9	11.3	7.0
2012	41	41	57.9	36.0
2013	59	68	--	--
2008-2012	156	158	24.9	15.5

[1] Source: Aerts et al. 2013, 2014

[2] Sighting rates were not provided in the 2013 annual report

3.8.9 Pacific Walrus

Two subspecies of walruses (*Odobenus rosmarus*) are recognized, the Atlantic walrus (*O. r. rosmarus*) and the Pacific walrus (*O. r. divergens*). The two subspecies occur in geographically isolated populations. The Pacific walrus is the only form occurring in U.S. waters, and is the only subspecies described below. USFWS received a petition on 8 February 2008, requesting that they list the Pacific walrus as a T&E species and designate critical habitat. On 8 September 2009, USFWS announced their 90-day finding on the petition, finding that the petition presented substantial scientific information indicating that the listing of the Pacific walrus, and announced their initiation of a status review (74 FR 46548-46551). On 10 February 2011 (76 FR7634-7679) the USFWS announced a 12-month finding in which they found that listing of the Pacific walrus (but not the Atlantic walrus) as a T&E species was warranted, but was precluded by higher priority actions. The announced finding currently gives them candidate species status under the ESA. Walruses are still harvested by Alaska Natives near the Chukchi Sea coast. Mean annual subsistence harvest is about 5,458 walruses (USFWS 2006a).

Distribution of Pacific Walruses

Pacific walruses are found throughout the continental shelf waters of the Bering and Chukchi Seas, and they occasionally move into the East Siberian and Beaufort Seas. Walruses, particularly females and calves, are often found moving with the pack ice year-round. In the winter, they are found in the Bering Sea, and in the summer, they are found throughout the Chukchi Sea (Figure 3.8.9-1) (USFWS 2010a). However, their range varies with the extent of sea ice. A few walruses may move as far east as the Canadian Beaufort Sea during the open water season, but most are found west of Barrow along the pack-ice front (MMS 2003a).

Spring migration usually begins in April, with most walruses moving north through the Bering Strait by late June. Most early spring migrants are females with calves. During migration, walruses exhibit gender segregation (Fay 1982), with most females, sub adults, and calves going to the Chukchi Sea, and most males going to Bristol Bay and the Gulf of Anadyr (Jay and Hills 2005). Walruses begin to migrate south with the advance of pack ice during the fall.

Walruses haul out of the water to rest and bear young when they are out of the water. They typically spend one-third of their time hauled out on land or ice. Traditional haulout sites along the Chukchi Sea coast are at Cape Thompson, Cape Lisburne, Icy Cape (MMS 2007b), and, more recently, Chukotka (Ovsyanikov 2003). In 2009-2011 and in 2013 walruses concentrated in large haul outs, that at times exceeded 20,000, near Point Lay in late August through September (Jay et al. 2012; Clarke et al. 2014). Walruses were not observed hauled out on the Chukchi Sea coast during 2012.

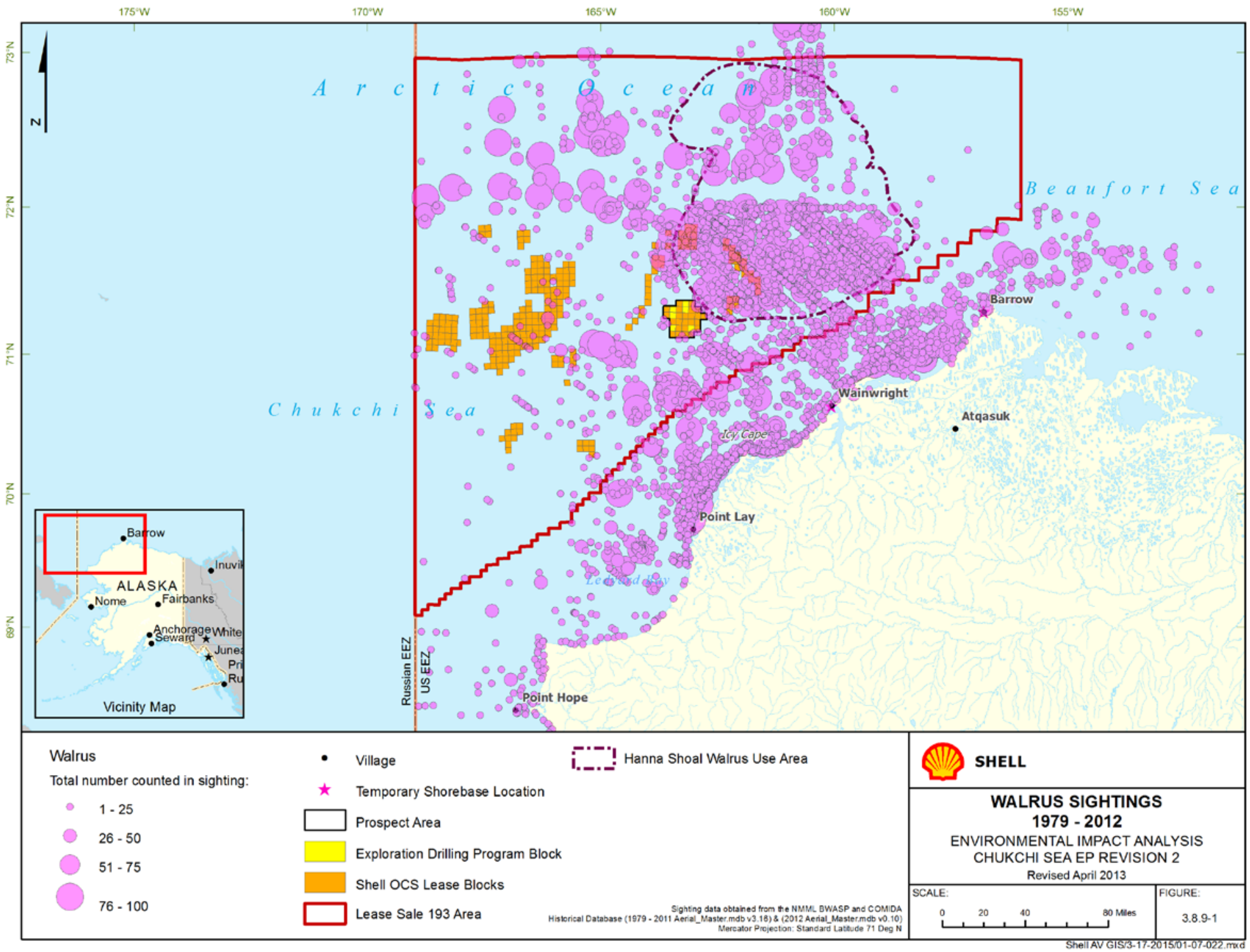
BWASP/COMIDA/ASAMM survey data (Figure 3.8.9-1) indicate that walruses are found throughout the Lease Sale 193 Area including Shell's Burger Prospect. Brueggeman et al. (1990, 1991a) observed walruses in or near the Burger Prospect area in 1989 and 1990 while monitoring the drilling of the historical exploration well (Table 3.7-2). A number of walruses were observed in the Lease Sale 193 Area during monitoring efforts associated with seismic surveys and drilling activities in 2006-2012 (Table 3.7-3).

Broken ice along shallow water is an important habitat for walruses, because their young often cannot dive for extended periods of time and need access to haulouts so they can rest and limit the time spent in cold water. Ice also provides a moving platform that increases the likelihood of finding fresh sources of food with each foraging trip. They are highly gregarious. Near land haulouts, food sources could possibly be exhausted more quickly, which could result in high competition for the resources and longer foraging trips to reach feeding areas such as Hanna Shoal (Jay et al. 2012). Walruses, including females with calves, remained as close to this area as possible until there was no longer any sea ice on which to haul (Jay et al. 2012). Ice is also important as a platform for giving birth (Fay 1982). Although walruses depend largely on sea ice as a platform in the Chukchi Sea, this is changing as summer pack ice diminishes (Monson et al. 2013; USFWS 2013a; Jay et al. 2012).

Life History of the Pacific Walrus

Pacific walruses prefer water less than 660 ft (200 m) deep because they are benthic feeders and must dive to the seafloor for their food (Fay and Burns 1988). In a study by Jay and Hills (2005) in Bristol Bay 98 percent of the satellite locations of tagged walruses were in water depths of less than or equal to 200 ft (60 m). The primary food source for walruses is bivalve mollusks, but walruses are opportunistic feeders and will also feed on other benthic organisms and occasionally ringed seals (Lowry and Fay 1984). While foraging, walruses create pits and furrows in the benthos by creating a stream of high-pressure water with their mouth. This stream pushes aside sediment and aids in prey detection. In a study of walrus benthic feeding grounds, scientists used side-scan sonar to map these furrows in order to locate high density feeding locations (Nelson et al. 1994).

Figure 3.8.9-1 Pacific Walrus Sightings 1979-2012



Mating occurs between January and March, but implantation is delayed until June or July. Gestation lasts 11 months and calves are born between mid-April and mid-June during the northern migration (Fay 1982). Walruses nurse their calves for approximately three years on ice, land, and at sea. Walruses are the only known pinnipeds to exhibit the aquatic nursing strategy (Boness and Bowen 1996). After about five months, calves also begin to feed on benthic organisms (Boness and Bowen 1996). Reproductive rates for walruses are low, with one calf born every two or more years.

Abundance of Pacific Walruses

The current size of the Pacific walrus population is not accurately known. Human exploitation may have brought the population down to an estimated 50,000 to 100,000 animals by the mid-1950s (Fay et al. 1997). A reduction of hunting pressure in the 1960s and 1970s is believed to have allowed the population to increase rapidly in size (Fay et al. 1989). Surveys by the United States and Russia between 1975 and 1990 produced population estimates that ranged from 201,039 to 234,020 (Garlich-Miller et al. 2011a). However, these estimates are considered conservative and have large confidence intervals.

A coordinated U.S.-Russian walrus population assessment was conducted in 2006 using thermal imagery which is thought to identify only walruses that are hauled out on the ice, and satellite telemetry data to adjust the numbers to account for walruses in the water. The resulting minimum Pacific walrus population estimate was 129,000 individuals (USFWS 2010a). This minimum population estimate is known to be negatively biased as only about 50 percent of available sea ice habitat was surveyed (USFWS 2010a).

Current information reports that the population is more than likely declining (Kochnev 2004). Walruses are still harvested by Alaska Natives near the Chukchi Sea coast. Mean annual subsistence harvest is about 5,458 walruses (USFWS 2006). The Pacific walrus is not currently listed as depleted under the MMPA, nor is it listed as threatened or endangered by the ESA. However, NOAA has prepared a status review of the walrus for potential listing under the ESA (Garlich-Miller et al. 2011a).

Occurrences of walruses in the area of Shell's Burger Prospect are regular and common. A total of 16,015 walruses were observed in the vicinity of Lease Sale 193 Area over a period of seven years (2006 to 2012) by vessel-based PSOs while monitoring seismic surveys and drilling activities in this area of the northeastern Chukchi Sea (Table 3.7-3 above). A large number of walruses (1,042 mostly in groups of 1 to 4 individuals) were also observed in Statoil lease block just north of Shell's Burger Prospect during the monitoring of Statoil's seismic survey program in August-September 2010 (Table 3.7-4) and 147 were observed in 2011 during Statoil geophysical and geotechnical surveys (Table 3.7-5). Most of these observations (73 percent) occurred on just a few days (28-31 August) when a large number of walruses moved from a receding ice edge towards land (Blees et al. 2010). A total of 11,737 were observed over six years (2008-2013) of CSESP marine mammal surveys in the northeastern Chukchi Sea (Table 3.7-6) (Aerts et al. 2013, 2014). Observed densities of walruses in the CSESP Burger Study Areas surrounding Shell's Burger Prospect are presented below in Table 3.8.9-1. Brueggeman et al. (1990, 1991a) observed 85 walruses in or near the Burger Prospect area in 1989 and 534 in 1990 (Table 3.7-2), while the historic Burger well was being drilled.

The likelihood of encountering a walrus in or near Shell's prospect will depend largely upon ice conditions at the time of exploration drilling activity as their presence is strongly linked to the presence of pack ice but it is likely that a number of walruses will occur in the area of Shell's Burger Prospect during the planned exploration drilling program.

Table 3.8.9-1 Walrus Densities in CSESP Burger Study Area 2008-2011 [1,2]

Year	Walruses/mi^2	Walruses/km^2	Walruses/mi^2		Walruses/km^2	
			Jul/Aug	Sep/Oct	Jul/Aug	Sep/Oct
2008	0.031	0.012	0.003	0.049	0.001	0.019
2009	0.070	0.027	0.096	0.013	0.037	0.005
2010	0.044	0.017	0.054	0.039	0.021	0.015
2011	0.647	0.250	0.054	0.262	0.021	0.101

[1] Source: Aerts et al. 2013
ND = similar data presentation was not provided in 2012 or 2013 annual report

In 2007, 2009 through 2011, and 2013, walruses were observed hauling out in large numbers with mixed sex and age groups along the Chukchi Sea coast of Alaska in late August, September, and October (Thomas et al. 2009; Garlich-Miller et al. 2011b; MacCracken 2012; Clarke et al. 2014). Monitoring studies conducted in association with oil and gas exploration suggest that the use of coastal haulouts along the Arctic coast of Alaska during the summer months is dependent upon the availability of sea ice. For example, in 2006 and 2008, walruses foraging off the Chukchi Sea coast of Alaska remained with the ice pack over the continental shelf during the months of August, September, and October. However in 2007 and 2009, the pack ice retreated beyond the continental shelf and large numbers of walruses hauled out on land at several locations between Point Barrow and Cape Lisburne, Alaska (Ireland et al. 2009; Thomas et al. 2009; Garlich-Miller et al. 2011a), and in 2010 and 2011, at least 20,000 to 30,000 walruses were observed hauled out approximately 3 mi (4.8 km) north of the Native Village of Point Lay, Alaska (Garlich-Miller et al. 2011b). No walruses hauled out at shore locations in 2012. In 2013, about 10,000 walruses were observed hauled out onshore near Point Lay (Clarke et al. 2014).

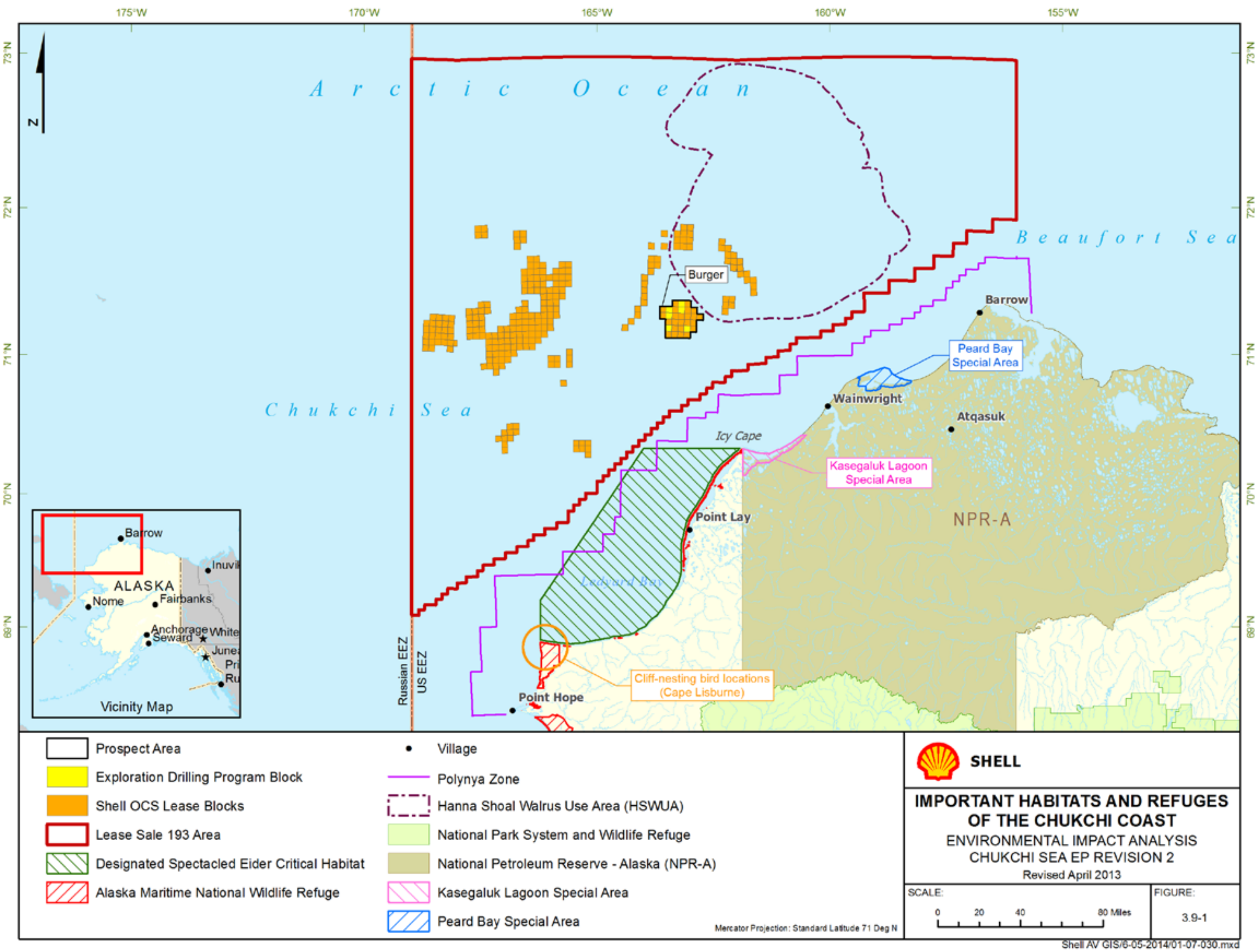
3.9 Sensitive Biological Resources

Shell’s Burger Prospect is not in an area identified as being especially sensitive or productive as biological habitat. A greater level of productivity occurs inland along the coastline where bird, fish, and marine mammal use, density, and species richness is generally greater. Bays and lagoons located along the coastline hold greater species abundance and with specific locations protected by state or federal regulation. Ledyard Bay has been designated critical habitat for the spectacled eider under the ESA. Peard Bay and Kasegaluk Lagoon are established as Special Areas by the U.S. Department of the Interior, Bureau of Land Management (BLM). This section discusses these and other Chukchi Sea locations that are considered particularly sensitive or important habitats. Locations of these resources are indicated on Figure 3.9-1.

3.9.1 Ledyard Bay

Ledyard Bay in the Chukchi Sea is a federally designated critical habitat unit for spectacled eiders, which are currently listed as threatened (USFWS 2011b). Ledyard Bay was designated because of its importance to migrating and molting spectacles eiders, and includes waters of Ledyard Bay within 1 to 46 mi (1.9 to 75 km) from shore. Waters approximately 16 to 82 ft (5 to 25 m) deep combined with marine aquatic flora and underlying benthic community are all protected. Three breeding eider populations molt in Ledyard Bay (Audubon 2009). Molting spectacled eiders occupy Ledyard Bay, July through October. Refer to Section 3.6 for a more detailed description of bird resources in Ledyard Bay.

Figure 3.9-1 Important Habitats and Refuges of the Chukchi Sea Coast



3.9.2 Peard Bay

Peard Bay is designated as a Special Area by BLM to protect nearshore areas and haulouts for marine mammals, as well as habitat for waterfowl breeding, molting, and staging (BLM 2013). A large concentration of spring and fall waterfowl combined with several seabird colonies occupying the coastal waters of Peard Bay make it a highly important area for biological resources (USFWS 2002; Davis and Thompson 1984). Peard Bay is a known molting area for long-tailed ducks from July through August, and is a staging area for the fall migration in September (Roseneau and Herter 1984). It may also be an important area for molting common eiders (Kinney 1985) and used by spectacled eiders (Peterson et al. 1999), and is an important staging area for shorebirds during fall migration (Johnson and Herter 1989; Brown et al. 2001b). Polar bears den along and just inland from the shore and marine mammal haulouts are prevalent (BLM 2013). A kelp bed has been identified about 12 mi (20 km) northeast of Peard Bay near Skull Cliff (Phillips et al. 1982; Phillips and Reiss 1985b).

3.9.3 Kasegaluk Lagoon

Kasegaluk Lagoon is designated as a Special Area by BLM (BLM 2013), who has applied certain protective measures to the area. Kasegaluk Lagoon supports large aggregations of beluga whales, spotted seals, and black brant. Productive lagoon waters provide important marine mammal habitat for beluga whale summer concentrations and pinniped haul outs, particularly spotted seals and Pacific walruses (Frost et al. 1993). Beluga whales usually arrive to the lagoon in late June and leave in late July and use the area for molting. Spotted seals arrive in mid-July and stay through early November, hauling out on spits and shoals in the area (Frost et al. 1993).

Kasegaluk Lagoon attracts a diversity of waterfowl and coastal seabirds, exceeding productivity of any other Arctic Alaska lagoon system (Johnson et al. 1992). Subsistence species such as common eider occupy lagoon waters during summer. The lagoon is particularly important to black brant during the molting and fall staging period, when as much as 45 percent of the Pacific Flyway population is found here (Johnson et al. 1993). Other bird species, such as glaucous gulls, arctic terns, lesser snow geese, and small shorebirds are relatively abundant in Kasegaluk Lagoon (Johnson et al. 1993).

Polar bears den near Kasegaluk Lagoon, and grizzly bears may concentrate to feed on marine mammal carcasses.

3.9.4 Refuges, Preserves, and Sanctuaries

The Alaska Maritime National Wildlife Refuge (NWR) spans Chukchi Sea coastal waters from Cape Lisburne to Cape Thompson. Coastal refuge waters are intended to conserve fish and wildlife populations and their habitat. Marine mammals, marine birds, migratory birds, bears, caribou and other mammal are protected to ensure populations occupying the refuge remain robust. Cape Thompson and nearby Cape Lisburne are the two largest arctic seabird colonies in the U.S. For some birds such as cormorants and horned and tufted puffins, this is as far north as they nest. Arctic-adapted black guillemots replace pigeon guillemots at these northern latitudes, although a few of the latter occasionally nest here. Only black guillemots nest at Cape Lisburne (USFWS 2009a).

3.9.5 Hanna Shoal and Hanna Shoal Walrus Use Area

Hanna Shoal is a shallow area of the Chukchi Sea shelf, located roughly 25 mi (40 km) northeast of the Burger Prospect. The shoal is generally considered to start at a water depth contour of about 131 ft (40 m) and rise to a water depth of about 72 ft (22 m) at its shallowest point. Hanna Shoal is an important area for the wide variety of benthic and pelagic fauna found there (Dunton et al. 2013). The combination of shallow waters and high bottom flow result in high secondary production (e.g. plankton), that supports Pacific walruses and other marine mammals which concentrate in the area for feeding. Research suggests that the Lease Sale 193 area may be used by Pacific walruses as a migration corridor between coastal haulout locations and Hanna Shoal (Aerts et al. 2012; Jay et al. 2012). According to walrus tagging studies conducted by Jay et al. (2012), Hanna Shoal was identified as an important feeding area for walruses. Walruses, including females with calves, remained as close to this area as possible until there was no longer any sea ice on which to haul (Jay et al. 2012).

Gray whales are known to feed in shallow areas of the Chukchi Sea coast where benthic fauna are abundant. In the 1980s and early 1990s, gray whales were commonly observed feeding near Hanna Shoal, but observations from 2008-2012 show relatively few gray whales used the area (Aerts et al. 2013). Recent studies of the benthic fauna at Hanna Shoal indicate that the ecosystem is highly complex and the distribution of organisms is patchy. Furthermore, the sea ice that contains high biomass of ice algae tends to cover Hanna Shoal later in the summer than in other areas of the Chukchi Sea (Dunton et al. 2013). Hanna Shoal is considered to be ecologically important: current and future research is focusing on multidisciplinary studies to obtain an ecosystem perspective on this region.

During the process of developing and promulgating incidental take regulations under the MMPA for the Chukchi Sea, the USFWS delineated an area of heavy use by walruses that they termed the HSWUA. The limits of the HSWUA were based on walrus utilization distributions determined from walruses tagged with satellite telemetry. USFWS overlaid the 50% utilization distributions in Jay et al. (2012) for both foraging and occupancy in the Hanna Shoal area, as defined bathymetrically by Smith (2011), for the months of June through September. The utilization distributions vary throughout this time period. At its greatest extent, the HSWUA encompasses approximately 9,500 mi^2 (24,600 km^2).

In the final rule for the current incidental take regulations in the Chukchi Sea, USFWS determined that it is critical to minimize disturbance to walruses in the HSWUA. In order to ensure there is no more than a negligible impact on small numbers of walruses, the agency determined that additional mitigation measures, such as seasonal restrictions, reduced vessel traffic, or rerouting vessels may be may be implemented for activities within the HSWUA. Additional measures will be implemented by the agency on a case by case basis depending on where the boundaries of the HSWUA are in relation to the project, the nature and timing of the activities, and other information (78 FR 35363-35427).

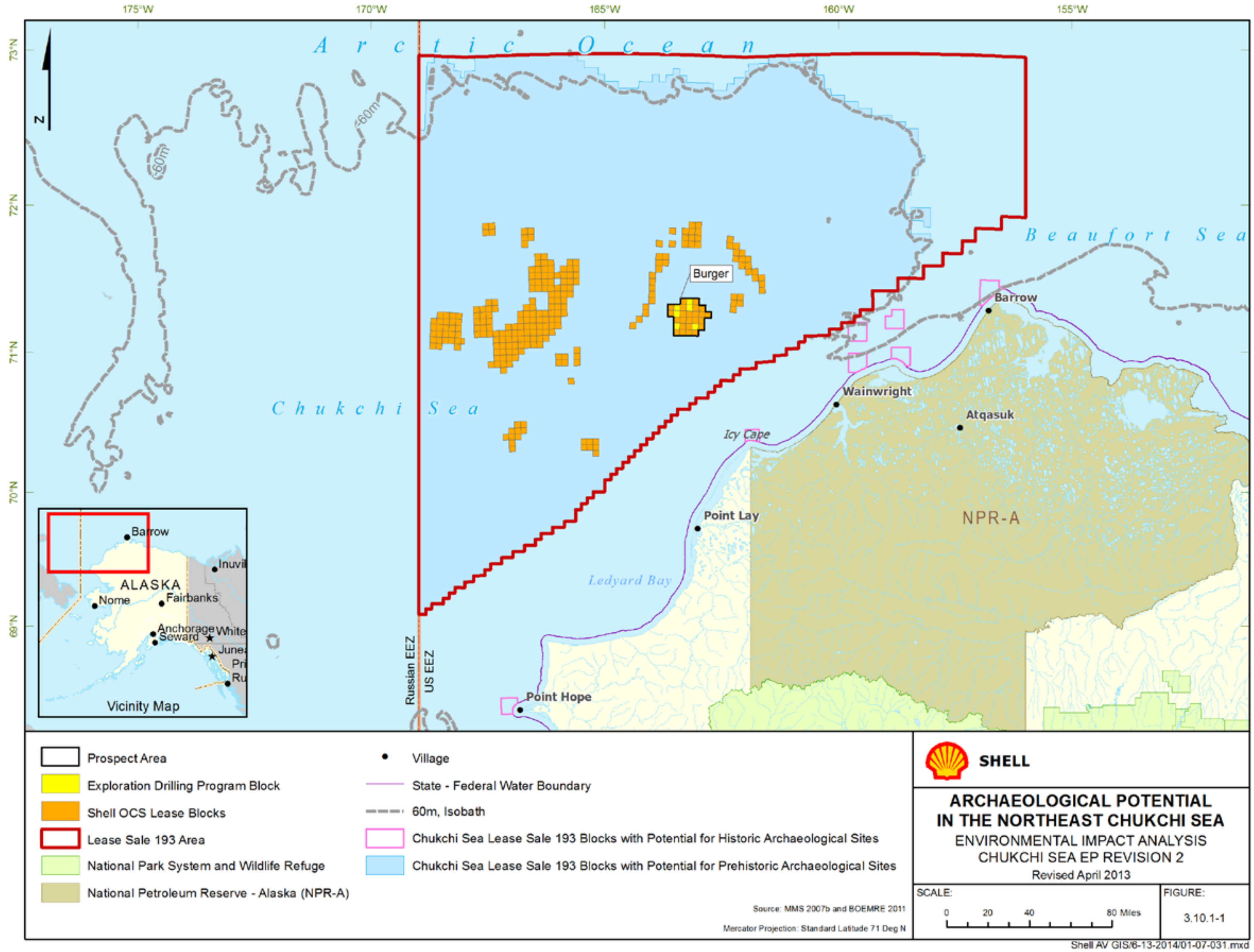
3.10 Cultural Resources

This section addresses the cultural resources potentially affected by the planned exploration drilling program. Cultural resources are physical resources associated with people, a society, or multiple societies. They are both built and natural parts of the physical environment that have some cultural value to one or more socio-cultural groups (King 1998). Cultural resources include historic sites, archaeological sites, cultural landscapes, historic documents, spiritual places, Native cultural items, historic and archaeological artifacts, and community values. They may be remnants of a past society, such as a prehistoric village, or resources of a current society, such as a fish camp a family uses every summer.

3.10.1 Offshore Cultural Resources

Offshore cultural resources include historic cultural resources and prehistoric cultural resources. Submerged historical resources include shipwrecks, submerged aircraft, and abandoned items of historical importance. Submerged prehistoric cultural resources include archaeological sites on relic sub-aerially exposed landforms. In areas with potential for submerged archaeological resources, BOEM requires lessees in the Lease Sale 193 Area to conduct geophysical surveys and prepare archaeological assessments for proposed drill sites per NTL 05-A01 and NTL 05-A03, and to submit the assessments to BOEM before an EP can be approved. Shell has conducted geophysical surveys and archaeological assessments for all six planned drill sites. The results of these assessments are discussed below.

Figure 3.10.1-1 Archaeological Potential in the Northeast Chukchi Sea



3.10.2 Submerged Prehistoric Archaeological Sites

Submerged prehistoric archaeological sites may be found in the Chukchi Sea in areas with water depths less than 200 ft (60 m) (MMS 2007b). The present day 200-ft (60-m) isobath is the location of the shoreline 13,000 years ago and where BOEM designated the boundary for prehistoric archaeological site potential (BOEMRE 2011b; MMS 2007b). All of Shell's EP Blocks fall within the area of potential for prehistoric sites (Figure 3.10.1-1).

A comprehensive Chukchi sea-level history is lacking, and archaeological and paleoecological data for human habitation and migration over the Bering Land Bridge is limited (Hoffecker and Elias 2003; Rogers 2012). Prehistoric archaeological remains within the Chukchi Sea would be significant to the understanding of Beringia and migration (Rogers 2012). However, current archaeological theories assert that human populations moved into North America from Asia between the Last Glacial Maximum (approximately 20,000 calibrated years before present (BP) and the beginning of the Holocene (11,600 calibrated BP) (Bigelow and Powers 2001; Hoffecker and Elias 2003; Holmes 2001). The current understanding of human migration over the Bering Land Bridge comes from a combination of onshore and offshore archaeological, paleoecological, and sea floor sediment studies (e.g., Bigelow and Powers 2001; Dumond 2001; Hoffecker and Elias 2003; Keigwin et al. 2006; Rogers 2012; Yesner and Pearson 2002).

An area's potential for having archaeological sites is based on bathymetry seafloor geology, past sea levels, and ethnographic and terrestrial archaeology models and knowledge. Relic landforms that were suitable for human activity and thus have a high probability of prehistoric archaeological sites include preserved paleo-river levees associated with paleo-river channels, river confluences, ponds, lakes, lagoons, or paleo-shorelines.

Prehistoric sites are not expected in some areas where the continental shelf is less than 200 ft (60 m) below current sea level because of certain environmental conditions. These areas with a lower archaeological site potential include areas where: "(1) there are no Quaternary sediments, and (2) where extensive ice gouging has reworked the Quaternary section, but these are not well defined and will have to be determined on a case-by-case basis" (MMS 2007b).

BOEM conducted a prehistoric resource analysis and a shipwreck update analysis for the Alaska OCS Chukchi Sea Oil and Gas Lease Sale 109 (MMS 1987a) in the Chukchi Sea. Much of the area in Lease Sale 109 corresponds to that of Lease Sale 193. In their prehistoric resource analysis for the Lease Sale 109, BOEM recommended that no further attention was required for archaeological resources. This recommendation was based on available data suggesting that most of the area experiences extensive ice gouging and other natural processes that would have destroyed any cultural resources (MMS 1987b). That report also stated the assessment could be reassessed based on new data becoming available. Due to enhances in technology and surveys over additional areas, new data interpretations will provide a better understanding of archaeological site potential.

BOEM may request additional cultural resource surveys based on recent remote-sensing studies regarding the effects of ice gouging. The studies indicate the presence of intact landforms just below the seafloor in some areas, despite evidence of past ice gouging events (MMS 2007b).

Shallow hazards surveys have been conducted at each of Shell's proposed drill sites, and archaeological assessments were prepared based on the shallow hazards data. No potential archaeological resources were identified at or near the Burger A drill site (Fugro GeoConsulting, Inc. 2010b), the Burger F drill site (Fugro GeoConsulting, Inc. 2010c), the Burger J drill site (GEMS 2009), the Burger R drill site (Fugro GeoConsulting, Inc. 2011b), the Burger S drill site (Fugro GeoConsulting, Inc. 2010d), or the Burger V drill sites (Fugro GeoConsulting, Inc. 2010f). All the EP blocks and drill sites are located in water depths of less than 200 ft (60 m), which is generally considered to be the lowest level of the sea approximately 13,000 years before present. Therefore these areas were subaerially exposed approximately 13,000 years before present prior to sea level rise (present day sea level) and could hold prehistoric archaeological resources. Such resources are most likely to occur along relict terrestrial landforms such as preserved levees or terraces associated with paleo-river channels or shorelines.

Buried Pleistocene channels have been identified in the area of the Burger A, F, and S drill sites, with the nearest such buried channels being located within 2,133 ft (650 m) of the Burger A drill site and within 869 ft (265 m) of the Burger F drill site. A buried Pleistocene channel would be penetrated by the drill path at the Burger S drill site. In all three of these cases, the possible levees that might have been constructed on the sides of these subsurface channel features have likely been eroded during the last sea-level rise and covered in turn by Holocene aged materials, thus the possibility of preserved archaeological sites on these subsurface channel features has been decreased and the potential for disturbance of any such sites by exploration drilling operations is very low (Fugro GeoConsulting, Inc. 2010b,c,d). No such channels or levees were identified near the Burger J, R and V drill sites.

3.10.3 Submerged Historical Archaeological Sites

Potential for submerged historic archaeological sites exists within the Chukchi Planning Area. Shell's lease blocks (Posey Blocks 6714, 6762, 6764, 6812, 6912, and 6915) do not fall within the locations with potential to contain historical archaeological resources and requiring an archaeological assessment (Figure 3.10.1-1). BOEM has identified the following lease blocks located within the Lease Sale 193 Area as having the potential to contain historic archaeological resources:

- OPD NR 03-04, Solivik Island: 6623,6624, 6673, 6674, 6723, and 6724;
- OPD NR 03-07 Point Hope: 6609, 6610, 6611, 6659 – 6661, and 6709 – 6711;
- OPD NR 04-01, Hanna Shoal: 6918-6920, 6968-6970, and 7018-7020;
- OPD NR 04-02, Barrow: 6566-6568, 6616, 6617, 6619, 6666-6668, 6716, 6801-6803, 6851-6853, 6901-6903, and 7102-7104;
- OPD NR 04-03, Wainwright: 6601-6603, 6651-6653, 6019-6021, 6069-6071, 6119-6121; and
- OPD NR 04-04, Meade River: 6002-6004, 6053, and 6054 (BOEMRE 2011b; MMS 2008b).

The vast majority of historical sites located in the Chukchi Sea are shipwrecks. Treatment, management, and ownership of shipwrecks vary depending on whether the shipwreck was abandoned and where they are. The President of the United States signed the Abandoned Shipwreck Act (Public Law 100-298; 43 U.S.C. 2101-2106) in April 1988. Under this act, the U.S. government asserted title to abandoned shipwrecks:

- Embedded in a state's submerged lands
- Embedded in coralline formations protected by a state on its submerged lands
- Located on a state's submerged lands and included or determined eligible for inclusion in the National Register

The U.S. government transferred management of many shipwrecks to respective states to manage, while maintaining title to shipwrecks in or on publicly managed properties. Indian tribes hold title to shipwrecks located in or on Indian lands (NPS 2002). Abandoned shipwrecks are included under many other laws governing cultural resources and historic properties, such as the NHPA.

Shipwrecks in the Chukchi Sea have a greater chance of being present than prehistoric archaeological sites. In the shipwreck update analysis for proposed Sale 109 (MMS 1987a), BOEM stated that shipwrecks might be present in the area northeast and west of Peard Bay and Point Franklin because the waters there are deeper and ice gouging is sparse. BOEM further stated that shipwrecks in shallower areas are more likely to have survived ice gouging than prehistoric sites because they have been present and experiencing ice gouging for a comparatively short period of time.

In the 2007 Final EIS for Lease Sale 193, BOEM (MMS 2007b) re-evaluated the potential to encounter offshore resources. It was determined that historic resources, such as shipwrecks, were more likely to be found intact in the OCS where they would be more protected from ice gouging and wave action than those closer to shore. It was also noted, however, that: “Assuming compliance with existing federal, state, and local archaeological regulations and policies and the application of BOEMRE’s Geological and Geophysical (G&G) Permit Stipulation 6 (regarding the discovery of archaeological resources) and CFR 251.6(a)(5) regarding G&G Explorations of the Outer Continental Shelf to not ‘disturb archaeological resources,’ most impacts to archaeological resources in shallow offshore waters of the Chukchi Sea Proposed Action area would be avoided” (MMS 2007b).

BOEM Shipwreck Database (MMS 2006a) is the most comprehensive dataset of shipwrecks in Alaska waters and contains 80 shipwrecks in the Chukchi Sea Planning Area. Table 3.10.2-1 lists these shipwrecks.

Table 3.10.2-1 Shipwrecks in the Chukchi Sea Planning Area

Vessel Name	Type	Date Wrecked	Location
Caulaincourt	French whaling ship	9/5/1861	At Point Belcher
Henry Kneeland	Whaling ship	6/22/1864	In the Chukchi Sea
Gratitude	Whaling bark	7/2/1865	40 mi from Cape Lisburne
Ontario	Whaling bark	9/27/1866	In the Chukchi Sea
Hae Hawaii	Whaling bark	9/22/1868	In the Seahorse Islands, off Point Franklin
Eagle	Whaling bark	9/30/1869	On Seahorse Shoal, off Point Franklin
Almira	Whaling ship	8/26/1870	Near Point Barrow
Hibernia	Whaling ship	8/28/1870	About 2 mi Southwest of Point Barrow
Comet	Whaling brig	9/2/1871	Between Point Franklin and Seahorse Islands
Roman	Whaling bark	9/7/1871	In the Seahorse Islands, off Point Franklin
Awashonks	Whaling bark	9/8/1871	South of Wainwright Inlet
Julian	Whaling ship	9/8/1871	South of Wainwright Inlet
Kohola	Whaling brig	9/9/1871	2 mi Northeast of Wainwright Inlet
Carlotta	Whaling bark	9/12/1871	Point Belcher, near Wainwright Inlet
Fanny	Whaling bark	9/13/1871	6 mi South of Point Belcher, ¼ mi from shore
Monticello	Whaling bark	9/13/1871	4 mi South of Point Belcher
Champion	Whaling ship	9/14/1871	Point Belcher, near Wainwright Inlet
Concordia	Whaling bark	9/14/1871	Point Belcher, near Wainwright Inlet
Contest	Whaling bark	9/14/1871	Point Belcher, near Wainwright Inlet
Elizabeth Swift	Whaling bark	9/14/1871	Point Belcher, near Wainwright Inlet
Emily Morgan	Whaling bark	9/14/1871	1 mi North of Point Belcher
Eugenia	Whaling bark	9/14/1871	Point Belcher, near Wainwright Inlet
Florida	Whaling ship	9/14/1871	In the Seahorse Islands, off Point Franklin
Gay Head	Whaling ship	9/14/1871	Point Belcher, near Wainwright Inlet
George	Whaling bark	9/14/1871	Point Belcher, near Wainwright Inlet
George Howland	Whaling bark	9/14/1871	Point Belcher, near Wainwright Inlet
Henry Taber	Whaling bark	9/14/1871	Point Belcher, near Wainwright Inlet
James D. Thompson	Whaling bark	9/14/1871	Point Belcher, near Wainwright Inlet
John Wells	Whaling bark	9/14/1871	Point Belcher, near Wainwright Inlet
Mary	Whaling ship	9/14/1871	South of Wainwright Inlet
Massachusetts	Whaling bark	9/14/1871	Point Belcher, near Wainwright Inlet
Navy	Whaling bark	9/14/1871	Point Belcher, near Wainwright Inlet
Oliver Crocker	Whaling bark	9/14/1871	Point Belcher, near Wainwright Inlet
Paiea	Whaling bark	9/14/1871	Point Belcher, near Wainwright Inlet
Reindeer	Whaling ship	9/14/1871	Point Belcher, near Wainwright Inlet
Seneca	Whaling bark	9/14/1871	Point Belcher, near Wainwright Inlet
Thomas Dickason	Whaling bark	9/14/1871	North of Wainwright Inlet
Victoria	Trading brig	9/14/1871	South of Wainwright Inlet
William Rotch	Whaling ship	9/14/1871	South of Wainwright Inlet
Roscoe	Whaling bark	8/19/1872	Off Point Barrow
Arctic	Whaling bark	7/7/1876	18 mi from the “Bend” (Point Belcher)
Three Brothers	Whaling bark	9/11/1877	Off Point Barrow
W.A. Farnsworth	Whaling bark	9/15/1877	Near Point Barrow
William H. Allen	Trading brig	8/2/1878	Off Cape Smyth

Table 3.10.2-1 Shipwrecks in the Chukchi Sea Planning Area

Vessel Name	Type	Date Wrecked	Location
Florence	Whaling bark	8/8/1878	4 mi South of Point Barrow
Daniel Webster	Whaling bark	7/12/1881	5 mi South of Point Barrow
North Star	Steam whaling bark	7/8/1882	Off Point Barrow, 2 ½ mi from shore
John Howland	Whaling bark	7/17/1883	South of Point Hope
Cyane	Whaling bark	8/23/1883	5 mi Northeast of Point Belcher
Louisa	Whaling bark	9/24/1883	Off Point Hope
Bowhead	Steam whaling bark	8/11/1884	Blossom Shoals, near Icy Cape
George and Susan	Whaling bark	8/10/1885	9 mi North of Wainwright Inlet
Mabel	Whaling bark	8/10/1885	At Wainwright Inlet
Clara Light	Whaling schooner/tender	8/31/1886	15 mi North of Point Franklin
Fleetwing	Whaling bark	8/3/1888	1 mi Northeast of Point Barrow
Mary and Susan	Whaling bark	8/3/1888	4 mi South of Point Barrow
Ino	Schooner	8/8/1888	At Cape Smyth
Ohio	Whaling bark	10/3/1888	At Point Hope
Thomas Pope	Whaling bark/tender	7/28/1890	Off Point Hope
Spy	Sloop	11/25/1890	At Point Barrow
William Lewis	Steam bark	10/3/1891	At Point Barrow
Emily Schroeder	Schooner	10/13/1893	Marryatt Inlet, Point Hope Lagoon
Hidalgo	Brig	7/24/1896	8 mi West of Cape Thompson, within 1 mile of Jabbertown
Navarch	Steam whaling bark	8/12/1897	Off Blossom Shoals, near Icy Cape
Orca	Steam whaling bark	9/21/1897	North of Seahorse Islands, off Point Franklin
Jessie H. Freeman	Steam whaling bark	9/22/1897	North of Seahorse Islands, off Point Franklin
Rosario	Schooner	7/2/1898	¾ mi Southwest of Point Barrow
Grampus	Steam whaling bark	7/18/1901	Near Point Barrow
Laura Madsen	Whaling schooner	10/14/1905	At anchorage off Point Barrow
Ivy	Schooner	9/1/1908	At Point Barrow
Helen Johnston	Gas schooner	7/29/1910	7 mi East of Point Hope
Transit	Schooner	8/25/1913	5 mi Southwest of Cape Smyth
Arctic	Auxiliary gas schooner	8/10/1924	16 mi South of Point Barrow
Lady Kindersly	Canadian power schooner	8/31/1924	Off Point Barrow
Lettie	Gas screw	9/9/1924	½ mi Northeast of Wainwright Inlet and ½ mi from shore
Baychimo	Trading/supply steamer	11/24/1931	Just South of Point Barrow
Arnold Liebes	Gas boat	1/1/1934	Off Point Barrow
C.B. Brower	Gas boat	1/1/1934	Off Point Barrow
Eli-Yuk	Oil screw	9/2/1963	Off Wainwright
Basil	Diesel boat	9/7/1950	At Cape Lisburne

Source: Table III.C.18 MMS 2007b

Many of the locations noted in Table 3.10.2-1 are generalized because they are based on historic reports. Few exact locations of shipwrecks are known. Using the generalized locations of reported wrecks, BOEM identified lease blocks that have a potential for containing shipwrecks and other historic archaeological sites (BOEMRE 2011b; MMS 2007b). None of Shell's Chukchi Sea lease blocks fall within these areas cited by BOEM (Table 3.10.2-1).

Shallow Hazards Surveys have been conducted at each of Shell's potential drill sites, and archaeological assessments were prepared based on the shallow hazards data. No potential archaeological resources were identified at or near the drill sites at Burger A (Fugro GeoConsulting, Inc. 2010b), Burger F (Fugro GeoConsulting, Inc. 2010c), Burger J (GEMS 2009), Burger R (Fugro GeoConsulting, Inc. 2011b), Burger S (Fugro GeoConsulting Inc. 2010d), or Burger V (Fugro GeoConsulting, Inc. 2010f). No facilities, shipwrecks, significant debris, or other man-made seafloor obstructions were detected during the shallow hazards surveys. The only man-made object around the proposed sites is the Burger #1 well site. The well was drilled in 1989-1990 in Posey Area Block 6814. The historic well was plugged and abandoned in 1990, with all surface wellhead equipment contained well below the seafloor at the bottom of the MLC. None of the observed unidentified side-scan sonar contacts or magnetic anomalies identified in the geophysical surveys at each drill site are believed to be of archaeological significance, and all will be avoided during the planned exploration drilling operations.

3.10.4 Onshore Cultural Resources

Shell proposes to lease existing onshore facilities in the Village of Wainwright and Barrow to support the offshore operations. In Barrow, the state-owned and operated Barrow Airport will provide most of the facilities along with the leasing of office space in Barrow. The NSB-operated airstrip and the local boat landings / ramps will be used in Wainwright.

The station at Wainwright was part of the Distance Early Warning (DEW) Line program – one of the more significant Cold War initiatives in the arctic and thus an important part of U.S. history. The system consisted of defense radar and communications stations stretching 3,000 mi (4,800 km) of coast from Greenland to Alaska. U.S. and Canada established over 50 stations providing early detection and warning of airborne threats (CEMML 2006, Griffiths et al. 2011, Salmon 2011).

The Wainwright DEW Line site is older than 50 years and is considered to be a historic property under federal and state definitions. It is listed in the AHRS as site number WAI-082. The U.S. Department of the U.S. Air Force (USAF) determined that, as a contributing element to the DEW line system, the Wainwright station is eligible for the National Register. The USAF determined that the entire DEW System is eligible for listing on the National Register under Criteria A and G for its association with events important in the history of the Cold War and the history of the development of the SOA (CEMML 2006). However, the DEW line system has not as of yet been nominated to the National Register.

Additional onshore cultural resources already listed on the AHRS include historic and prehistoric sites, which have the potential to be impacted in the unlikely event of a major oil spill or in the event of construction associated with any shorebase facilities. Historic sites types include both Iñupiat and non-Native sites associated with camping, subsistence activities, whaling, or trading. Prehistoric sites are found along the entire coast between Barrow and Point Lay, and are sometimes associated with human remains. Prior to any onshore activities, such as the construction of new docks or facilities, modification of existing facilities or airstrips, or OSR training, Shell or its contractors will consult with the appropriate authorities and identify all known cultural resources in the vicinity.

3.10.5 Paleontological Resources

This section addresses the paleontological resources potentially affected by the planned exploration drilling. The Act PRPA (Public Law [P.L.] 111-011, Omnibus Public Land Management Act of 2009, Subtitle D – Paleontological Resources Protection) defines a paleontological resource as, “any fossilized remains, traces, or imprints of organisms preserved in or on the earth’s crust, that are of paleontological interest and that provide information about the history of life on earth” and which does not include materials associated with an archaeological resource. The PRPA is a relatively new law, and federal guidance to the application of this act is still in development. The act focuses on regulating the collection of paleontological resources; defining what is a legal and illegal collection (NPS 2010). To date, the act lacks formal procedures for federal agencies to address impact to paleontological resources.

Paleontological resources in the Chukchi Sea are of particular interest because they can provide information not only of the ecological history of the sea, but also the paleoecology of Beringia. The Chukchi seafloor was a subaerial land mass connecting Alaska and Siberia in the late Pleistocene to the early Holocene. Beringia extended from the Mackenzie River, Canada to the Lena River valley, Siberia (West 1996). The intercontinental land mass, or Bering Land Bridge, which connected east and west Beringia existed when sea levels were significantly lower than today, during the Late Pleistocene. It spanned over 620 mi (1,000 km) north to south (Elias and Brigham-Grette 2007). At that time, the Chukchi shelf was a broad, steppe-tundra valley with large drainage systems flowing through the valley into the Arctic Ocean through Canyons near Wrangel Island and through Barrow Canyon (Hill and Driscoll 2008; Rogers 2012).

A comprehensive Chukchi sea-level history is lacking, and data on the paleoevironment of the Bering Land Bridge is limited (Hoffecker and Elias 2003; Rogers 2012). Much of what is known about the Bering Land Bridge is from studies and data collected on either side of the Chukchi Sea. Data from the seafloor itself is somewhat limited, and any new data can add to the understanding of the paleoenvironment and the sea-level history.

Recently, Statoil USA E&P, Inc. ancillary activities recovered paleontological resources in four boreholes and one archaeology-dedicated core taken from their Chukchi Sea lease blocks. Wood fragments were found in the geotechnical cores; mollusk shell fragments, from the archaeological core. Wood samples were sent to labs for radiocarbon dating and speciation test. Mollusk shell fragments were also radiocarbon dated. Soil chemistry and sedimentation were also examined (Rogers 2012). Perhaps the most interesting results from this study are those from the wood fragments.

Some of the first recovered from the Chukchi shelf, the wood fragments are potentially the northern most found wood in Beringia. Dating analyses of the fragments indicate that they are approximately 43,000 to 50,000 radiocarbon years BP (14 calibrated (C) years BP). These dates suggest the samples are from the Middle Wisconsin or Karginsky interstadial, as it is referred in Siberia. This interstadial occurred between major Wisconsinan glaciations (about 57,000 to 25,000 14C years BP) and was characterized by reduced ice sheet occurrence (Colinvaux 1996; Rogers 2012; West 1996). Some researchers have argued that this period consisted of a mild dry climate, while others, a colder, moist climate (see discussion in Rogers 2012). Others posit that during this period, regional climates existed (Brigham-Grette et al. 2004; Elias and Brigham-Grette 2007). Speciation analysis found that most of the plant cell structure no longer exists; however, some observations could be made. One sample was likely from a spruce, pine, or larch; one was likely a broad-leaved plant; and one, likely a conifer (Rogers 2012).

3.11 Socioeconomic Resources

The section discusses the socioeconomic environment in both the NSB and Northwest Arctic Borough (NWAB), but focuses on the NSB villages of Barrow, Wainwright, Point Lay, and Point Hope, as they are the coastal villages closest to Shell's Burger Prospect and the planned exploration drilling activities (Figure 3.11-1).

3.11.1 Community Profile

North Slope Borough

The North Slope geographic area includes three regions with different climate, drainage, and geological characteristics: the Arctic Coastal Plain, the Brooks Range Foothills, and the northern portion of the Brooks Range. Arctic Slope Regional Corporation (ASRC) is the Alaska Native Claims Settlement Act (ANCSA) regional corporation for the NSB and has substantial land and mineral rights. Most inhabitants of villages in the region are Iñupiat Natives. Traditional whaling and other subsistence hunting, fishing, trapping, and gathering activities are vital to the Iñupiat culture throughout the region.

In land mass, the NSB is the largest borough in the SOA and encompasses 89,000 mi^2 (230,000 km^2). It extends across the top of Alaska from Point Hope on the Chukchi Sea to the Canadian border, and from the Brooks Range to the Arctic Ocean (NSB 2005). Less than 8,000 residents (NSB 2010) inhabit the eight villages of Kaktovik, Nuiqsut, Anaktuvuk Pass, Atqasuk, Barrow, Wainwright, Point Lay, and Point Hope. Iñupiat have lived in the region for centuries, and trading between Alaskan and Canadian bands has existed during this time (ADCCED 2007a).

The NSB government is principally funded by oil tax revenues. The NSB provides public services to all of its communities and is the primary employer of local residents. North Slope oil field operations provide employment to over 5,000 non-residents, who rotate in and out of oil field work sites from Anchorage, other areas of the state, and the lower 48 states. Census figures are not indicative of this transient work site population (ADCCED 2007a).

Air travel provides the only year-round access, while land transportation provides seasonal access. The Dalton Highway provides road access to Prudhoe Bay, although it is restricted during winter months. "Cat-trains" are sometimes used to transport freight overland to and from Barrow during the winter.

Barrow

Barrow is the northernmost community in the U.S. and is also the largest city on the North Slope. It is located on the Chukchi Sea coast, 10 mi (16 km) south of Point Barrow, 140 mi (227 km) from the Burger Prospect. It is 725 air-mi (1,170 air-km) from Anchorage and is the economic, transportation, and administration hub of the NSB. The community's traditional name is Ukpeagvik, which means “place where snowy owls are hunted” (University of Arkansas 2007).

Archaeological evidence indicates that the area was inhabited from at least 500 anno domini (A.D.) . The Birnirk archaeological site is an important site dating from about 500 to 900 A.D. The people who lived at this site were among the earliest people of Alaska's Arctic Coast who lived in a similar manner to modern whale and seal hunters of the area. This site was designated a National Landmark in 1962 (NPS 2007).

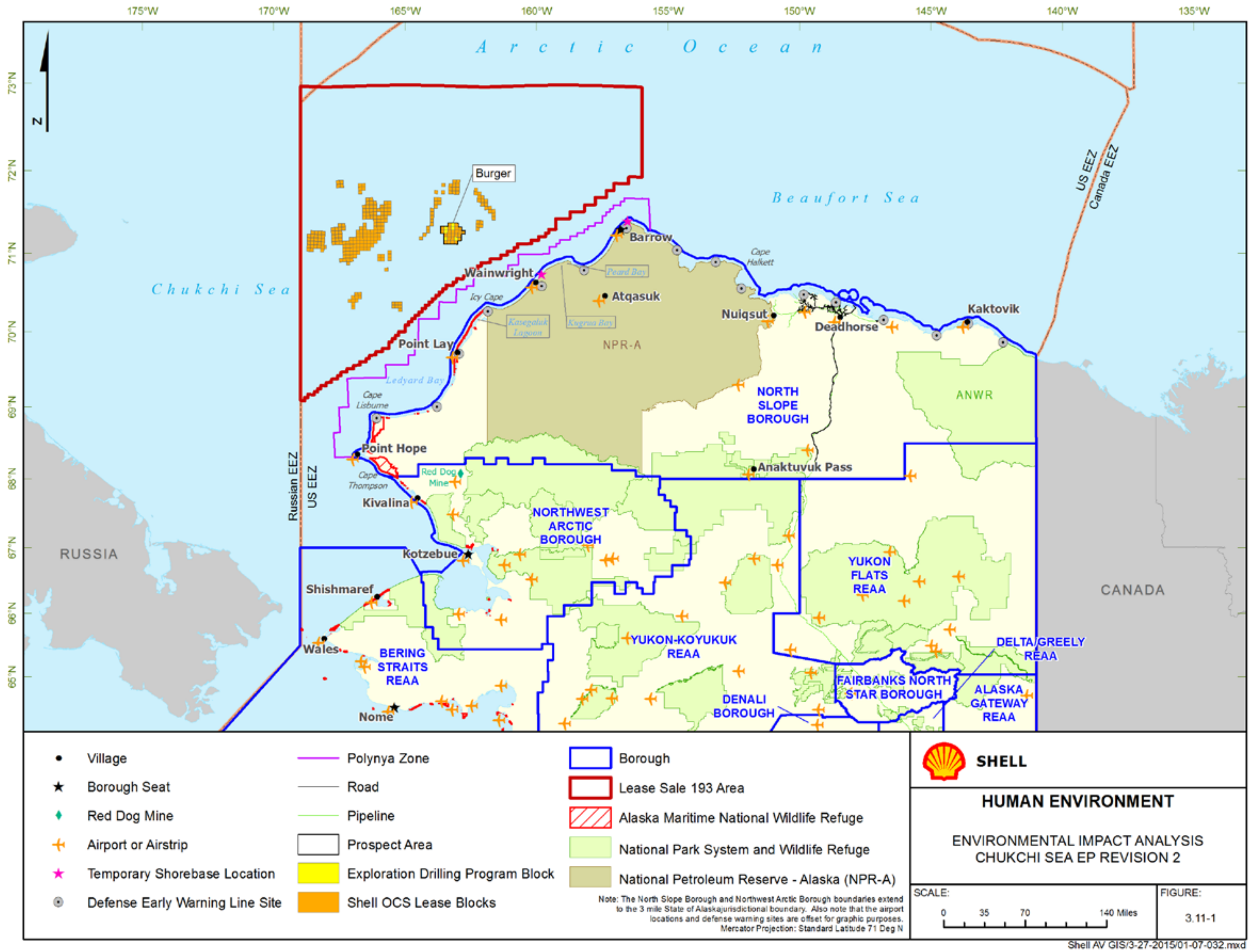
The name Barrow comes from Point Barrow, which was named by Captain Beechey of the Royal Navy in 1825 while he was mapping the Arctic coastline. The Point was named after Sir John Barrow of the British Admiralty (ADCA 2008; ASRC 2007; NSB 2008a; University of Arkansas 2008). In 1881, the U.S. Army established a meteorological and magnetic research station near the community (ADCA 2008; University of Arkansas 2008). Construction of the DEW line station and exploration of the NPR-A in the mid 1900s brought many people into the area (ADCA 2008, ASRC 2007, NSB 2008a, University of Arkansas 2008). The City of Barrow was incorporated in 1958 and the NSB was formed in 1972 (ADCA 2008).

Most of the houses in Barrow are connected to a piped water and sewage system. Most households heat their houses with natural gas. The Barrow Utilities and Electric Cooperative supplies electricity, natural gas, water, and sewer services to residents of the city. There are also two companies that deliver water and the NSB provides trash collection (ADCA 2008; ASRC 2007; NSB 2008a).

Barrow is serviced by the Barrow and Browerville fire stations. The community has four hotels, many restaurants, a bank, two grocery/merchandise stores, and several convenience stores. Communication into and within the city include telephone, mail, public radio, cable television, and internet access (ASRC 2007; NSB 2008a).

UIC is the ANCSA village corporation for Barrow and owns approximately 252 mi^2 (652 km^2) in the area.

Figure 3.11-1 Human Environment



Wainwright

Wainwright is approximately 72 mi (116 km) southwest of Barrow on the Chukchi Sea coast, 78 mi (126 km) from the Burger Prospect. It sits on a coastal bluff eroded by waves (NSB 2008b), and is the third largest village on the North Slope (University of Arkansas 2008). The village's traditional name is Olgoonik (in English) or Ulġuniq (in Iñupiaq) (MacLean 1980).

The region around Wainwright has been used by Iñupiat for generations. Many historic hunting and fishing camps are located in the area. The residents identify with the coastal environment and refer to themselves as Taġiuġmiut "people of the sea" (NSB 2005). The present village was not settled until 1904, when the Alaska Native Service built a school and began providing medical and other services in this location (ADCA 2008; University of Arkansas 2008). The village's English name, Wainwright, was taken from Wainwright Lagoon, which was named after Lt. John Wainwright in 1826. The City of Wainwright was incorporated in 1962 (ADCA 2008).

The NSB provides all utilities in Wainwright. Water is obtained from Merekruak Lake and trucked to Wainwright where it is treated, stored, and then delivered to household holding tanks (ADCA 2008). The community water system was constructed in 1998, but water and sewage utilities have been upgraded in recent years (NSB 2005). In 2003, approximately 94 percent of the households had water piped to their houses and 93 percent had flush toilets that connected to the sewer system. Approximately 97 percent of the households rely on diesel fuel as a heating source. Electricity, which is supplied by the NSB Power and Light System, is generated using diesel fuel (NSB 2005).

Wainwright is serviced by a health clinic, a police station, and a fire station. The Alak School accommodates children from pre-school through the twelfth grade. The village also has one hotel, one restaurant, and the Olgoonik Village Corporation-run general store (NSB 2005; NSB 2008b).

Point Lay

Point Lay is the only unincorporated traditional village in the NSB (Deadhorse is also unincorporated, but it is not a traditional village). Point Lay is approximately 150 mi (240 km) southwest of Barrow, 92 mi (148 km) from the Burger Prospect. The village sits on a coastal bluff and is protected from the ocean by Kasegaluk Lagoon. The Inupiaq name for the village is Kali, meaning "mound," and referring to the elevated ground on which the village sits (NSB 2005, 2008c). The ANCSA village corporation for Point Lay is the Cully Corporation. According to the NSB, Point Lay may be the last remaining village of the Kuukpaagruk.

Early Kuukpaagruk Iñupiat inhabitants lived along the coast and rivers in the Point Lay area. They lived in small groups hunting and fishing local resources. Gradually, they congregated in the Point Lay area. Following the establishment of a trading post in the 1920s and a school in 1930, the population began to grow. The original village of Kali was located on a barrier island. From there it was moved to the banks of the Kokolik River; after which it was moved to its current location (NSB 2005, NSB 2008c).

The NSB provides utilities for Point Lay. The Public Works Department maintains a water system that includes piped and hauled water. It also maintains the sewage system. In 2003, approximately 60 percent of the households had flush toilets that were connected to the village sewage system (NSB 2005). Diesel fuel or a combination of diesel and electricity are the two most common means of heating houses in Point Lay. The NSB Power and Light System generates electricity using diesel fuel (NSB 2005). The village has a health clinic, a school, a cultural center, a construction camp, a fire station, and a general store, which is operated by the Native Village of Point Lay (NSB 2008c).

Point Hope

Point Hope sits on a large gravel spit near the tip of the Lisburne Peninsula that extends approximately 15 mi (24 km) into the sea. The village is located approximately 315 mi (500 km) southwest of Barrow, 206 mi (332 km) from Burger Prospect.

The Point Hope peninsula (Tikigaq or Tikeraq) is the longest, continually inhabited location in the North Slope and perhaps in Alaska. Archaeological evidence shows that Tikeraqmuit Iñupiat have inhabited this area for at least the last 2,500 years. Some of the more well known archaeological villages are Old Tigara, New Tigara, Ipiutak, and Jabbertown (NSB 2005; NSB 2008d; University of Arkansas 2008; ADCA 2008). The Ipiutak archaeological site was listed in the National Register in 1966. The site has been designated a National Historic Landmark. In 1979, the Ipiutak Archaeological District, which includes the Ipiutak Site and other resources, was listed in the National Register (NPS 2008b, 2008c).

The NSB provides electricity, water and sewage services, and trash collection services. The Public Works Department maintains a piped water system and water haul system within the city. Diesel fuel or a combination of diesel and electricity are the two most common means of heating houses in Point Lay. The NSB Power and Light System generates electricity from diesel fuel (NSB 2005). The village has a health clinic, a school, a senior citizens center, a fire station, and a general store, which is operated by the Tikigaq Village Corporation, the ANCSA village corporation for Point Hope (NSB 2008d).

Northwest Arctic Borough

The NWAB is the second largest borough in Alaska, by size, encompassing approximately 39,000 mi^2 (101,000 km^2) along Kotzebue Sound and along the Wulik, Noatak, Kobuk, Selawik, Buckland, and Kugruk Rivers. It has a population of 7,523 in 2010 (U.S. Census Bureau 2010). The area has been occupied by Iñupiat for at least 10,000 years. Communities located within the Borough include: Ambler, Buckland, Deering, Kiana, Kivalina, Kobuk, Kotzebue, Noorvik, Selawik, and Shungnak and the unincorporated community of Noatak. NANA Regional Corporation is the ANCSA regional corporation for the NWAB.

The City of Kotzebue is the "hub" of northwest Alaska and is the transfer point between ocean and inland shipping. It does not have a natural harbor, and is ice-free for only three months each year. Deep draft vessels must anchor 15 mi (24 km) offshore, and cargo is lightered to the docking facilities. Local barge services provide cargo to area communities. The Ralph Wien Memorial Airport supports daily jet service and air taxis to Anchorage via Nome.

Activities related to government, mining, health care, transportation, construction, and service industries contribute to the NWAB economy. The Red Dog Mine, 90 mi (145 km) north of Kotzebue, is the world's largest zinc and lead mine, and provides 370 direct year-round jobs and over a quarter of the Borough's wage and salary payroll. The mineral rights are owned by NANA Regional Corporation and leased to Teck Cominco Alaska Inc., which owns and operates the mine and shipping facilities. Cominco Alaska, Maniilaq Association, the NWAB School District, CH2M Hill, and Kikiktagruk Iñupiat Corporation are the Borough's largest employers. The smaller communities rely on subsistence food-gathering and Native craft-making. About 162 Borough residents hold commercial fishing permits.

3.11.2 Demographics

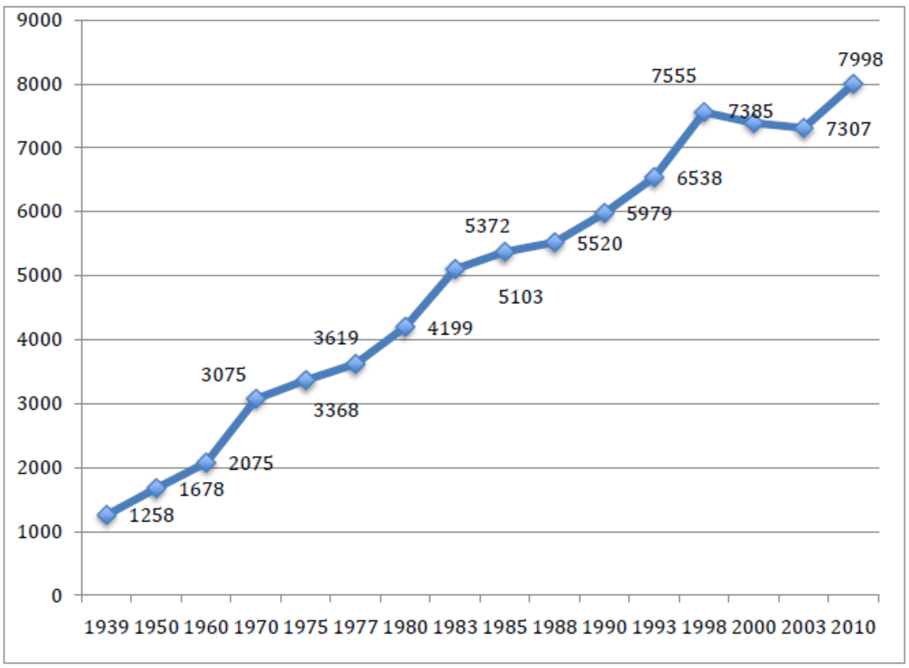
Demographics of the North Slope Borough

According to the NSB 2010 Economic Profile and Census Report (NSB 2010), the population within the NSB increased steadily from 1,258 residents in 1939 to 7,555 residents in 1998. The population decreased to 7,307 residents in 2003 and has increased to a high of 7,998 in 2010 (Figure 3.11.2-1).

According to the NSB's 2010 census, the villages of Barrow, Anaktuvuk Pass, Atqasuk, Kaktovik, Point Hope, and Point Lay gained residents from 2003 to 2010. The community of Nuiqsut's population decreased by one, and Wainwright's decreased by 10 residents during this same time period.

The majority of the population of the NSB is Iñupiat, indicated as American Indian and Alaska Native in the U.S. census (U.S. Census Bureau 2010). Figure 3.11.2-2 depicts the population by ethnicity.

Figure 3.11.2-1 North Slope Borough Population 1939-2010



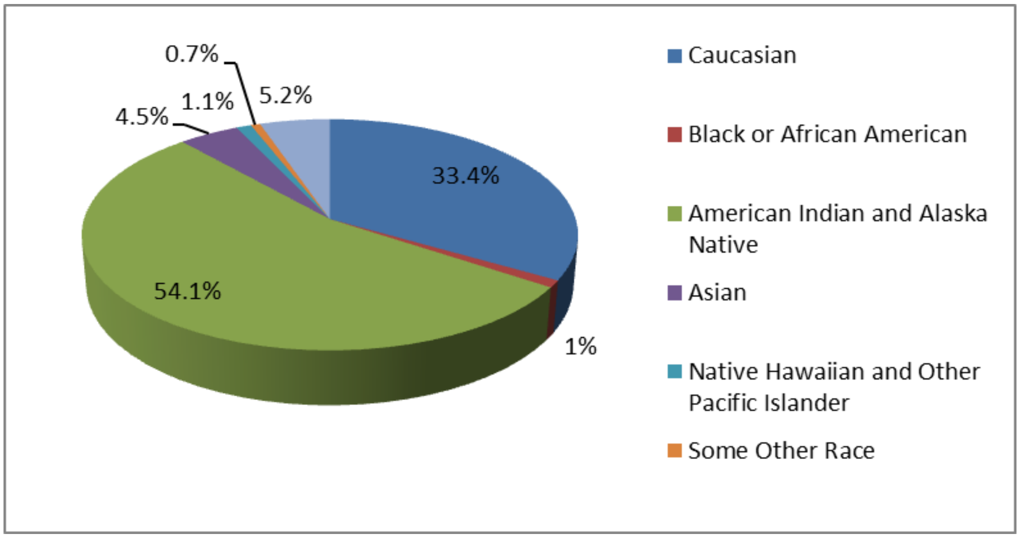
Source: NSB 2010

Table 3.11.2-1 Barrow Age Distribution Compared with that of Alaska and the U.S. 2010

Age Category	Barrow 2010 [1]	Alaska 2010 [1]	U.S. 2010 [1]
19 years and younger	39.4 %	29.2%	26.9%
20 to 34 years	22.7%	22.2%	20.3%
35 to 54 years	24.3%	28.7%	27.9%
55 years and older	13.7%	19.9%	24.9%

[1] Percent of total population depicted (Source: U.S. Census Bureau 2010)

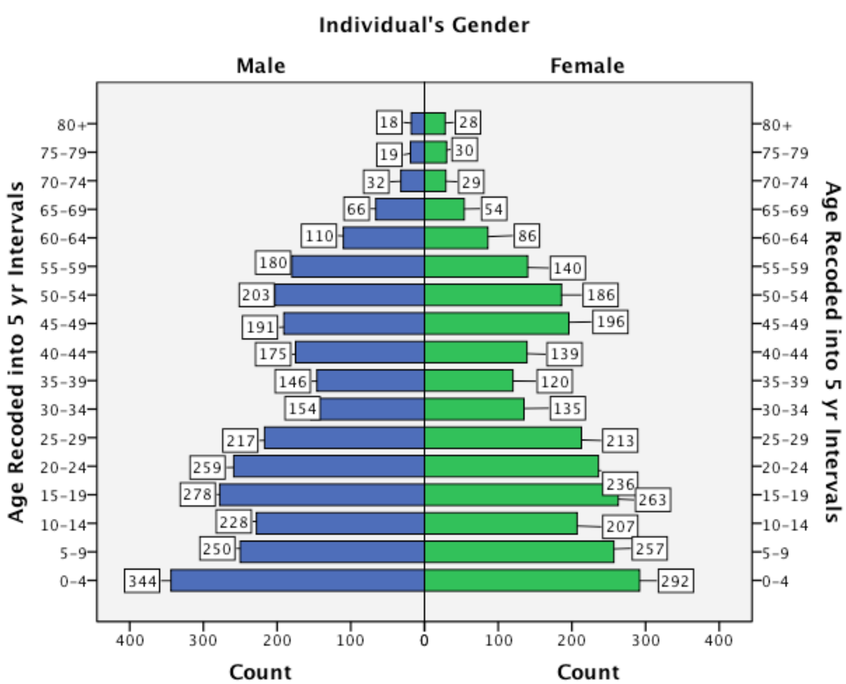
Figure 3.11.2-2 North Slope Borough Population by Ethnicity in 2010



Source: U.S. Census Bureau 2010

Median and average ages in the NSB are below those of the rest of the SOA and the rest of the United States (NSB 2010; U.S. Census Bureau 2010) (Figure 3.11.2-3). These demographic characteristics indicate the future need for education funding, housing, healthcare, and other public services, as well as job opportunities, workforce development, and training programs for NSB residents. The NSB (NSB 2010) reported a decline since 2003 in the total dependency ratio for the Borough. In this period, there was an increase in the number of individuals between 16 and 64 years of age in conjunction with only slight increases in the younger and older cohorts.

Figure 3.11.2-3 North Slope Borough Population by Age and Gender in 2010



Source: NSB 2010

Barrow Demographics

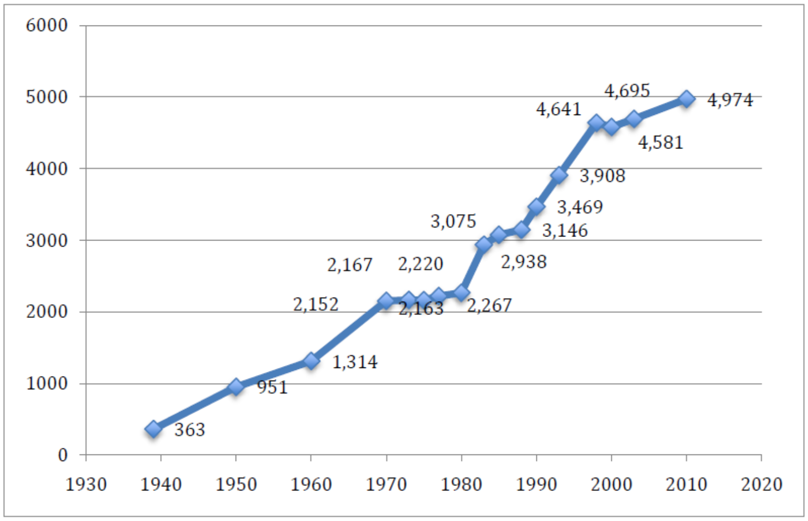
Current estimates put Barrow's population at just over 4,000. The SOA estimate is 4,380 (ADCA 2013), and the U.S. Census Bureau 2010 estimate is 4,212 (U.S. Census Bureau 2010). The NSB census for 2010 placed the Barrow population at 4,719 (NSB 2010).

According to the ADCA (2008), early U.S. census figures for Barrow include:

- 200 in 1880;
- 152 in 1890;
- 0 in 1900;
- 446 in 1910;
- 322 in 1920; and
- 330 in 1930.

Figure 3.11.2-4 shows population numbers from 1939 to 2010. From the years 1939 to 1998, Barrow population experienced periods of growth or remained stable. Following 1998, it appears that the population began to decline; however, in recent years it appears that the population is beginning to increase once more (NSB 2010).

Figure 3.11.2-4 Barrow Population 1939-2010

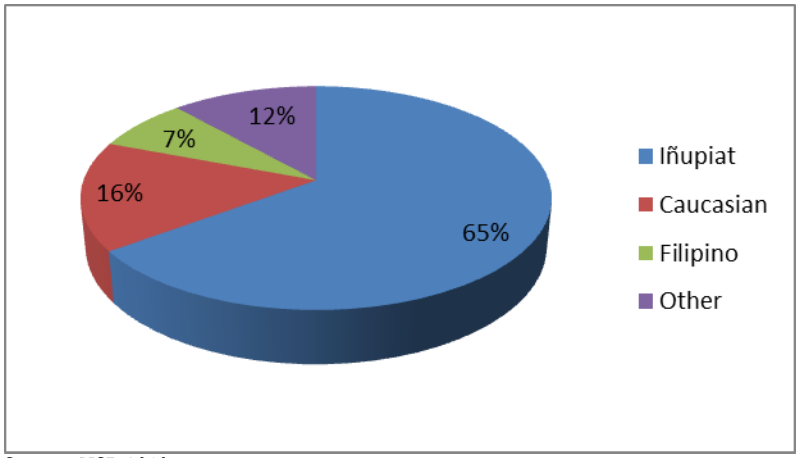


Source: NSB 2010

Shepro et al. (2003) found that Barrow had a relatively young population in 2003. In the NSB census for 2010, the average age increased slightly, but was still younger than the state and nation. This is consistent with what the U.S. Census Bureau found in 2010. The NSB 2010 census indicated a median age of 27, while the U.S. Census Bureau reported a median age of 28. Table 3.11.2-1 compares age groups in Barrow, Alaska, and U.S. populations. In order to make an adequate comparison, only population numbers for the year 2010 are used.

While the ethnic makeup of Barrow is diverse, the majority of the population in Barrow is Iñupiat. Figure 3.11.2-5 depicts the ethnic makeup of Barrow in 2010 (NSB 2010).

Figure 3.11.2-5 Barrow Ethnic Makeup in 2010



Source: NSB 2010

<u>Wainwright Demographics</u>

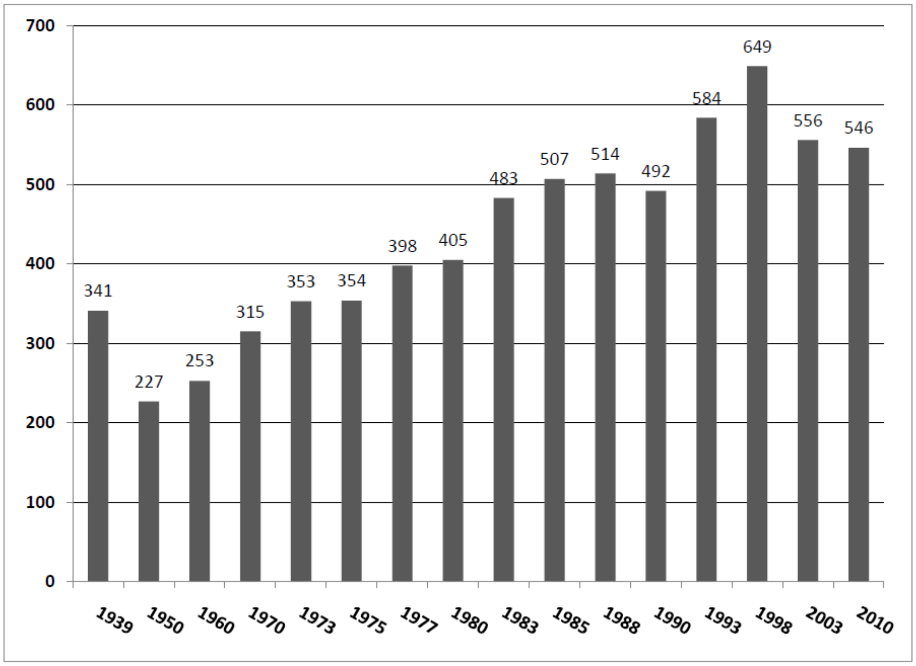
Recent population estimates put Wainwright's population between 500 and 600. According to the *2010 Economic Profile and Census Report* Wainwright's population is 546 (NSB 2010). ADCA (2008) estimated Wainwright's population at 572; the 2010 U.S. Census estimated the population at 556.

According to the ADCA (2008), early U.S. census figures for Wainwright include:

- 0 in 1880;
- 72 in 1890;
- 0 in 1900;
- 0 in 1910;
- 99 in 1920; and
- 197 in 1930.

Figure 3.11.2-6 shows population numbers from 1939 to 2010. Based on the earlier data presented, the population has experienced some fluctuation while gradually increasing. Looking at more recent data, it appears that the population is now either slowing growing or remaining static (NSB 2010).

Figure 3.11.2-6 Wainwright Population 1939-2010



Source: Data from NSB 2010

Shepro et al. (2003) concluded that the higher 1998 population number may be a result of increased employment availability, and thus an influx of people into the community, associated with the installation of the water and sewage systems. After the projects were completed, the job opportunities declined and workers left the village (Shepro et al. 2003). More recent information states that the population has declined by 15 percent (or 98 people) since 1998 (NSB 2010).

In 2003, Shepro et al. (2003) noted that Wainwright had a relatively young population. They found that 37.3 percent of the population was younger than 17 years old. This was down from 41.1 percent in 1998 (Shepro et al. 2003). More recent data from the NSB 2010 census shows that Wainwright still has a relatively young population with 41.5 percent of the population under the age of 19. This is higher than the 2010 U.S. Census estimate of 36.6 percent. Table 3.11.2-2 compares age groups in Wainwright, Alaska, and U.S. populations. In order to make an adequate comparison, only population numbers for the year 2010 are used.

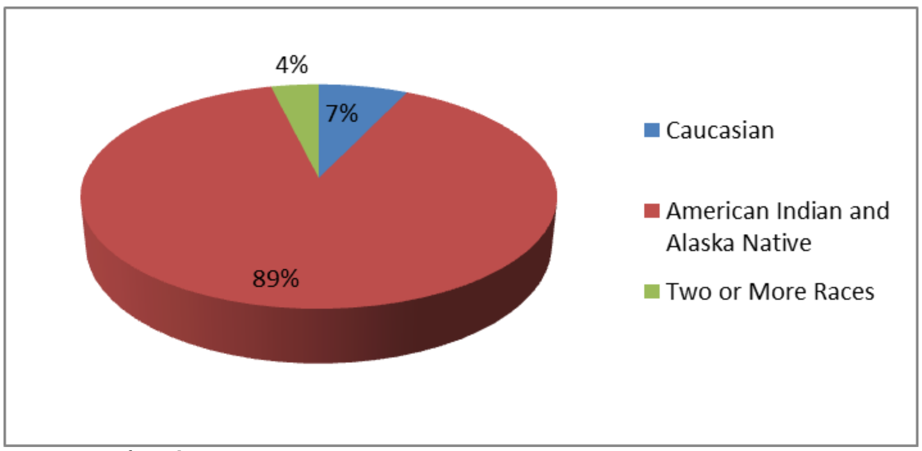
Table 3.11.2-2 Wainwright Age Distribution Compared with that of Alaska and the U.S. 2010

Age Category	Wainwright 2010 [1]	Alaska 2010 [1]	U.S. 2010 [1]
19 years and younger	36.6%	29.2%	26.9%
20 to 34 years	22%	22.2%	20.3%
35 to 54 years	26.4%	28.7%	27.9%
55 years and older	15%	19.9%	24.9%

[1] Percent of total population depicted (Source: U.S. Census Bureau 2010)

The majority of the population in Wainwright identifies itself as Iñupiat. According to the NSB 2010 Economic Profile and Census Report (NSB 2010) 94.6 percent of the population identified itself Iñupiat; while 5.4 percent identified as non-Iñupiat. This is consistent with the 2010 U.S. Census, which broke down ethnicity in more detail (Figure 3.11.2-7).

Figure 3.11.2-7 Wainwright Ethnic Makeup in 2010



Source: Data from the U.S. Census Bureau 2010

Point Lay Demographics

Current estimates put Point Lay's population at 274 (NSB 2010). The SOA estimate is 196 (ADCA 2013), and the U.S. Census Bureau 2010 estimate is 189 (U.S. Census Bureau 2010).

According to the ADCA (2008), early U.S. census figures for Point Lay include:

- 30 in 1880;
- 77 in 1890;
- 0 in 1900;
- 0 in 1910;
- 0 in 1920;
- 0 in 1930; and
- 117 in 1940.

Figure 3.11.2-8 shows population numbers from 1939-2010. There was a significant population number decrease after 1939. The community was abandoned circa 1960 and re-established in 1973 (NSB 2005). From 1973-2010, the population generally grew steadily (NSB 2010). However, current U.S. Census and SOA data contradicts this information; 2010 U.S. Census data estimates the population of Point Lay to be 189 and the Alaska Department of Commerce, Community, and Economical Development (ADCCED) currently estimates the population to be 196 (ADCA 2013). These numbers are much different than the NSB Census estimate of 274 (NSB 2010).

Figure 3.11.2-8 Point Lay Population 1939-2010

Source: NSB 2010

Point Lay has a young population, however, the median age rose from 18 to 21 between 2003 and 2010 (NSB 2010). Shepro et al. (2003) found that almost 56 percent of the people whose age was reported in 2003 were 19 years old or younger; according to 2010 U.S. Census data, these numbers have decreased since 2003. Table 3.11.2-3 compares age groups in Point Lay, Alaska, and U.S. populations. In order to make an adequate comparison, only population numbers for the year 2010 are used. From this table it can be seen that Point Lay's population is considerably younger than that of Alaska in general and the U.S.

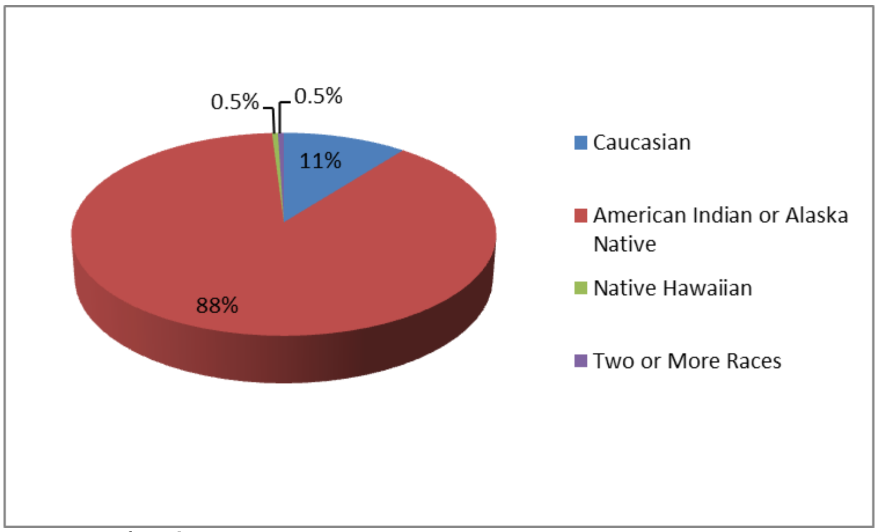
Table 3.11.2-3 Point Lay Age Distribution Compared with that of Alaska and the U.S. 2010

Age Category	Point Lay 2010 [1]	Alaska 2010 [1]	U.S. 2010 [1]
19 years and younger	36.6%	29.2%	26.9%
20 to 34 years	27.5%	22.2%	20.3%
35 to 54 years	24.9%	28.7%	27.9%
55 years and older	11%	19.9%	24.9%

[1] Percent of total population depicted (source: U.S. Census Bureau 2010)

The majority of the population in Point Lay identifies itself as Iñupiat in 2010. According to the 2010 Economic Profile and Census Report (NSB 2010) 89.2 percent of the population identified itself Iñupiat; while 9.7 percent identified as non-Iñupiat. This result is consistent with the 2010 U.S. Census, which broke down ethnicity in more detail (Figure 3.11.2-9).

Figure 3.11.2-9 Point Lay Ethnic Makeup in 2010



Source: Data from the U.S. Census Bureau 2010

Of the 0.5 percent that reported being of two or more ethnicities, 100 percent reported being part Alaska Native or American Indian.

Point Hope Demographics

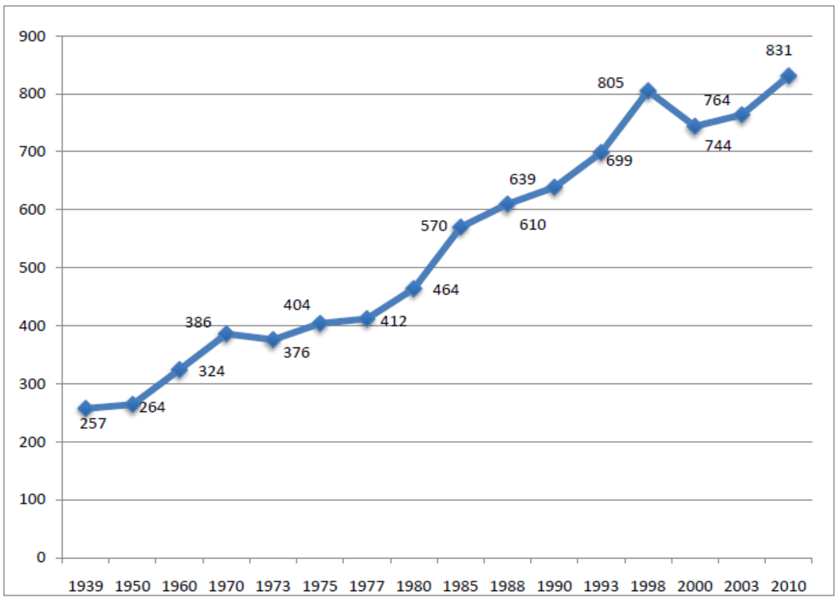
Current estimates put Point Hope's population at 831 (NSB 2010). The SOA estimate is 656 (ADCA 2013), and the U.S. Census Bureau 2010 estimate is 674 (U.S. Census Bureau 2010).

According to the ADCA (2008), early U.S. Census figures for Point Hope include:

- 0 in 1880;
- 301 in 1890;
- 623 in 1900;
- 243 in 1910;
- 141 in 1920; and
- 139 in 1930.

Figure 3.11.2-10 shows population numbers from 1939 to 2010. This data shows Point Hope's population grew steadily from 1939 to 1998. After that time, it decreased slightly but grew from 2003 to 2010 (NSB 2010).

Figure 3.11.2-10 Point Hope Population 1939-2010



Source: Data from the U.S. Census Bureau 2010

The median age of the population in Point Hope is 28 (NSB 2010). The 2010 U.S. Census found that 28.1 percent of the people whose age was reported in 2010 were 19 years old or younger. This is less than the percentage that the U.S. Census Bureau found in 2000. Table 3.11.2-4 compares age groups in Point Hope, Alaska, and U.S. populations. In order to make an adequate comparison, only population numbers for the year 2010 are used. From this table it can be seen that Point Hope's population is considerably younger than that of Alaska in general and the U.S.

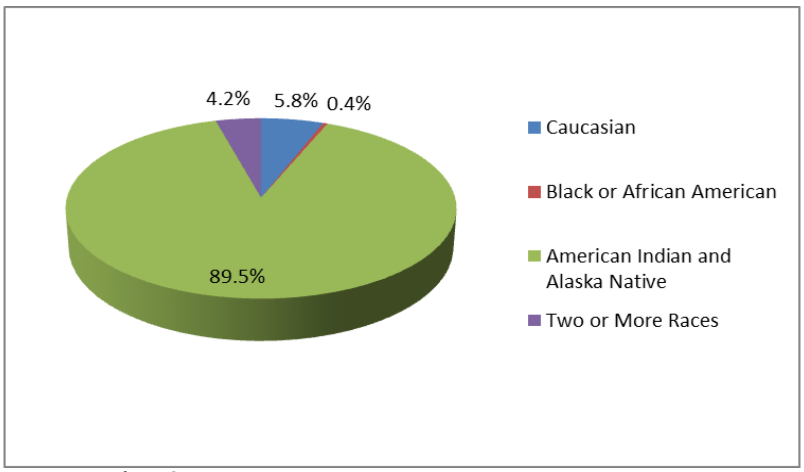
Table 3.11.2-4 Point Hope Age Distribution Compared with that of Alaska and the U.S. 2010

Age Category	Point Hope 2000 [1]	Alaska 2010 [1]	U.S. 2010 [1]
19 years and younger	39.2%	29.2%	26.9%
20 to 34 years	23.4%	22.2%	20.3%
35 to 54 years	20.7%	28.7%	27.9%
55 years and older	16.8%	19.9%	24.9%

[1] Percent of total population depicted (Source: US Census Bureau 2010)

The majority of the population in Point Hope identified itself as Iñupiat in 2010. The 2010 Economic Profile and Census Report (NSB 2010) reported that 92.6 percent of the population identified itself Iñupiat; while 7.4 percent, as non-Iñupiat (NSB 2010). This result is similar to the 2010 U.S. Census, which broke down ethnicity in more detail (Figure 3.11.2-11).

Figure 3.11.2-11 Point Hope Ethnic Makeup in 2010

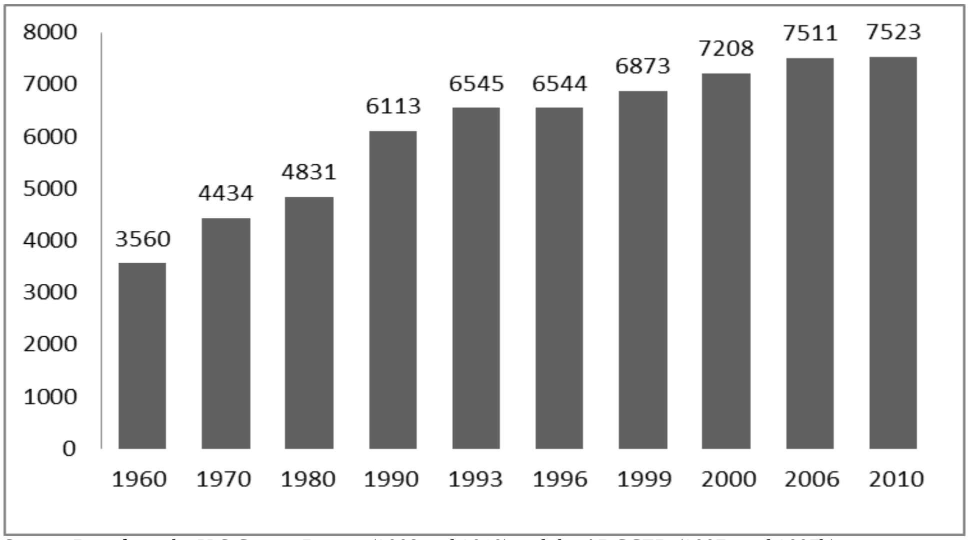


Source: Data from the U.S. Census Bureau 2010

Northwest Arctic Borough Demographics

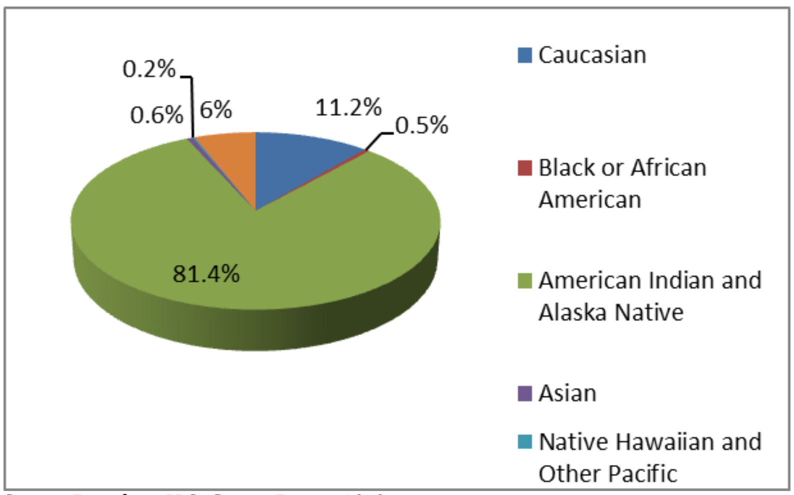
Figure 3.11.2-12 shows that population numbers for the NWAB increased from 3,560 in 1960 to 7,523 in 2010 (U.S. Census Bureau 2010; ADCCED 2007a and 2007b). The majority of the population in the NWAB identifies itself as American Indian and Alaskan Native (Figure 3.11.2-13). The median and average ages in the NWAB have remained stable since 2000, remaining lower than the SOA and nation (U.S. Census Bureau 2010) (Figure 3.11.2-14).

Figure 3.11.2-12 Northwest Arctic Borough Population 1960-2010



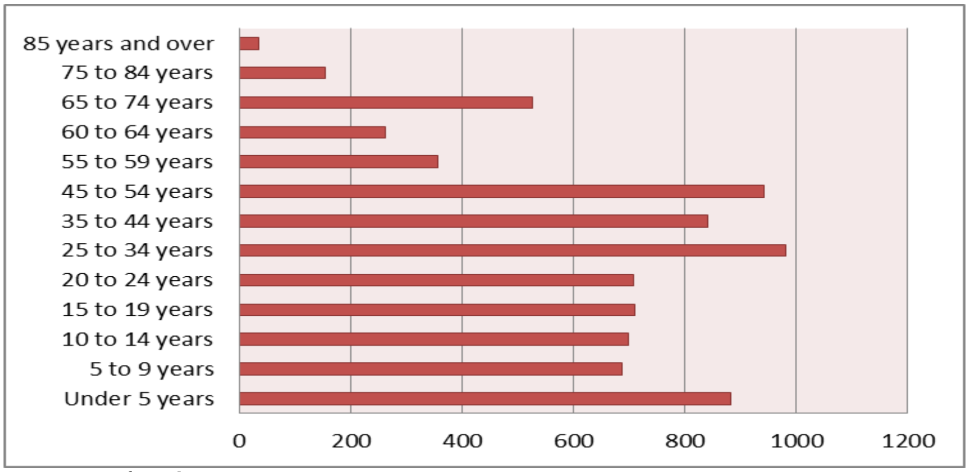
Source: Data from the U.S Census Bureau (2008 and 2010) and the ADCCED (2007a and 2007b)

Figure 3.11.2-13 Northwest Arctic Borough Ethnic Makeup in 2010



Source: Data from U.S. Census Bureau 2010

Figure 3.11.2-14 Northwest Arctic Borough Population by Age in 2010



Source: Data from the U.S. Census Bureau 2010

3.11.3 Employment

The NSB is the predominant economic driver on the North Slope. Oil and gas development within its geographic boundaries generates revenues for building infrastructure and extending public facilities and services. However, most of the NSB residents in the workforce do not have jobs in the oil and gas industry. The largest employer is the NSB with most of the residents working for the NSB government, NSB School District, city government, and state or federal government. The Tables 3.11.3-1 and 3.11.3-2 illustrate the employment breakdown.

Government, mining, health care, transportation, services and construction support the NWAB economy. The Red Dog Mine, which is 90 mi (144.8 km) north of Kotzebue, provides 370 year-round jobs and more than a quarter of the borough's salary and wages. Teck Cominco Alaska Inc. operates the mine. Cominco Alaska, Maniilaq Association, the NWAB School District, and Kikiktagruk Iñupiat Corporation are the borough's largest employers (ADCCED 2007a). Almost half of the population of the NSB works for the NSB government, with 47.35 percent of residents considered to be government workers (ADCA 2013).

Table 3.11.3-1 Employment of North Slope Borough Residents by Employer

Employer	2003 Count	2003 %	2010 Count	2010 %
Federal Government	61	2.8%	41	1.7%
State Government	26	1.2%	25	1.0 %
City Government	66	3.0%	113	4.6%
NSB Government	705	32.2%	742	30.5%
NSB School District	409	18.7%	427	17.5%
NSB Capital Improvement Projects (CIP)	10	0.4%	28	1.1%
Private Construction Firm	43	1.9%	37	1.5%
ASRC or subsidiary	88	4.0%	69	2.8%
Village corporation/subsidiary	295	13.5%	334	13.8%
Finance/Insurance	6	0.2%	3	0.1%
Transportation	53	2.4%	45	1.8%
Communications	8	0.3%	8	0.3%
Trade	31	1.4%	21	0.9%
Ilisagvik	62	2.8%	67	2.7%
Other	197	9.3%	374	15.3%
Total	2,191	100%	2443	100%

Source: NSB 2010

Table 3.11.3-2 NSB Employment by Employer, Gender, and Ethnicity in 2010

Employer	Gender	Iñupiat	Caucasian	Other
		Count	Count	Count
Federal Government	Male	7	6	3
	Female	14	6	5
State Government	Male	5	4	0
	Female	7	6	3
City Government	Male	43	5	3
	Female	49	2	1
NSB Government	Male	283	72	68
	Female	207	52	59
NSB School District	Male	51	92	38
	Female	109	102	35
NSB CIP	Male	21	3	1
	Female	3	0	0
Oil Industry	Male	26	6	1
	Female	4	0	1
Private construction firm	Male	13	4	6
	Female	13	0	1
ASRC or subsidiary	Male	29	2	3
	Female	33	0	2
Village corp./subsidiary	Male	157	13	7
	Female	147	4	4
Finance/Insurance	Male	0	0	0
	Female	0	0	0
Transportation	Male	14	4	15
	Female	8	2	2
Communications	Male	4	2	1
	Female	8	2	2
Other	Male	134	64	71
	Female	134	60	61
Total		1525	511	395

Source: NSB 2010

The number of jobs in the oil industry held by NSB residents in the oil industry from 1980 to 2003 has not been remarkable (Table 3.11.3-3). Numbers of jobs in the oil industry ranged from a high of 46 in 1988 to 16 in 1998. Workforce participation by NSB residents in the oil industry in 2003 was 23 jobs. In order to increase the economic benefit within the villages, more local hire is needed. This is a challenge for the oil and gas industry in partnership with the NSB, ASRC, the SOA, community colleges, University of Alaska, vocational technical schools, and job training facilities (Northern Economics, Inc. 2006).

Table 3.11.3-3 Estimated Number of Jobs by Sector in the North Slope Borough

Sector	1980	1988	1993	1998	2003
Federal Government	100	83	37	39	61
State Government	12	20	25	35	26
City Government		71	61	57	66
NSB Government	642	1,087	893	989	777
NSB School District		419	345	289	409
Private Construction	201	95	21	66	43
Regional/Village Corporations		311	304	407	383
Transportation	107	122	45	43	53
Oil Industry	30	46	21	16	23
Services	71	84	53	83	108
Other	176	168	138	368	242
Total	1,689	2,506	1,943	2,392	2,191

[1] Source: Northern Economics Inc. 2006

Barrow Employment

The NSB is the primary employer for the city of Barrow, providing 47.5 percent of the jobs (NSB 2010). Additional job opportunities are provided by tribal governments and the private sector, including: the Native Village of Barrow, ASRC, Arctic Slope Native Association, Iñupiat Community of the Arctic Slope (ICAS), NSB School District and UIC.

The 2010 US Census reported that the average per capita income was $26,159 and the mean income per household was $96,412. It was also reported that 9 percent of households and 7.9 percent of families made less than $15,000 yearly. 13.1 percent of the population and 10.4 percent of families were reported as being below the federal poverty level.

The 2010 NSB Census (NSB 2010) reported that 25.7 percent of the population was unemployed, while the U.S. Census in 2010 reported only 10.8 percent unemployment. This is higher than both state (5.8 percent) and national (8.7 percent) unemployment rates.

Barrow is seen as the economic and administrative center for the North Slope.

Wainwright Employment

The NSB (28 percent), NSB School District (21 percent), and Olgoonik Corporation and Subsidiaries (22 percent) employ 71 percent of all workers in the community of Wainwright (NSB 2010).

The 2010 NSB Census reported an average income per household of $54,200. The unemployment rate was reported to be 26.3 percent, which is higher than both state and federal unemployment rates. The 2010 NSB Census also reported that 19.4 percent of households were below the poverty level.

Another 21 percent of Wainwright residents also participated in the making and selling of crafts with an average annual income of $887 being reported from art sales (Shepro et al. 2003).

Point Lay Employment

The NSB and NSB School District employ 67 percent of the Point Lay population with 14 percent being employed by the Village Corporation and subsidiaries (NSB 2010).

The 2010 NSB Census reported an average income of $56,515 and an average Iñupiat income of $54,708. The unemployment rate was reported to be 21 percent, which is higher than both state and federal unemployment rates. It was also reported that 10 households (or 20 percent) were below the poverty level.

An average of 20 percent of the population of Point Lay participated in the selling of crafts, with an annual reported income of $368 from this source (Shepro et al. 2003).

Point Hope Employment

The NSB, Tikigaq Corporation, and the NSB School District are the primary employers for the community of Point Hope (NSB 2010).

The 2010 NSB Census reported an average income per household of $56,242 and an average Iñupiat income per household of $54,000. The unemployment rate was reported to be 31.9 percent, which is again higher than both state and federal unemployment rates. According to the 2010 US Census, 9 percent of all people and 6.1 percent of all families were living below the poverty level.

On average 21 percent of the population participated in making and selling Native crafts, providing an annual average income of $2,373 (Shepro et al. 2003).

3.11.4 Existing Offshore and Coastal Infrastructure

There is no offshore infrastructure and only limited coastal infrastructure in the vicinity of the project area. Coastal infrastructure is localized in the neighboring villages. These villages include Barrow, Wainwright, Point Lay, and Point Hope.

Shell will use existing infrastructure in the villages of Wainwright and Barrow as temporary shorebase facilities. Specifically, Shell intends to use the Wainwright airstrip and marine ramps and the Barrow Airport as shorebase facilities.

Transportation

There is no road system connecting any of these four villages with each other or other communities in the state. Barrow, the NSB center and largest community in the North Slope, has a paved road system. The other villages in the borough have gravel roads. Barrow has an airport that accommodates jet service. Point Lay, Point Hope, and Wainwright each have an airstrip with regularly scheduled and chartered commercial service.

Utilities

The NSB supplies water, sewer, solid waste, and electricity to Barrow, Wainwright, Point Lay, and Point Hope. Water and sewer services are a combination of piped and trucked services. Natural gas is used to generate electricity in Barrow. The majority of Barrow households use baseboard/boiler heating systems, use of these systems has seen a five percent increase since 2003 (NSB 2010). In the villages of Point Hope, Point Lay, and Wainwright, diesel fuel is used to generate electricity. Diesel fuel or a combination of diesel and electricity are used as heat sources in these villages.

Communications

The NSB villages have digital telephone service, dial-up internet, community teleconference centers, cable television, public radio, video distance education system, wide area data network, and two-way radio.

Health, Education, and Community Services

Barrow has a regional hospital. A health clinic is located at each of the other villages. There are elementary, middle, and high schools in Barrow. Barrow is also home to Ilisagvik College. The other three villages have one school each. These schools accommodate pre-school through twelfth grade.

There are two fire stations in Barrow and one each in Wainwright, Point Lay, and Point Hope. Additionally, each of the four villages has a police station/public safety department.

3.11.5 Land Use

Within the NSB, land use is community related: residential, commercial, public institutional uses, subsistence, industrial and resource development, transportation, and recreation (NSB 2005). The NSB Comprehensive Plan defines four land use zoning districts: Village District, Barrow District, Conservation District, and Resource Development District. The James Dalton Highway Transportation Corridor District is defined separately as a Transportation Corridor (ASCG 2005). With adoption of the NSB Comprehensive Plan in 2005, two districts were proposed for implementation through Title 19 Land Management Regulations. These proposed districts are a Special Habitat District and Subsistence Use District.

Barrow is its own district. The villages of Point Lay, Wainwright, and Point Hope are zoned Village District. The goal of the Village Districts is to maintain traditional values and lifestyles in the vicinity of the NSB communities. Traditional land uses occur through the NSB for subsistence and cultural purposes. Traditional land uses have occurred for thousands of years. It is difficult to map traditional land use and subsistence areas because patterns and locations change with the seasons, animal migrations, and weather. Due to the complexity in mapping traditional land use areas, subsistence areas are generally documented on a project specific basis.

The Conservation District encompasses the entire NSB, except for the Barrow District, Village Districts, and Resource Development District. The goal of the Conservation District is preservation of the natural ecosystem, which includes the subsistence species upon which local residents depend. Up until 2005, the NSB had rezoned 932,903 acres from Conservation District to Resource Development District.

The purpose of the Resource Development District is to accommodate large-scale resource extraction balanced with protecting subsistence resources and coordinating with the NSB Comprehensive Plan policies. Requirements for rezoning from Conservation to Development District are a Master Development Plan and approval by both the NSB Planning Commission and Assembly.

3.11.6 Subsistence

Subsistence use as defined by Alaska Statute 16.05.940(33) is:

> *"…the noncommercial, customary, and traditional use of wild, renewable resources by a resident domiciled in a rural area of the state for direct personal or family consumption as food, shelter, fuel, clothing, tools, or transportation, for the making and selling of handicraft articles out of non-edible by-products of the fish and wildlife resources taken for personal or family consumption and for customary trade, barter, or sharing for personal or family consumption."*

The Iñupiat of the North Slope have adapted to survive in a harsh environment. Their way of life that has enabled them to survive is founded on close family ties, teamwork, cooperation and the sharing of resources and knowledge. Their way of life is dependent on and defined by subsistence.

The cultural identity of the NSB residents has been rooted in a subsistence lifestyle and its associated social and cultural framework for thousands of years (NSB 2005). Subsistence is not a recreation or merely a means to provide food; subsistence is a way of life (Brower 2005).

Although subsistence is more than gathering food, subsistence foods are one of the more crucial aspects of the Iñupiat lifestyle and are perceived to maintain the health and strength of the Iñupiat people (Brower 2005; NSB 2005). Subsistence is integrated throughout all aspects of The North Slope Comprehensive Plan (NSB 2005).

Shepro et al. (2003) reported that almost all Iñupiat households in the NSB utilize subsistence food sources. Subsistence helps maintain familial and social networks and relationships. Harvest from subsistence activities is shared among family, friends, the community, between North Slope communities, and with relatives and friends as far away as Fairbanks and Anchorage. Whaling crews, for example, have been traditionally and continue to be based on kinship relationships (MMS 2007b; BOEMRE 2011b; FSEIS, NSB 2005).

While subsistence plays an important part in the economies of local communities, it is much more than a means of obtaining physical sustenance. Residents depend upon subsistence for spiritual sustenance and cultural identity (Brower 2005). Animals that are considered subsistence resources are featured in and play supporting roles in traditional stories. Like other orally-based cultures, stories are a means of recording history, passing on environmental knowledge, teaching social etiquette, and strengthen social bonds. The presence of subsistence animals in and stories about subsistence related activities convey the importance of subsistence within Iñupiat society. North Slope Iñupiat assign the highest cultural value to subsistence activities (Nelson 1979; BOEMRE 2011b, FSEIS). Subsistence plays an important role in planning and management of the NSB (NSB 2005).

Even though subsistence remains an integral part of the socioeconomics of the North Slope, the dominant cash culture of the western world influences the Iñupiat resulting in significant challenges to traditional and cultural values, especially values around land use and subsistence.

Some studies indicate that higher levels of household cash income have been correlated with peoples' commitment to, and returns from, natural resource harvesting (NRC 1999). Despite high paying job opportunities, many young Iñupiat men have chosen to balance wage employment with seasonal subsistence activities (Kleinfield et al. 1983; Kruse 1991 cited in BOEMRE 2011a, FSEIS), thus continuing traditional cultural, socioeconomic activities and customs. Wild foods and other products traditionally have been traded among households within a community via extensive, non-commercial, kinship-based networks (MMS 2007b; NSB 2010; BOEM 2011a). According to NSB surveys of the harvest of subsistence resources, these subsistence resources continue to be vital in household economies (Table 3.11.6-1). The Iñupiat have drawn and continue to draw upon collective experiences to respond to the challenges of both the Arctic and modernity. Subsistence resources and activities are crucial for Iñupiaq culture and way of life.

Table 3.11.6-1 North Slope Borough Household Consumption of Subsistence Resources

Consumption	1998		2003	
	Households[1,2]	Percent [1,2]	Households[1,2]	Percent[1,2]
None	35	3	165	13
Very little	128	12	217	17
Less than half	211	20	182	14
Half	216	21	241	19
More than half	188	18	183	14
Nearly all	134	13	165	13
All	126	12	130	10
Total	1,038	100	1,283	100

[1] Data indicate households that responded to a question regarding how much of the meat, fish, and birds eaten in the household came from local food sources
[2] Source : Shepro et al. 2003 in NSB 2005

Subsistence Resources

There are two major subsistence-resource categories: coastal/marine and terrestrial/aquatic. Animals hunted by residents of Chukchi Sea villages that are in the coastal/marine category include whales, seals, walruses, waterfowl, and fish while those included in the terrestrial/aquatic category include caribou, fish, moose, Dall sheep, and terrestrial vegetation (MMS 2007b). Vegetation gathering for subsistence purposes along the Chukchi Sea coast is fairly limited (MMS 1990). Many of the subsistence species important to the Iñupiat, such as bowhead whales, seals, polar bears and walruses, can be found seasonally distributed throughout the Chukchi Sea, including the project areas. The vast majority of subsistence hunting and fishing activities by local residents occur much closer to shore than in the areas of Shell's planned exploration drilling activities over 60 mi (97 km) offshore. Figure 3.11.6-1 depicts the general marine mammal subsistence calendar for the villages of Barrow, Wainwright, Point Lay, and Point Hope. Subsistence windows may vary slightly since this figure was generated, due to climate change or other ecological changes. In addition, Wainwright started a fall bowhead hunt in 2011. Figure 3.11.6-2 depicts the general subsistence fishing calendar for the villages of Barrow, Wainwright, Point Lay, and Point Hope.

Stephen R. Braund and Associates, through an ongoing process of documenting subsistence activities has produced maps of subsistence activities for the NSB and the Northwest Alaska communities. The NSB has collected more recent data on subsistence statistics for the NSB 2010 Economic Profile and Census Report (NSB 2010). Figures 3.11.6-3 through 3.11.6-11 depict selected subsistence use areas for Barrow, Wainwright, Point Lay, and Point Hope. BOEM (MMS 2008a) also provided maps of areas used for subsistence by residents of Barrow, Wainwright, Point Lay, and Point Hope in their multi-sale EIS, using the same data. Additional maps of subsistence areas are found in earlier EISs prepared by BOEM (MMS 1987a,b, 1991, 2007b).

Chukchi Sea village residents utilize many marine resources for subsistence. Regional subsistence activities include fishing, waterfowl and sea duck harvests, and hunting for seals, polar bears, walruses, and bowhead and beluga whales. Depending upon the village’s hunting success of a certain species, another species may become a priority in order to provide enough nourishment to sustain the village. The percentages of the subsistence harvest represented by various groups of resources are indicated in Table 3.11.6-2. Marine mammals represent the majority of the harvest on a volume basis. The relative importance of the different marine mammal species in the harvest is indicated in Table 3.11.6-3. Whale meat, blubber, and skin are shared among and between villages of the North Slope, including villages that do not take part in bowhead whaling hunting. Muktuk (whale skin and blubber) and meat are important parts of the subsistence economy of these communities (MMS 2007b). Table 3.11.6-4 provides the number of bowhead whales harvested per year. The time periods during which bowhead whales were harvested by Point Hope, Point Lay, and Wainwright hunters are indicated in Table 3.11.6-5. Barrow hunters harvest bowheads during spring and fall hunts; dates during which harvests have occurred in recent years are indicated in Table 3.11.6-6. Summaries of subsistence harvests by village are provided below.

Figure 3.11.6-1 Marine Mammal Subsistence Annual Cycle, Chukchi Villages

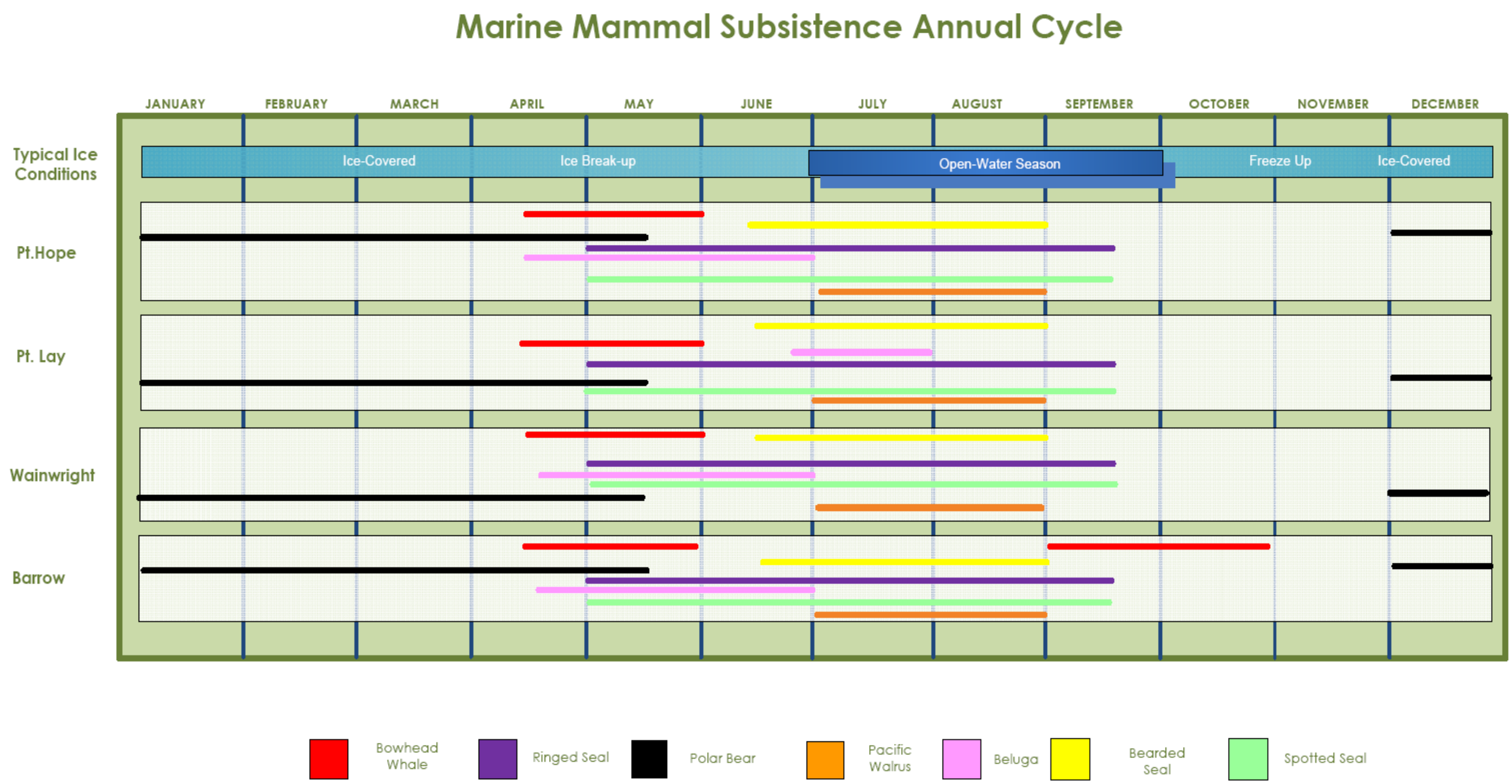
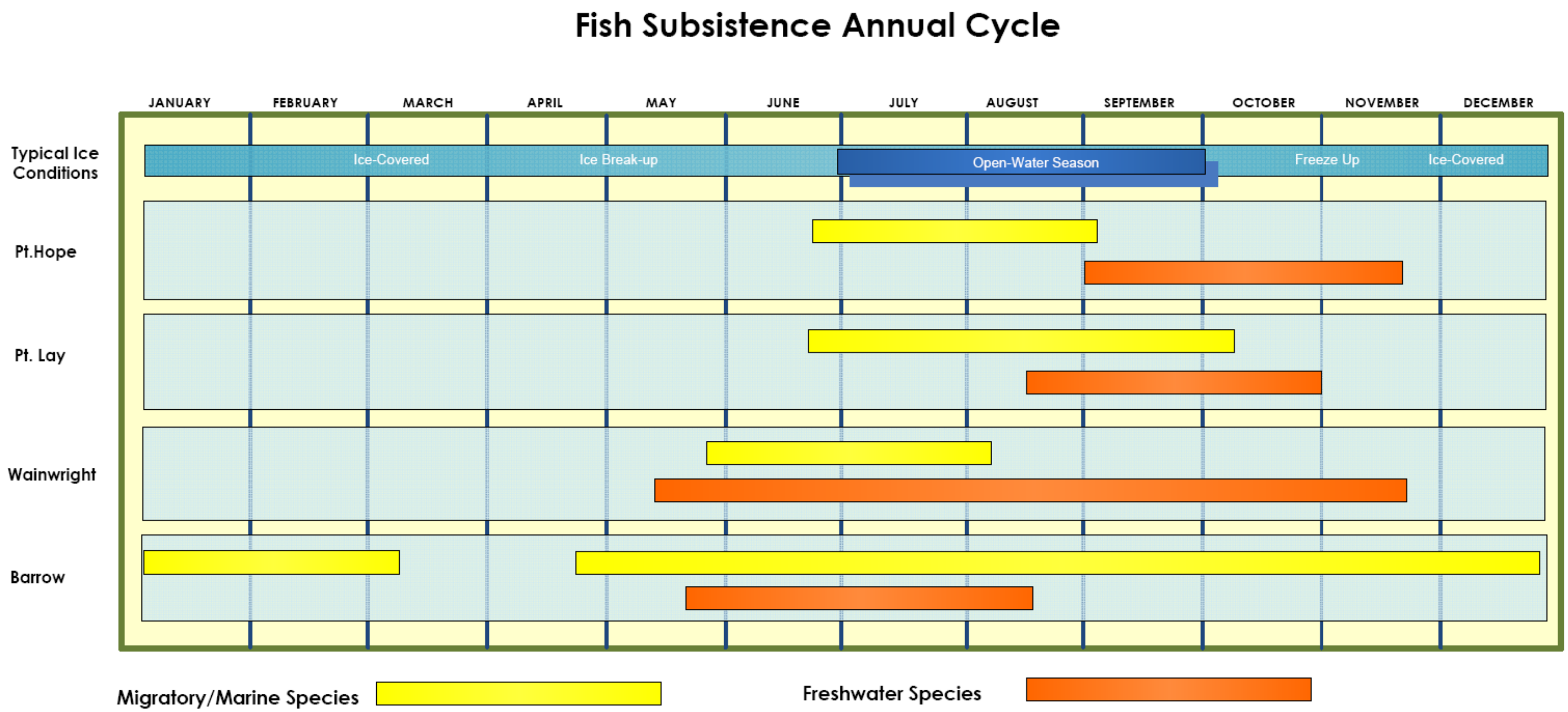


Figure 3.11.6-2 Subsistence Fishing Annual Cycle for Chukchi Villages



Sources: NSB 2005, MMS 2007b, and personal communication with Arlene Thomas (Thomas 2008).

Figure 3.11.6-3 Selected Barrow Subsistence Use Areas for Walrus and Waterfowl

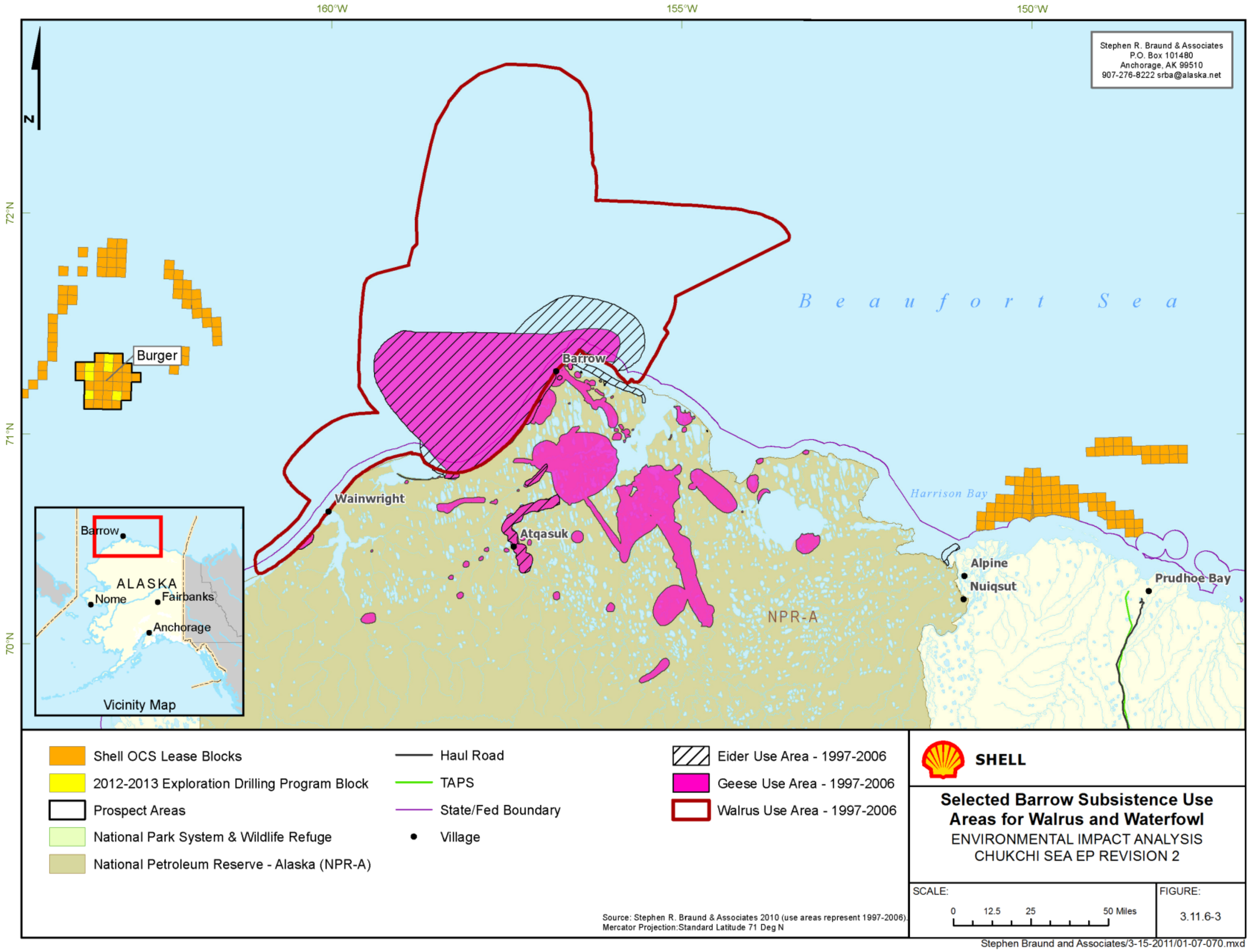


Figure 3.11.6-4 Selected Barrow Subsistence Use Areas for Bowhead and Seal

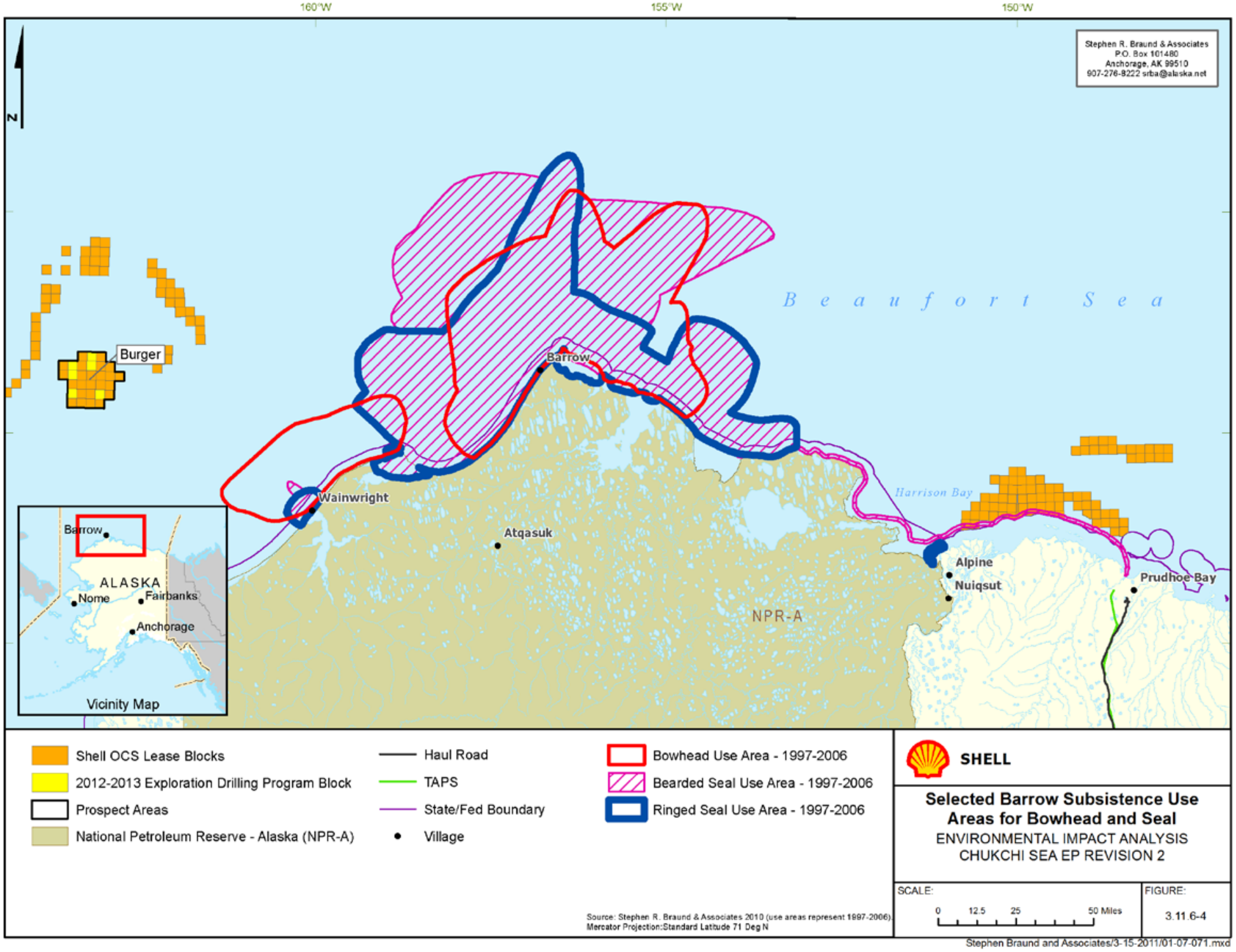


Figure 3.11.6-5 Selected Wainwright Subsistence Use Areas: Walrus and Waterfowl

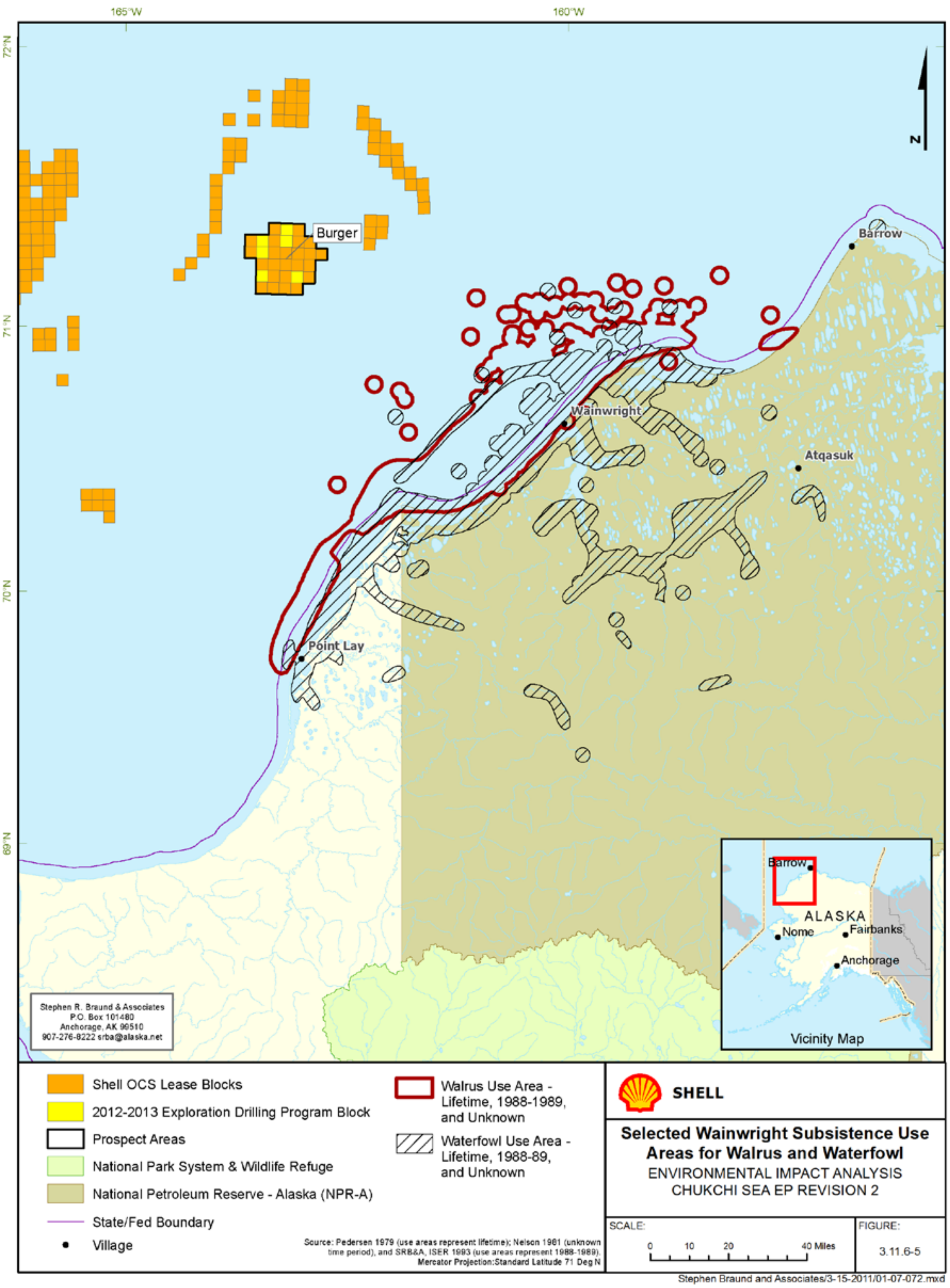


Figure 3.11.6-6 Selected Wainwright Subsistence Use Areas: Beluga, Bowhead, Seal

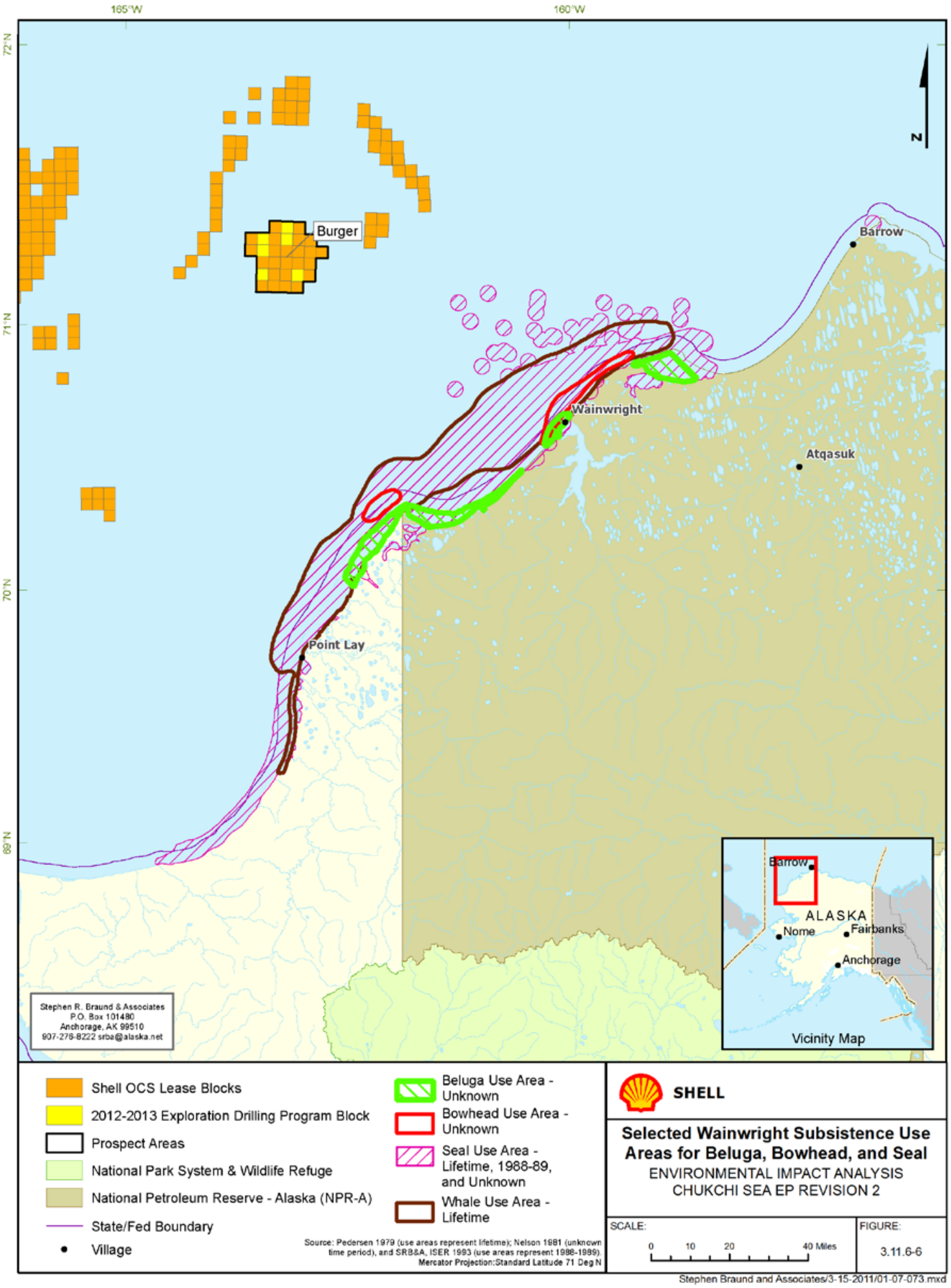


Figure 3.11.6-7 Selected Point Lay Subsistence Use Areas for Walrus and Waterfowl

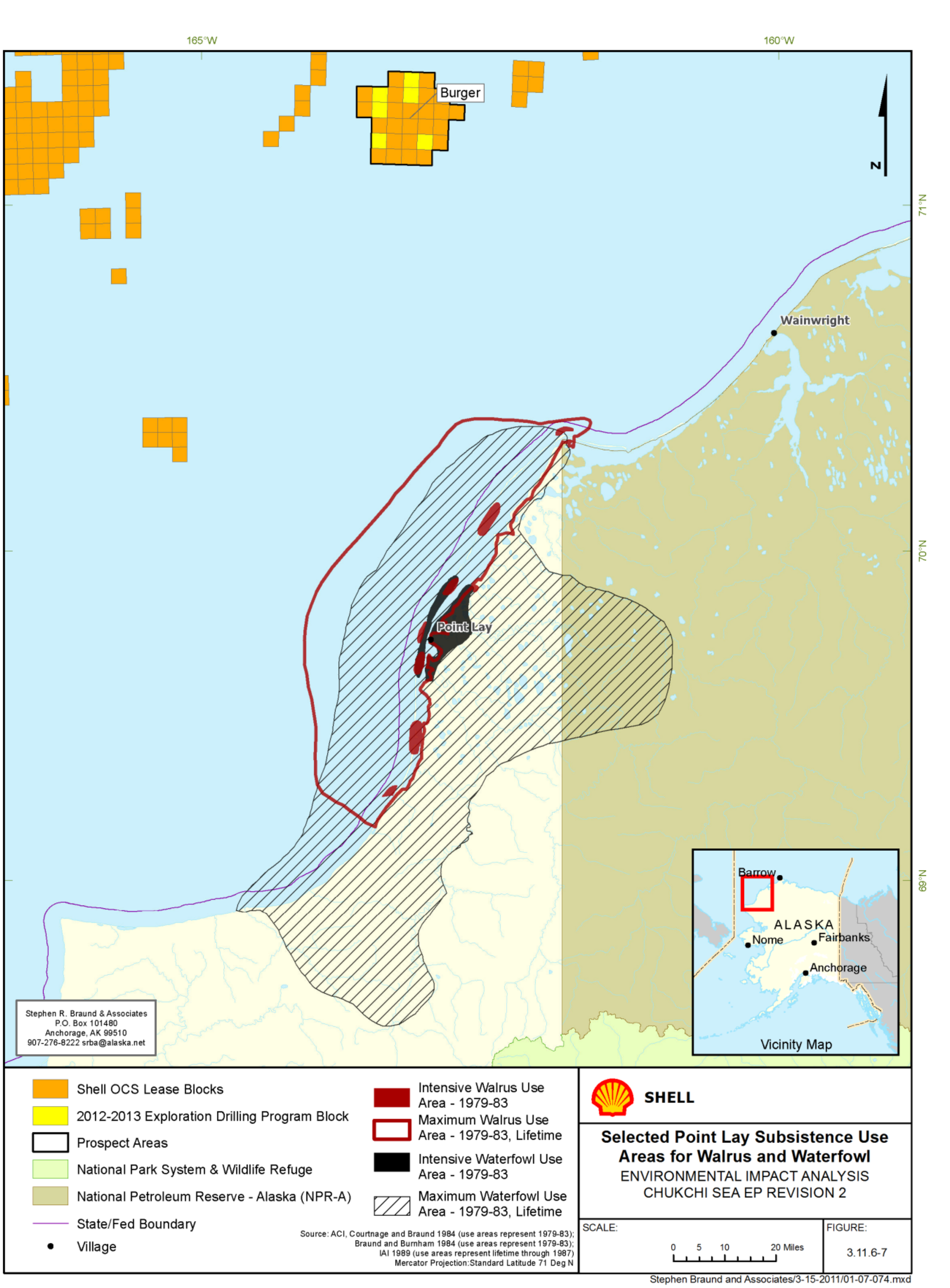


Figure 3.11.6-8 Selected Point Lay Subsistence Use Areas for Beluga, Bowhead, Seal

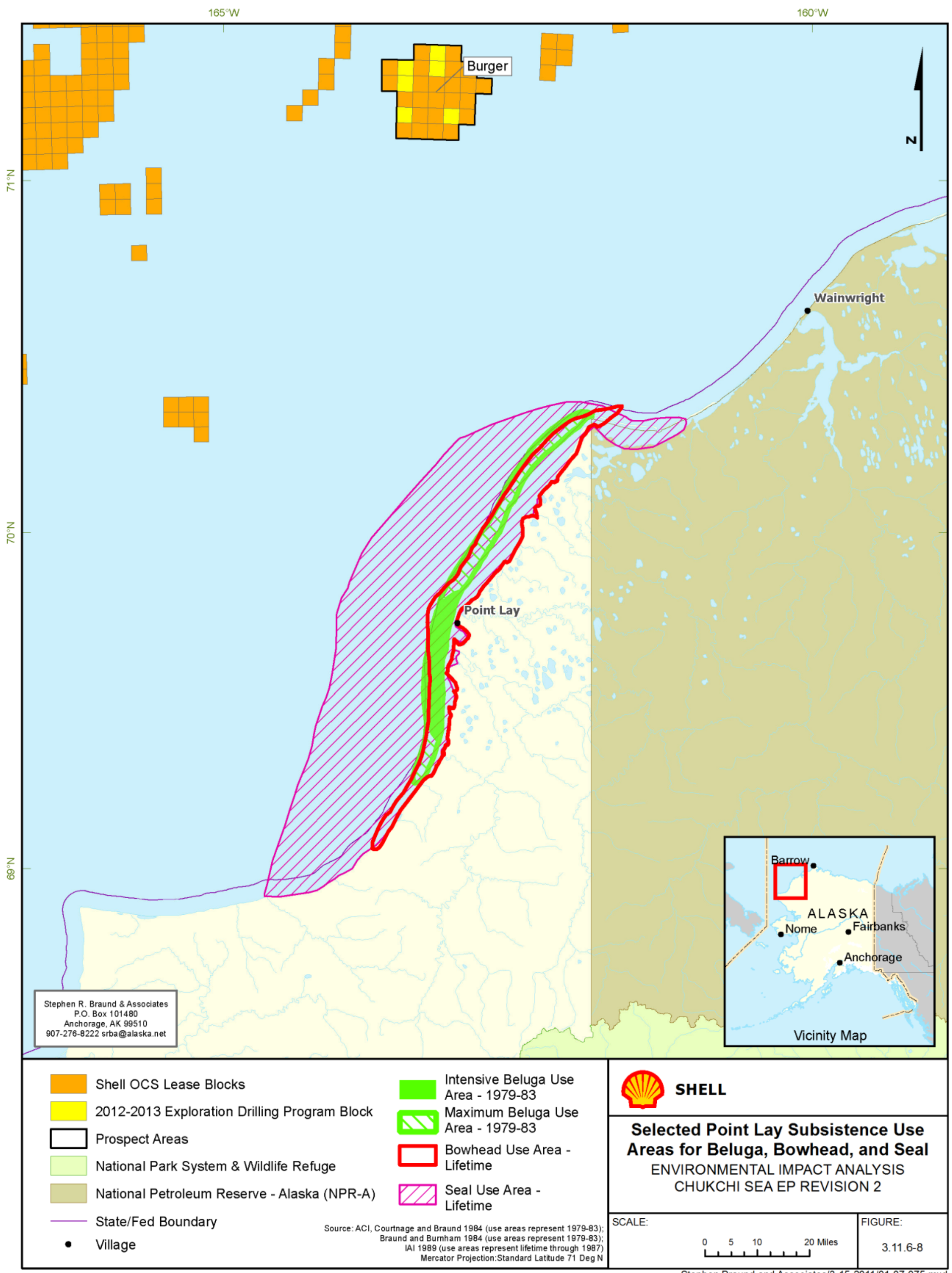


Figure 3.11.6-9 Selected Point Hope Subsistence Use Areas for Walrus and Waterfowl

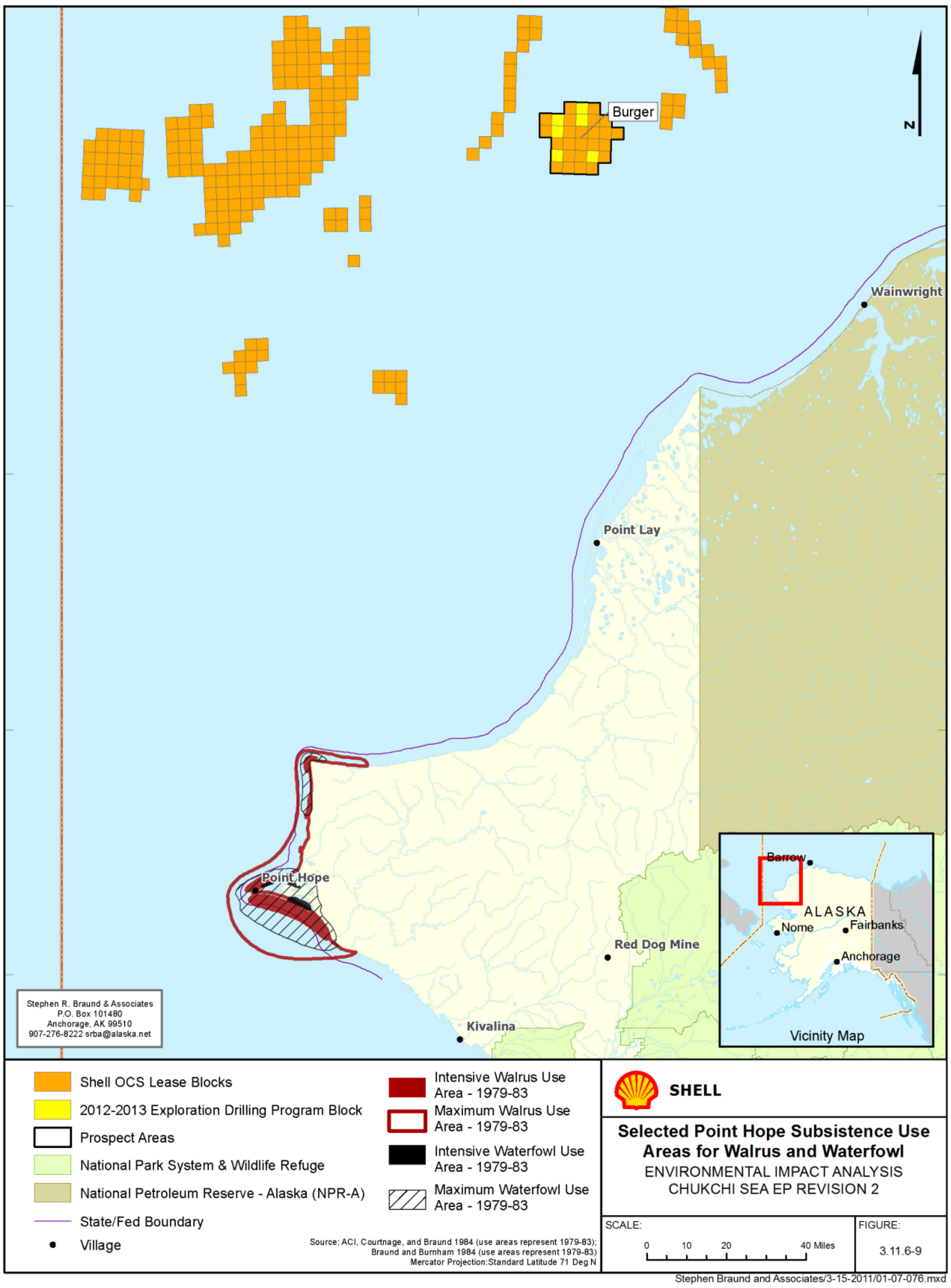


Figure 3.11.6-10 Selected Point Hope Subsistence Use Areas for Beluga, Bowhead, Seal

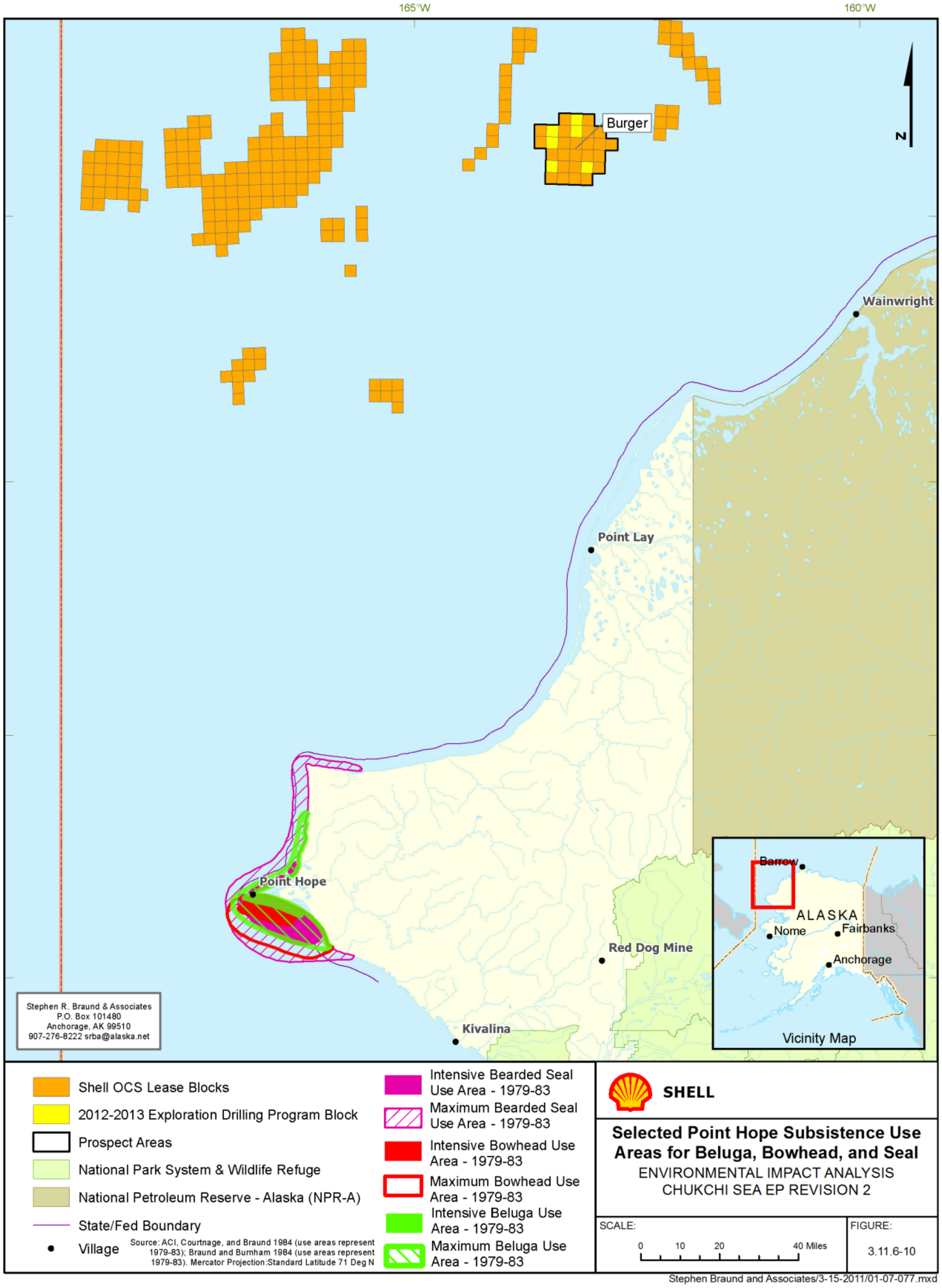


Figure 3.11.6-11 Selected Barrow, Point Hope, Point Lay, Wainwright Subsistence Areas

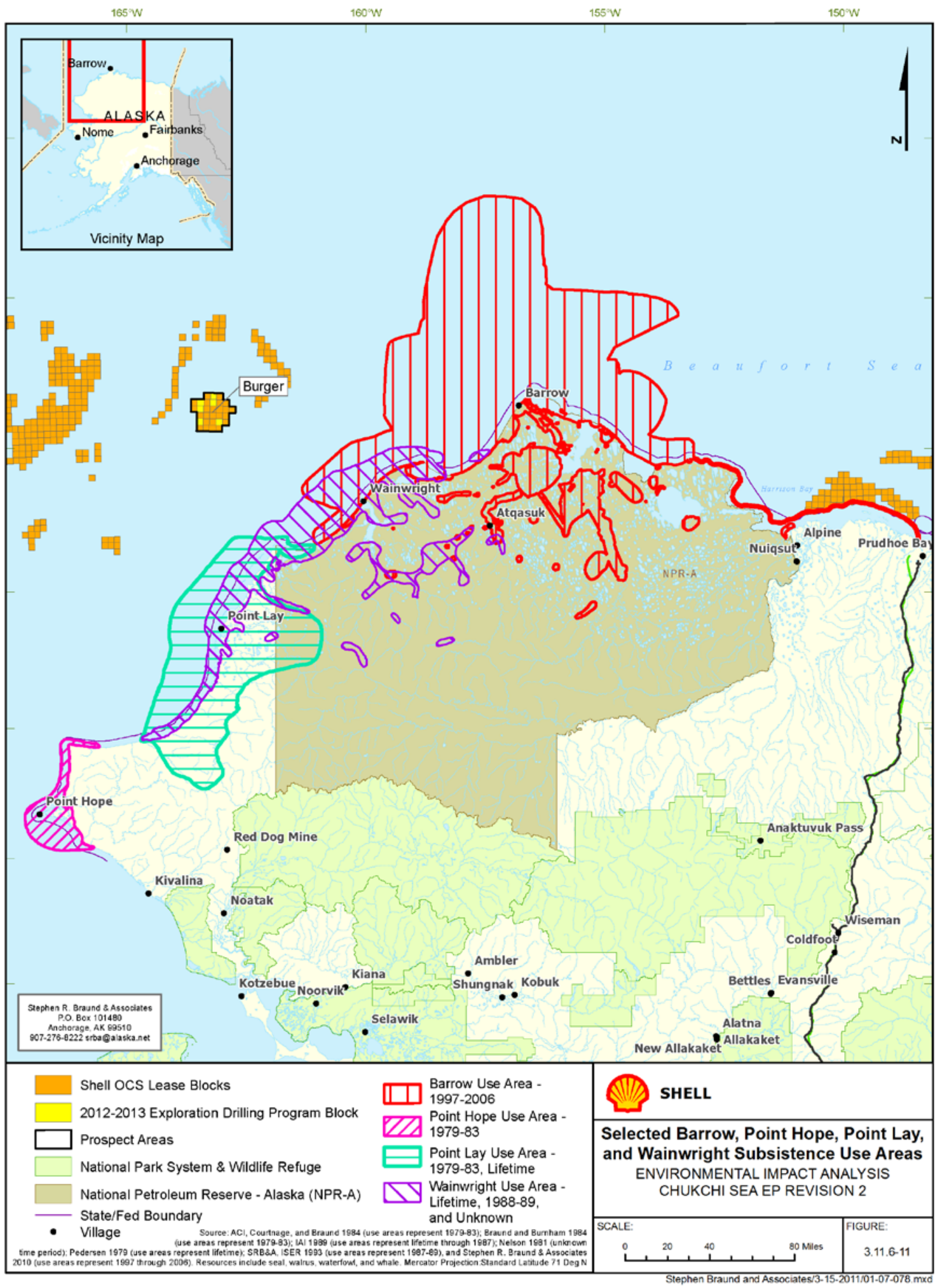


Table 3.11.6-2 Annual Subsistence Harvest by Chukchi Villages

Resource	Edible Pounds Harvested by Village (year)							
	Barrow 1989 [1]		Wainwright 1989 [1]		Point Lay (1997) [1]		Point Hope (1992) [1]	
Marine mammals	508,181	58%	243,595	69%	76,853	72%	262,009	78%
Terrestrial mammals	14,683	25%	83,389	24%	21,426	20%	35,548	11%
Fish	118,471	14%	17,385	5%	2,983	3%	30,589	9%
Birds/eggs	29,446	3%	7,211	2%	5,836	5%	9,429	3%
Total	870,781	100%	351,580	100%	107,098	100%	337,575	100%

[1] Source: MMS 2008a citing ADF&G 1995, 1996; Fuller and George 1997.

Table 3.11.6-3 Percent of Subsistence Harvest Represented by Marine Mammals

Resource	Years[1,2,3]	Percent of Total Subsistence Harvest by Village			
		Barrow	Wainwright	Point Lay	Point Hope
Bowhead	1962-1982	21.3%	8.2%	--	22.3%
	1989	74%	42%	0%	9%
Beluga	1962-1982	0.5%	2.7%	--	6.5%
	1989	0%	0%	84%	52%
Walrus	1962-1982	4.6%	18.5%	--	2.9%
	1989	15%	49%	6%	21%
Ringed seal	1962-1982	4.3%	[2]4.4%	--	14.8%
	1989	3%	1%	3%	0%
Spotted seal	1962-1982	--	--	--	--
	1989	0%	0%	3%	0%
Bearded seal	1962-1982	2.9%	2.3%	--	8.9%
	1989	4%	2%	3%	0%
Total	1962-1982	38.1%	36.1%	--	55.4%

[1]1962-1982 data from MMS 1991 citing ACI and SRBA 1984, and Stoker 1983
[2]1962-1982 data is for hair seals which includes ringed seals and spotted seals
[3]1989 data is from MMS 2008a

Table 3.11.6-4 Bowheads Harvested by Barrow, Wainwright, Point Lay, and Point Hope 1978-2011

Year	Barrow	Wainwright	Point Lay	Point Hope
1978	4	2	0	2
1979	3	1	0	3
1980	9	1	0	0
1981	4	3	0	4
1982	0	2	0	1
1983	2	2	0	1
1984	4	2	0	2
1985	5	2	0	1
1986	8	3	0	2
1987	7	4	0	5
1988	11	4	0	5
1989	10	2	0	0
1990	11	5	0	3
1991	12	4	0	6
1992	22	0	0	2
1993	23	5	0	2
1994	16	4	0	5
1995	19	5	0	1
1996	24	3	0	3
1997	30	3	0	4
1998	25	3	0	3
1999	24	5	0	2
2000	18	5	0	3
2001	27	6	0	4
2002	22	1	0	0
2003	16	5	0	4
2004	21	4	0	3
2005	29	4	0	7
2006	22	2	0	0
2007	20	4	0	3
2008	21	2	0	2
2009	19	1	1	1
2010	22	3	0	2
2011	18	4	1	3

[1]Source: Suydam and George 2004, 2012; George and Tarpley 1986; George et al. 1987, 1988, 1990, 1992, 1994, 1995, 1998, 1999, 2000; Suydam et al. 1995, 1996, 1997, 2001a, 2002, 2003, 2004, 2005b, 2006, 2007, 2008, 2009, 2010, 2012

Table 3.11.6-5 Bowhead Whale Harvests for Point Hope, Point Lay, and Wainwright 1984-2012

Year	Point Hope		Point Lay		Wainwright	
	# Whales	Harvest Period	# Whales	Harvest Period	# Whales	Harvest Period
1984	2	Apr 24 – May 26	0	--	2	May 18 – May 21
1985	1	May 10 – May 10	0	--	2	May 11 – May 18
1986	2	May 24- Jun 01	0	--	3	May 04 – Jun 24
1987	5	Apr 30 – May 28	0	--	4	May 05 – Jun 02
1988	5	Apr 27 – Apr 30	0	--	4	Apr 25 – May 08
1989	0	--	0	--	2	May 15 – May 27
1990	3	Apr 21 – Apr 30	0	--	5	May 06 – May 13
1991	6	Apr 17 – Apr 26	0	--	4	Apr 29 – May 04
1992	2	Apr 30 – May 01	0	--	0	--
1993	2	Apr 26 – May 04	0	--	5	Apr 29 – May 30
1994	5	May 03 – Jun 04	0	--	4	May 06 – Jun 06
1995	1	Jun 06 – Jun 06	0	--	5	May 09 – Jun 16
1996	3	Apr 14 – Apr 22	0	--	3	May 02 – May 23
1997	4	Apr 17 – Apr 26	0	--	3	May 08 – May 18
1998	3	May 22 – May 24	0	--	3	Apr 29 – May 27
1999	2	May 17 – May 17	0	--	5	Apr 30 – Jun 09
2000	3	Apr 17 – Jun 04	0	--	5	Apr 30 – May 24
2001	4	Apr 23 – May 01	0	--	6	May 01 – May 17
2002	0	--	0	--	1	May 08 – May 08
2003	4	Apr 20 – Apr 23	0	--	5	Apr 18 – May 12
2004	3	Apr 20 – May 12	0	--	4	Apr 18 – May 11
2005	7	Apr 30 – May 23	0	--	4	Apr 28 – May 19
2006	0	--	0	--	2	May 10 – May 11
2007	3	Apr 16 – May 17	0	--	4	May 05 – May 29
2008	2	May 08 – May 25	0	--	2	May 18 – May 26
2009	1	May 30	1	May 5	1	June 5
2010	2	May 20 – Jun 7	0	--	2	May 4 – May 25
					1	Oct 7
2011	3	Apr 22 – April 30	1	May 13	3	Apr 29 – May 24
					1	Oct 28
2012	5	Apr 26 – May 12	1	April 13	4	Apr 22 – May 29
Total	83	Apr 14 – Jun 07	3	--	99	Apr 18 – Jun 24

[1]Source: George and Tarpley 1986, George et al. 1987, 1988, 1990, 1992, 1994, 1995, 1998, 1999, 2000; Suydam et al. 1995, 1996, 1997, 2001a, 2002, 2003, 2004, 2005b, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013

Table 3.11.6-6 Bowhead Whale Harvests for Barrow 1984-2012

Year	Spring Harvest [1]		Fall Harvest [1]		Total Harvest [1]
	# Whales	Harvest Period	# Whales	Harvest Period	# Whales Harvested
1984	4	May 19 – May 21	--	--	4
1985	4	May 09 – May 28	1	Oct 13 – Oct 13	5
1986	7	Apr 27 – May 06	--	--	7
1987	5	May 01 – Jun 15	2	Oct 22 – Oct 29	7
1988	8	Apr 24 – May 06	3	Sep 15 – Sep 17	11
1989	3	Apr 23 – May 28	7	Oct 02 – Oct 28	10
1990	6	May 09 – May 24	5	Oct 01 – Oct 14	11
1991	8	Apr 28 – May 16	4	Sep 27 – Oct 04	12
1992	2	May 28 – May 29	20	Aug 31 – Oct 13	22
1993	9	Apr 21 – May 02	--	--	9
1994	15	May 03 – May 20	1	Oct 01 – Oct 01	16
1995	8	May 06 – Jun 01	11	Sep 04 – Oct 17	19
1996	5	Apr 25 – May 29	19	Sep 10 – Sep 26	24
1997	10	May 04 – Jun 04	21	Sep 11 - Oct 21	31
1998	9	May 08 – May 27	16	Sep 19 – Oct 07	25
2000	5	Apr 24 – May 30	13	Sep 26 – Oct 08	18
2001	20	Apr 28 – May 18	7	Oct 07 – Oct 09	27
2002	3	May 03 – May 30	19	Sep 30 – Oct 25	22
2003	10	Apr 19 – Jun 01	6	Oct 08 – Oct 14	16
2004	6	Apr 23 – Jun 04	15	Sep 18 – Oct 23	21
2005	16	Apr 28 – May 23	13	Oct 01 – Oct 05	29
2006	3	May 11 – May 18	19	Sep 25 – Oct 03	22
2007	13	Apr 24 – May 27	7	Oct 07 – Oct 11	20
2008	9	Apr 27 – May 11	12	Oct 05 – Oct 23	21
2009	4	May 17 – May 23	15	Sep 26 – Oct 10	19
2010	14	May 1 – May 15	8	Oct 7 – Oct 11	22
2011	7	Apr 26 – May 22	11	Oct 8 – Oct 30	18
2012	14	Apr 22 – May 16	10	Oct 1 – Oct 19	24
All years	227	Apr 23 – June 15	265	Aug 31 – Oct 30	492

[1] Source: George and Tarpley 1986, George et al. 1987, 1988, 1990, 1992, 1994, 1995, 1998, 1999, 2000; Suydam et al. 1995, 1996, 1997, 2001a, 2002, 2003, 2004, 2005b, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013

Barrow

Barrow is located on Demarcation Point between the Beaufort and Chukchi Seas, making it a prime location for accessing important subsistence resources. Residents in Barrow mainly hunt bowhead and beluga whales, seals, walruses, polar bears, birds and caribou for subsistence use. Residents conduct these activities at different times of the year. The activities are seasonal, and depend on the behavior of the animal being hunted. The most recent data available to the public regarding subsistence harvests in Barrow is from 1989 (ADF&G 2000). Subsistence harvest statistics for Barrow are presented in Table 3.11.6-7.

Table 3.11.6-7 Barrow Subsistence Harvest Data 1989

Resources Harvested	Estimated Number [1]	Estimated Pounds [1]	Average Pounds [1]	Pounds Per Capita [1]
All Resources	--	872,092.00	930.73	289.16
Fish	68,287	118,471.00	126.44	39.28
Salmon	2,088	12,244.00	13.07	4.06
Non-Salmon Fish	66,199	106,226.00	113.37	35.22
Land Mammals	1,774	214,683.00	229.12	71.18
Large Land Mammals	1,705	214,676.00	229.11	71.18
Small Land Mammals	68	7.00	0.01	0.00
Marine Mammals	--	508,181.00	542.35	168.50
Birds and Eggs	12,869	29,446.00	31.43	9.76
Vegetation	--	1,312.00	1.40	0.44

[1] Source: ADF&G 2000

The NSB surveys households to understand subsistence participation rates, broken-down by household racial composition. NSB found that nearly 60 percent of Iñupiat households receive half or more of their diet from subsistence foods while only about one in ten non-Iñupiat households are similarly dependent (NSB 2010). The NSB household survey also found a change in the dependence on subsistence resources between 2003 and 2010 for Barrow households that only longitudinal studies can capture.

In general, there seems to be a decrease in the intensive use of wildlife resources. Whereas nearly half (46 percent) of Iñupiat households in 2003 depended on wildlife resources for more than half of their diet, this proportion decreased to about one third (34 percent) in 2010. In contrast, a much higher proportion of Caucasian households in Barrow seem to be using at least small amounts of subsistence resources. Whereas in 2003 four out of ten Caucasian households did not use any subsistence foods, by 2010 this proportion had shrunk by half to one in six households.

The principal focus of Barrow subsistence users is marine mammals (NSB 2005). Thus, marine mammals related activities are discussed in detail. Marine mammal subsistence activities include hunting bowhead and beluga whales, walruses, polar bear, and bearded, ringed and spotted seals (MMS 2007b; AES-RTS 2009).

Barrow residents hunt bowhead whales for their meat, oil, baleen, and bone. Bowhead meat and oil are integral parts of Barrow Iñupiat diet. Spring bowhead whaling occurs from mid-April to late May. Spring whaling takes place from ice leads from Point Barrow southwestward along the Chukchi Sea coast to the Skull Cliff area. Fall bowhead whaling occurs from August to October in an area that extends 10 mi (16 km) west of Barrow to 30 mi (48 km) north of Barrow, and southeast 30 mi (48 km) off Cooper Island with an eastern boundary on the east side of Dease Inlet. Occasionally, bowhead whale hunting may extend east as far as Smith Bay (Figure 3.11.6-4) and Cape Halkett or Harrison Bay (Figures 3.11.6-4 and 3.11.6-11).

The spring hunt for beluga whale occurs from April to June in the spring leads between Point Barrow and Skull Cliff. Later in the spring, whalers in Barrow hunt belugas in open water around the barrier islands off Elson Lagoon (Figure 3.11.6-4).

Barrow residents harvest walruses for their meat, hides, and ivory tusks. The walrus supplies food and material for clothing and arts and crafts. Residents hunt walruses in early summer to early fall, June to September, from west of Barrow southwestward to Peard Bay (Figure 3.11.6-3). Barrow residents hunt seals for their meat, oil, and skins. The meat and oil serve as dietary supplements. Seal skin is used in clothing as wells as for boats. Barrow whalers continue to use seal-skin boats. Seal hunting occurs primarily in winter, with some open-water seal hunting along the Chukchi coastline and in the Beaufort Sea as far east as Dease Inlet and Admiralty Bay (Figure 3.11.6-4).

Barrow residents hunt polar bear for their meat and pelts. They hunt polar bear during the fall and winter – October to June – in the same areas where walruses are hunted.

Residents hunt brown bear, caribou, moose, and Dall sheep both for their meat and hides (NSB 2005). Furbearing animals, which are harvested primarily for their hides, include arctic fox, red fox, river otter, ground squirrel, weasel, wolf, and wolverine (NSB 2005). Hunters use snow machines to travel during the winter to hunt for terrestrial mammals such as caribou, wolf, wolverine, and fox. These animals have been reported being harvested as far as Fish and Judy Creeks which are about 120 mi (193 km) east of Barrow (MMS 2006a).

Birds hunted include common eider, king eider, spectacled eider, Steller’s eider, mallard, long-tailed duck, northern pintail, scoter, brant, Canada geese, snow geese, white fronted geese, tundra swan, crane, loons, red-throated loon, and ptarmigan (NSB 2005; ADF&G 2008). Barrow residents also hunt for migratory birds along the Chukchi Sea coast. Migratory bird hunting areas in the Chukchi Sea extend southwest along the coast to Skull Cliffs located 45 mi (72 km) from Barrow and southeast along the Beaufort Sea coast to Dease Inlet (Figure 3.11.6-3).

Fish harvested include all five species of Pacific salmon: chum, coho, chinook, pink and sockeye. Fish harvested include smelt, Arctic cod, arctic cisco, arctic flounder, Saffron, sculpin, burbot, arctic char, lake trout, grayling, pike, broad whitefish, bull head white fish, Bering cisco, least cisco, humpback whitefish, and round white fish (Johnson and Daigneault 2008; AES-RTS 2009). Figure 3.11.6-11 depicts subsistence fishing areas for residents of Barrow, Wainwright, and Point Lay. As depicted in this figure, residents of Barrow, Wainwright, and Point Lay generally conduct marine subsistence fishing within two miles of the shore. Near Point Lay, fishing may extend seaward for 2.5 mi (4.0 km). The closest subsistence fishing area, near Icy Cape, is approximately 60 mi (97 km) from the Burger Prospect.

Wainwright

Wainwright is situated on the Chukchi Sea coast approximately 100 mi (161 km) southwest of Barrow. Residents of Wainwright hunt from Icy Cape in the South to Point Franklin and Peard Bay in the north. Wildlife congregates near the Kuk River lagoon system where residents gather to hunt. Subsistence activities include fishing and hunting birds, land mammals, and marine mammals (Table 3.11.6-8).

Table 3.11.6-8 Wainwright Subsistence Harvest Data 1989

Resources	Estimated Number	Estimated Pounds	Average Pounds	Per Capita Pounds
All Resources		351,581.00	2,954.46	751.24
Fish	64,567	17,385.00	146.09	37.15
Salmon	180	1,044.00	8.77	2.23
Non-Salmon Fish	64,387	16,341.00	137.32	34.92
Land Mammals	760	83,389.00	700.75	178.18
Large Land Mammals	713	83,387.00	700.73	178.18
Small Land Mammals	47	2.00	0.02	0.00
Marine Mammals		243.594.00	2,047.01	520.50
Birds and Eggs	2,735	7,211.00	60.60	15.41

[1] Source : ADF&G 2000

The vast majority of Iñupiat families in Wainwright participate in the local subsistence economy (NSB 2010). The principal subsistence resources for Wainwright are marine resources (NSB 2005). Marine mammal subsistence activities include hunting bowhead and beluga whales, walruses, polar bears, and seals (MMS 2007b). Between 1998 and 2010, there has been a decline in the number of households that rely on a steady diet of (nearly all or all) wild foods and an increase in the number of households that consume very little subsistence foods, but there has not been a change in the proportion of families that report consuming half of more of their foods from subsistence activities (NSB 2010).

Bowhead whaling by Wainwright residents has been conducted primarily in the spring. Spring bowhead whale hunting, occurs from April to June in leads offshore of Wainwright. Whaling camps are sometimes located 10 to 15 mi (16 to 24 km) from shore. The first successful hunt for bowheads in the fall by Wainwright whaling crews in at least 90 years occurred in October 2010, with the harvest of a bowhead off Point Franklin. Wainwright crews have conducted fall whaling for bowheads since then (Suydam et al. 2011, 2012).

The beluga whale hunt takes place in the spring lead system from April to June, but this hunt only occurs if no bowheads are in the area. Wainwright hunters also hunt belugas later in the summer from July to August along the coastal lagoon systems. Belugas are harvested primarily for the meat they provide. Subsistence use areas for beluga and bowhead whales are indicated in Figure 3.11.6-6.

Wainwright residents harvest walruses for their meat, hides, and ivory tusks. The walrus supplies food and material for clothing and arts and crafts. Wainwright subsistence hunters pursue walruses from July to August at the southern edge of the retreating pack ice. From August to September they may hunt walruses at local haul-outs, with the main area being from Milliktagvik north to Point Franklin. Icy Cape is a known walrus haulout location and subsistence hunting ground near Wainwright Subsistence use areas for walruses are indicated in Figure 3.11.6-5.

Wainwright residents hunt polar bear for their meat and pelts. Polar bear subsistence hunts occur in the fall and winter around Icy Cape, at the headland from Point Belcher to Point Franklin, and at Seahorse Island.

Fur bearing animals, which are harvested primarily for their skins, include wolverine, wolf, weasel, ground squirrel, river otter, red fox, and arctic fox. Other land mammals harvested are brown bear, caribou, and moose (ADF&G 2008).

Wainwright residents harvest common eider, king eider, spectacled eider, Steller's eider, mallard, long-tailed duck, northern pintail, scoter, brant, Canada geese, snow geese, white fronted geese, Pacific loon, and ptarmigan (ADF&G 2008). Wainwright residents hunt migratory birds north along the coast to Skull Cliff, south along the coast to Kasegaluk Lagoon and inland along the Kuk River. Subsistence use areas for waterfowl are indicated in Figure 3.11.6-5.

Wainwright residents subsistence fish for chum salmon, Chinook salmon, pink salmon, smelt, capelin (grunion), Saffron, flounder, sculpin, burbot, char, lake trout, grayling, pike, broad whitefish, Bering cisco, least cisco, humpback whitefish, and round whitefish (Johnson and Daigneault 2008).

Point Lay

Point Lay is the smallest community on the North Slope. The village is situated near Kasegaluk Lagoon, and the community's main subsistence focus is on beluga whales. Data on the Point Lay subsistence harvest is provided in Table 3.11.6-9.

Table 3.11.6-9 Point Lay Subsistence Harvest Summary

Resources	Estimated Number [1]	Estimated Pounds [1]	Average Pounds [1]	Per Capita Pounds [1]
All Resources		107,231.00	2495.83	890.11
Fish	2,807	2,983.00	69.38	24.74
Salmon	147	425.00	9.88	3.52
Non-Salmon Fish	2,660	2,559.00	59.50	21.22
Land Mammals	458	21,426.00	498.27	177.71
Large Land Mammals	167	21,309.00	495.56	176.74
Small Land Mammals	292	117.00	2.72	0.97
Marine Mammals		76,853.00	1787.27	637.41
Birds and Eggs	3,531	5,836.00	135.73	48.40
Vegetation		223.00	5.19	1.85

[1] Source : ADF&G 2000

Beluga whaling, and walrus and polar bear hunts comprise the main marine mammal subsistence hunting activities for Point Lay residents. Point Lay hunters traveled in the past to Barrow, Wainwright, or Point Hope to participate in bowhead whale harvest. Point Lay became a member of the International Whaling Commission in 2008 to receive a quota of the bowhead whale hunting seasons. They landed one bowhead whale in the spring of 2009, none in 2010 (due to ice and weather), one in 2011, and one during spring 2012 (Suydam et al 2011; Suydam et al 2012; UMIAQ 2013). No bowhead whales were harvested in Point Lay in 2013 (UMIAQ 2013).

Beluga whales are harvested from the middle of June to the middle of July. The hunting area is concentrated in Naokak and Kukpowruk Passes south of Point Lay (Figure 3.11.6-8). Hunters use boats to herd the whales into the shallow waters of Kasegaluk Lagoon where the belugas are harvested. If the July beluga hunt is unsuccessful, Point Lay hunters may travel as far north as Utukok Pass and as far south as Cape Beaufort in search of beluga whales (MMS 2007b).

Walruses are hunted from June to August – depending on favorable ice conditions – along the entire length of Kasegaluk Lagoon, south of Icy Cape, and as far as 20 mi (32 km) offshore (AES-RTS 2009). Subsistence use areas for walrus hunting are indicated in Figure 3.11.6-7.

Ringed and bearded seals are available year-round. Ringed and bearded seals are hunted 20 mi (32 km) and 30 mi (48 km) north of Point Lay, respectively, with bearded seals concentrated in the Solivik Island area and up to three miles north off the island. Bearded seals are also hunted from south of Point Lay to the southern end of Kasegaluk Lagoon. Point Lay residents subsistence hunt for polar bears from September to April along the coast with the hunting area rarely extending more than two miles offshore. Subsistence use areas for seals are indicated in Figure 3.11.6-8.

Furbearing animals which are harvested primarily for their hides include arctic fox, red fox, land otter, parka squirrel, wolf, marmot, and wolverine (ADF&G 2008; NSB 2005). Residents hunt brown bear, caribou, and moose both for their meat and hides (ADF&G 2008).

Birds harvested include eider (unidentified by species in the data set), long-tailed duck, northern pintail, brant, Canada geese, murre, and ptarmigan, and collect bird eggs (unidentified in data collection) (ADF&G 2008). Residents living in Point Lay subsistence hunt for migratory birds north along the coast to Icy Cape and South along the coast into Ledyard Bay.

Point Lay residents fish chum salmon, king salmon, smelt, Arctic cod, trout, grayling, humpback whitefish, and saffron cod primarily to supplement their diet (ADF&G 2008).

Additionally, residents harvest berries, other green vegetation, and mushrooms.

Point Hope

Point Hope, on the western edge of the NSB, is one of the oldest continuously occupied Iñupiat Eskimo areas in Alaska (ADCCED 2013). Although other subsistence resources are utilized, Point Hope residents regard themselves as “first and foremost” a whaling people (NSB 2005). Their primary subsistence resources are included in Table 3.11.6-10, which presents information on the top five subsistence species harvested.

Table 3.11.6-10 Top Five Species Harvested at Point Hope Alaska, Calendar Year 1992

Species	Edible Pounds Harvested [1]	Number Harvested [1]	Pounds Per Household [1]	Pounds Per Capita [1]	Percent of Total Harvest [1]
Beluga	137,172	98	879	196	40.3
Walrus	55,797	72	358	80	16.4
Bearded Seal	28,242	160	181	40	8.3
Caribou	26,303	225	169	38	7.7
Bowhead	23,365	3	150	33	6.9

[1] Source : Fuller and George 1997

Point Hope is predominantly Iñupiat and the vast majority of Iñupiat families reported they participate in the local subsistence economy (NSB 2005; NSB 2010). Between 1998 and 2010 there has been an increase in the number of households that consume “very little” subsistence foods while at the same time there has been a reported decrease in the proportion of families that say “half or more” of their foods come from subsistence activities.

The people of Point Hope identify themselves as a whaling culture. Bowhead whales are hunted for their meat, oil, baleen, and bone. Bowhead meat and oil are an integral part of the diet. Baleen and bone are used in arts and crafts (e.g., baleen baskets) that are sold to supplement income. Because Point Hope is located close to the pack ice lead, residents are well-situated to hunt for bowheads. Bowhead whales are hunted from March to June from whaling camps along the ice edge south and southeast of Point Hope (Figure 3.11.6-10). The pack-ice lead is rarely more than 6 to 7 mi (10 to 11 km) offshore (MMS 2007b).

Residents harvest beluga whales primarily for their meat. They take part in two beluga whale hunts a year. The first hunt occurs from late March through June. This hunt coincides geographically and temporally with the bowhead whale hunt. The residents of Point Hope consider the beluga hunt an indicator of the success of the bowhead hunt (MMS 2007b). Thus, the beluga whale has value not only as a subsistence resource in its own right, but also as related to another important subsistence resource. The second beluga hunt occurs later in the summer, from July to August. During this second hunt, Point Hope residents hunt beluga whales in the open water near the southern shore of Point Hope close to the beaches, as well as north of Point Hope as far as Cape Dyer (Figure 3.11.6-10, MMS 2007b).

Like other Iñupiat communities, Point Hope residents harvest walruses for meat and ivory. According to BOEM, the importance of the walrus is directly related to the fluctuating population of the walrus. Hunters harvest walruses from May to July along the southern shore from Point Hope to Akoviknak Lagoon (Figure 3.11.6-9, MMS 2007b). Seal hunting occurs through most of the year, with the general exception of September and October.

Point Hope residents hunt polar bear for their meat and their fur. Primary polar bear hunting takes place from January to April, and occasionally from October to January (MMS 2007b). Residents hunt these mammals in the area south of the point, as far out as 10 mi (16 km) from shore, in the same region where seal are hunted (MMS 2007b).

Caribou are also an important resource that Point Hope residents hunt throughout the year, with peak activities in August and September, when the animals are in prime condition. Caribou is the primary source of meat for Point Hope residents (MMS 2007b). The annual average of caribou harvested from 1962 to 1982 accounted for 29.5 percent (765 caribou) of the total subsistence harvest (MMS 2007b). Point Hope residents hunt for migratory birds for subsistence around the Point Hope and Cape Lisburne areas (ADF&G 2008).

Fish are harvested in the open water during summer months, as well as under ice in the fall and winter (NSB 2005). Craig and Halderson (1986) reported large runs of chum and pink salmon in rivers south of Point Hope. Pink salmon and, to a lesser degree, chum salmon, occur with any regularity in nine drainages north of Point Hope and presumably maintain small populations in several of the northern drainages; most occurring in streams along the Chukchi Sea coast west of Barrow (MMS 2007b).

The NSB 2010 census documents the importance of subsistence sharing in Point Hope. All NSB communities share subsistence foods, but Point Hope is unique in that residents report higher rates of sharing with other NANA communities and sharing with Anchorage households than other NSB communities (NSB 2010).

3.11.7 Minority and Lower Income Groups

With their subsistence lifestyle and culture, the Iñupiat residents of the North Slope are considered a minority/Native American community under the Presidential Executive Order on Environmental Justice. The Iñupiat are a minority population in the SOA and are the indigenous inhabitants of Alaska nearest to the exploration project area.

Although many North Slope residents’ overall quality of life has improved as oil and gas revenues have come into the NSB, providing funding for public facilities and services, recently the poverty level in communities outside Barrow has been increasing (NSB 2005). In 1998, 76 households in the NSB were either at the poverty level or considered to be “very low income” (NSB 2005). Of those families in the NSB whose incomes were below the poverty line in 1999, 86 percent were Native (Northern Economics, Inc. 2006). In 2010, a total of 365 out of 1,605 households were below the poverty income threshold, a substantial increase since 2003 when the number of households was only 100 (NSB 2010). A higher percentage of Iñupiat households fall below the poverty income threshold level, with 23.2 percent of households below compared to 21.3 percent of all households. Table 3.11.7-1 shows the poverty levels in Barrow, Point Lay, Point Hope, and Wainwright.

Table 3.11.7-1 Poverty Levels in Barrow, Point Lay, Point Hope, and Wainwright 2003

Community	Poverty Level [1] (Number of Households)	Total Households Reporting [1]
Barrow	227	943
Point Lay	10	50
Point Hope	26	165
Wainwright	20	134

[1] Source: NSB 2010

The NSB conducted a census and economic profile in 2003 and in 2010. The 2003 results are the background information utilized in the North Slope Comprehensive Plan that addresses the issues, goals and objectives of the communities in the region to maintain subsistence activities and to improve the quality of life in the region (NSB 2005).

3.11.8 Health of the North Slope and Northwest Arctic Boroughs

The baseline public health and welfare of the NSB residents is a fundamental component of any review of the communities in the region. Community health is addressed in the NEPA process in relation to natural resource development and is now considered more thoroughly in the EIS process (MMS 2008a; Wernham 2007). This analysis requires an understanding of the public health issues and concerns expressed by residents of the nearest coastal communities.

NSB residents have expressed concerns about the potential associations between oil development and health. These concerns range from possible links between contaminants and increased risks of cancer, asthma, and thyroid disease, to a rise in social problems such as alcoholism, domestic violence, and suicide (Ahtuangaruak 2003 in Wernham 2007).

To mitigate concerns, it is important to clarify why the activities associated with the exploration drilling program in EP Revision 2 will not adversely impact the residents and communities on the North Slope. The project is designed to minimize interference with NSB residents and avoid unreasonable conflicts with subsistence resources and subsistence activities, by inclusion of the following measures, among others:

- Helicopters out of Wainwright will provide support for crew change, provision re-supply, and SAR operations on isolated flight paths;
- Planned exploration drilling activities will occur at least 78 mi (126 km) offshore from Wainwright, the nearest community on the coast. The sheer distance between the project location and coastal community will prevent any project activities from intruding on everyday community life;
- Shell’s air permit requirements will ensure the protection of air quality in the project and coastal communities. Modeling indicates that air quality standards (NAAQS) will be met at the edge of the drilling unit. Shell’s air permit will require mandatory monitoring and reporting requirements to verify air quality standards are met;
- Shell has developed, and will implement, a comprehensive plan for preventing the spill of oil into the environment and, in the unlikely event of a release, contingency plans to recover any oil, including the capability to respond to a “worst case” spill event (see Section 2.10 for more detailed discussion of this topic); and
- Shell has developed, and will implement, a detailed Plan of Cooperation (POC) to mitigate impacts to subsistence resources and subsistence activities, particularly in regard to bowhead whales, and avoid any unreasonable interference with subsistence resources and activities.

Public health focuses on health outcomes and factors that determine these outcomes. Public health issues of the NSB to be considered include possible effects in the Health Effect Categories: General Health; Psychosocial Issues; Injuries; Nutrition; Non-communicable and Chronic Diseases; Contaminant Exposure; Infectious Diseases; Maternal-Child Health; Sanitation and Health Services Infrastructure and Capacity.

General Health

General population health indicators include life expectancy, mortality rates, infant mortality, and general health and well being surveys (Lanier et al. 2003).

Programs to control tuberculosis epidemics and other infections were initiated in the 1950s and improved through upgraded safe water and sanitation systems (ADEC 2008). By 1989, infectious disease accounted for only 1.3 percent of deaths in Alaskan Natives. Mortality rates have declined and life expectancy has increased; however, overall mortality rates are still 1.5 times higher than the U.S. white population. Life expectancy of Alaska Natives in the NSB is about four years shorter than Alaska residents overall and six years shorter than the national average (NSB 2012).

Recent studies show a clear downward trend in infant mortality for all Alaska, but less so for the North Slope and Northwest Arctic (ANTHC 2008a). Overall, the infant mortality rates appear higher in the two northern boroughs, but have seen a general decrease from 1977 to 2009 (NSB 2012). Infant Mortality Rate can fluctuate sharply because a relatively small change in the number of actual deaths can make a considerable difference in the rate of deaths due to a relatively small birthrate for these regions. Leading causes of infant mortality in these regions include accidents, birth defects and Sudden Infant Death Syndrome (Goldsmith et al. 2004).

The health status of North Slope communities since the era of epidemic infectious disease is now characterized by a rise in diabetes, cancer, and ongoing social and psychological strain and change, including alcohol and substance abuse, violence, and suicide. According to the NSB Health Analysis Report cancer, heart disease, unintentional injury, chronic respiratory diseases and suicide are the leading causes of death in the NSB (NSB 2012).

Psychosocial Issues

Psychosocial concerns such as alcohol-related problems and the links between a cultural shift to a cash economy, western education, and health impacts are complex (Alaska Native Tribal Health Consortium [ANTHC] 2008a in MMS 2008a). For instance, the studies that examine the current pattern of suicide for indigenous peoples suggest that acculturative stress and economic development exert opposing influences on suicide rates in Iñupiat communities (Travis 1984). The suicide rates for Alaskan Natives in the NSB are still are higher than national rates but appear to be decreasing in recent years (ANTHC 2008a in MMS 2008a). The suicide rate in the NSB is nearly four times the national rate (BOEM 2012).

Few studies have directly examined the influence of oil and gas operations on social and psychological health in the North Slope. The benefits related to economic gains and employment associated with oil and gas development, however, is well documented. According to some social studies, these benefits may underlie some of the documented improvement in social and psychological health indicators discussed above, including the importance of a cash economy to support subsistence activities (Pedersen in prep in MMS 2008a). The NSB Health Analysis Report found that unemployment was linked to poor overall health as well (NSB 2012).

Cultural stress mitigation is necessary at times because of the large influx of nonresident workers creating the potential for cultural conflict. Recognizing this potential conflict, BOEM has developed lease stipulations that require lessees to develop and institute a cultural orientation program for workers (MMS 2008a). Domestic violence and child abuse are now generally acknowledged as epidemic problems (BOEM 2012).

Injuries

Accidental injury is the second leading cause of death on the North Slope and, although declining, accident mortality rates remain over 3.5 times higher for Alaska Natives than the overall rate for U.S. whites. The NSB rate for ATV and snow machine accidents is more than twice as high as the rate for Alaskan Natives in general (ANTHC 2008b). Hospitalization rates for injuries in the NSB are over twice the state average. Alcohol is estimated to be involved in up to 40 percent of injuries and deaths in Alaska Natives (BOEM 2012; NSB 2012).

Nutrition

Based on available harvest data, ADF&G estimated that subsistence foods accounted for 33 percent of protein requirements and nearly half the caloric requirements for residents of Arctic communities (ADF&G 2000). Available data suggest that younger Iñupiat people are consuming relatively higher proportions of market foods (Nobmann et al. 2005), which are often of poor nutritional value (Bersamin et al. 2006). According to the NSB Health Analysis Report, more than 95 percent of households reported using subsistence foods in 2009. Subsistence food use remains high in the NSB (NSB 2012).

Because of the importance of subsistence foods to the nutrition of North Slope communities, food security depends on access to traditional foods, as well as economic resources. Health risks based on nutritional intake choices, therefore, would depend on the degree of impacts on subsistence activities (Wernham 2007).

Noncommunicable Diseases

Noncommunicable diseases are increasingly prevalent in Alaskan Native communities and include diabetes, high blood pressure and related metabolic disorders, vascular disease, chronic lung diseases, cancer, and endocrine disorders such as thyroid disease. In the NSB, type II diabetes, high blood pressure (hypertension), and dyslipidemia are increasingly prevalent (Alaska Native Medical Center 2008). The subsistence diet is the most important protective factor against these problems; numerous studies have demonstrated that this transition has been caused by a transition to market foods and an increasingly sedentary lifestyle (Adler et al. 1996; Murphy et al. 1995; Bjerregaard et al. 2004).

Cardiovascular and cerebrovascular disease rates in the NSB are lower than Alaska and overall U.S. rates. Although it is the third leading cause of death in the North Slope region, rates of cardiovascular disease mortality have been decreasing, consistent with statewide and national trends. NSB mortality rates for cardiovascular disease are 10 percent lower than the U.S. population; however, many of the risk factors are increasing, such as smoking (BOEM 2012).

Chronic lung disease includes chronic obstructive pulmonary disease (COPD), asthma, and chronic bronchitis, which are associated with these risk factors: smoking, air pollution, poor indoor air quality, changes in local energy use and possibly severe pulmonary infections in early childhood. Chronic pulmonary disease rates among Alaska Native have risen 192 percent since 1979 (BOEM 2012). The NSB had the highest mortality rate for COPD of any region in the state (Day et al. 2006) and nearly three times the national average (BOEM 2012). Smoking rates in the NSB are high: 44 percent of North Slope residents reported being smokers (Wernham 2007). Air pollution is an exacerbating factor for chronic pulmonary disease (EPA 2006a) (see section below on air pollution under Contaminant Exposure and Impacts-Air Quality and also a more complete discussion in Section 3.1.3, Air Quality).

Cancer is now the leading cause of death in the NSB (NSB 2012), increasing by more than 50 percent since 1969 (BOEM 2012) and has become a matter of great concern to communities. Lung cancer is the most common type of cancer (41 percent) and is highly associated with tobacco use. However, breast and colon cancer have contributed to the increase as well (BOEM 2012). The high rates of smoking documented on the North Slope are one identified risk factor for lung cancer. Radon gas exposure also is a risk factor, but radon levels in Alaska generally are low (AMAP 1998). Other risk factors for lung cancer include industrial exposure to asbestos, uranium, arsenic, nickel, and chromium.

Stomach cancer is more frequent in Alaskan Natives than the U.S. population. The major known risk factor is infection with the bacteria Helicobacter pylori, and is present in 85 percent of Alaskan Native adults who live in rural Alaska (Parkinson et al. 2000).

Contaminant Exposure

Contaminant exposure to environmental pollutants such as persistent toxic substances and POPs is of great concern to the circumpolar community as a whole. The Arctic is a focus for atmospheric, riverine, and marine pathways that result in the long range transport of contaminants into and within the Arctic (UNEP 2006).

The NSB has maintained an extensive program of monitoring and testing subsistence resources for contaminants. The results have been encouraging; the levels of contaminants such as PCBs (organic pollutants not typically associated in high quantities with modern oil and gas operations) in subsistence foods have been substantially lower than those reported in similar resources in Canada and Greenland (MMS 2008a).

Assessing the risks from radionuclides, POPs, heavy metals, PCBs, dioxins, and furans, the Alaska Native Health Board advised that the "benefits of a traditional food diet far outweigh the relative risks posed by the consumption of small amounts of contaminants in traditional foods." It has been further indicated that exposure to POPs can be limited by eating smaller, younger animals, animals from a lower trophic level, and by choosing lean tissues over fatty tissues from marine mammals (ADH&SS 2004a, 2004b; Alaska Native Health Board 1999). A risk assessment for exposure to PCBs and DDT (not generally associated with oil and gas operations) on fish in the Colville River, found no evidence of a significant health risk (ATSDR 2003).

There are a number of health effects associated with exposure to persistent toxic substances; however, there have been few Alaska-based health studies examining these effects. Overall PCB concentrations are declining in humans, including in Arctic regions. One study of an eastern Canadian arctic community found that concentrations of PCBs and organochlorine pesticides declined steadily between 1993 and 2000 (Dallaire et al. 2002; ADH&SS 2004a).

Air pollution is another contaminant source. The BOEM reviews EPA's six criteria pollutants as indicators of air quality for lead, ozone, particulate matter, carbon monoxide, nitrogen dioxide, and sulfur dioxide. BOEM compares project emissions to established maximum allowable concentrations for these pollutants to avoid effects on human health and the environment. Extensive air monitoring data have been collected across the North Slope, including in the vicinity of the project, that data is presented in EP Revision 2, Appendix K. The modeling developed with that data is presented in Section 4.1 of this document. Recent air quality data have not shown violations of the NAAQS in the vicinity of the project (Table 3.1.3-1).

Infectious Disease

Infectious disease mortality rates have declined dramatically over the past 50 years in the NSB with intensive public health interventions and improved living conditions and sanitation. However, respiratory infections are highly prevalent in Alaskan Natives and have been the subject of several studies showing particularly high rates of lower respiratory infections in infants and children in at least one rural Alaska region (Singleton et al. 2006). People with chronic lung diseases such as COPD are more vulnerable to complications of respiratory infections. The high rate of chronic lung disease on the Arctic coast may contribute to respiratory infection prevalence in the NSB. The contribution of existing oil and gas operations to rates of respiratory infections, if any, has not been studied.

Blood borne and sexually transmitted infections including human immunodeficiency virus (HIV), hepatitis B and C, gonorrhea and chlamydia have been studied in the Northern Region of Alaska. No new cases of HIV have been reported in the NSB since 1995 (NSB 2012). The prevalence of HIV and gonorrhea appears to be lower in this region than in the general U.S. population, though the prevalence of Chlamydia in the NSB is higher than the general U.S. population. Native Alaskans experience some of the highest rates of both chlamydia and gonorrhea in the state (NSB 2012). Risk factors for these infections include IV drug use and high-risk sexual behavior (ADH&SS 2007).

Maternal-Child Health

Maternal-child health reflects important health disparities in the NSB and includes an elevated rate of teen pregnancies and premature deliveries, compared with the general Alaska population. Premature birth, low birth weight, and Fetal Alcohol Syndrome have complex and similar risk factors, including smoking, alcohol use, drug abuse, poor prenatal care, and lower educational attainment.

The NSB Health Analysis Report and NSB 2010 Census (NSB 2010; NSB 2012) indicated that the health of North Slope children was generally worse than the health of children in the SOA. Overall, 63 percent of NSB children and 89 percent of all Alaska children have “very good” to “excellent” health. An estimated 60 percent of Iñupiat children in the NSB were reported to have “very good” to “excellent” health, compared to 84 percent of Caucasian children and 75 percent of children of other ethnicities in the borough.

Sanitation

Sanitation is important to Alaskan Native health. Infrastructure improvements were instrumental in efforts to control historic infectious disease epidemics in rural Alaska. The NSB provides water and sewer services in villages. The NSB Health Analysis Report (NSB 2012) estimated “92 percent of NSB households have modern water and sewer service, compared with an average of 76 percent for Tribal Health Regions statewide as of 2008.”

Health Services Infrastructure

Health services infrastructure of Chukchi Sea coastal villages is provided through a mix of federal, state, and local government entities. The NSB Department of Health and Social Services and the Arctic Slope Native Association provide health care services to most residents of the region. Residents of Point Hope generally receive health care from Maniilaq Association of Kotzebue. The physical isolation of Chukchi Sea coastal communities, however, can make access to health care extremely difficult for these communities (NSB 2005).

The NSB Health Analysis Report (NSB 2012) indicated that access to health care is one of the key factors with influencing the region’s health. An estimated 97 percent of NSB heads of households have health insurance, which is higher than the statewide estimate of 82 percent. The level of care available in the communities is limited and travel is generally required to access advanced medical care. The NSB is classified as a medically underserved area by the U.S. Health Resources and Services Administration (NSB 2012).

3.11.9 Coastal Zone Management Programs

The CZMA, enacted in 1972, was intended to help regulate coastal development. The corresponding Alaska Statute, the Alaska Coastal Management Act (ACMA), went into effect in 1977.

The SOA did not pass legislation required to extend the ACMP, allowing the ACMP to sunset at 12:01 AM, Alaska Standard Time, on 1 July 2011.

3.12 Coastal and Marine Uses

3.12.1 Military Activities

The USCG has conducted relatively limited activities in the Chukchi Sea in the recent past, but it is likely to increase activities in the near future. Based on observations of changing climate and specifically the retreating ice pack, the USCG plans to extend its operations to northern Alaska (Fredrickson 2008; Committee on the Assessment of U.S. Coast Guard Polar Icebreaker Roles and Future Needs 2005; USCG 2008a). In 2005, the Icebreaker Committee found that economic activity, including commercial fishing, cruise ships, and natural resource exploitation, was moving north and gave a recommendation that the U.S. should maintain year-round icebreaker capability to support national security and science interests (Committee on the Assessment of U.S. Coast Guard Polar Icebreaker Roles and Future Needs 2005). Additionally, there is interest in international boundary claims (Figure 3.12.1-1) and future international maritime arctic shipping routes (Figure 3.12.1-2) (USCG 2008a). District 17 (Alaska) of the USCG has stated that, “all coast guard missions in southern Alaska must be expanded to northern Alaska” (USCG 2008a).

In 2012, the USCG conducted Arctic Shield operations in response to substantial increases in Arctic maritime activities during the summer season. This operation provided an air, surface, and shore-side USCG presence in the arctic. The program was in operation from July through October 2012 (USCG 2012a).

The USCG uses both aircraft and marine vessels to carry out its mission in Alaska. USCG aircraft and marine vessels will be discussed separately.

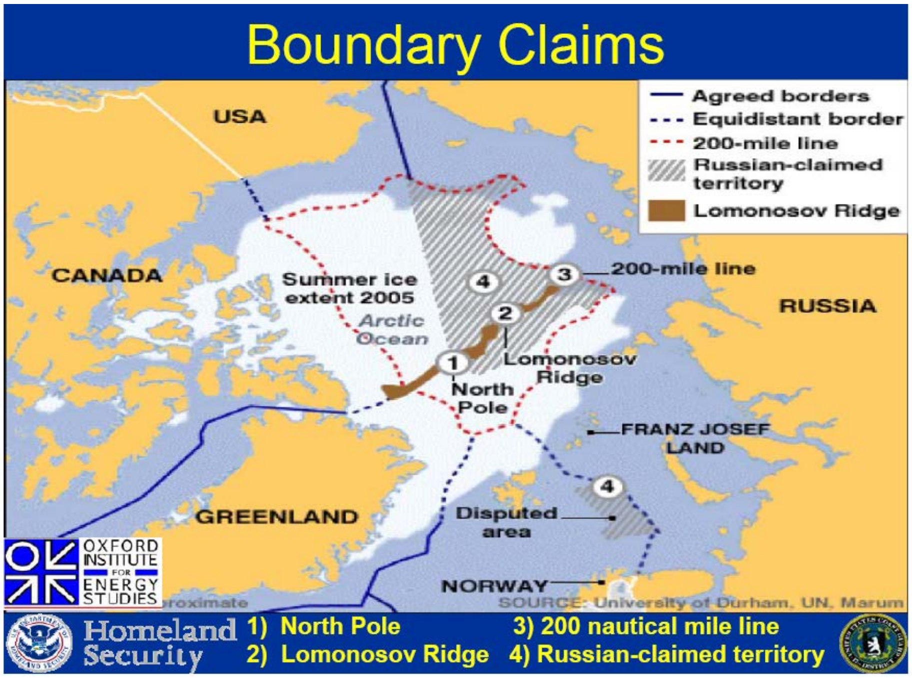
Icebreakers

The USCG conducts activities in the Arctic and Antarctic regions. There are three icebreakers in the USCG fleet; the U.S. Coast Guard Cutter (USCGC) *Polar Star*, USCGC *Polar Sea*, and the USCGC *Healy*. All three of the icebreakers are part of science operations (USCG 2008b). At this time, one icebreaker, the USCGC *Healy*, operates in the Arctic waters. Scheduling of scientific cruises does not occur years in advance. The USCG meets with agencies sponsoring scientific endeavors initially in the fall of the year prior to the proposed endeavor (USCG 2008c). Shell does not know whether any USCG icebreakers will be in the Chukchi Sea during the exploration drilling seasons covered in the revised Chukchi Sea EP.

<u>USCGC *Polar Star*</u>

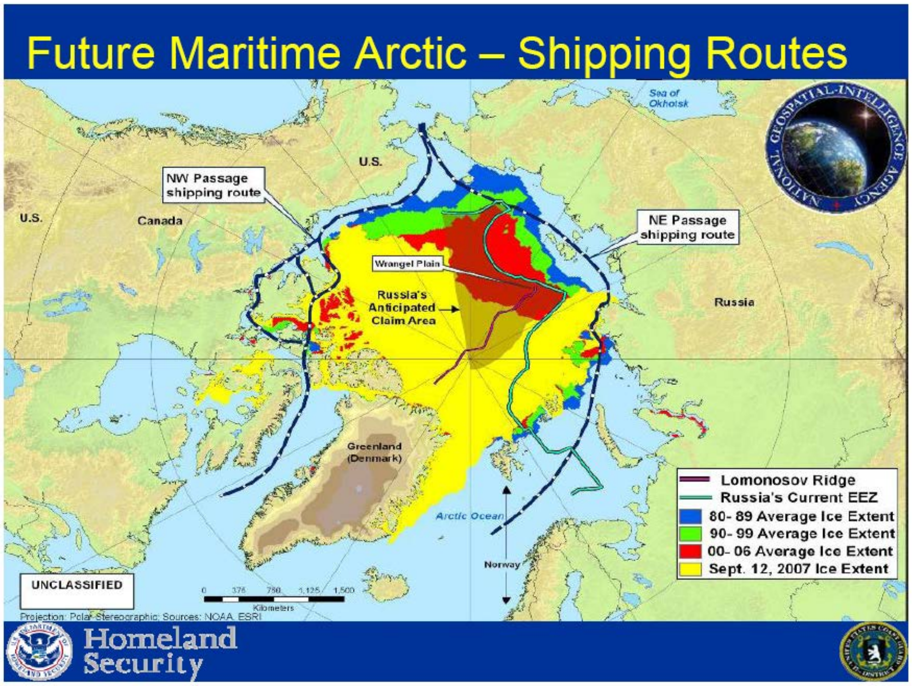
The USCGC *Polar Star* was recently reactivated following several years in caretaker status. The USCG deployed the icebreaker to support Operation Deep Freeze in Antarctica in December 2013.

Figure 3.12.1-1 Boundary Claims



(Source: USCG 2008a)

Figure 3.12.1-2 Potential Future Arctic Maritime Shipping Routes



(Source: USCG 2008a)

USCGC Polar Sea

Until recently, the USCGC Polar Sea's primary mission entailed breaking a route to U.S. research stations in Antarctica (Doughton 2007). During the summer of 2007, it underwent considerable changes. USCG District 17 publicized that the USCGC Polar Sea would embark on an Arctic mission in 2008 (USCG 2008a), and the ship's crew boasts that it routinely operates in the Bering and Chukchi seas, the Arctic Ocean, and around the continent of Antarctica (USCG 2008d). In April and May of 2008, the USCGC Polar Sea conducted a multi-mission homeland security patrol in Arctic waters (Brooks 2008). In 2009, the cutter completed a science-based deployment into Arctic waters to study core and water samples and polar bears (Juneau Empire 2009). The Polar Sea is currently in inactive status (USCG 2013) and is home-ported in Seattle, Washington (USCG 2012b).

USCGC Healy

The USCGC Healy is the USCG's newest and most technologically advanced icebreaker. According to the USCG, the ship's primary mission is "to function as a world-class high latitude research platform with emphasis on Arctic science" (USCG 2008b). Since 2002, the USCGC Healy has supported scientific endeavors in waters off of Alaska during its Arctic West Summers (USCG 2008e). In addition to scientific support, the Healy is capable of other missions such as search and rescue, environmental protection, and law enforcement (USCG 2012c).

For Arctic West Summer 2012, the USCGC Healy traveled over 18,100 nmi and conducted over 687 over-the-side science casts. Scientists aboard the vessel created a data baseline for the ecological study of Hanna Shoal, serviced subsurface moorings in the Beaufort Sea, and added data to the bathymetric mapping project of the extended continental shelf (USCG 2012d).

Currently, the USCG is in the initial planning stages of acquiring a new polar icebreaker. The estimated timeframe for delivery of a new icebreaker is one decade (USCG 2013).

Aircraft

Considering the USCG initiative to expand all its current Alaska operations to the north, it is reasonable to assume that USCG air patrol operations in the North Slope area will increase. The USCG is currently using aircraft to gather information regarding northern Alaska to establish Arctic operations baseline information. With this information, the USCG will determine what kind of USCG presence will be needed in the future (Fredrickson 2008).

On 25 October 2007, the USCG conducted its first air mission in northern Alaska. The HC-130 Hercules airplane flew from Barrow to the North Pole, initiating its Arctic Domain Awareness mission. According to PA1 Kurt Fredrickson, the main purpose of this flight was to determine how well instruments and radio communications worked in the cold weather conditions (Fredrickson 2008). The overall purpose of the mission is to provide the USCG a better understanding of the current Arctic environment by testing personnel and equipment capabilities. The program has continued annually since 2007.

The first 2011 domain awareness flight was conducted 22 March. 2011 operations included three exercises to practice elements of SAR, pollutions response, towing operations, and mass casualty response with local communities and state agencies. The 2011 season expanded operations utilizing cutters, aircraft and personnel from across the state to support 2011 operations from May through August (USCG 2008b, c, d, e, and f). Associated with this mission, members of the USCG participate in engagement with North Slope communities, Native corporations, and tribal representatives (Brooks 2008). The Arctic Domain Awareness flights program was continued in the summer of 2012. Activities included the use of C-130 aircraft to fly federal and state partners over the Arctic in order to raise awareness of issues (USCG 2012a).It is presumed that the USCG will conduct missions over the next few years in the Arctic to collect baseline information. While the USCG has publicized that it will increase activities in this region in the future, the extent of the increase is currently not defined.

3.12.2 Shipping

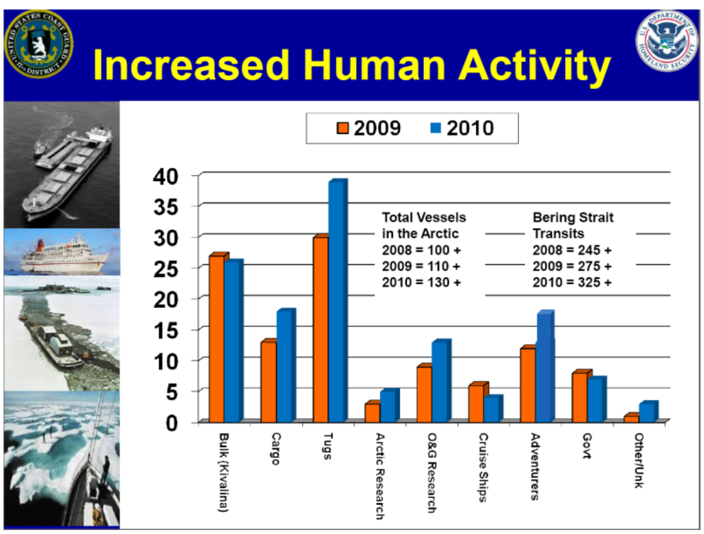
Freight arrives by barge in the summer, and air-cargo year round, to the communities on the North Slope. Transit into the Chukchi Sea is only possible on average for four months out of the year, due to ice formation in the Bering Strait. Northern Air Cargo serves Barrow once a day, Monday, Wednesday, and Friday (NAC 2012). Commercial flights are also available through select airlines serving the communities in the Chukchi Sea area.

The USACE is currently studying the viability for the future location of an Arctic deepwater port. In May of 2011 the USACE and Alaska DOT&PF held an arctic ports planning charrette to discuss the need for an Alaska arctic deepwater port. The anticipated increase in vessel traffic in the arctic has increased this need (RISE Alaska, LLC 2011). The Alaska Deep Draft Arctic Port Study was released by the USACE in January 2013. From a potential 14 sites, the USACE narrowed the study to Port Clarence and Nome. Both sites could potentially support a deepwater port, or the results of the study may indicate that just one is needed. In addition, although the study focuses on Nome and Port Clarence, additional sites could be evaluated independently or if funding becomes available at a later date (USACE 2013). In February, 2015, the USACE published a public notice (USACE 2015) announcing the Draft Integrated Feasibility Report, EA, and Finding of No Significant Impact for the study. The study proposes deepening the Nome Harbor to minus 28 ft. (8.53 m) mean lower low water by dredging and extending the existing causeway a total of 2,150 ft. (655 m) with an additional 450 ft. (137 m) dock.

3.12.3 Other Vessel Activity

Vessel activity for endeavors such as ecotourism, recreational vessel traffic, and adventure traffic crossing the Bering Strait has increased in recent years (Loy 2012). Four to seven cruise ships conduct as many as 10 cruises each year in the Bering Sea and Arctic each year (USCG 2012a). The number of adventure transits through the Northwest Passage increased from 12 vessels in 2009 to 17 in 2010 (USCG 2011). See Figure 3.12.3-1 for a summary of the increased vessel traffic in the Arctic and Bering Strait transits from 2009 to 2010.

Figure 3.12.3-1 Increased Vessel Traffic in Arctic, 2009 - 2010



3.12.4 Commercial Fishing

Under the current Fisheries Management Plan for Fish Resources of the Arctic Management Area, commercial fishing is prohibited in the Chukchi Sea. Commercial fishing is not known to have occurred in the past in the area of Shell's Burger Prospect or elsewhere in the northeastern Chukchi Sea. There is currently no regulatory authority for commercial fishing in the NSB. The rugged climate and the lack of identified resources have prevented any commercial fishing facilities from developing. The only involvement that residents of the NSB have in the commercial fishing industry is by taking part in the Bristol Bay Fishery. In turn there are no fisheries-related tax revenues collected from any of the North Slope communities.

3.12.5 Mariculture

No mariculture is conducted in the Lease Sale 193 Area or elsewhere in the northeastern Chukchi Sea or adjacent coastal waters.

3.12.6 Other Mineral Uses

Mining for coal, industrial minerals, and metallic minerals occurs in various areas within the NSB. Coal is the most prominent resource with an estimated four trillion tons of high rank coal existing between three basins (Cape Beaufort, Deadfall Syncline, and Kukpowruk River) on the North Slope, two of which (Deadfall Syncline and Kukpowruk River) are located in the Chukchi Sea area.

Industrial minerals (such as sand and gravel) can be harvested out of beach and river deposits located around Barrow. In addition there are about a dozen other industrial mineral sites located on rivers at various oilfields.

Metallic minerals are mined in the following locations:

- Misheguk Mountain (chromium)
- Siniktanneyak Mountains (chromium)
- Nimiuktuk (barium)
- Drenchwater (zinc, lead, silver)
- Whoopee Creek (zinc, lead, copper, cadmium, silver, gold)
- Story Creek (lead, zinc, silver, gold)
- Kivliktort Mountain (zinc, lead, barium)
- Kady (zinc, copper, lead, silver, gold)
- Outwash Creek (lead, zinc, copper, silver, manganese, nickel)
- Itkillik River West (barium, lead, zinc, copper),
- Porcupine Lake (copper, zinc, silver, fluorite)
- Esotuk Glacier (copper, lead, zinc, tin, tungsten, fluorite)
- Romanzof Mountains (copper, molybdenum, lead, zinc, silver, tin, fluorite, uranium)

At least five of the metallic mineral mines are located in the Chukchi Sea area.

THIS PAGE
INTENTIONALLY LEFT BLANK

4.0 DIRECT AND INDIRECT ENVIRONMENTAL IMPACTS

This section presents the results of the analyses of potential direct and indirect impacts of Shell's planned exploration drilling activities under EP Revision 2 on the physical, biological, and sociocultural resources affected by each of the impact factors. Separate subsections are included for each of the following resources: air quality, water quality, sediments, lower trophic organisms, fish and essential fish habitat, birds, marine mammals, T&E species, sensitive resource areas, cultural resources, subsistence and socioeconomics, and coastal and marine uses. (Cumulative impacts are presented in Section 5.0. The results of an analysis of the probability and potential direct and indirect effects associated with a VLOS are presented in Section 6.0.)

Section 4.0, and the subsequent individual subsections within Section 4.0 that address each of the physical, biological, and sociocultural resources, are organized to cover the following topics:

- Key elements of Shell's exploration drilling activities in EP Revision 2, with a focus on those elements that have changed from Shell's approved EP Revision 1.
- The aspects of Shell's activities that are identified as having a potential to impact each of the physical, biological, and sociocultural resources considered. These "impact factors" include aircraft traffic, vessel traffic, drilling sound, ZVSP survey sound, drilling unit mooring and MLC construction, air emissions, drilling waste discharges, other permitted discharges, small liquid hydrocarbon spill, and shorebase presence.
- The modeling efforts conducted by Shell to delineate the air emissions, sound profile, and drill cuttings and drilling fluid discharges associated with EP Revision 2. The results from these modeling efforts inform Shell's analysis of direct and indirect environmental impacts.
- Definitions of the impacts on each individual resource based on: (1) a "significance threshold" that is used to determine whether a particular impact has a significant (or not significant) impact on that resource, and, in most cases, (2) a four-category scale (i.e., negligible, minor, moderate or major) to define the level of adverse, or beneficial, effects associated with each impact factor on each resource.
- An analysis of the effects of each impact factor on each resource based upon available information, and including one more of the following: the nature of the activity and impact, the spatial extent of the impact and the resource affected, literature and data on the resource's response to the activity, information on conditions at the Burger Prospect, modeling or other estimation results and experience from Shell's 2012 exploration drilling activities, recovery times for the resource, and the effectiveness of mitigation measures.
- Based on the significance and level of effects definitions adopted, a determination of the level of effect (negligible, minor, moderate or major) of each impact factor on each resource, and a determination of the overall impact of EP Revision 2 activity on each resource.

<u>Description of Shell's EP Revision 2</u>

In EP Revision 2, Shell proposes to drill up to six exploration wells on six identified locations within the Burger Prospect using two drilling units: the *Discoverer* and the *Polar Pioneer*. This is an expansion in the level of potential activity from EP Revision 1, which was approved by BOEM (BOEM 2011a). In that approved EP, Shell proposed to drill at the same well locations using one drilling unit, the *Discoverer*. The additional drilling unit, the *Polar Pioneer*, is a non-selfpropelled, semi-submersible drilling unit. Descriptions of these two drilling units are included in Section 1.0 of the EP, and in the Preface and Section 2.0 of this EIA. These drilling units are accompanied by an expanded number of support vessels, aircraft, and OSR vessels. Descriptions of these vessels, aircraft, and response assets are included in Sections 1.0 and 13.0 of the EP and in the Preface and Section 2.0 of this EIA.

The scope of activities analyzed in this section includes the transit of two drilling units and support vessels to and from the Burger Prospect more than 64 mi (103 km) offshore of the Chukchi Sea coastline. Specifically, Shell will mobilize both of its drilling units, the *Discoverer* and the *Polar Pioneer*, and support vessels through the Bering Strait on or about 1 July each drilling season,[7] reaching the Burger Prospect as early as 4 July, as ice conditions permit. Shell will moor and stabilize the two drilling units (anchor handling) at their designated locations. EP Revision 2 anticipates two drilling units operating simultaneously. The minimum distance between any two drill sites on the Burger Prospect (Burger A and Burger F) is 2.0 mi (3.2 km), and the maximum distance (Burger S to Burger V) is 13.7 mi (22.0 km) (Figure 2.1-1). The most likely drilling scenario would place the two drilling units from 7 to 10 mi (11.3 to 16.1 km) apart. A MLC will be constructed at each drill site, though a MLC already exists at Burger A as a result of Shell's 2012 exploration drilling activities.

For the first time, Shell is including the option of utilizing a MLC ROV system to construct MLCs; this option would increase the time the drilling units are available for drilling the wells. Therefore, MLCs could be constructed using either the conventional method with the drilling units or by the newly-proposed MLC ROV system.

Additional activities include ice management, drilling operations for two drilling units, helicopter support and crew rotations and logistics, air operations in Barrow, ice reconnaissance flights using fixed wing aircraft, discharge monitoring, and marine mammal monitoring. The remaining support for drilling operations will be provided by ocean-going vessels. Shell also proposes to conduct one geophysical survey, or ZVSP survey, at each of the six well drill site after the well is drilled. Each ZVSP survey, which relies upon an airgun array to gather geophysical information at various depths, typically takes 10 to 14 hr. In addition to these offshore activities, onshore support facilities will be used in Barrow and Wainwright. Shell anticipates expansion of its air support shorebase in Barrow to lease an additional 40-person accommodation. Shell also anticipates expanding its air and shorebase facilities at Wainwright to include additional storage yard space. Additional descriptions of these shorebases are included in Sections 1.0 and 14.0 of the EP and in the Preface and Section 2.0 of this EIA.

Each season, drilling will cease on or around 31 October. Shell will demobilize the drilling units and support vessels out of the Chukchi Sea at the end of each drilling season. The exploration drilling activities under EP Revision 2 are anticipated to occur over multiple drilling seasons.

Kotzebue Sound Mooring Location Selection Criteria

The site of these four, closely spaced, temporary mooring locations, in Goodhope Bay in the western portion of Kotzebue Sound, were selected in large part because the area has been selected and approved by the SOA as a PPOR in addition to traditional knowledge received from nearby communities Communities did not indicate issues (such as subsistence use conflicts) with Shell's mooring location.

The review process for selecting PPORs considers the existence of sensitive resources such as historic properties. Subsea surveys have not been conducted at the location, but it is the conclusion of an archaeological review requested by Shell that there is low potential for any effects to historic resources from the planned moorings and staging in Goodhope Bay. Shell visited the local communities in January 2014 (Kotzebue), July 2014 (Kotzebue and Deering) and in January 2015 (Kotzebue, Deering and Buckland) and informed local residents of Shell's proposed activities, including the mooring of vessels in Goodhope Bay, southwestern Kotzebue Sound. During these meetings (see the Plan of Cooperation [Appendix D]) the residents did not raise concerns that the mooring of the vessels would cause disturbance to subsistence resources or subsistence use.

[7] *See supra* note 2.

Shell will employ SAs and Community Liaison Officers (CLO) in nearby communities to mitigate potential disturbances to subsistence issues that may arise. In addition, Shell will establish a Communication Center (Com Center) in Kotzebue. The SAs and CLOs will be hired, and the Com Center established prior to Shell vessels entering Kotzebue Sound.

Beluga whales enter Kotzebue Sound from the north after the ice recedes in early to mid-June (Morseth 1997; Huntington 1999). They then travel into Eschscholtz Bay, which is in the southeastern portion of Kotzebue Sound, where they may behunted until early July (Huntington 1999). Beluga feeding and calving has been documented by subsistence hunters and scientists collecting traditional knowledge about beluga hunting practices in Eschscholtz Bay, (Morseth 1997; Huntington 1999). In mid-July, belugas leave the bay and head west where they migrate past Goodhope Bay (Huntington 1999). The important subsistence hunting, calving, and feeding grounds documented in these studies (in Eschscholtz Bay) are east of Goodhope Bay where Shell's vessels will be staged and therefore Shell's activities in Kotzebue Sound are not anticipated to interfere with beluga whale subsistence hunting, feeding, or calving.

In addition to SAs and Com Centers, Shell will implement the following measures. PSOs will be placed on vessels when they transit in and out of Kotzebue Sound. These PSOs will advise the vessel captains of the presence of marine mammals and whether a ship course alteration is necessary to avoid disturbing the animals. Shell will also participate in the Kotzebue Sound regional acoustic recorder network, managed by the Northwest Arctic Borough Science Department. This array will collect information on marine mammal vocalizations, ambient sound levels, and the influence of Shell and other vessel traffic to underwater sound levels.

Impact Factors Associated with Shell's EP Revision 2

Based on Shell's evaluation of EP Revision 2 activities, monitoring reports from past environmental surveys, relevant peer reviewed literature, stakeholder engagement, and Plan of Cooperation (POC) meetings, Shell has identified a number of aspects of its comprehensive exploration drilling program as having the potential to impact the environment:

- Aircraft traffic - The number of aircraft and aircraft traffic associated with EP Revision 2 is higher than the levels proposed in Shell's EP Revision 1 in order to support two drilling units operating simultaneously. Under EP Revision 2, Shell will employ four helicopters (three for crew changes and one for SAR) and three fixed-wing aircraft (two for protected species observer and ice monitoring flights and one for crew changes). Aircraft traffic consists primarily of approximately 40 round trip helicopter flights weekly between the Burger Prospect and shorebase facilities at Barrow; this is an increase from EP Revision 1 which estimated 12 round trips weekly. Two fixed-wing aircraft will be used for PSO overflights and ice reconnaissance, on a daily basis when possible. In addition to this routine aircraft traffic between the Burger Prospect and Barrow, aerial surveys for marine mammals will be conducted along a standardized route, attempted daily, for the duration of the exploration, and fixed wing aircraft crew change between Barrow and Wainwright once every three weeks.
- Vessel traffic - Vessel traffic associated with EP Revision 2 is higher than the levels proposed in Shell's EP Revision 1 in order to support two drilling units operating simultaneously. New vessels include a second drilling unit and science vessels to support monitoring requirements under the NPDES exploration facilities GP. The two drilling units will be supported by additional vessels for ice management, anchor handling, resupply, and crew transport, as well as OSR vessels and barges staged near the drilling units, with a full complement of crew and OSR equipment. The total number of support vessels has also increased. Additional vessels will be used occasionally to support exploration drilling activities in the Chukchi Sea (e.g., ice management, anchor handling, offshore supply, alternate MLC ROV System vessel and OSR augmentation) and are therefore included in Chukchi Sea EP Revision 2 and analyzed in this EIA.

The expected frequency of OSV visits to the drilling units has been increased from 17 round trips / season in EP Revision 1 to 30 round trips/ season in EP Revision 2.

- Sound energy generated by drilling and ice management - Drilling and ice management sound levels under EP Revision 2 will increase as Shell plans to use two drilling units, the *Discoverer* and the *Polar Pioneer*, which will operate simultaneously. Only the drillship *Discoverer* was evaluated in EP Revision 1. Continuous sounds will also be generated from supporting activities, including anchor handling, construction of a MLC using the MLC ROV system, support vessels in Dynamic Positioning mode (DP), and ice management. Because the number of support vessels has increased, the sound associated with EP Revision 2 is greater than that under EP Revision 1. A discussion of Shell's modeling of these sounds is provided below.
- Sound energy generated by ZVSP surveys - As described in EP Revision 2, Shell plans to conduct a geophysical activity referred to as a ZVSP survey at each Chukchi Sea drill site. A ZVSP survey program was also proposed in EP Revision 1. During ZVSP survey operations, a string of geophones (receivers) will be hung in the wellbore to record the sonic waves created by the firing of a sound source (airgun array), which is suspended from the deck of the drilling unit into the water adjacent to the riser (Figure 2.4-1). The geophones will be relocated in the wellbore after each firing of the sound source until the entire wellbore has been surveyed. Each ZVSP survey will take approximately 10 to 14 hr to complete; the majority of that time will involve relocating the geophones in the wellbore. The sound source will be triggered approximately 216 times over the course of each survey. A two-airgun (2×250 in.^{3} airguns) or three-airgun array (3×150 in.^{3}) will likely be used to perform each ZVSP survey.
- Drilling Unit Mooring (anchor handling) and MLC construction - EP Revision 2 introduces the possibility of using a new method to construct MLCs, a MLC ROV system. Shell estimates the physical manifestations of anchor disturbances associated with mooring the two drilling units to be 3.7 ac (14,923 m^2). The physical effects of mooring, combined with MLC construction would be restricted to a very small portion of the Chukchi Sea seafloor area, 4.01 to 5.2 8ac (16,158 to 21,354 m^2), depending on MLC construction by drill bit or by MLC ROV system. The MLC ROV system results in the larger disturbance area. Approximately 10 additional acres (0.04 km^2) may be indirectly impacted by the re-deposition of cuttings from MLC construction and drilling to thickness of 0.4 in. (1.0 cm).
- Air emissions **-** Shell estimated offshore air emissions for its proposed activities in EP Revision 2 (e.g., drilling units, MLC ROV system, support vessels, OSR assets) to create a NEPA emissions inventory. The NEPA emissions inventories calculate short-term emissions, expressed as pounds of pollutant per hour (lb/hr), and annual emissions, expressed as tpy. The NEPA emissions inventories are used to conduct dispersion modeling of emissions associated with the exploration drilling activities as described in EP Revision 2. Because the level of activity has increased between EP Revision 1 and EP Revision 2, the air emissions are higher in EP Revision 2. A discussion of Shell's modeling of these air emissions is discussed below. BOEM has regulatory authority regarding air quality for the OCS off the coast of the North Slope Borough (NSB) .
- Drill cuttings and drilling mud discharges - Changes in EP Revision 2, including using two drilling units operating simultaneously and the possibility of constructing an MLC using a MLC ROV system instead of a drill bit, increase the drilling-related discharges in any given season. EP Revision 2 also includes changes to drilling fluids components and BOP fluids. Drill cuttings and drilling muds will be discharged below the sea surface under the conditions and limitations of EPA's NPDES exploration facilities GP; drilling fluids will also comply with the permit. Permit limits and conditions placed on the discharge content, volume, and rate ensure they do not result in undue degradation of water quality (Table 4.2.1-1). The deposition area of drill cuttings and fluids and discharge plumes is provided in Table 4.2.1-3. Discharge modeling performed for both the *Discoverer* and the *Polar Pioneer*, based on maximum prevailing current speeds of 25 cm/s,

shows that sedimentation depth of muds and cuttings at greater than 1 cm thickness will occur within approximately 500 m of the drilling unit discharge point (Fluid Dynamix, 2014a,b,c,d). Concentrations of total suspended solids, a transient feature of the discharge, are modeled to be below 15 mg/L at distances approximately 1000 m from the drilling unit discharge point. No overlapping impacts are associated with the two drilling units operating simultaneously at the Burger Prospect given the size of the plumes and location of even the two closest well sites. As a result, the increased level of activity associated with EP Revision 2 should not affect the impact conclusions associated with these discharges.

- Other permitted discharges - Other permitted discharges include the non-drilling wastewater discharges from the drilling units (Tables 2.7-4 and 2.7-5), and similar wastewaters discharged from the support vessels (Table 2.7-6) as part of normal vessel operation, into the Chukchi Sea. These wastes will be generated by the drilling units and support vessels, and include: domestic and sanitary wastewaters, deck drainage, cooling water, ballast water, desalination wastes, boiler blowdown, and fire control system test water. Under EP Revision 2, the increased number of vessels results in increases in the projected volumes of these discharges (Tables 2.7-4 and 2.7-5). These discharges will be conducted in accordance with, and authorized under NPDES exploration facilities GP for the drilling units, which contains a number of conditions that place limitations on effluent constituents and discharge rates, and mandate discharge monitoring and reporting. Vessels will be at various scattered locations across the Chukchi Sea when in transit or on standby, and any ephemeral impacts associated with vessel discharges will be limited to the proximities of discharge outfalls. As a result, the increased level of activity associated with EP Revision 2 should not affect the impact conclusions associated with these isolated discharges.
- Small liquid hydrocarbon spill - EP Revision 2 considers the impacts associated with responding to a small spill, defined as 48 bbl or less. A small spill, such as a release of 48 bbl of diesel fuel, is the most probable type and volume of spill, if any, to occur. Over 99 percent of a small spill (diesel fuel) would evaporate (48 percent) or disperse (51 percent) within 48 hr. Shell is required to have a comprehensive spill prevention and response plans and capabilities in place. Shell's plans include measures to prevent any spill release from occurring and to respond in the event of a spill, including capabilities for responding to a "worst case" scenario release. There are no substantive changes in Shell's modeling or response planning for a small spill from EP Revision 1.
- Shorebase presence - Onshore support facilities will be used in Barrow and Wainwright. EP Revision 2 includes an expansion in Shell's shorebase presence at Barrow that results in new emissions units that were not included in EP Revision 1. Onshore activities include support facilities in Barrow (generators used at a 75-person man-camp, and an aircraft hangar requiring heat), vehicle transportation in Barrow to support personnel and supply to and from the drill site, and aircraft and helicopter take-off and landing activity at Barrow (for crew transport, ice reconnaissance, and marine mammal observation). There will be an expansion of the air support shorebase in Barrow to lease an additional 40-person accommodation. Shell also anticipates expanding air and shorebase facilities at Wainwright to include additional storage yard space.

<u>Resources Considered</u>

Section 3.0 of this EIA describes, in detail, the environmental conditions and the physical, biological and sociocultural resources that may be affected by the planned exploration drilling activities in EP Revision 2, or which could affect the planned operation or activities. In considering the impacts of its exploration drilling activities under EP Revision 2, Shell analyzed the following physical, biological, and sociocultural resources:

- Air quality
- Water quality
- Sediments
- Lower trophic organisms
- Fish and essential fish habitat
- Marine and coastal birds
- Marine mammals
- T&E species (birds and marine mammals)
- Sensitive areas
- Cultural resources
- Subsistence and Socioeconomics
- Coastal and marine uses

Those resources described in Section 3.0, but not analyzed further in Section 4.0, such as terrestrial mammals, have been determined to be unaffected by Shell's exploration drilling activities under EP Revision 2.

Screening Analysis to Determine When An Impact Factor Affects A Resource

A screening analysis was conducted to determine which environmental resources could be potentially affected by the identified impact factors associated with the exploration drilling activities as detailed in EP Revision 2. As discussed above, Shell's EP Revision 2 incorporates Shell's prior approved exploration drilling plan (EP Revision 1) with the additional changes introduced in EP Revision 2. All the proposed activity associated with the drilling activities was considered when determining potential effects on physical, biological, and sociocultural resources. The results of this screening analysis are presented below in Tables 4.0-1 and 4.0-2. A "Y" in the corresponding table cell indicates there is potential for an effect on the resources and that analyses were conducted for this EIA.

Table 4.0-1 EP Revision 2 Potential Effects on Environmental Resources

Resource	Impact Factor [1]				
	Aircraft Traffic	**Vessel Traffic**	**Drilling Sound**	**ZVSP Survey Sound**	**Drilling Unit Mooring and MLC Construction**
Air Quality	Y	Y	--	--	Y
Water Quality	--	--	--	--	Y
Sediments	--	--	--	--	Y
Lower Trophic	--	--	Y	Y	Y
Fish	--	Y	Y	Y	Y
Birds	Y	Y	Y	Y	--
Marine Mammals	Y	Y	Y	Y	Y
T&E Species	Y	Y	Y	Y	Y
Sensitive Areas	Y	Y	Y	Y	--
Cultural Resources	--	--	--	--	Y
Subsistence	Y	Y	Y	Y	--
Socioeconomics	--	--	--	--	--
Coastal/marine uses	N/A	N/A	N/A	N/A	N/A

[1] Cells with a (Y) indicate the impact factor could potentially affect the identified resource; a (--) indicates no potential effect
[2] Coastal and marine uses evaluated differently than other resources. See Section 4.12 for more information on impacts on coastal and marine uses.

Table 4.0-2 EP Revision 2 Potential Effects on Environmental Resources

Resource	Impact Factor [1]				
	Air Emissions	**Drilling Waste Discharges**	**Other Permitted Discharges**	**Small, Liquid Hydrocarbon Spill**	**Shorebase Presence**
Air Quality	Y	--	--	Y	Y
Water Quality	--	Y	Y	Y	--
Sediments	--	Y	--	Y	--
Lower Trophic	--	Y	Y	Y	--
Fish	--	Y	Y	Y	--
Birds	Y	Y	Y	Y	Y
Marine Mammals	Y	Y	Y	Y	--
T&E Species	Y	Y	Y	Y	Y
Sensitive Areas	--	Y	Y	Y	--
Cultural Resources	--	--	--	--	--
Subsistence	Y	Y	Y	Y	Y
Socioeconomics	--	--	--	--	Y
Coastal/marine uses	Y	--	--	Y	Y

[1] Cells with a (Y) indicate the impact factor could potentially affect the identified resource; a (--) indicates no potential effect

Modeling of Air Emissions, Discharges, and Sound Profile

Some of the impact factors identified above are associated with a single well and the total impact for the exploration drilling activities is simply the sum of the impacts from all the wells in the program with no synergistic effects between wells due to separation in time and space. Other types of impacts have the potential to be synergistic if the impacting activities were conducted simultaneously or in such close geographical proximity that their effects overlap. Shell identified the following components of its exploration drilling activities that could possibly have synergistic effects: sound generation associated with drilling activity (including the drilling units, MLC construction, anchor handling, support vessels, ice management, and ZVSP surveys), air emissions from various sources, drilling waste discharges, and other permitted vessel discharges. Modeling of air emissions, some discharges, and sound have been conducted for EP Revision 2. These modeling efforts take into account Shell's entire exploration drilling program, and make numerous conservative assumptions that result in an overestimate of likely program impacts. The following sections describe these modeling efforts.

Air Emissions

For the air quality analysis, NEPA emissions inventories were prepared to detail the sources, activities and emissions associated with Shell's exploration drilling activities. The air pollutants addressed include: NO_X, CO, PM_{10}, $PM_{2.5}$, VOC, SO_2, Pb, and GHGs. The NEPA emissions inventories were used to conduct dispersion modeling to estimate ambient concentrations of air pollutant emissions associated with the drilling activities described in EP Revision 2. Three distinct modeling efforts were conducted: (1) the impact of vessel and drilling emissions at onshore locations, (2) the impact of vessel and drilling emissions at the offshore areas used for subsistence hunting and fishing, and (3) the impact of shorebase and aircraft activity at onshore locations. An overview of the air emissions data and modeling is presented here. The emissions inventories and modeling methods and results are described in detail in the following documents:

- Appendix K of EP Revision 2 – Shell Chukchi Sea Outer Continental Shelf Lease Exploration Plan Revision 2, Appendix K AQRP and NEPA Emissions Inventories (Air Sciences Inc. 2015)
- Attachment A to this EIA - Arctic Offshore Air Quality Impacts: Recommendations for Appropriate Criteria for Determining Significance Under NEPA

- Attachment B to this EIA - Shell OCS Exploration Program – Chukchi Sea Air Quality Technical Report Onshore Areas (ENVIRON 2015a)
- Attachment C to this EIA - Shell OCS Exploration Program – Chukchi Sea Air Quality Technical Report Offshore Subsistence Area (ENVIRON 2015b)

Shell's offshore air emission modeling considers Shell's proposed activities (e.g., drilling units, MLC ROV system, support vessels, OSR assets) and the emission units on them. The NEPA emissions inventory provided in Appendix K of EP Revision 2 identifies the "emission factor" associated for each pollutant and each emission unit. The "emission factor" is expressed as a mass of emissions for a given activity level. The emission factors were selected based on a hierarchy of available data (with limited exceptions). First, when available, emission factors were selected from emission source tests conducted for specific equipment currently present on drilling units, vessels, or at shorebase locations. If source test data were not available, emission factors provided by equipment vendors were used. If neither source tests nor vendor data were available, emission factors were selected from the EPA's compilation of emission factors. Together, the activity level and emission factors enable the calculation of short-term emissions, expressed as pounds of pollutant per hour (lb/hr), and annual emissions, expressed as tpy. Short-term emissions are based on equipment nameplate ratings, modified by limitations established from a combination of safety policies and good engine care policies.

The NEPA emission inventories adopt a number of conservative assumptions that result in an overestimate of the actual onshore and offshore emissions associated with EP Revision 2. Actual activities and locations may vary but are expected to contribute to lower air emission impacts than estimated in the dispersion modeling. In particular, the following conservative assumptions were adopted:

- Annual emissions from the two drilling units are based on the continuous operation of engines, boilers and incinerators (at 80 percent load for engines; 100 percent load for boilers and incinerators) for the entire 120–day season (2,880 hr per season) even though that is a significant overestimate of their use.
- Annual emissions from certain engines, boilers and incinerators on a number of support vessels are based on continuous operation 24 hr per day for the entire 120–day season (2,880 hr per season) even though that is a significant overestimate of these engine's use.
- Annual emissions from emergency generator engines, lifeboat engines, rescue crafts and seldom used engines on support vessels are assumed to operate 500 hr in the season, even though that is a significant overestimate of these engines' use.
- Annual emissions from the small OSR equipment are based on operation of engines 8 hr per day for the entire 120–day season even though they will only be used for training exercises and is a significant overestimate of this equipment's use.
- Annual emissions from drilling units do not account for the use of any of the existing emission control systems (e.g., selective catalytic reduction, catalyzed diesel particulate filters) when they are currently installed and will be used to reduce emissions.
- Annual emissions from the support vessels do not account for the use of selective catalytic reduction emission control systems when they are currently installed and will be used to reduce emissions.
- Annual SO_2 emissions are calculated assuming higher, conservative 100 ppm sulfur content even though Shell will purchase and use only ULSD or a fuel with equal or lower sulfur content (but that will be mixed with fuel blending with any residual non-ULSD fuel that may remain in the tanks of support vessels or drilling units prior to the drilling season).

Impacts of vessel and drilling emissions on onshore air quality

To evaluate the effect of the offshore project's air emissions on onshore air quality, dispersion modeling was completed using this offshore NEPA emissions inventory. Discussions with BOEM[8] indicate the agency's intention to follow EPA's Guideline on Air Quality Models for conducting dispersion modeling. Through agreement with BOEM, CALPUFF was determined to be an appropriate model for use to simulate the dispersion of emissions from the drilling units and their associated vessels at the shoreline. CALPUFF is the EPA-recommended air quality dispersion model for distances greater than 31 mi (50 km).

Shell conservatively assumed that the two drilling units are operating at the two lease blocks closest to shore (drill sites J and V). Predicted concentrations were modeled at 5,034 receptors for the onshore air assessment. Maximum onshore concentrations, background concentration, and design concentrations (project emissions plus background concentrations) for each criteria pollutant - NO_2, PM_{10}, $PM_{2.5}$, CO, and SO_2 - are predicted to occur at various locations along the Chukchi Sea shoreline or onshore. As discussed below in Section 4.1.1, the modeling results indicate those concentrations attributable to the drilling units and their associated offshore support vessels are far less than half the NAAQSs and half or less than half the Maximum Allowable Increases (MAI) at all onshore receptors. MAI are also referred to as PSD Increments. See Attachment C to - this EIA for additional detail on this modeling and the results.

Impacts of vessel and drilling emissions on offshore subsistence use air quality

To evaluate the potential effect of the offshore project's air emissions on offshore subsistence use air quality, dispersion modeling was completed using the same offshore NEPA emissions inventory used to model onshore air quality (described above). Shell again made conservative assumptions about the locations of the sources of air emissions. For example, modeling the drilling units at the two lease blocks closest to the subsistence use area results in the greatest potential impacts to subsistence activities because at distances larger than a few miles where there is no elevated terrain, air quality concentrations are inversely proportional to the distance between the emission unit and the receptor. By agreement with BOEM, the areas to be evaluated for subsistence are the areas offshore near the Burger Prospect and the coastal areas. Pollutant concentrations were modeled at 1,800 receptors in the offshore subsistence use area.

Air quality dispersion modeling simulations were used to estimate ambient concentrations attributable to emission units associated with the exploration activities. CALPUFF was also used to model the offshore air quality emissions within the subsistence use areas. CALPUFF is the EPA-recommended air quality dispersion model for distances greater than 31 mi (50 km). Because the nearest boundary of the subsistence use area is located more than 43 mi (70 km) from the closest candidate drilling location, the CALPUFF model was appropriate for use. Maximum offshore hourly concentrations, background concentration, and design concentrations (project emissions plus background concentrations) for each criteria pollutant - NO_2, PM_{10}, $PM_{2.5}$, CO, and SO_2 - are predicted using CALPUFF to calculate the maximum hourly concentrations of each pollutant.

Offshore emissions effects on offshore subsistence areas will impact only remote and inaccessible offshore areas, where comparatively healthy people are present, if at all, for limited periods of time. The NAAQS were established to protect nationwide air quality in areas reasonably accessible to the general public, and specifically to protect the health of the most vulnerable populations. Because the NAAQS are not appropriately applied to this offshore environment, Shell selected more suitable offshore criteria. Shell developed offshore subsistence use criteria after reviewing scientific evidence and Occupational Safety and Health Administration (OSHA) state and federal standards (see Attachment A to the EIA for a

[8] Meeting between Shell and BOEM held on 15 May 2013 at BOEM's offices in Anchorage Alaska.

detailed description of these offshore criteria). The criteria adopted are more protective than OSHA's exposure standards, and thus have a built-in margin of safety. The criteria are set at levels adequate to ensure no significant impacts on the health of exposed workers and subsistence hunters and fishermen (if any), and to avoid significant impacts to marine life and other environmental resources present in the offshore regions of the Arctic Ocean. As discussed in Section 4.1.2, the modeling results indicate that concentrations attributable to the drilling units and their associated offshore support vessels are well below the selected impact criteria for offshore locations. See Attachment C (ENVIRON 2015b) of EP Revision 2 for additional detail on this modeling and the results.

Impacts of onshore and aircraft emissions on onshore air quality

The following onshore activities associated with the exploration drilling activities as described in EP Revision 2 will result in air emissions: support facilities in Barrow (generators used at a 75-person man-camp, and an aircraft hangar requiring heat), vehicle transportation in Barrow to support personnel and supply to and from the drill site, and aircraft and helicopter take-off and landing activity at Barrow (for crew transport, ice reconnaissance, and marine mammal observation). The emissions from each of the individual emission sources are provided in Appendix K of EP Revision 2. As discussed in Section 2.5, because the emissions related to the onshore emission units activities are so low, no Clean Air Act (CAA) minor or major permits are required, nor is any dispersion modeling necessary to demonstrate CAA compliance.

Although the CAA would not require dispersion modeling of the onshore source of air emissions under Shell's EP Revision 2, at the request of BOEM, Shell conducted air dispersion modeling that aggregated these onshore sources in Barrow. The dispersion modeling used AERMOD, which is recommended by EPA and other regulatory agencies as the appropriate model for industrial sources where the distance between the emission sources and the receptor is less than 31 mi (50 km). For this modeling, receptors were placed over the entire Barrow area with a spacing of 328 ft (100 m), with the exception of the man camp and the airport. Additional receptors were placed along the ambient air boundaries of the camp and airport at a spacing of 32.8 ft (10 m). In all, a total of 6,272 receptors were used in the analysis. The results of the modeling, including maximum concentrations, background concentration, and design concentrations for each pollutant are provided in Attachment B of this EIA.

Discharges

Shell modeled the discharge of drill cuttings and drilling fluids from the Burger wells in order to predict the dispersion and deposition of the discharged drill cuttings, water-based drilling fluids, and cement. This modeling utilizes the Offshore Operators Committee (OOC) Mud and Produced Water Discharge model (Fluid Dynamix 2014a,b,c,d). The simulation modeling was conducted based on the equipment and design of the two drilling units, the *Discoverer* and the *Polar Pioneer*. Modeling was conducted at an individual well site first to determine the deposition area and plume size to then determine whether there would be any potential for overlapping effects if two drilling units were operating simultaneously at nearby well locations. All six wells at the Burger Prospect are very similar with respect to water depth, total depth, diameter, and volumes of cuttings and drilling fluids. Therefore, the results from the discharge modeling for one well can be used to characterize all of Shell's proposed wells at the Burger Prospect. Shell's assessment of the impacts of discharges is based on the results of modeling for Burger J. The maximum discharge rates, seabed depositional area, and total suspended solids (TSS) for Burger J are utilized in the environmental impacts analysis.

Discharge modeling performed for the *Polar Pioneer* and the *Discoverer*, based on maximum prevailing current speeds of 9.84 in./second (s) (25 cm/s), shows that sedimentation depth of muds and cuttings at greater than 1 cm thickness will occur within approximately 1,641 ft (500 m) of the drilling unit's discharge point (Fluid Dynamix, 2014a,b,c,d). Concentrations of total suspended solids, a transient feature of the discharge, are modeled to be below 15 milligrams per Liter (mg/L) at distances approximately 3,281 ft (1,000 m) from the drill discharge point. The most likely drilling scenario would place the two drilling units from 7 to 10 mi (11.3 to 16.1 km) apart. At these distances there will be no interaction, or overlap, of discharge plumes from the two drilling units. The closest drill sites on the Burger Prospect (Burger A and Burger F) are approximately 2 mi (3.3 km) apart. Modeling results still indicate that little to no interaction of the discharge plumes would occur. Both drilling units are predicted to experience the same prevailing current direction, which results in the discharge plumes from each drilling unit moving in the same direction (as opposed to towards each other), further minimizing the chances of interaction. Given the finding that environmental impacts would not overlap, there was no modeling of multiple drill sites.

<u>Sound Profile</u>

Shell conducted sound modeling in order to predict the noise footprint of drilling and related activities to support this EIA and its request for MMPA authorization for the non-lethal taking of whales and seals in conjunction with EP Revision 2. Shell's sound propagation modeling consisted of multiple steps. The first was to determine the sound footprint for each discrete noise generating activity at the Burger Prospect, and then to determine the aggregate sound footprint for simultaneous activities.

Shell determined the appropriate sound footprint for each relevant activity including drilling, support vessels in DP mode, mudline cellar construction, anchor handling, ice management activities, and ZVSP surveys. When available, Shell used actual measured sound levels to determine the extent of sound propagation for the activity. For example, Shell relied upon its 2012 sound measurements of the *Discoverer* drilling at the Burger Prospect; its 2013 sound measurements of the *Nordica* in DP mode to represent support vessels; its 2012 sound measurements of the *Discoverer* while constructing the MLC at Burger A; its 2012 sound measurements for the *Tor Viking* while conducting anchor handling on the Burger Prospect; and its 2012 sound measurements for the *Tor Viking* while conducting ice management on the Burger Prospect. In those limited instances when sound measurements were not available for the activity, Shell relied on a sound propagation model and available data to estimate the sound footprint. For example, Shell estimated the sound footprint for the *Polar Pioneer* by combining a source level derived from acoustic measurements of several comparable semi-submersible drilling units with an estimate of sound propagation from the Marine Operations Noise Model (MONM; Austin et al. 2013). The MONM was also used to determine the sound footprint of ZVSP survey activities, assuming different airgun array configurations. Shell adopted the following conservative assumptions to account for model uncertainty, measurement variability, and provide precautionary sound exposure estimates:

- A radii safety factor increase of 1.3 or 1.5 was applied to each activity sound estimate. This had the effect of increasing the estimated exposure area.
- Because measured sound levels for a separate MLC ROV system were not available, the sound footprint for MLC construction was defined from measurements of the MLC construction from the *Discoverer* in 2012. Sounds from a separate MLC ROV system could be expected to be quieter.

Based on these individual activity measurements, Shell modeled aggregate sound under several likely "activity scenarios" that combined different activities assumed to occur simultaneously. That is, the sound propagation modeling assumes multiple, concurrently-operating sound sources from different possible activity combinations. With this method, Shell estimated the total areas ensonified to continuous sound levels sounds ≥120 dB root mean square (rms) under nine distinct, likely activity scenarios. These scenarios were derived from a realistic operational timeline that considered various combinations of continuous sound sources that may operate at the same time at one or more sites (drill sites) or locations (ice management). The following nine representative activity scenarios, shown in Table 4.0-3, were modeled to estimate areas exposed to continuous sounds ≥120 dB rms:

- Drilling at one site using the *Discoverer* (used as the sound source for the single site drilling-only scenario as a conservative measure because it is expected to be the louder of the two drilling units)
- Drilling at one site using the *Discoverer* with one support vessel in DP mode
- Drilling at two sites: with the *Polar Pioneer* and one support vessel in DP mode at one site and the *Discoverer* and one support vessel in DP mode at a second site
- Constructing a MLC at two different sites
- Anchor handling at one site
- Drilling at one site using the *Polar Pioneer* with one support vessel in DP mode and anchor handling at a second site
- Constructing a MLC at two different sites and anchor handling at a third site
- Two vessels conducting ice management activities
- Four vessels conducting ice management activities

Table 4.0-3 Sound Propagation Modeling Results of Representative Drilling Related Activity Scenarios and Estimates of the Total Area Potentially Ensonified above Threshold Levels at the Burger Prospect in the Chukchi Sea, Alaska During the Planned 2015 Exploration Drilling Program

Activity Scenario Number	Activity Scenario Description	Threshold Level (dB re 1 µPa)	Single Day Area Potentially Ensonified (km^2)		Activity Days per Season		Total Area Potentially Ensonified (km^2)	
			Summer	Fall	Summer	Fall	Summer	Fall
1	Drilling at 1 site	120 dB	10.2	10.2	4	4	40.8	40.8
2	Drilling and DP Vessel at 1 site	120 dB	111.8	111.8	2	6	223.6	670.8
3	Drilling and DP Vessel (1 site) + Drilling and DP Vessel (2nd site)	120 dB	295.5	295.5	21	20	6,205.5	5,910.0
4	Mudline Cellar Construction at 2 different sites	120 dB	575.5	575.5	14	14	8,057.0	8,057.0
5	Anchor Handling at 1 site	120 dB	1,534.9	1,534.9	3	3	4,604.7	4,604.7
6	Drilling and DP Vessel at 1 site + Anchor Handling at 2nd site	120 dB	1,759.2	1,759.2	8	8	14,073.6	14,073.6
7	Mudline Cellar Construction at 2 different sites + Anchor Handling at 3rd site	120 dB	2,046.3	2,046.3	6	6	12,277.8	12,277.8
8	Two-vessel Ice Management	120 dB	937.4	937.4	20	10	18,748.0	9,374.0
9	Four-vessel Ice Management	120 dB	1,926.0	1,926.0	4	4	7,704.0	7,704.0
10	ZVSP at 2 different sites	160 dB	0.0	898.0	0	2	0.0	1,796.0

The concurrent ice management activity scenarios (8 and 9) were modeled and assessed separately from non-ice management scenarios due to the temporal and spatial variability of ice conditions relative to the other activities. It is possible that ice management and drilling activities could have overlapping acoustic footprints, however, it is difficult to meaningfully quantify the countless ways in which this could occur due to the temporal and spatial variability of ice conditions. Additionally, ice management could occur at distances from the drill sites that would result in independent, non-overlapping acoustic footprints with respect to continuous sound sources operating at or near exploration drill sites. For these reasons, concurrent ice management activity scenarios were modeled separately from non-ice management scenarios, and results from each were summed together to conservatively estimate the maximum total area ensonified to continuous sound levels ≥120 dB re 1 µPa rms.

The ice management activity scenarios assumed either two or four vessels engaged in concurrent operations. The two-vessel scenario assumed a single ice management vessel positioned 1,641 ft (500 m) to the northeast of two different drill sites. The four-vessel scenario assumed ice management associated with two different drill sites with one vessel located 1,641 ft (500 m) to the northeast of each site and a second vessel positioned 1.24 mi (2 km) to the northeast of each site.

Finally, a tenth scenario was included for ZVSP survey activities, which would be completed in the fall after the completion of a well, and would last a relatively short period of time (10 to 14 hr). For this scenario Shell modeled the footprint of the pulsed sounds emitted by the airgun array to estimate the area ensonified at levels ≥160 dB rms.

These representative activity scenarios were modeled for different drill site combinations and, as a conservative measure, the combinations corresponding to the largest ensonified area were chosen to represent the given activity scenario. The scenarios that involved anchor handling and ice management resulted in the largest estimated areas ensonified at levels ≥120 dB rms. The largest area estimated to be exposed to continuous sounds ≥120 dB rms during a single activity scenario resulted from concurrent MLC construction at two different sites and anchor handling at a third site (scenario 7). Scenarios that involved drilling and/or DP vessel operations produced the smallest acoustic footprints. The smallest area estimated to be ensonified by continuous sounds ≥120 dB rms during a single activity scenario resulted from one drilling unit (the *Discoverer*) alone at a single drill site (scenario 1). Combining the highest activity scenario (scenario 7) with the four-vessel ice management scenario (scenario 9) resulted in the maximum total area that might be ensonified to ≥120 dB rms. While this combined scenario resulted in the highest sound, it would occur for only brief periods of time relative to the entire exploration drilling program. Detailed modeling results were used to calculate the areas (in km^2) ensonified at levels ≥120 dB rms (continuous) and ≥160 dB rms (pulsed) (Table 4.0-3). The potential impacts on whales and seals that may result from these modeled sounds are discussed in Section 4.7 on marine mammals.

Definitions Adopted to Determine Significance Impacts and Effect Levels

In BOEM's NEPA analysis of Shell's EP Revision 1, BOEM evaluated the level of effects of Shell's proposed exploration activities for each resource (BOEM 2011a). BOEM established a "significance threshold" to determine whether a particular activity has a significant (or not significant) impact on that resource. Required mitigation measures could reduce otherwise "significant" impacts to a level of "not significant." A finding of no significant effect does not mean that there is no effect. Next, BOEM established a four-category scale (i.e., negligible, minor, moderate or major) to describe the relative degree or anticipated level of effect of an activity on a specific resource.

This is the first opportunity for Shell to review the significance threshold and level of effects definitions that BOEM adopted when it completed the EA for Shell's EP Revision 1. BOEM's definitions provide useful guidance for capturing and defining significance and levels of effects that was not available when Shell prepared the EIA for EP Revision 1. When available, Shell analyzed significance and the level of effects of the activities defined in EP Revision 2 under the same definitions that BOEM adopted in Appendix B of BOEM's EA for Shell's EP Revision 1. In some instances (e.g., certain air quality impacts, sensitive biological resources, marine and coastal uses), there are no definitions from BOEM that can be adopted in this EIA. Those instances required additional consideration and Shell's approach is detailed in the resource subsection.

Direct and Indirect Impact Analyses

Potential direct and indirect impacts on these resources from the identified impact factors are described in Sections 4.1 through 4.12. Shell analyzed the quantity and quality of the effects associated with each impact factor. One or more of the following are included in the analysis: the nature of the activity and impact, the spatial extent of the impact and the resource affected, literature and data on the resource's response to the activity, information on conditions at the Burger Prospect, modeling or other estimation results, data and experience from Shell's 2012 exploration drilling activities, recovery times for the resource, and the effectiveness of mitigation measures. A separate analysis of the effects of each impact factor on each resource is provided.

Relying on the significance thresholds and level of effects definitions, this EIA provides conclusions about the estimated level of effect associated with each impact factor on each resource. These are then used to derive an overall conclusion of the level of effects for EP Revision 2 on each resource considered.

Shell's impact analyses indicate that the potential environmental impacts associated with Shell's exploration drilling activities as detailed in the EP Revision 2 would range from negligible effects to minor effects for the various resources (Table 4.0-4). These results are consistent with BOEM's determination based on its EA for Shell's EP Revision 1 and take into account the additional activity associated with EP Revision 2, including the modeling results for air emissions, drilling discharges, and sound energy.

Table 4.0-4 Summary of Impact Assessments of Shell's Exploration Drilling Program under EP Revision 2

Resource	Section	EP Revision 2
Air quality	4.1	Minor
Water quality	4.2	Minor
Seafloor sediments	4.3	Minor
Lower trophic organisms	4.4	Minor
Fish and Essential Fish Habitat	4.5	Minor
Birds	4.6	Minor
Marine mammals	4.7	Minor
Threatened and endangered species	4.8	Minor
Sensitive Biological resources	4.9	Minor
Cultural resources	4.10	None
Socioeconomics	4.11	Negligible
Subsistence	4.11	Negligible
Coastal and marine uses	4.12	Negligible

4.1 Impacts on Air Quality

The analysis of air quality for the exploration drilling activities in EP Revision 2 differs from that in EIA EP Revision 1. As detailed in EIA Section 2.8, the air quality analysis differs in two key respects:

- First, CAA jurisdiction changed from EPA to BOEM, which now requires Shell to request authorization of air emissions under an approved EP according to the requirements set forth by BOEM.
- Second, changes in Shell's exploration drilling activities (EP Revision 2) result in increases of total anticipated emissions. These changes include the use of two drilling units operating simultaneously, increases in numbers and activities of vessels and aircraft, and expanded shorebases.

For the EIA air quality analyses, NEPA emissions inventories are provided in Appendix K of EP Revision 2 that details the sources, activities and emissions associated with Shell's EP Revision 2. The NEPA emissions inventories were used to conduct dispersion modeling of emissions associated with the exploration drilling activities as described in EP Revision 2. Three modeling efforts were completed: 1) potential onshore air quality impacts from vessel and drilling unit emissions, 2) potential air quality impacts in offshore subsistence use areas, and 3) potential onshore air quality impacts from shorebase and aircraft emissions.

The emissions inventory and modeling methods and results are described in the following documents:

- Appendix K of EP Revision 2 - *Shell Chukchi Sea Outer Continental Shelf Lease Exploration Plan Revision 2, Appendix K, AQRP and NEPA Emission Inventories* (Air Sciences Inc. 2015)
- Attachment A to this EIA - *Arctic Offshore Air Quality Impacts: Recommendations for Appropriate Criteria for Determining Significance Under NEPA*
- Attachment B to this EIA - *Shell OCS Exploration Program – Chukchi Sea Air Quality Technical Report Onshore Areas* (ENVIRON 2015a)
- Attachment C to this EIA - *Shell OCS Exploration Program – Chukchi Sea Air Quality Technical Report Offshore Subsistence Area* (ENVIRON 2015a)

Air quality modeling from vessel and drilling unit emissions was conducted to estimate ambient concentrations of air pollutants at onshore locations and for the offshore subsistence hunting and fishing use areas. Discussions with BOEM[9] indicate the agency's intention to follow EPA's Guideline on Air Quality Models for conducting dispersion modeling. CALPUFF is the EPA-recommended air quality dispersion model for distances greater than 31 mi (50 km). All onshore areas and offshore subsistence use areas in the Lease Sale 193 Area are located at distances greater than 31 mi (50 km) from the Burger Prospect. Through agreement with BOEM, CALPUFF was determined to be an appropriate model for use to simulate the dispersion of emissions from the drilling units and their associated vessels at the shoreline and in offshore subsistence use areas. Separate modeling efforts with different receptors were conducted for onshore and offshore areas used for subsistence because different impact assessment criteria are appropriate for each geographic area, as detailed in Attachment A of this EIA.

At BOEM's request, air dispersion modeling was also conducted for shorebase and aircraft sources associated with the exploration activities that are located onshore in Barrow, Alaska. AERMOD was used

[9] Meeting between Shell and BOEM held on 15 May 2013 at BOEM's offices in Anchorage Alaska.

to simulate the dispersion of emissions from these sources onshore because EPA recommends its use for computation of concentrations within 31 mi (50 km) from a source.

Air quality in the Lease Sale 193 Area and onshore in the North Slope region is good, as described in Section 3.1. The following sections summarize Shell's analyses and evaluate the potential impacts to onshore and offshore air quality from emissions related to the exploration activities, including potential impacts on climate change and Arctic haze, and any air quality impacts that may occur as a result of a small liquid hydrocarbon spill. The analyses are supported by additional information included in EIA Attachments A, B and C, as well as Appendix K of EP Revision 2. Shell has concluded that the overall potential effects on air quality from the exploration activities as described in EP Revision 2 are minor (Table 4.1-1). These analyses include Shell's proposed assessment criteria for determining potential levels of effect and/or significance for the project. Shell acknowledges that BOEM may apply different criteria in the EA for the project to determine levels of effect and/or significance for air quality and all other resources based on the information provided within this EIA.

Table 4.1-1 Potential Effects of Shell's Exploration Drilling Program on Air Quality

Resources / Analyzed Activity	EP Revision 2
Air Quality (overall)	Minor
Small liquid hydrocarbon spill	Negligible
Offshore Air Quality	
Vessel and drilling emissions	Minor
Onshore Air Quality	
Vessel and drilling emissions	Minor
Shorebase and aircraft emissions	Not Significant

4.1.1 Impacts of Vessel and Drilling Emissions on Onshore Air Quality

The impact analyses in Section 4.1.1 and Section 4.1.2 are based on air emissions from the *Discoverer* and *Polar Pioneer* drilling units and all support vessels as described in Appendix K of EP Revision 2 and Attachment B of the EIA. The following is a list of the vessels that are included for the air emissions evaluation:

- Drilling units – *Discoverer* and the *Polar Pioneer*
- Ice management vessels (x2)
- Anchor handlers (x3)
- OSVs (x2)
- Science vessels (x2)
- OSRV (x1)
- OSR tug (x1) and barge (x1)
- Support tugs (x2)
- Supply tug (x1; used for support purposes)
- MLC ROV system vessel
- OST (x1)

Under NEPA, BOEM evaluates impacts to air quality as a result of oil and gas activities on the Alaska OCS at the nearest onshore areas, particularly the area of maximum impact over an area of at least 7.7 mi^2

($20\ km^2$). For the purpose of this analysis of impacts of vessel and drilling unit emissions on onshore air quality, Shell is adopting the air emissions significance thresholds used by BOEM in its Environmental Assessment of Shell's EP Revision 1 (BOEM 2011a). Shell is not relying on BOEM's level of effects definitions (BOEM 2011a) because they were based on an EPA air permitting regime that no longer applies. Instead, Shell is utilizing EPA's Significant Impact Levels (SILs) for Class II air quality areas in Alaska to assess level of effects. SILs are screening thresholds that are routinely used by EPA to evaluate the level of a project's air emissions. If the modeled concentration of a pollutant is less than the SIL for that pollutant, the impact is deemed to be de minimis and no further analysis is warranted. If the modeled concentration of a pollutant exceeds the SIL, it does not mean that the impact is significant, only that further analysis is warranted. In this full impact analysis, the entire facility's compliance with the applicable NAAQS is evaluated, taking background concentrations and facility-wide potential emissions into account.

Significance Threshold

A significant effect on air quality is determined when:

(1) project-related emissions cause an increase in pollutant concentrations over the nearest onshore area of at least $7.72\ mi^2$ ($20\ km^2$) that;

- (a) exceeds half of any of the NAAQS (except for ozone); or
- (b) exceeds half of the MAI for any pollutant for the PSD for a Class II area under 40 CFR 52.21(c) or 18 AAC 50.020(b); or
- (c) is expected to exceed half the ozone NAAQS based on an analysis of the potential increase in the ozone precursor emissions of VOC and NO_X; or

(2) design concentrations violate the NAAQS or the AAAQS.

Level of Effect

Negligible

- Project-related emissions cause concentrations for all pollutants to be less than the applicable SILs for Class II areas.

Minor

- Project-related emissions cause concentrations of at least one pollutant to be equal to or greater than the applicable SILs for Class II areas.

Moderate

- Project-related emissions cause concentrations of all pollutants to be equal to or greater than the applicable SILs for Class II areas.

To evaluate the effect of the offshore project's air emissions on onshore air quality using the significance threshold criteria above, dispersion modeling was completed using the offshore NEPA emissions inventory in Appendix K of EP Revision 2. Shell provides a conservative assessment of air emissions under the offshore NEPA emissions inventory where all emission units on all drilling units and vessels are operating at the same time every hour of the season, which will not occur during normal operation. In order to evaluate the greatest potential onshore impact from the exploration drilling activities, it is assumed that the drilling units are operating at the two lease blocks closest to shore. A more detailed discussion of the NEPA emissions inventory is provided in Appendix K of EP Revision 2.

Predicted concentrations were modeled at 5,034 receptors for the onshore air assessment. Maximum onshore concentrations, background concentration, design concentrations (project emissions plus background concentrations) for each criteria pollutant - NO_2, PM_{10}, $PM_{2.5}$, CO, and SO_2 - are summarized in Table 4.1.1-1. The maximum concentrations are predicted to occur at various locations along the Chukchi Sea shoreline (Attachment B, ENVIRON 2015a). The modeling results indicate that the concentrations attributable to the drilling units and their associated offshore support vessels are far less than half the NAAQS and half or less than half the MAI at all onshore receptors. Furthermore, design concentrations (maximum existing or background concentrations plus concentrations attributable to the exploration activity) are far less than the NAAQS. Based on this analysis, the impact of emissions of air pollutants associated with the exploration drilling activities as described in the EP Revision 2 would be deemed non-significant.

The most representative maximum background air quality values available were selected for this evaluation. Maximum onshore concentrations determined by CALPUFF occur on the shoreline between Wainwright and Point Lay. The background concentrations from the nearest monitoring station to the modeled maximum concentration for each pollutant and averaging period were selected to estimate total concentrations reported in Table 4.1.1-1. Point Lay was the nearest monitoring station for all pollutants and averaging times except for peak 3-hr and 1-hr SO_2 concentrations (Wainwright background values selected for these two categories). Although PM modeled peaks are nearer to Point Lay, Wainwright PM backgrounds were not considered representative because of contamination from road dust from the adjacent unpaved road discussed in SLR (2011) and SLR (2012a,b,c).

A comparison of the modeled project concentrations to the SILs indicate that only two pollutants exceed the SIL criteria (NO_2 1-hr and $PM_{2.5}$ 24-hr). Under the above-referenced level of effects definitions, the offshore air emissions associated with Shell's EP Revision 2 will have only a minor impact on air quality at coastal villages or elsewhere on the North Slope.

Table 4.1.1-1 Predicted Concentrations at Onshore Receptors

Pollutant	Averaging Time	Modeled Conc. [1] (µg/m³)	SIL Criteria [2] (µg/m³)	50% NAAQS Criteria (µg/m³)	50% MAI Criteria [3,4] (µg/m³)	Background Conc.[5] (µg/m³)	Design Conc. (µg/m³)	NAAQS (µg/m³)
NO_2	1-hr	36	7.5	96	NA	40	76	188
	Annual	0.03	1	50	12.5	1.4	1.4	100
PM_{10}	24-hr	4	5	75	15	24	28	150
	Annual	0.02	1	NA	8.5	N/A	N/A	NA
$PM_{2.5}$	24-hr	4	1.2	17.5	4.5	5.5	10	35
	Annual	0.02	0.3	6	2	2.0	2	12
CO	1-hr	12	2,000	20,000	NA	1,490	1,502	40,000
	8-hr	8	500	5,000	NA	1,280	1,288	10,000
SO_2	1-hr	0.1	7.8	98	NA	11.6	12	196
	3-hr	0.1	25	650	256	14.1	14	1,300
	24-hr	0.03	5	182.5	45	13.4	13	365
	Annual	0.0002	1	40	10	4.8	5	80

[1] Source: ENVIRON 2015a (Attachment B to this document); Averaged over a 7.72 mi^2 (20 km^2) area.
[2] EPA Class II SILs specified in 40 CFR 51.165(b)(2) and EPA guidance.
[3]NA – Not Applicable (there are no MAI established for these pollutants/averaging times).
[4]MAI criteria are based on 50% of the PSD allowable increment.
[5] See Table 3.1.3-1 for information on background concentrations and NAAQS.

Ozone

Unlike other criteria pollutants that result primarily from combustion equipment on the drilling units and vessels, effects of ozone from the exploration project are not analyzed using the dispersion modeling discussed above. Ozone levels in the Arctic are affected through production via photochemistry or transport from the upper atmosphere.

Ozone formation and destruction mechanisms are complex, causing ozone concentrations to vary widely on geographical and temporal scales. The photochemical production of ozone requires several necessary conditions to be satisfied: (1) NO_X must be available, (2) VOCs must be available, and (3) ambient conditions must be favorable. Sunlight is required, which is why higher ozone values occur during summer afternoons in areas where sunlight is intense (Ahrens 2013). Under favorable ambient conditions, ozone production occurs slowly if VOCs are scarce and there is an optimum VOC/NO_X ratio that maximizes the ozone concentration reached in one day. A VOC/NO_X ratio of about 10 is considered optimum for producing maximum ozone. In ozone production, NO_X behaves like a catalyst and produces several molecules of ozone before being removed. The number of ozone molecules produced per NO_X molecule reacted has been defined as ozone production efficiency (OPE). An OPE of 10 can be considered the upper bound of efficient ozone production for the Arctic.

Physical conditions in the Arctic do not favor ozone formation. Local anthropogenic emission sources are sparse because of limited human activities. In addition, the low temperatures slow many of the chemical reactions involved in forming ozone and low solar radiation slows photolysis reactions that initiate ozone formation. Meteorological conditions with limited solar radiation and sub-zero temperature in October and November rule out any possibility of significant ozone production. While the temperature rises in summer months, the timeframe during which exploration drilling will be occurring, the North Slope often experiences overcast clouds and rain; both are unfavorable conditions for ozone production. Prevailing onshore winds are not common and even negligible in some years.

CALPUFF modeling was used to evaluate NO_X emissions from Shell's offshore sources of exploration activity in the Chukchi Sea (Attachment B) and to predict totally reactive nitrogen available for ozone production. CALPUFF predicted 8-hr maximum onshore totally reactive nitrogen concentrations were generally lower than 1 ppb. Maximum totally reactive nitrogen concentrations above 2 ppb were not common and were generally associated with low solar radiation (e.g., overcast, rain, fog, and snow). Two events in August 2009 were identified where onshore NO_X concentrations were associated with clear skies. Maximum 8-hr onshore totally reactive nitrogen concentrations during these events ranged from 2 to 3 ppb.

The low abundance of background VOC in this region severely limits the tendency for ozone formation even when more NO_X is present. Hydrocarbon measurements from sensors were analyzed to examine background VOC concentrations in the region. Measurement data from Barrow were compiled and field measurement programs conducted in the Arctic were examined to characterize VOC and non-methane hydrocarbon (NMHC) concentrations in the region. Using the Barrow NMHC measurements and the VOC/NMHC ratios observed in other Arctic field studies, background VOC concentrations estimates range from 0.4 ppb in July, to 2.4 ppb in November. VOC concentrations are expected to be lower than 1 ppb during the months with drilling emissions and ambient conditions that ozone can form. Because the additional VOC emissions from the proposed drilling operations are negligible, they will not have a large contribution to the region (see Appendix K of EP Revision 2).

As previously stated, the maximum predicted 8-hr totally reactive nitrogen onshore concentration based on simulations of drilling seasons in three different years was 3 ppb. To achieve an efficient VOC/NO_X ratio of 10 for ozone formation, 30 ppb of VOC would be needed. However, the background VOC concentrations in the area are less than 1 ppb during drilling activity, 30 times lower. The lack of VOC needed to support ozone formation strongly suggests NO_X emissions will destroy ozone in the region. Low NO_X concentrations of about 0.1 ppb could effectively produce ozone based on a favorable VOC/NO_X ratio of 10. In this case a favorable OPE of 10 would yield an ozone increase of about 1 ppb.

A compilation of all these data suggests potential ozone impacts from Shell's proposed drilling operations are very unlikely. BOEM considers it a significant impact when the potential increase in the ozone concentration exceeds half the ozone NAAQS (i.e., 75/2 = 37 ppb) or cumulative ozone design concentrations exceed the NAAQS (75 ppb).

Shell's proposed exploration drilling operations in the Chukchi Sea are expected to comply with BOEM's ozone criteria with expected ozone concentrations much less than an increase of 37 ppb and cumulative concentrations less than the 75 ppb NAAQS. While there is not an SIL criterion against which to measure the impacts, if any, ozone associated with Shell's proposed drilling, because ozone formation resulting from the project is expected to be limited, Shell anticipates impacts on onshore air quality, if any will be negligible.

4.1.2 Impacts of Vessel and Drilling Emissions on Offshore Air Quality

BOEM has not formally established air quality criteria for offshore locations for subsistence use, and Shell is not aware of relevant examples of offshore air quality analyses for subsistence use areas. As discussed in Attachment A of the EIA, NAAQS are not appropriate standards to apply to the Arctic offshore (especially the Chukchi Sea) because it is a remote environment inaccessible by the general public. In addition, under the CAA, NAAQS are only implemented in air quality control regions, which do not extend beyond the State's 3-mile seaward boundary. Shell, therefore, proposes that conservative limits based primarily on occupational health criteria are appropriate measures of impact to subsistence hunters and fishermen, who may venture into the subsistence areas off the coast of Alaska. These individuals are present, if at all, only for limited periods of time and are comparatively healthier than the more susceptible population that NAAQS are designed to protect.

BOEM's Environmental Assessment of Shell's EP Revision 1 (BOEM 2011a) did not establish specific definitions for significance and level of effects for air quality impacts on offshore subsistence use. Shell relies on occupational health criteria to define significance and level of effects. The criteria adopted are more protective than OSHA's exposure standards, and thus have a built-in margin of safety. The following air quality significance thresholds and levels of effect are provided for evaluating emissions on offshore air quality in subsistence areas based on the analysis provided in Attachment A of the EIA.

Significance Threshold

A significant effect on air quality is determined when the project plus background emissions cause an increase in pollutant concentrations in the subsistence use area equal to or greater than the following criteria:

- $PM_{2.5}$ and PM_{10}: 500 µg/m^3 (1-hr average concentration, not to be exceeded)
- NO_2: 3,760 µg/m^3 (2 ppm) (1- hr average concentration, not to be exceeded)
- CO: 55,000 µg/m^3 (50 ppm) (1-hr average concentration, not to be exceeded)
- SO_2: 5,200 µg/m^3 (2 ppm) (1-hr average concentration, not to be exceeded)

Level of Effect

Definitions of level of effects for air quality are:

Negligible

- Project-related emissions cause concentrations for all pollutants to be less than 10 percent of the significance thresholds.

Minor

- Project-related emissions cause concentrations for at least one pollutant to be equal to or greater than 10 percent of the significance thresholds but less than 50 percent of the significance thresholds.

Moderate

- Project-related emissions cause concentrations for at least one pollutant to be equal to or greater than 50 percent of the significance thresholds.

To evaluate the effect of the project's offshore air emissions on air quality in offshore subsistence use areas, dispersion modeling was completed using the offshore NEPA emissions inventory in Appendix K of EP Revision 2. This NEPA emissions inventory was also used in the analysis under Section 4.1.1 to determine onshore concentrations from offshore sources. Shell provides a conservative assessment of air emissions under the NEPA emissions inventory where all emission units on all drilling units and vessels are operating at the same time every hour of the season which will not occur during normal operation. In order to evaluate the greatest potential offshore impact from the exploration drilling activities, it is also assumed that the drilling units are operating at the two lease blocks closest to the subsistence use areas. A more detailed discussion of the NEPA emissions inventory is provided in Appendix K of EP Revision 2.

Pollutant concentrations were modeled at 1,800 receptors in the offshore subsistence use area. By agreement with BOEM, the subsistence areas to be evaluated for air quality impacts are the areas used for subsistence hunting and fishing offshore. The area of subsistence use in the Chukchi Sea that is modeled is identified in Figure 3.11.6-11. The analysis evaluates potential air quality impacts within the subsistence area because it is reasonable to expect human activity in this area. Human presence is increasingly unlikely beyond the area modeled offshore; locations seaward of the subsistence use area were therefore not evaluated in this modeling assessment.

The most representative maximum background air quality values available were selected for this evaluation. These values are highly conservative, given that the monitors are located onshore and adjacent to villages containing sources of air pollutants. Maximum offshore concentrations determined by CALPUFF occur at the seaward edge of the subsistence zone west of Wainwright. The background concentrations from the nearest monitoring station to the modeled maximum concentration for each pollutant and averaging period were selected to estimate total concentrations reported in Table 4.1.2-1. Wainwright background concentrations were selected for all pollutants and categories except for PM, instead, Point Lay PM backgrounds were deemed more representative. Wainwright PM background concentrations were not considered representative because of contamination from entrained road dust from the adjacent unpaved road, as discussed in SLR (2011) and SLR (2012a).

Maximum predicted offshore design concentrations in the offshore subsistence area are compared to the offshore impact criteria in Table 4.1.2-1. Locations of these predicted maximum design concentrations (Attachment C, ENVIRON 2015b) are more than 29 mi (47 km) from any coastal village (Table 4.1.2-2). Maps indicating predicted peak concentrations of these pollutants throughout the offshore subsistence use area are provided in Attachment C (ENVIRON 2015b). As shown in Table 4.1.2-1, the total cumulative concentrations of all of the offshore air pollutants associated with the exploration drilling activities as described in EP Revision 2 are expected to be less than 50 percent of the significance criteria and therefore would have a minor impact on overall offshore air quality.

Table 4.1.2-1 Predicted Concentrations at Offshore Receptors

Pollutant	Averaging Time	Peak Modeled Concentration ($\mu g/m^3$) [1]	Background Concentration ($\mu g/m^3$) [2]	Total Cumulative Concentration ($\mu g/m^3$)	Offshore Subsistence Area Impact Criteria ($\mu g/m^3$) [3]
NO_x	1-hr	52.1	40.1	92.5	3,760
PM_{10}	1-hr	24.4	60	84.44	500
$PM_{2.5}$	1-hr	24.4	14	36.6	500
CO	1-hr	16.2	953	969	55,000
SO_2	1-hr	0.1	8.1	8.2	5,200

[1] Source: ENVIRON 2015b (Attachment C to the EIA)

[2] Background concentrations are documented in Table 3.1.3-1. It should be noted that Table 3.1.3-1 provides 1-hr background concentrations only for gaseous pollutants but for particulate matter, the 24-hr values from Table 3.1.3-1 are adjusted by the ratio of 24-hr to 1-hr concentration of 0.4 from the SCREEN3 model. Thus for PM_{10} the peak measured 24-hr concentration from Table 3.1.3-1 of 24 $\mu g/m^3$ is multiplied by 2.5 to get 60 $\mu g/m^3$ while for $PM_{2.5}$ the peak measured 24-hr concentration of 5.5 $\mu g/m^3$ is multiplied by 2.5 to get 14 $\mu g/m^3$.

[3] See Attachment A of this EIA for additional detail on offshore impact criteria.

Table 4.1.2-2 Distances from Locations of Maximum Predicted Pollutant Concentrations

Pollutant	Averaging Time	Distances from Locations of Peak Predicted Pollutant Concentration mi (km) to: [1]				
		Barrow	Wainwright	Pt. Lay	Pt. Hope	Shore
NO_x	1-hr	129 (208)	46 (73)	57 (91)	189 (304)	13 (21)
PM_{10}	1-hr	118 (190)	35 (57)	66 (107)	200 (322)	20 (32)
$PM_{2.5}$	1-hr	118 (190)	35 (57)	66 (107)	200 (322)	20 (32)
CO	1-hr	127 (204)	43 (69)	58 (93)	191 (307)	13 (21)
SO_2	1-hr	127 (204)	43 (69)	58 (93)	191 (307)	13 (21)

[1] Locations of peak predicted concentrations are indicated in Figure 6 in Attachment C (ENVIRON 2015b) of this EIA.

Ozone

Unlike other criteria pollutants that result primarily from combustion equipment on the drilling units and vessels, effects of ozone from the exploration project are not analyzed using the dispersion modeling discussed above. As described under Section 4.1.1, ozone is produced primarily through photochemistry from available NO_X and VOC emissions in the atmosphere. The offshore areas have less background VOC emissions available for ozone production than onshore areas where more development exists, therefore no ozone impacts are expected.

4.1.3 Impacts of Shorebase and Aircraft Emissions on Onshore Air Quality

The air quality assessment for the emissions associated with onshore shorebase activities is provided separately from the drilling units and offshore support vessel emissions analyses in Section 4.1.1 and Section 4.1.2 for two reasons:

- The distance between the drilling units and the onshore facilities in Barrow is over 135 mi, so no overlap in the impact areas of the two operations is expected.
- Offshore drilling program activities' concentrations would generally not be additive with the onshore facilities concentrations for the short-term averaging times (1-hr, 3-hr, 8-hr and 24-hr).

For these short durations, the meteorological conditions are expected to carry pollutants in the same direction, and therefore onshore and offshore air emissions are not expected to overlap.

The EPA and the ADEC have jurisdiction over the ambient air quality accessible to the general public onshore in Alaska. The CAA requires the EPA to establish air quality standards "based on such criteria and allowing an adequate margin of safety, are requisite to protect the public health." CAA Section 109 (a)-(b). Under the CAA, these standards must be reviewed and revised at five year intervals by EPA and independently reviewed by a scientific review committee. Under this rigorous program, these standards have been set at levels that EPA and the scientific review committee have determined will protect human health with a margin of safety, including the health of sensitive individuals like the elderly, the chronically ill, and the very young. These ambient air quality standards are commonly used in NEPA assessments to evaluate onshore air quality impacts.

Section 110 of the CAA requires states to develop and adopt into their regulations state implementation plans (SIPs) which provide for the implementation, maintenance, and enforcement of these standards. States are also required, in their SIPs, to include a program to provide for the enforcement of the standards and for the "regulation of the modification and construction of any stationary source within the areas covered by the plan as necessary to assure that national ambient air quality standards are achieved, including a permit program." CAA Section 110(a)(2)(C) and 40 CFR part 51.

Alaska is currently a SIP-approved State and has delegated authority from the EPA, meaning that the ADEC has developed, and the EPA has approved, regulations that provide for the implementation, maintenance, and enforcement of these standards and public health, as required by the CAA. Title 18 of AAC Chapter 50 presents these regulations and EPA approval is presented in 40 CFR part 52 Subpart C.

Onshore owners and operators of emission sources are required to comply with ADEC regulations that apply to all entities that allow or cause air pollutants to be emitted into the ambient air. These ambient air quality management standards require that reasonable precautions be taken to minimize dust emissions, visible emissions, particulate matter emissions, sulfur-compound emissions, and requiring that no person may permit any emission which is injurious to human health or welfare, animal or plant life, or property, or which would unreasonably interfere with the enjoyment of life or property. 18 AAC 50.055 and 50.110. Furthermore, as outlined in 18 AAC 50, the ADEC requires permitting and associated air dispersion modeling for new and modified emission sources that exceed certain permitting thresholds. These thresholds have been established, and approved by the EPA, to ensure that the national standards are achieved, and thus public health is protected.

At the Barrow Airport, aircraft activities will include helicopter flights at a frequency of about 40 per week, daily fixed-wing flights for ice reconnaissance and marine mammal monitoring, and limited fixed-wing crew transport. Aircraft emissions will be brief and intermittent as aircraft take off and land. Dispersion of pollutants will be improved by the aircraft propellers and helicopter rotors, and air quality impacts to areas accessible to the general public will be minimal. The gas fired boiler used for space heating at a hangar will be similar in size to others in use in Barrow. Use of low-emitting natural gas fuel will minimize any off-site air quality impacts associated with space heating. In Barrow, the NARL personnel camp is powered by three diesel-fueled generator engines. The ADEC has issued Pre-Approved Emission Limit AQ1395PL201 to restrict emissions below requirements to obtain a permit for the NARL man-camp. The emissions provided in Appendix K of EP Revision 2, which include the contributions from aircraft, a heater, and motor vehicles in the Barrow area, are all below any levels that would require CAA permitting and any associated dispersion modeling.

As discussed above, the onshore support facility activities do not require CAA permitting or dispersion modeling. For purposes of this analysis, Shell concludes the air quality impacts associated with onshore support facility activity is not significant.

BOEM requested that Shell conduct a separate dispersion modeling analysis of the shorebase activities. That information is provided in Attachment B to the EIA.

4.1.4 Impacts of Air Emissions on Climate Change

The estimated GHG emissions for the drilling units and support vessels are approximately 187,625 tons per year (Appendix K). The drilling units and their support vessels combined projected CO_2 emissions will account for approximately 0.3 percent of the Alaska 2005 total statewide estimated GHG emissions of 53 million tons per year and 1.1 percent of the Alaska 2005 statewide oil and gas industry estimated GHG emissions of 15 million tons per year. The projected GHG emissions and impact to climate change from the proposed Shell exploration drilling activities will be insignificant in relationship to the Alaska 2005 total statewide and Alaska oil and gas industry GHG/CO_2 emissions.

4.1.5 Impacts of Air Emissions on Arctic Haze

Arctic haze is a winter and early spring phenomenon caused by anthropogenic air pollution from the Eurasian continent. It forms primarily due to the concentration of air pollutants in the Arctic during periods when precipitation and turbulent mixing is minimized (Rozell 1996). Because Shell's exploration drilling activities will occur in the Arctic summer and early fall months of July through October, when the Arctic Haze phenomenon has not historically occurred, Shell's exploration drilling activities are not expected to contribute to Arctic haze by more than de minimis levels.

4.1.6 Impacts of a Small Liquid Hydrocarbon Spill on Air Quality

Section 2.10 of this EIA addresses the potential sources and types of oil spills that could occur, the probabilities of such spills occurring, Shell's plans for responding to a small spill (defined as 48 bbl or less), and Shell's WCD planning scenario. As explained in Section 2.10, Shell's categories of spill sizes are different from, but not incompatible with, those used by BOEM. The probability of a large (> 48 bbl) liquid hydrocarbon spill is so low that it is not regarded as reasonably foreseeable for this analysis of potential direct and indirect impacts. Nonetheless, a small spill, such as a release of 48 bbl of diesel fuel, is the most probable type and volume of spill, if any, to occur as a result of this exploration drilling program. (The probability of a large oil spill occurring and the potential impacts associated with such an improbable event are discussed in Section 6.0.) Prudent planning and state and federal regulatory requirements nevertheless require that Shell have comprehensive spill prevention and response plans and capabilities in place. Shell's plans include measures to prevent any spill release from occurring and to respond in the event of a spill, including capabilities for responding to a "worst case" scenario release. In the unlikely event of a spill, implementation of Shell's comprehensive spill response plan would minimize the impacts from the spill. Response equipment and trained personnel would be available on site to deploy boom and recovery equipment for the control and removal of product spilled into the environment. Additionally, the procedures of Shell's FTP for fuel transfer between vessels would be utilized in accordance with BOEM lease stipulation No. 6, USCG requirements, and Shell's operating procedures. A small spill, such as a release of 48 bbl of diesel fuel, would have localized, short-term, and temporary effects on air quality. These potential impacts of a small spill on air quality would be negligible as analyzed below.

An unconfined release of 48 bbl of diesel would result in the volatilization of HAPs such as benzene, ethylbenzene, naphthalene, toluene, and xylene (BLM 2002). However, in the open ocean conditions of the Chukchi Sea, they would quickly disperse. Emissions would also occur only over the small area of the spill – about 20 to 200 ac (0.1 to 0.8 km^2) – for a brief time period. This represents the unmitigated scenario since pre-booming before fuel transfers should contain the spill within a very small area, less than 5 ac (0.2 km^2). For example, emissions of VOCs from a crude oil spill are generally negligible about 24 hr after the release (IT Alaska, Inc. 2001). Over 99 percent of a 48-bbl diesel spill in the Chukchi Sea would evaporate or disperse within 48 hr of the release (Section 2.10). Therefore, emissions of VOCs from a 48-bbl spill of diesel would be far less than 100 tons/year (yr), which is BOEM's defined level of effect for negligible (BOEM 2011a). Air quality effects from a diesel spill would be short-term and temporary. Effects on air quality from a 48-bbl diesel spill are therefore considered negligible.

Conclusion

In summary, the impact of emissions of air pollutants associated with EP Revision 2 will have only a minor impact on air quality at coastal villages or elsewhere on the North Slope and would be deemed non-significant under the significance criteria in Section 4.1.1. Concentrations of offshore air pollutants associated with EP Revision 2 are expected to be less than 50 percent of the significance criteria and therefore would have a minor impact on overall offshore subsistence use area air quality. The onshore project activities would not require CAA permitting or associated dispersion modeling, therefore, those impacts are not significant. Effects on air quality from a 48-bbl diesel spill would result in less than 100 tons/year of VOCs, and are therefore considered negligible. Overall, impacts on air quality from EP Revision 2 are not significant and are anticipated to be minor.

4.2 Impacts on Water Quality

The analysis of impacts on water quality for the exploration drilling activities in EP Revision 2 differs from that in the EIA for EP Revision 1. As detailed in EIA Section 1.5.7 Clean Water Act and Section 2.7 Waste Management, the water quality analysis in this EIA differs in a few key respects:

- In November 2012, the EPA issued a new five-year NPDES exploration facility GP (EPA 2012a). This permit authorizes certain discharges from oil and gas exploration facilities in the Chukchi Sea and imposes various effluent limitations, monitoring requirements, and conditions.
- New EMP under NPDES exploration facilities GP. This monitoring plan addresses monitoring of the benthic environment, receiving water chemistry, sediment characteristics before drilling, discharge plumes during drilling, and sediment and benthic samples after drilling.
- Changes in Shell's exploration drilling activities in EP Revision 2 will result in increased volumes of cuttings and drilling fluids, increased permitted vessel discharges, and increases in total suspended solids and turbidity. These changes include the use of two drilling units operating simultaneously, increases in numbers and activities of vessels, and MLC construction by drill bit or by ROV system.
- Dispersion modeling simulations were conducted based on the equipment and design of the drilling units, the *Discoverer* and the *Polar Pioneer.*

Discharges related to EP Revision 2 activities permitted under NPDES exploration facilities GP include drill cuttings and water-based drilling fluids, excess cement, oil-free deck drainage, treated sanitary waste, BOP fluids, domestic waste, non-contact cooling water, bilge water, and ballast water. Support vessels will discharge domestic wastewater and treated sanitary waste according to applicable NPDES VGP regulations or per MARPOL standards and requirements. Information on EP Revision 2 drilling fluids and BOP fluids, and drilling and non-drilling wastes and wastewater management are found in EIA Sections 2.6 and 2.7, respectively.

Water quality in the Lease Sale 193 Area and onshore in the North Slope region is good, as described in Section 3.2. Discharges into waters of the U.S. are subject to control under the CWA. The primary mechanism for regulating discharges under the CWA is Section 402, which authorizes the NPDES exploration facilities GP. Prior to issuing the NPDES exploration facilities GP, the EPA conducted a mandatory environmental analysis (Ocean Discharge Criteria Evaluations) of the effects of the discharges that would be authorized and concluded that the discharges from offshore oil and gas exploration facilities authorized under the GP would not result in unreasonable degradation of ocean waters (EPA 2012b). EPA determined that these discharges will not result in:

- Major adverse changes in the ecosystem diversity, productivity, and stability of the biological community within the area of discharge and surrounding biological communities.
- Threat to human health through direct exposure to pollutants or through consumption of exposed aquatic organisms.
- Loss of aesthetic, recreational, scientific, or economic values.

The NPDES exploration facilities GP also has requirements that apply to all discharges, including, but not limited to:

- No discharge of floating solids, debris, deposits, foam, scum or other residues of any kind
- No discharge of diesel, trisodium nitrilotriacetic acid, sodium chromate, or sodium dichromate

As part of BOEM's Environmental Assessment of Shell's EP Revision 1, BOEM defined significance thresholds and level of effect for water quality in Appendix B (BOEM 2011a). This analysis utilizes these definitions in assessing the impacts of drilling fluids and permitted wastes on water quality.

<u>Significance Threshold</u>

- action is likely to violate its NPDES exploration facilities GP,
- in the event of an accidental spill of crude oil or refined oil, total aromatic hydrocarbon or total aqueous hydrocarbon criteria for the Alaska marine or fresh-water quality standards are exceeded, or
- the action is otherwise likely to introduce changes in the physical, chemical, or biological characteristics of a water body which case an unreasonable degradation of the marine environment as defined at 40 CFR 125.121 and determined in accordance with 40 CFR 125.122.

<u>Level of Effects</u>

Negligible

- Temporary and localized impacts to water quality that do not cause an "unreasonable degradation under" 40 CFR 125.122

Minor

- Long-term and/or widespread impacts to water quality that do not cause an "unreasonable degradation" under 40 CFR 125.122

Moderate

- Impacts to water quality that exceed NPDES exploration facilities GP criteria or cause a temporary or localized "unreasonable degradation" under 40 CFR 125.122

Impacts to water quality at the Burger Prospect from intentional discharges associated with EP Revision 2 that are conducted under the conditions set forth in the NPDES exploration facilities GP will be localized and temporary, occurring over relatively short periods of time (weeks to a few months during exploration drilling at individual locations). Because these discharges are regulated through Section 402 of the CWA, they must comply with water quality standards. As a result of the analyses that follow, Shell has concluded that the potential effects on overall water quality from the exploration program as described in EP Revision 2 will be minor (Table 4.2-1).

Table 4.2-1 Potential Effects of Shell's Exploration Drilling Program on Water Quality

Resource / Analyzed Activity	EP Revision 2
Water Quality (overall)	Minor
From drilling wastes	Minor
From other permitted discharges	Negligible
From small liquid hydrocarbon spills	Negligible

4.2.1 Impacts of Drilling Wastes on Water Quality

The volume of sediment, cuttings and wastewater released to the water column in the region of Burger Prospect would cause higher levels of suspended solids, turbidity, hydrocarbon, metals, and temperatures in the water column in the areas of the discharges. However, the discharge of drill cuttings, drilling fluids, MLC sediments, and wastewater would be highly localized around the drill site. All drilling wastes consisting of drilling fluids, drill cuttings, excess cement and cement tank rinsate, and BOP fluid (Table 2.7-3) associated with the two drilling units in Shell's EP Revision 2 will be discharged as authorized through the NPDES exploration facilities GP. The permit limits and conditions placed on the discharge content, volume, and rate, which ensure they do not result in serious impacts to water quality, are provided below in Table 4.2.1-1.

Table 4.2.1-1 Limitations on Water-Based Drilling Fluids and Drill Cuttings Discharge 001

Discharge Parameter	Limitation / Condition [1]			
Free oil	No discharge			
Metal Concentrations	Mercury 1 mg/kg		Cadmium 3 mg/kg	
Toxicity	Minimum 96-hr LC_{50} of 30,000 ppm			
Maximum Discharge Rate	Water Depth 0 to 5 m	Water Depth 5 to 20 m	Water Depth 20 to 40 m	Water Depth >40 m
	No discharge	500 bbl/hr	750 bbl/hr	1,000 bbl/hr

[1] Source: EPA NPDES General Permit AKG-28-8100

Shell modeled the discharge of drilling wastes from the Burger Prospect wells to predict the dispersion and deposition of the discharged drill cuttings, water-based drilling fluids, and cement, using the OOC Mud and Produced Water Discharge model (Fluid Dynamix 2014a,b,c,d). The dispersion modeling of the drilling waste discharges was generated with the volumes and rates presented in EIA Section 2.0, Table 2.7-3. The dispersion modeling simulations were conducted based on the equipment and design of the drilling units, the *Discoverer* and the *Polar Pioneer*. The deposition location of drill cuttings and fluids and discharge plumes is in Table 4.2.1-2. All drill sites planned by Shell for the Burger Prospect are very similar in water depth, total depth, diameter, and volumes of cuttings and drilling fluids, so that the results from the modeling for one drill site are characteristic of all proposed Burger wells. The following assessments are based on the results of modeling for Burger J drill site. The discharge and dispersion modeling data presented for the Burger J drill site also approximates the results for the other five Burger wells. Additionally, the maximum discharge rates, deposition, and TSS for Burger J are utilized for the environmental impact analyses of discharge on water quality.

The impact of the discharge of drill cuttings and drilling fluids from two drilling units operating at the same time on the Burger Prospect is expected to be minimal. Discharge modeling performed for both the *Discoverer* and the *Polar Pioneer*, based on maximum prevailing current speeds of 9.84 in./s (25 cm/s), shows that sedimentation depth of muds and cuttings at greater than 1 cm thickness will occur within approximately 1,641 ft (500 m) of the drilling unit discharge point (Fluid Dynamix 2014a,b,c,d). Concentrations of total suspended solids, a transient feature of the discharge, are modeled to be below 15 mg/L at distances approximately 3,281 ft (1,000 m) from the drilling unit discharge point.

The most likely drilling scenario would place the two drilling units from 7 to 10 mi (11.3 to 16.1 km) apart. At these distances there will be no interaction, or overlap, of discharge plumes from the two drilling units. The closest drill sites on the Burger Prospect (Burger A and Burger F) are approximately 2 mi (3.3 km) apart. Modeling results still indicate that little to no interaction of the discharge plumes would occur. Both drilling units are predicted to experience the same prevailing current direction, which results in the discharge plumes from each drilling unit moving in the same direction (as opposed to towards each other), further minimizing the chances of interaction. Three basic drilling fluids will be used: 1) gel polymer sweeps / weighted gel / polymer fluid for the upper well sections; 2) KLA-SHIELD inhibitive WBM for the lower well sections; and, 3) water based abandonment fluid for the end of well. The components of the KLA-SHIELD Inhibitive WBM are identified in EIA Section 2.0, Table 2.6.2. The components of the water based abandonment fluids are identified in EIA Section 2.0, Table 2.6.3. Drilling fluids in the intervals are indicated below in Table 4.2.1-2. Cement is discharged only as part of the seafloor discharge (Discharge 013) scenarios and is included in the volume of drill cuttings. Discharges for each of the Burger wells include the discharge of an estimated maximum of 2,427 bbl of drilling fluids at the end of drilling operations.

Table 4.2.1-2 Drilling Fluids in the Six Well Intervals Described in EP Revision 2

Well Interval	Proposed Drilling Fluids [1]	General Discharge Location
1	Riserless Gel / Polymer Sweeps & Weighted Gel / Polymer Fluid	Seafloor
2	Riserless Gel / Polymer Sweeps & Weighted Gel / Polymer Fluid	Seafloor
3	Riserless Gel / Polymer Sweeps & Weighted Gel / Polymer Fluid	Seafloor
4	KLA-SHIELD –Inhibitive WBM	Sea surface
5	KLA-SHIELD –Inhibitive WBM	Sea surface
6	KLA-SHIELD –Inhibitive WBM	Sea surface

[1] Source Drilling Fluids Plan

Micro-organisms, primarily bacteria, build up naturally in untreated mud systems, and the bacteria break down, or degrade, various components of the drilling fluids. The biocide Busan 1060 has been added as a contingency drilling fluid component to the base fluids of the KLA-SHIELD Inhibitive WBM, and as an additive for the abandonment fluids, that will be used to prevent this bacterial growth.

EPA (2008) has concluded that this biocide is practically non-toxic to birds, slightly to moderately toxic to laboratory mammals, and practically non-toxic to moderately toxic to marine species (fish and invertebrates). A maximum of 0.4 pounds per barrel of Busan 1060 is planned for any water based fluid formulations. Shell's current drilling fluid plan (M-I SWACO 2014) contains the results of toxicity tests on 17 different water based drilling fluid formulations, all of which contain 0.4 lb/bbl of the biocide Busan 1060. Of the 17 tests, six of the fluids had LC50 values >500,000 ppm with the remaining 11 tests ranging between 91,800 ppm and 365,000 ppm.

EPA's NPDES exploration facilities GP requires operators to use drilling fluids that have an LC50 value greater than 30,000 ppm and this must be verified and documented by laboratory testing. EPA (2012b) concluded in its Ocean Discharge Criteria Evaluation prepared for the NPDES exploration facilities GP, that such drilling fluids will not result in unreasonable degradation of marine waters, and this included an assessment of persistence and bioaccumulation of the drilling fluids and their components in the Chukchi Sea. EPA further concluded that the discharges are not likely to affect species protected under the ESA which includes most of the marine mammal species in the area and several bird species of seabirds.

Design of the Wells and Discharge by Interval

The design of the wells has six intervals from the MLC to the bottom hole; each of these is a discrete drilling interval (Table 4.2.1-2). Discharge modeling simulations were performed for a conventional drilling method (MLC by drill bit) as well as drilling operations in conjunction with an MLC ROV system. Discharge modeling simulations were performed for each of the six discrete drilling intervals with two discharge locations: seafloor (Discharge 013 Table 2.7-3) and sea surface (Discharge 001 Table 2.7-3).

The upper intervals, drilled prior to the marine riser being installed, will be discharged at the seafloor; the lower intervals will be discharged through the disposal caisson approximately 22 to 25 ft (6.7 to 7.6 m) below the sea surface. Cement is discharged only with the seafloor discharge scenarios and is included in the volume of drill cuttings. Discharges for each of the Burger wells include the discharge of an estimated maximum of 2,427 bbl of drilling fluids at the end of drilling operations. The total volumes of drilling wastes to be discharged at the Burger drill sites are provided in EIA Section 2.0, Tables 2.7-1 and 2.7-2. Volumes and rates of the expected drilling waste discharges for Burger J drill site are provided in Table 4.2.1-3 by interval. Discharges at the other Burger drill sites would be similar. Results of the discharge modeling are also discussed in Section 4.3 on Seafloor Sediments.

Table 4.2.1-3 Discharge Scenario for the Burger J Well

Discharge Location	Drilling Interval	Total Cuttings (bbl)	Total Drilling Fluids (bbl)	Proposed Hours of Discharge	Effluent Discharge Rate (bbl/hr)
Seafloor	1	3,703	840	66	83
Seafloor	2	316	456	5.2	149
Seafloor	3	1,070	1,911	34.4	87
Seafloor Total	**1-3**	**5,089**	**3,207**	**--**	**--**
Sea surface	4	349	1,997	23.3	101
Sea surface	5	452	2,573	29	104
Sea surface	6	114	976	37.2	29
Total Sea Surface	**4-6**	**915**	**5,546**	**--**	**--**
Total while drilling	**1-6**	**6,004**	**8,753**	**--**	**--**
Sea surface	drilling unit pit	-	2,427	2.5	1,000
Total (Drilling plus reserve pit volume)	**--**	**6,004**	**11,180**	**--**	**--**

[1] Source: Fluid Dynamix 2014b

Total Suspended Solids

The primary effect of the discharges will be increased TSS in a plume down current of the discharge location. Most of this effect is ameliorated within 1,640 ft (500 m) of the discharge locations through settling and dispersion. Surface sediments consist of fine materials such as silts and clays, which remain in suspension for a longer duration. TSS concentrations from the drilling of Interval 1, which is the MLC, therefore extend a greater distance from the discharge location. Suspended particles in water 16 ft (5 m) above the seafloor in the Chukchi Sea have been reported at 0.6 to 4.4 mg/l (Feder et al. 1994b).

Predicted TSS in the water column at distance from the discharge based on the model results are indicated below in Table 4.2.1-4.

Table 4.2.1-4 Predicted TSS Concentrations from Drilling Waste Discharges at Burger J

Discharge Location	Drilling Interval	TSS in Water Column (mg/l) [1]		
		328 ft (100 m)	984 ft (300 m)	0.62 mi (1 km)
Seafloor	1 using MLC Bit	320.4	89.6	14.0
Seafloor	1 using MLC ROV System	169.9	45.8	8.4
Seafloor	2	287.8	79.5	12.7
Seafloor	3	151.2	42.1	6.6
Sea surface	4	51.7	10.4	1.8
Sea surface	5	82.5	10.6	1.9
Sea surface	6	11.7	3.8	0.6
Sea surface	Drilling unit pit	181.0	97.7	31.3

[1] Source: Fluid Dynamix 2014a,b,c,d

The impacts to water quality would cease when the discharge is concluded. Impacts to water quality from the discharge of drilling wastes and cement will be localized, and will occur over a short period of time (weeks to months during exploration drilling at an individual drill site). The model results indicate that plumes with TSS concentrations above ambient levels are unlikely to extend from one drill site to another for even the closest drill sites. The most likely drilling scenario would have the drilling units 7 to 10 mi (11.3 to 16.1 km) apart. Drill sites in proximity to each other would be subject to the same current regime and plumes would flow in the same direction. Therefore, water quality impacts from drilling two wells concurrently with two drilling units would be similar to the effects of drilling two wells at different times with the same drilling unit.

Based on the significance thresholds and level of effects definitions determined by BOEM (BOEM 2011a) and provided above in Section 4.2, permitted drilling discharges associated with Shell's EP Revision 2 will not be significant. There may be low level metal signatures in the sediments at the drill sites that last more than one season but do not result in unreasonable degradation of the marine environment. Drill cuttings discharged and deposited on the seafloor sediments could re-suspend into the water column with currents and storm events. Impacts from drilling waste discharges on water quality would be localized and relatively short-term with some persistence of metal from drill cuttings and fluids; however, this would not result in unreasonable degradation, and therefore, would have a minor level of effect.

4.2.2 Impacts of Other Permitted Discharges on Water Quality

Other permitted discharges include the non-drilling wastewater discharges from the drilling units (Tables 2.7-4 and 2.7-5) and similar wastewaters discharged from the support vessels (Table 2.7-6) as part of normal vessel operation into the Chukchi Sea. These vessels will be at various scattered locations across the Chukchi Sea when in transit or on standby, while the ephemeral impacts associated with vessel discharges will be generally limited to the area within 330 ft (100 m) of the discharge outfall. The Chukchi Sea is a very large open water body of more than 230,000 mi^2 (595,697 km^2) and the Lease Sale 193 Area itself being 53,125 mi^2 (137,593 km^2). Given the size of the Chukchi Sea, distribution of the vessels, and the size and composition of the discharges, effects of these other permitted will be negligible for the reasons described below.

A number of other wastes will be generated by the drilling units and support vessels, including: domestic and sanitary wastewaters, deck drainage, cooling water, ballast water, desalination wastes, boiler blowdown, and fire control system test water. The compositions, projected rates, and projected volumes of these discharges are presented in EIA Section 2.0, Tables 2.7-4 and 2.7-5. These discharges will be conducted in accordance with, and authorized under NPDES exploration facilities GP, which contains a number of conditions that place limitations on effluent constituents and discharge rates, and mandate discharge monitoring and reporting. Volumes and rates will differ between the two drilling units because of the different numbers of persons on board, differing equipment, and differing technologies. Food wastes from the drilling units will most likely be incinerated; however, they could be shipped out of the Arctic for disposal if operations warrant.

Domestic and Sanitary Wastewaters

Domestic wastes include graywater from showers, sinks, laundries, and galleys. Graywater does not require treatment prior to discharge as only environmentally friendly soaps and solutions (phosphate free, water soluble, nontoxic, biodegradable) are used aboard vessels engaged in the exploration drilling operations. Graywater from the drilling units will be discharged according to limitations listed in Table 4.2.2-1. Food waste from the drilling units while drilling will generally be incinerated (or shipped offsite for disposal) and will not be discharged to the Chukchi Sea. Sanitary wastes (e.g., “black water” from urinals and toilets) will be treated in the drilling units’ onboard MSD prior to discharge under the limitations in Table 4.2.2-2. All support vessels will also treat their sanitary wastes in USCG-approved MSDs prior to discharge. Support vessels will discharge domestic waste and sanitary waste to the sea after treatment per MARPOL standards and requirements.

Table 4.2.2-1 Chukchi Sea NPDES Exploration Facilities GP Limitations Domestic Waste Discharges

Parameter	Limit		Monitoring Requirement	
	Avg Monthly Limit	Max Daily Limit	Sample Frequency	Sample Type
Floating solids	No discharge	No discharge	Daily	Visual
Foam	No discharge	No discharge	Daily	Visual
pH	6.5 to 8.5	6.5 to 8.5	Monthly	Grab
Flow	--	--	Monthly	Estimated

Table 4.2.2-2 Chukchi Sea NPDES Exploration Facilities GP Limitations on Sanitary Waste Discharges

Parameter	Limit		Monitoring Requirement	
	Avg Monthly Limit	Max Daily Limit	Sample Frequency	Sample Type
Flow	--	--	Daily	Measured / recorded
BOD	30 mg/L	60 mg/L	Weekly	Grab or composite
TSS	30 mg/L	60 mg/L	Weekly	Grab or composite
Floating solids	No discharge	No discharge	Daily	Visual
Foam	No discharge	No discharge	Daily	Visual
Oily sheen	No discharge	No discharge	Daily	Visual
pH	6.5-8.5	6.5-8.5	Weekly	Grab
Fecal coliform	100 colonies/mL	200 colonies/mL	Weekly	Grab
Total residual chlorine*	--	1.0 mg/L	Weekly	Grab

*if used as a disinfectant

Primary pollutants of concern in sanitary wastes are biological oxygen demand (BOD), TSS, coliform bacteria, and residual chlorine. MSDs will reduce coliform bacteria and residual chlorine to levels stipulated by the permit or lower. Monitoring requirements will ensure these permit limits are met. Organic compounds in the wastes will result in some increases in BOD in ambient waters and increased suspended solids. These effects will be limited to the area immediately surrounding the discharge location as they would be quickly diluted and dispersed due to the water depths and currents found at the prospect, and would last only minutes longer than the discharges. The EPA (2012b) has determined that discharges of sanitary and domestic wastewaters under these conditions will not result in unreasonable or substantial water quality degradation in the Chukchi Sea. The environmental impact of domestic wastes on water quality is localized and temporary and therefore the level of effect is negligible.

Blackwater discharges from vessels (Table 2.7-6) are subject to Section 302 of the CWA and USCG regulations at 33 CFR Part 159 or MARPOL Annex IV. Primary pollutants of concern in blackwater are BOD, TSS, coliform bacteria, and residual chlorine. Only blackwater that is first treated in a USCG approved Type I or Type II MSD, or an International Maritime Organization (IMO) approved sewage treatment plant or sewage comminuting and disinfecting system will be discharged. Treatment will reduce coliform bacteria and suspended solids to levels to meet or exceed USCG or IMO standards. Organic compounds in the wastes will result in some increases in BOD in ambient waters and increased suspended solids. Increases in BOD, TSS and chlorine will be limited to the area immediately surrounding the discharge location as they would be quickly diluted and dispersed due to the water depths and currents found at the prospect, and would last only minutes longer than the discharges.

As analyzed above, graywater and blackwater discharges associated with EP Revision 2 will have temporary and localized impacts on water quality that do not cause an unreasonable degradation under 40 CFR 125.122. The level of effect of domestic and sanitary wastewater discharges on overall water quality is negligible.

Deck Drainage

Deck drainage is water that collects on impervious surfaces of the vessel and consists largely of rainwater, sea spray, and washwater. During a storm or high sea event, the contingency plan is to open up the rubber plugs and scuppers and allow discharge overboard as long as the deck drainage is not contaminated with oil or grease. Discharges of deck drainage could affect water temperature, salinity, and pH (through dilution). The primary pollutant of concern in deck drainage is oil that could be entrained in the waters as they move across oily surfaces on the deck and elsewhere. Vessel operators will minimize the introduction of on-deck debris, garbage, residue and spill into deck washdown and runoff discharges. Machinery on deck will have coamings or drip pans to collect any oily water from machinery and prevent spills, and the drip pans must be drained to a waste container for proper disposal and/or periodically wiped and cleaned. On each drilling unit, deck drainage that moves across surfaces that could be contaminated with oil is diverted through an OWS. Separated oily waters are stored for onshore treatment and disposal at a TDS. Per the NPDES exploration facilities GP requirements, deck drainage discharges can have no free oil, and are monitored/tested once per discharge. The deck drainage discharges associated with EP Revision 2 will have temporary and localized impacts on water quality and therefore will have a negligible impact on water quality.

Cooling Water

Seawater cooling systems use ambient seawater to absorb the heat from propulsion and auxiliary mechanical systems on the drilling unit and larger vessels. The water is circulated through an enclosed system and does not come in direct contact with machinery, but still may contain small amounts of sediment from water intake and traces of hydraulic or lubricating oils. Discharges of cooling water could affect water temperature, salinity, and pH (through dilution). The temperature of the discharged cooling water is elevated over the temperature of the receiving seawater. Dispersion and attenuation of the thermal plumes likely to be created by cooling water discharges from the *Discoverer* (Table 4.2.2-3) and the *Polar Pioneer* (Table 4.2.2-4) have been modeled, and the modeling results indicate that such discharges are only slightly warmer than ambient waters when returned to the environment, and that the cooling water quickly returns to ambient conditions due to rapid dilution and dispersion given the open water conditions. The modeling indicates that the difference in the cooling water effluent and the ambient seawater would be reduced to near zero (0.5 °C) within 33 to 820 ft (10 to 250 m). Any measureable effects on water quality due to these discharges would be restricted to a very small area in the Chukchi Sea and last for a relatively short time after the discharge ceases (Tables 4.2.2-3 and 4.2.2-4). The cooling water volumes associated with these drilling units are much larger than those associated with the support vessels. These cooling water discharges will have a temporary and localized impact on water quality and do not cause an unreasonable degradation under 40 CFR 125.122, and therefore will have a negligible impact on water quality.

Table 4.2.2-3 Predicted Water Quality Impacts of *Discoverer* Cooling Water Discharges

Discharge Outlet	Effluent Sources and Characteristics [1]			Impact on the Ambient Water Quality [1]					
	Volume (bbl/day)	Temp (°C)	Salinity (psu)	Excess Temp (°C)	Plume Depth (m)	Plume width (m)	Distance Source (m)	Duration (min)	Affected Area (m^2)
1	34,286	5.1	30	0.05	5.0	40	180	1	50
2	17,143	4.2	30	0.05	4.2	24	114	2	1
3	17,486	16.1	30	0.05	2.0	54	216	56	6,500
4	17,486	16.1	30	0.05	2.0	54	216	56	6,500
5	20,571	4.2	30	0.05	5.0	25	112	1	1
6	343	12.0	30	0.05	0.3	7	80	15	320

[1] Source: Fluid Dynamix. 2014e

Table 4.2.2-4 Predicted Water Quality Impacts of *Polar Pioneer* Cooling Water Discharges

Discharge Outlet	Effluent Sources and Characteristics [1]			Impact on the Ambient Water Quality [1]						
	Volume (bbl/day)	Temp (°C)	Salinity (psu)	Excess Temp (°C)	Plume Depth (m)	Plume width(m)	Distance Source (m)	Duration (min)	Affected Area (m^2)
1	21,385.33	13.33	30	0.05	2.0	68	350	80	14,000

[1] Source: Fluid Dynamix 2014f

Ballast Water

Ballast water is seawater pumped into or out of ballast water tanks to manage vessel draft, buoyancy, and stability. Discharge volumes and rates vary by vessel type. Ballast water discharge volumes for the drilling units are provided in Table 2.7-4 and 2.7-5. Larger vessels have ballast water capacities of over 6,000 bbl. Ballast water may contain rust inhibitors, flocculent compounds, epoxy coating materials, zinc or aluminum (from anodes), iron, nickel, copper, bronze, silver, and other material or sediment from inside the tank, pipes, or other machinery (EPA 2008). Discharges of ballast water could affect water temperature, salinity, and pH (through dilution). USCG regulations (33 CFR 151 Subpart D) mandate that vessel operators maintain a ballast water management plan, discharge the minimal volumes necessary for operations, clean ballast tanks regularly to remove sediments, and minimize or avoid uptake of ballast waters near sewage outfalls, areas of active dredging, or where propellers may stir up sediments. Under the NPDES exploration facilities GP and regulations, no free oil may be discharged; the discharge must not produce a sheen. Given these requirements and practices, contaminants would be expected to be temporary, localized, and in such low concentrations as not to cause unreasonable degradation under 40 CFR 125.122, and, therefore, level of effects of ballast water on water quality would be negligible.

Desalination Wastes, Boiler Blowdown, and Fire Control System Test Water

Desalination wastes are produced by the watermaker which operates via evaporation/condensation of seawater. The remaining stream has slightly higher concentrations of all dissolved solids. Thus, the waste stream is seawater with more salt, hardness and all other dissolved components. Fire control system test water is also seawater that is discharged directly overboard in very small quantities during the testing of the system. Boiler blowdown is the discharge of water and minerals drained from boiler drums to minimize solids buildup in the boiler, and consists of freshwater with solids resulting from evaporation and dissolution. Desalination wastes, boiler blowdown and fire control system test water will not contact oiled surfaces.

Discharges of desalination wastes could affect water temperature, salinity, and pH (through dilution). The EPA has evaluated the environmental impact of these types and quantities of vessel discharge in territorial seas as part of their NPDES program prior to issuing their GPs for vessels (VGP) and exploration facilities (EPA 2006a, 2008c, 2012a), and concluded they would not result in unreasonable degradation of ocean waters of the Chukchi Sea (as defined in above). Additionally, the NPDES exploration facilities GP and VGP mandate that no free oil be discharged with desalination wastes, cooling water, and ballast water as they, too, must meet the “sheen test” requirement.

Water quality effects of these discharges will be temporary based on their content and volume, lasting only hours (at most) longer than the specific activity. Water quality effects of these discharges will have only a localized, generally limited to the area within a few meters of the discharge. Impacts of desalination wastes, boiler blowdown, and fire control system test water would be temporary and localized, and would not cause unreasonable degradation under 40 CFR 125.122 and, therefore, the level of effects would be negligible.

4.2.3 Impacts of a Small Liquid Hydrocarbon Spill on Water Quality

Releases of oil in the marine environment can affect water quality as well as other resources. Section 2.10 of this EIA addresses the potential sources and types of oil spills that could occur, the probabilities of such spills occurring, Shell's plans for responding to a small spill (defined as 48 bbl or less), and Shell's WCD planning scenario. As explained in Section 2.10, Shell's categories of spill sizes are different from, but not incompatible with, those used by BOEM. The probability of a large (> 48 bbl) liquid hydrocarbon spill is so low that it is not regarded as reasonably foreseeable for this analysis of potential direct and indirect impacts. Nonetheless, a small spill, such as a release of 48 bbl of diesel fuel, is the most probable type and volume of spill, if any, to occur as a result of this exploration drilling program. (The probability of a large oil spill occurring and the potential impacts associated with such an improbable event are discussed in Section 6.0. of this EIA.) Prudent planning and state and federal regulatory requirements nevertheless require that Shell have comprehensive spill prevention and response plans and capabilities in place. Shell's plans include measures to prevent any spill release from occurring and to respond in the event of a spill, including capabilities for responding to a "worst case" scenario release. In the unlikely event of a spill, implementation of Shell's comprehensive spill response plan would minimize the impacts from the spill and any effects on sediments. Response equipment and trained personnel would be available on site to deploy boom and recovery equipment for the control and removal of product spilled into the environment. Additionally, the procedures of Shell's FTP for fuel transfer between vessels would be utilized in accordance with BOEM lease stipulation No. 6, USCG requirements, and Shell's operating procedures.

The only reasonably foreseeable release, based on spill statistics, is a small spill. Potential impacts associated with the unlikely event of a small spill are greatly minimized by Shell's FTP, OSRP, and the distance from shore at which most activities would take place.

Diesel fuels do not tend to form emulsions. Because they are of low viscosity, light distillates tend to evaporate and disperse readily into the water column by even gentle wave action. There is also a high potential for dissolution to occur, from both surface sheens and droplets dispersed in the water column. The ADIOS2 model indicates that about 51 percent of a small diesel spill would disperse into the water column and 48 percent would evaporate after 48 hr (Table 2.10-2). The water-soluble fractions of diesel are dominated by two- and three-ringed polycyclic aromatic hydrocarbons (PAH), which are moderately volatile (NRC 2003b). Cripps and Shears (1997) reported maximum concentrations of 540 ppm for n-alkanes and 222 ppm for PAHs, on the day after a release of diesel fuel in coastal Antarctica, and that these levels returned to background levels within one week. The constituents of these oils are light to intermediate in molecular weight and can be readily degraded by aerobic microbial digestion. Diesel is so light that it is not possible for the oil to sink and pool on the seafloor. Diesel dispersed in the water column can adhere to suspended sediments, but this generally only occurs in coastal areas with high TSS loads (NRC 2003b), and would not be expected to occur to any appreciable degree in offshore waters of the Chukchi Sea. Suspended sediment loads from drilling waste discharges would occur much lower in the water column than a surface diesel spill and would be unlikely to entrain the hydrocarbons if such a release were to occur near the drilling unit. Long-term persistence in sediments can occur under heavy loading and reducing conditions where biodegradation rates for anaerobic bacteria are low, but that would not be expected to occur from a small spill offshore. Diesel oil is readily and completely degraded by naturally occurring microbes, generally in time frames of one to two months (NOAA 2006).

Water column effects from a small spill would likely be restricted to a small area of <200 ac (0.8 km^2) and have a duration of less than one week. This effects analysis is based on an uncontrolled release. The probability of such a spill occurring is greatly minimized by Shell's OSRP, FTP, and best management practices. Any effects, if should such a spill were to occur, would be greatly minimized and mitigated by prevention and recovery efforts as described in Section 2.10. Given these measures and practices, any effects on water quality would be localized and short-term. According to the definitions of level of effects in BOEM's EA (2011a) of Shell's EP Revision 1, Appendix B, the impacts of a small spill (48 bbl) on water quality would be negligible.

Conclusion

The environmental impacts associated with drill cuttings and fluids may persist due to the presence of metals; however, there would be no unreasonable degradation of the marine environment, and therefore the level of effects for drilling waste discharges on water quality would be minor. The environmental impact of domestic wastes and other permitted discharges (deck drainage, cooling water, desalination wastes, boiler blowdown, and fire control system test water) on water quality are localized and temporary and therefore the level of effect is negligible. Effects on water quality from a 48-bbl diesel spill would be localized and short-term, and impacts are therefore considered negligible. Based on significance thresholds and level of effects definitions determined by BOEM (BOEM 2011a) and analysis provided in Section 4.2, impacts associated with Shell's proposed activities in EP Revision 2 will not degrade the marine environment, will not be significant, and will have minor impacts on water quality.

4.3 Impacts on Seafloor Sediments

The analysis of impacts on seafloor sediments for the exploration drilling activities in EP Revision 2 differs from that in EIA EP Revision 1. As detailed in the discussion of mooring the two drilling units and MLC construction (EIA Section 2.3), and the discussion of drilling wastes (EIA Sections 3.2 and 4.2), the seafloor sediment impacts analysis in this EIA differs in a few key respects:

- Mooring of two drilling units
- MLC construction either by drill bit or MLC ROV system
- Increased volumes of cuttings and drilling fluids, increased permitted vessel discharges, and increases in total suspended solids and turbidity
- EPA's new five-year NPDES exploration facilities GP, which authorizes certain discharges from oil and gas exploration facilities in the Chukchi Sea and imposes various effluent limitations, monitoring requirements, and conditions
- New EMP under the NPDES exploration facilities GP. This EMP addresses monitoring of the benthic environment, receiving water chemistry, sediment characteristics before drilling, discharge plumes during drilling, and sediment and benthic samples after drilling
- Dispersion modeling simulations conducted based on the equipment and design of the drilling units, the *Discoverer* and the *Polar Pioneer.*

In BOEM's environmental assessment of Shell's EP Revision 1, impacts on seafloor sediments were analyzed as part of the impacts analysis of lower trophic organisms. Seafloor sediments can also influence water quality if they are disturbed by currents and sediment is suspended in the water column. Likewise, lower trophic organisms are part of and affected by disturbance of seafloor sediments. BOEM defined significance thresholds and levels of effect in Appendix B of the EA (BOEM 2011a). Since impacts on seafloor sediments could affect both lower trophic organisms and the lower water column, the significance thresholds and level of effects for both water quality and lower trophic organisms are utilized in this section.

Significance Threshold

- Water Quality: action is likely to violate its NPDES exploration facilities GP permit,
- Water Quality: in the event of an accidental spill of crude oil or refined oil, total aromatic hydrocarbon or total aqueous hydrocarbon criteria for the Alaska marine or fresh-water quality standards are exceeded, or
- Water Quality: the action is otherwise likely to introduce changes in the physical, chemical, or biological characteristics of a water body which case an unreasonable degradation of the marine environment as defined at 40 CFR 125.121 and determined in accordance with 40 CFR 125.122.
- Lower Trophic: Adverse impact that results in a decline in abundance and/or change in distribution requiring three or more generations for the indicated population to recover to its former status.

Level of Effects

Negligible

- Water Quality: Temporary and localized impacts to water quality that do not cause an unreasonable degradation under 40 CFR 125.122
- Lower Trophic: No measurable impacts. Population-level effects are not detectable.
- Lower Trophic: Localized, short-term disturbance or habitat effect experienced during one season that is not anticipated to accumulate across multiple seasons
- Lower Trophic: No population level impacts to reproductive success or recruitment are anticipated
- Lower Trophic: Mitigation measures are implemented fully and effectively or are not necessary

Minor

- Water Quality: Long-term and/or widespread impacts to water quality that do not cause an “unreasonable degradation” under 40 CFR 125.122
- Lower Trophic: Population-level effects are not detectable
- Lower Trophic: Widespread annual or chronic disturbances or habitat effects or anticipated to accumulate across 1 year, or localized effects that are anticipated to persist for more than 1 year
- Lower Trophic: Mitigation measures may be implemented on some, but not all, impacting activities, indicating that some adverse effects are avoidable
- Lower Trophic: Unmitigatable or unavoidable adverse effects are short-term and localized

Moderate

- Water Quality: Impacts to water quality that exceed NPDES exploration facilities GP criteria or cause a temporary of localized “unreasonable degradation” under 40 CFR 125.122
- Lower Trophic: Disturbances could occur, but not on a scale resulting in population-level effects
- Lower Trophic: Widespread annual or chronic disturbances or habitat effects could persist for more than 1 year and up to a decade
- Lower Trophic: Widespread implementation of mitigation measures for similar activities may be effective in reducing the level of avoidable adverse effects
- Lower Trophic: Unmitigatable or unavoidable adverse effects are short-term and widespread, or long-term and localized

The following sections summarize Shell's analyses and evaluate the potential impacts to seafloor sediments. Shell has concluded that the overall potential effects on seafloor sediments from the exploration activities as described in EP Revision 2 are minor (Table 4.3-1).

Table 4.3-1 Potential Effects of Shell's Exploration Drilling Program on Seafloor Sediments

Resource / Analyzed Activity	EP Revision 2
Seafloor sediments (overall)	Minor
From mooring and MLCs	Negligible
From drilling wastes	Minor
From small liquid hydrocarbon spill	Negligible

4.3.1 Impacts of Drilling Unit Mooring and MLCs on Seafloor Sediments

The seafloor will be directly disturbed by construction of MLCs and mooring the drilling units at each drill site. Dimensions of these impacts are provided in Tables 2.3-1 and 2.3-4. Seafloor disturbance from these activities for the entire exploration drilling program, consisting of six drill sites, are presented below in Table 4.3-1-1. Information is provided for two different types of MLC construction contemplated in EP Revision 2: using the drilling unit MLC bit system to construct an MLC and using the MLC ROV System (proposed for the first time in EP Revision 2) to construct an MLC. As noted below, using the MLC ROV System will result in a higher level of seafloor disturbance than using the drilling unit MLC bit system.

Table 4.3.1-1 Seafloor Sediments that may be Disturbed by Mooring and MLC Construction

Time Period	Activity	Total Seafloor Area Directly Disturbed		Total Sediment Volume Displaced	
		ft^2	m^2	ft^3	bbl
Drilling Program	Mooring Drilling Unit[1]	160,640	14,923	1,206,208	214,306
If MLC Bit is Used for MLC Construction					
Drilling Program	MLC Bit	6,450	600	124,686	22,218
If MLC ROV System is Used for MLC Construction					
Drilling Program	All MLC ROV system	40,416	3,756	916,272	163,182

[1] anchor total includes contingency for re-setting 16 anchors, if necessary

The physical manifestations of anchor disturbances associated with mooring the drilling units (3.7 ac, [14,923 m^2]) will attenuate after removal over time by the natural movement of seafloor sediments and ice scours. Duration is therefore dependent on water depth, currents, characteristics of the sea bottom sediments, and the frequency of ice gouging and sediment disturbance by biota such as gray whales, walruses, and benthic infauna. Durations on the order of five to ten years have been reported for anchor disturbances in low energy areas such as portions of the North Sea (DTI 2003). Centaur & Associates, Inc. (1984) reported that anchoring in sand or muddy sand sediments may not result in anchor disturbances, but should there be any disturbances, they would not be expected to persist. The drill sites are in water depths of 147 to 150 ft (44.8 to 45.8 m) with sediments consisting of mud, gravelly mud, gravelly sand, and muddy sand. These physical effects of drilling unit mooring and MLC construction would be restricted to a very small portion of the Chukchi Sea seafloor area (4.01 to 5.28 ac [16,158 to 21,354 m^2]), depending on MLC construction by drill bit or by MLC ROV system. The seafloor area disturbed by mooring and MLC construction represents less than 0.0000038 to 0.0000047 percent of the seafloor of the Chukchi Sea. The seafloor impacts associated with mooring and MLC construction associated with Shell's exploration drilling activities as described in EP Revision 2 are therefore expected to be negligible.

4.3.2 Impacts of Drilling Wastes on Seafloor Sediments

Drilling wastes consisting of drilling fluids, drill cuttings, and cement will be discharged and subsequently be deposited on the seafloor altering the seafloor relief, sediment constancy, and metals. Shell conducted dispersion modeling of the drilling waste discharges with the volumes and rates presented in EIA Section 2.0, Table 2.7-3 using the OOC model (Fluid Dynamix 2014a,b,c,d) as described above in Section 4.2.1 and Table 4.2.1-3. Modeling simulations were performed for each drill site, using either the MLC bit (on the drilling unit) or the MLC ROV system to construct the MLC (as discharged volumes vary depending on how the MLC is constructed). The MLC ROV system includes: an excavator bucket, a rotating cutter, augur, drill, or a rock hammer to excavate the MLC. The ROV will sit on the sea floor and use several different techniques to mobilize the seafloor drill cuttings sediments. The sediments will be pumped away via a pump mounted on the ROV and discharged away from the excavation site. The predicted depth of the deposition and the seafloor area encompassed by the deposits are presented below in Tables 4.3.2-1 and 4.3.2-2.

The impact from the discharge of drill cuttings and drilling fluids from two drilling units operating at the same time on the Burger Prospect is expected to be minimal. Discharge modeling performed for both the *Discoverer* and the *Polar Pioneer* based on maximum prevailing current speeds of 9.84 in/s (25 cm/s), shows that sedimentation depth of muds and cuttings at greater than 0.4 in (1 cm) thickness will occur within approximately 1,641 (500 m) of the drilling unit discharge point (Fluid Dynamix, 2014a,b,c,d). Concentrations of TSS, a transient feature of the discharge, are modeled to be below 15 mg/L at distances approximately 3,281 ft (1,000 m) from the drilling unit discharge point.

The most likely drilling scenario would place the two drilling units from 7 to 10 mi (11.3 to 16.1 km) apart. At these distances there will be no interaction, or overlap, of discharge plumes from the two drilling units. The closest drill sites on the Burger Prospect (Burger A and Burger F) are approximately 2 mi (3.3 km) apart. Modeling results still indicate that little to no interaction of the discharge plumes would occur. Both drilling units are predicted to experience the same prevailing current direction, which results in the discharge plumes from each drilling unit moving in the same direction (as opposed to towards each other), further minimizing the chances of interaction.

Table 4.3.2-1 Predicted Seafloor Accumulations of Drilling Wastes using MLC Bit

Thickness (in.)	Thickness (cm)	Area with Accumulation to Thicknesses per Drill Site[1]							
		Approximate Extent Per Drill Site				Approximate Extent Per Program (6 wells)			
		ha	m²	ft²	ac	ha	m²	ft²	ac
39.4	100	0.1	1,000	12,000	0.3	0.6	6,000	65,000	1.5
3.9	10	0.3	3,000	31,000	0.7	1.7	18,000	183,000	4.2
0.4	1	1.1	11,000	118,000	2.7	6.6	66,000	708,000	16.2

[1] Source: Fluid Dynamix 2014c,d

Table 4.3.2-2 Predicted Seafloor Accumulations of Drilling Wastes using MLC ROV System

Thickness (in.)	Thickness (cm)	Area with Accumulation to Thicknesses per Drill Site[1]							
		Approximate Extent Per Drill Site				Approximate Extent Per Program (6 wells)			
		ha	m²	ft²	ac	ha	m²	ft²	ac
39.4	100	0.4	4,000	43,000	1.0	2.4	24,000	260,000	6.0
3.9	10	1.0	10,000	108,000	2.5	6.0	60,000	645,000	14.8
0.4	1	2.2	22,000	236,000	5.4	13.2	132,000	1,420,000	32.6

[1] Source: Fluid Dynamix 2014a,b

Heavy metal concentrations would be expected to increase slightly in these areas of deposition because of the heavy metal content of the discharges. Past modeling of similar discharges in the Chukchi Sea (Shell

Global Solutions 2009) indicates that increases in mercury, cadmium, and chromium, if any, would be minimal. Table 4.3.2-3 lists predicted metal concentrations in seafloor sediments as a result of the program and compares the concentrations to those found to have ecological effects (Long et al. 1995). The enrichment of heavy metal concentrations would be restricted to a very small portion of the Chukchi Sea seafloor, would be at levels typically found to have little or no ecological effect, and would be expected to be ameliorated within a few years by the dispersion of these deposited materials by ice gouging and currents. The level of effects is therefore considered minor.

Table 4.3.2-3 Predicted Increases in Metals in Sediments from Drilling Waste Discharges

Parameter	Mercury (ppm) [1,2]		Cadmium (ppm) [1,2]		Chromium (ppm) [1,2]	
	Likely [3]	Max [4]	Likely [3]	Max [4]	Likely [3]	Max [4]
Predicted Concentration	0.0211	0.479	0.0168	0.144	0.718	0.718
Effect Range Low[5]	0.150	1.20	81.0	-	-	-
Effects Range Medium[6]	0.710	9.60	37.0	-	-	-
Natural Sediment Beaufort	0.039		0.190		0.588	
Natural Sediment Chukchi	NA		NA		0.820	

1 Source: Shell Global Solutions 2009
2 Concentrations based on OOC modeling of estimated discharges as described in Section 2.7
3 Based on average heavy metal concentrations in drilling fluids
4 Based on maximum allowable concentrations in drilling fluids under NPDES GP AKG-28-0000
5 Per Long et al. (1995) value is the concentration equivalent to the lower 10th percentile of the compiled study data; concentrations below this value are interpreted as rarely associated with adverse effects
6 Per Long et al. (1995) value is the concentration equivalent to the 50th percentile of the compiled study data; concentrations below this value and above Effects Range Low (ERL) value are interpreted as occasionally associated with adverse effects; concentrations above these values are interpreted as frequently associated with adverse effects

Crippen et al. (1980) investigated increases in heavy metal concentrations from exploration drilling waste discharges in water depths of only about 23 ft (7 m) in the Canadian Beaufort Sea. Wells drilled in this water depth would provide a much thicker sediment layer than that predicted for Shell's Chukchi Sea exploration drilling activities with water depths from 130 to 160 ft (40 to 50 m). Barite used at the Canadian Beaufort site contained 14.2 ppm mercury. Crippen et al. (1980) found that concentrations of mercury, lead, zinc, cadmium, arsenic, and chromium were elevated in the Canadian Beaufort seafloor sediments as much as 185, 35, 15, 9, 2.4, and 0.7 times background in some locations within 147.6 ft (45 m) of the discharge point. Some effects were noticed for a distance of 5,900 ft (1,800 m) from the well. Mercury concentrations in discharged barite are restricted under the current NPDES exploration facilities GP to 1 ppm; this concentration is much lower than the historic Canadian Beaufort example above. Shell has selected barite from a domestic commercial source having the lowest mercury concentration (<1 ppm) in the world for its Chukchi Sea exploration drilling activities. Nortec (1982) monitored trace metal concentrations in seafloor sediments before and after on-ice disposal of drilling wastes in very shallow water depths of 4.3 to 16.4 ft (1.3 to 5.0 m) in the U.S. Beaufort Sea. They concluded that observed differences in metal concentrations were attributed to natural spatial and temporal variations with the exception of elevated chromium and zinc levels in sediments at one discharge site.

Sediment samples at the 34 stations in a 30 x 30 nmi (55 x 55 km) CSESP Burger Study Area were analyzed for metal and hydrocarbon concentrations (Neff et al. 2010). The results of the analyses are summarized in EIA Section 3.0, Table 3.3.1-5. Concentrations of all measured hydrocarbon types were found to be well within the range of non-toxic background concentrations reported by other Alaskan and Arctic coastal and shelf sediment studies (Neff et al. 2010; Dunton et al. 2012). Metal concentrations were found to be quite variable. Average concentrations of all metals except for arsenic and barium were found to be lower than those reported for average marine sediment.

Trefry et al. (2012) confirmed findings by Neff et al. (2010) that concentrations of all measured hydrocarbon types were well within the range of non-toxic background concentrations reported by other Alaskan and Arctic coastal and shelf sediment studies.

Neff et al. (2010) assessed the concentrations of metals and various hydrocarbons in sediments at the historic Burger and Klondike wells in the Chukchi Sea, which were drilled in 1989-1990. Surface and subsurface sediments collected in 2008 at the historic drill sites contained higher concentrations of all types of analyzed hydrocarbon in comparison to the surrounding area. The same pattern was found for the metal barium, with concentrations 2 to 3 times greater at the historic drill sites (mean = 1,410 µ/g and 1,300 µ/g) than in the surrounding areas (639 µ/g and 595 µ/g). Concentrations of copper, mercury, and lead were elevated in a few samples from the historic drill sites where barium was also elevated. All observed concentrations of hydrocarbons or metals in the sediment samples from the historic drill sites were below levels (below ERL or Effects Range Low of Long et al. 1995) believed to have adverse ecological effects (Neff et al. 2010). Similar results were reported by Trefry and Trocine (2009) for the historic Hammerhead drill sites in the Beaufort Sea.

These data show that the potential accumulation of heavy metals in discharged mud accumulations on the Chukchi Sea seafloor associated with drilling exploration wells is very limited and does not pose a threat. Small increases in concentrations of metals from permitted discharges will likely be evident for a number of years until gouged by ice, redistributed by currents, or buried under natural sedimentation. The drilling waste discharges will be conducted as authorized by the NPDES exploration facilities GP, which limits the metal content and flow rate for such discharges. The EPA (2012b) analyzed the effects of these types of discharges, including potential transport of pollutants such as metals by biological, physical, or chemical processes, and has concluded that these types of discharges do not result in unreasonable degradation of ocean waters. The seafloor impacts associated with discharges of drilling wastes associated with Shell's exploration drilling activities as described in EP Revision 2 would be restricted to a very small area in the Lease Sale 193 Area and would not result in "undue degradation" of ocean waters and therefore would be minor.

4.3.3 Impacts of a Small Liquid Hydrocarbon Spill on Sediments

Section 2.10 of this EIA addresses the potential sources and types of a hydrocarbon spill, Shell's plans for responding to a small spill (defined as 48 bbl or less), and Shell's WCD planning scenario. As explained in Section 2.10, Shell's categories of spill sizes are different from, but not incompatible with, those used by BOEM. The probability of a large (> 48 bbl) liquid hydrocarbon spill, is sufficiently small to conclude it would not occur during the proposed exploration drilling activities. Prudent planning and state and federal regulatory requirements nevertheless require that Shell have comprehensive spill prevention and response plans and capabilities in place. Shell's plans include measures to prevent any spill release from occurring and to respond in the event of a spill, including capabilities for responding to a "worst case" scenario release. In the unlikely event of a spill, implementation of Shell's OSRP would minimize the impacts from the spill and any effects on sediments. Response equipment and trained personnel would be available on site to deploy boom and recovery equipment for the control and removal of product spilled into the environment. Additionally, the procedures of Shell's FTP for fuel transfer between vessels would be utilized in accordance with BOEM lease stipulation No. 6, USCG requirements, and Shell's operating procedures.

As discussed in Sections 2.10 and 4.1.6 of this EIA, a small spill, such as a release of 48 bbl of diesel fuel, is the most probable type and volume of spill, if any, to occur as a result of EP Revision 2. Diesel is much lighter than water. It is therefore not possible for this oil to sink to the bottom and pool on the seafloor where it could contaminate sediments. Oil dispersed in the water column can adhere to fine-grained sediments that could then settle to the seafloor. However, this is more probable in nearshore areas with high suspended sediment loads (NOAA 2006). This would not be expected to occur in offshore waters of the Chukchi Sea, where evaporation and dispersion are rapid, and suspended sediment loads are low (1 to 5 ppm, Feder 1994b). Suspended sediments from drilling waste discharges would occur much lower in the water column than a surface diesel spill and would be unlikely to entrain the hydrocarbons if such a release were to occur near the drilling unit. A small spill would have a short duration, with over 99 percent of the diesel evaporated or dispersed within 48 hr. Diesel that was to reach the seafloor through adsorption and deposition would be degraded naturally by microbes within a period of one to two months (NOAA 2006). Given the temporary duration of any impacts, a release of 48 bbl of diesel would be expected to have negligible effects on seafloor sediments in the Burger Prospect area.

Conclusion

The seafloor impacts associated with drilling unit mooring and MLC construction associated with Shell's exploration drilling activities as described in EP Revision 2 are expected to be negligible. The impacts from drilling wastes on seafloor sediments are localized but intermediate term due to enrichment of heavy metal concentrations in a small portion of the Chukchi Sea seafloor at levels typically found to have little or no ecological effect, and expected to be ameliorated within a few years by the dispersion of these deposited materials by ice gouging and currents. Therefore, the level of effect of drilling waste on seafloor sediments is expected to be minor. The level of effect for impacts of a small liquid hydrocarbon spill on seafloor sediments of the Burger Prospect is deemed to be negligible. Overall, based on significance thresholds and level of effect definitions determined by BOEM (BOEM 2011a) and analysis provided in Section 4.3, impacts associated with Shell's proposed activities in EP Revision 2 are not significant and will have minor impacts on seafloor sediments and not degrade the marine environment.

4.4 Impacts on Lower Trophic Organisms

EP Revision 2 exploration drilling activities that could result in direct or indirect environmental impacts on lower trophic organisms in proximity to the Burger Prospect include: sediments displaced during anchoring of vessels and drilling rigs, construction of MLCs, permitted discharges through the NPDES exploration facilities GP, or a small liquid hydrocarbon spill during vessel refueling. Sound energy generated by ice management, exploration drilling, and ZVSP surveys could also affect lower trophic organisms. In general, the analysis of impacts on lower trophic organisms for the exploration drilling activities in EP Revision 2 does not differ substantively from the analysis in EIA EP Revision 1; the key changes are drilling unit mooring and MLCs and drilling waste discharge.

Lower trophic level communities present in the Burger Prospect include phytoplankton (including epontic organisms), zooplankton, and benthic organisms (including hard-bottom communities). Lower trophic level organisms provide much of the diet for fish, birds, and marine mammals in the Alaskan Chukchi Sea. Plankton and marine invertebrates are found in the Chukchi Sea in various stages of their life cycles while drifting in ocean currents. Their abundance and distribution depends largely on physical factors such as wind, currents, turbidity, nutrient availability, and light along with ecological attributes such as competition and predation. The planktonic and benthic communities recorded in the Burger Prospect during baseline studies are typical of those found across large areas of the Chukchi Sea. No especially sensitive or unique benthic communities are known to occur within or near the Burger Prospect. Further information on lower trophic organisms found in the Chukchi Sea are discussed in Section 3.4 along with site-specific information on their abundance and distribution within Shell's Burger Prospect (Tables 3.4.2-2, 3.4.3-2, and 3.4.3-3).

BOEM established a significance threshold and definitions for levels of effect for lower trophic organisms (BOEM 2011a). The threshold and definitions below are excerpted from Appendix B of BOEM's (2011) EA of Shell's EP Revision 1.

Significance Threshold

- Adverse impact that results in a decline in abundance and/or change in distribution requiring three or more generations for the indicated population to recover to its former status.

Level of Effects

Negligible

- No measurable impacts. Population-level effects are not detectable.
- Localized, short-term disturbance or habitat effect experienced during one season that is no anticipated to accumulate across multiple seasons.
- No population level impacts to reproductive success or recruitment are anticipated.
- Mitigation measures are implemented fully and effectively or are not necessary.

Minor

- Population-level effects are not detectable.
- Widespread annual or chronic disturbances or habitat effects anticipated to accumulate across 1 year, or localized effects that are anticipated to persist for more than 1 year.
- Mitigation measures may be implemented on some, but not all, impacting activities, indicating that some adverse effects are avoidable.
- Unmitigatable or unavoidable adverse effects are short-term and localized.

Moderate

- Disturbances could occur, but not on a scale resulting in population-level effects
- Widespread annual or chronic disturbances or habitat effects could persist for more than 1 year and up to a decade
- Widespread implementation of mitigation measures for similar activities may be effective in reducing the level of avoidable adverse effects
- Unmitigatable or unavoidable adverse effects are short-term and widespread, or long-term and localized

Any impacts of Shell's EP Revision 2 on lower trophic organisms will be limited to a relatively small portion of the Chukchi Sea. Furthermore, lower trophic resources are widespread, and any effects would be temporary given the short generation times of planktonic organisms, including epontic organisms and the ability of benthic organisms, including hard-bottom communities to re-colonize. As presented in the analyses below, Shell has concluded that the overall potential effects on lower trophic organisms from the exploration activities as described in EP Revision 2 would be minor (Table 4.4-1).

Table 4.4-1 Potential Effects of Shell's Exploration Drilling Program on Lower Trophic Organisms

Resource / Analyzed Activity	EP Revision 2
Lower Trophic Organisms (overall)	Minor
From drilling and ice management sound	None
From ZVSP survey sound	Negligible
From Drilling Unit mooring and MLCs	Minor
From drilling wastes	Minor
From other permitted discharges	Negligible
From small liquid hydrocarbon spills	Negligible

4.4.1 Impacts of Drilling and Ice Management Sound on Lower Trophic Organisms

No impacts on lower trophic organisms due to exposure to sound energy generated by exploration drilling, ice management, or vessel traffic are anticipated. Phytoplankton species are characterized by having relatively resistant unicellular structures (Harris 1986). Studies on euphausiids and copepods, which are some of the more abundant and biologically important groups of zooplankton in the Chukchi Sea, have documented the use of hearing receptors to maintain schooling structures (Wiese 1996) and detection of predators (Hartline et al. 1996; Wong 1996) respectively, and therefore have some sensitivity to sound. However, the intensity of sound energy required to negatively impact zooplankton is much greater than that which will be generated by Shell's planned exploration drilling activities.

Expected received levels with distance from these activities are presented in Table 2.9-1. Drilling itself is expected to generate sound levels up to 185 dB at the drilling unit, but received sound levels from drilling which would be reduced to 160 dB within <11 yd (<10 m) and to 120 dB within 0.9 mi (1.5 km). Greater sound levels are produced when drilling with the MLC bit, which generates sound levels that would be reduced to 160 dB within 78 yards (yd) (71 m) and to 120 dB within 5.1 mi (8.2 km).

Vessels engaged in ice management will generate sound levels up to 196 dB at the vessel. These levels would be reduced to 160 dB within 66 yd (60 m), and to 120 dB within 6.0 mi (9.6 km). Anchor handling is the loudest with received levels of sound of 120 dB likely being experienced out to distances of 8.7 mi (14 km).

The effect of drilling sound on zooplankton has not been studied; however, the effect of other types of underwater sound, such as seismic airgun arrays, has been investigated. Based on these studies, it is expected that sound energy generated by exploration drilling and ice management will have no impact on benthic invertebrates.

Sound energy generated by exploration drilling and ice management will have less impact on benthic invertebrates than described in Section 4.4.1 for seismic surveys as these drilling and related activities produce lower sound energy levels (Burns et al. 1993). Sound energy generated by exploration drilling activities and ice management will likely have no impact to zooplankton because these received sound levels will be at lower levels than that generated from seismic equipment (Burns et al. 1993) and would be expected to have no effect on lower trophic organisms.

4.4.2 Impacts of ZVSP Survey Sound Energy on Lower Trophic Organisms

Sound energy generated by airguns associated with the ZVSP survey would be expected to have little or no impact on plankton or benthic invertebrates. Bodies of marine invertebrates are generally the same density as the surrounding water so that sudden changes in pressure, such as that caused by sudden loud sound, are unlikely to cause physical damage. Some research has been done evaluating potential effects of sound energy generated by larger airguns associated with seismic surveys on marine invertebrates (e.g., crabs and bivalves) and other marine organisms (e.g., sea sponges and polychaetes). Studies on brown shrimp in the Wadden Sea (Webb and Kempf 1998) have revealed no particular sensitivity to sounds generated by airguns used in seismic activities with sound levels of 190 dB rms at 3.3 ft (1.0 m) in water depths of 6.6 ft (2.0 m). According to reviews by Thomson and Davis (2001) and Moriyasu et al. (2004), seismic survey sound pulses have limited effect on benthic invertebrates, and observed effects are typically restricted to animals within a few meters of the sound source. A recent Canadian government review of the impacts of seismic sound on invertebrates and other organisms (CDFO 2004) included similar findings. This review noted "there are no documented cases of invertebrate mortality upon exposure to seismic sound under field operating conditions." (CDFO 2004) Some sublethal effects (e.g., reduced growth, behavioral changes) were noted (CDFO 2004).

However, no appreciable adverse impact on planktonic or benthic populations would be expected due in part to large reproductive capacities and naturally high levels of predation and mortality of these populations. This is consistent with BOEM's (MMS 2007b) conclusions that the effect of seismic exploration on benthic organisms probably would be very low and not measurable (MMS 2007b). Effects on lower trophic organisms from operation of the airguns associated with ZVSP survey are not expected to result in measureable impacts, and therefore would be expected to be negligible.

4.4.3 Impacts of Drilling Unit Mooring and MLCs on Lower Trophic Organisms

Direct disturbance of the seafloor from the setting and removal of anchors during mooring of the drilling units and from the construction of MLCs will affect seafloor sediments, thus having an impact on lower trophic organisms and their habitat. No impacts on planktonic organisms are anticipated as a result of drilling unit mooring or MLC construction. Many species of benthic organisms are sedentary and have little or no mobility, and are therefore sensitive to habitat disturbance. Benthic organisms within the area directly affected by MLC construction, excavation and anchor mooring would likely be decimated due to the weight and force of the anchors and MLC drill bit or subsequent displacement.

Over the duration of EP Revision 2 (up to six wells), benthic habitat on the Chukchi Sea seafloor would be impacted by drilling unit mooring and MLC construction by a total of 4.01 to 5.28 ac (16,158 to 21,354 m^2), depending on whether MLC construction is done by drill bit or by MLC ROV system. The MLC ROV system results in a higher level of seafloor disturbance. The seafloor area of lower trophic benthic habitat that would be directly disturbed by mooring and MLC construction would be small, as it represents less than 0.0000038 to 0.0000047 percent of the seafloor of the Chukchi Sea. Re-colonization by lower trophic benthic communities could take a number of years. Seafloor severely disturbed by ice gouging in the high Arctic have been found to be largely re-colonized within eight to nine years (MMS 2007b). As part of the ecosystem based CSESP, there have been several sampling surveys of the benthic ecology which indicate high density and biomass but characterized by species found throughout the North Pacific region and the Bering and southeastern Chukchi Seas (Blanchard and Knowlton 2013). There do not appear to be particularly sensitive benthic populations on the Burger Prospect, and benthic surveys during 2008 – 2012 indicate that the average density of microfauna found on the Burger Prospect is higher than on two adjacent prospects (Blanchard and Knowlton 2013a,b). Material discharged from the seafloor during mooring and MLC construction would be similar in composition to naturally-occurring seafloor sediments, and its contribution to turbidity from waves and currents would be about the same as the sediments existing at the seafloor surface before drilling activities (BOEM 2012).

In sum, drilling unit mooring and MLC construction impacts on lower trophic benthic resources would be localized (not widespread) and short-term during a short drilling season, and impacts would not be chronic or population-wide. (EP Revision 2 anchoring and MLC construction would occur only a few days out of the drilling season which would start on or around 4 July and end on or around 31 October.) Based on BOEM's (2011) definitions of level of effect on lower trophic, the impacts from mooring and

MLCs on lower trophic organisms would be minor given the small total area of direct seafloor disturbance and with re-colonization of benthic organisms in that small area taking a few years.

4.4.4 Impacts of Drilling Wastes on Lower Trophic Organisms

Discharges of water based drilling fluids and drill cuttings produce effects similar to seafloor disturbances, although bentonite clays in drilling fluids flocculate upon mixing with seawater and settle more quickly than disturbed seafloor sediments (Neff 2005; BOEM 2012). Drilling fluids and cuttings discharges generally disperse in water into an upper plume and a lower plume. The upper plume contains about 10 percent of the mass of drilling fluid solids (Neff 2005), consists of very fine particles and soluble material, and is important in contributing to water quality impacts. Dispersion of particles in the upper plume is influenced by particle size, ambient current velocities, and release depth. The lower plume contains the majority (90 percent) of discharged material and is considered to be the more important regarding possible impacts on the benthos.

Impacts on Benthic Organisms

Most benthic invertebrates are sedentary or are relatively non-mobile. Benthic organisms near the discharge locations will therefore be exposed to suspended sediments in the water column temporarily, but to the cuttings and drilling fluids that are deposited on the seafloor for a number of years depending on the depth of deposition. The primary effects of exploration drilling waste discharges on benthic organisms will be smothering by the deposition of these materials, change in predator/prey relationships within benthic communities (habitat modification), and the possibility of long-term biological effects caused by toxicity of the drilling fluids and/or cuttings constituents (EPA 2006b). Additional effects include redistribution of seafloor materials and increased particulate matter suspended in the water. The suspended particles would be carried by currents away from the site, and be greatly diluted in the down current waters.

There is relatively little information on the effects of various deposition depths on arctic biota (Dunton et al. 2003; Hurley and Ellis 2004); most such studies have investigated the effects of deposition of dredged materials (Wilbur 1992). Burial depths as low as 1.0 in. (2.54 cm) have been found to be lethal for some benthic organisms (Wilbur 1992; EPA 2006b). The seafloor areas predicted by the OOC model to experience accumulations of deposited drill cuttings, drilling fluids, and cement, to various thicknesses, at a single well, are presented in Table 4.3.2-1. The maximum deposition thickness of 75 to 91 in. (190 to 230 cm), depending on whether the MLC bit or MLC ROV system is used for MLC construction, occurs within about 22 to 98 ft (10 to 30 m) of the discharge location. Deposition thickness is $\leq$ 0.4 in. (1.0 cm) beyond 623 to 1,690 ft (190 to 515 m) from the discharge location (Fluid Dynamix 2014a,b,c,d).

Accumulations of cuttings and drilling fluids on the seafloor from the other Burger wells would be similar as the wells are of similar depth and design. A total of about 5.4 to 32.6 ac (2.2 to 13.2 ha) of seafloor within the Chukchi Sea would be expected to experience accumulations of $\geq$ 0.4 in. ($\geq$ 1.0 cm) when all six wells in the EP are drilled. This represents less than 0.000011% to 0.000024 percent of the seafloor of the Chukchi Sea.

A 2008 investigation (Trefry and Trocine 2009) of the drill site for the historic Hammerhead well, which was drilled in the U.S. Beaufort Sea in 1985, revealed no substantive differences between the benthic community found at the site and benthic communities at other locations in that area of the Beaufort Sea. This time period represents a known maximum. Re-colonization in the Chukchi Sea will probably occur in a similar or shorter time period.

Neff et al. (2010) determined the concentrations of metals and various hydrocarbons in sediments at the historic Burger and Klondike wells in the Chukchi Sea, which were drilled in 1989-1990. Surface and subsurface sediments collected in 2008 at the historic drill sites contained higher concentrations of all types of analyzed hydrocarbon in comparison to the surrounding area. The same pattern was found for the metal barium, with concentrations 2 to 3 times greater at the historic drill sites (means = 1,410 µg and 1,300 µg) than in the surrounding areas (639 µg and 595 µg). Concentrations of copper, mercury, and lead were elevated in a few samples from the historic drill sites where barium was also elevated. All observed concentrations of hydrocarbons or metals in the sediment samples from the historic drill sites were below levels (ERLs) of Long et al. (1995) believed to have adverse ecological effects (Neff et al. 2010).

Similarly, Trefry et al. (2014) found that metals varied throughout the Lease Area due to natural variation in sediment texture and grain size and were generally shown to be consistent with naturally occurring levels. A few exceptions were from surveys around two historical (1989) exploratory oil and gas drill sites showing elevated barium concentrations within 200 m of one drill site relative to background values. Elevated concentrations of copper, mercury, lead, and zinc also were found in sediments from 3–4 stations within 200 m of the same two drill sites. At the sites tested, sediments in the Lease Area were essentially unaffected with respect to trace metals of anthropogenic origin, excluding small areas nearby drilling sites.

Fox et al. (2014) tested seawater, sediments, and faunal samples at 58 stations near sites of old exploratory wells. Also sampled were random reference sites within a 56 km (34.8 mi) grid surrounding the drill sites to understand natural environmental background levels. They found no meaningful statistical differences in mercury in water or sediments between the samples collected. Faunal samples tested included amphipods, clams, snow crab, and Arctic cod. Laboratory results showed minimal evidence of elevated mercury or biomagnification when compared to background mercury levels within this range of organisms (Fox et al. 2014).

The NPDES exploration facilities GP limits discharges offshore Alaska to a low level of toxicity. The EPA has determined that exploration drilling discharges are expected to comply with marine water quality criteria outside of a 330 ft (100 m) area around an exploration drilling discharge point in the Chukchi Sea (EPA 1985; EPA 2006b). Despite this zone of potential water quality impacts from discharges, there is no evidence of the effects on lower trophic-level organisms. Studies by Neff (1991) indicated drilling fluid had no effect on plankton, and studies in the 1980s, 1999, 2000, and 2002. MMS (2003a) also found that benthic organisms near historical drill sites in the Beaufort Sea have accumulated neither petroleum hydrocarbon nor heavy metals, except for barium.

Modeling (Shell Global Solutions 2009) of discharges associated with Shell’s exploration drilling activities as described indicate that there will be some increases in metal concentrations in the sediments but that these are below levels that cause measurable environmental effects (see discussion in Section 4.3.2 and Table 4.3.2-3). The predicted increases in concentrations of metals will likely be evident for a number of years until gouged by ice, redistributed by currents, or buried under natural sedimentation. These data show that the potential accumulation of heavy metals in discharged drilling fluid accumulations on the Chukchi Sea seafloor associated with drilling exploration wells is very limited and does not pose a threat. In summary, impacts of the discharge of drill cuttings and drilling fluids on benthic organisms will be minor given that they would be restricted to a very small area in the Lease Sale 193 Area, will not result in “undue degradation” of the marine environment, and re-colonization will occur over a time period of a few years.

Impacts on Planktonic Organisms

The discharges could potentially impact phytoplankton by increasing TSS loads in the water column and increasing turbidity. Blockage of sunlight to lower depths could then reduce photosynthesis resulting in lower growth rates in phytoplankton. Any such effects will be restricted to a small area forming an extremely small portion of the Chukchi Sea. Modeling of similar discharges indicates that TSS concentrations will be reduced to <100 ppm within about 328 ft (100 m) or less from the discharge (Shell

Global Solutions 2009). Plankton will not remain in this plume area for more than minutes or hours as the ocean currents will move them out of the plumes (Aldredge et al. 1986). Aldredge et al. (1986) studied the effects of drill cuttings and drilling fluids discharges on phytoplankton and found no reduction in photosynthesis. Reviews of existing information indicate little if any effect on phytoplankton (NRC 1983 in Neff 2005). Any reduction in photosynthesis or other effects on phytoplankton will be restricted to the area within 328 ft (100 m) of the discharge and will be temporary, lasting only minutes or hours after the discharge is complete.

Fine-grained particulates and other solids in drilling fluids and cuttings could cause sublethal effects to organisms in the water column. The responses observed following exposure to drilling fluids include alteration of respiration and filtration rates, and altered behavior. Zooplankton in the immediate area of discharge from exploration drilling operations could be adversely impacted by sediments in the water column, which could clog respiratory and feeding structures. Additionally, the zooplankton could suffer abrasions. Fine grained particles and other solids from drilling fluids and cuttings would likely result in short-term impacts and not likely affect population levels of zooplankton.

Toxicity of drilling fluids may also potentially impact zooplankton. In a study of crab and mysid larvae subjected to lignosulfonate drilling fluids, Neff (2005) observed that the larvae stopped swimming at low levels of toxicity; however, Shell will not be using lignosulfonate muds. Planktonic and larval forms are generally the most sensitive of organisms found in Alaska that have had acute lethal bioassays done following exposure to water based drilling fluid. Not all of these organisms have shown sensitivity to short-term exposure to drilling fluid (Tornberg et al. 1980).

EP Revision 2 includes the addition of 28 drilling fluid components. Some of these are base fluid additives and others are contingency products that may be used depending of conditions encountered. Measured toxicity of these components is provided in Table 4.4.1-1; by international standards (Table 4.4.1-2) these components are non-toxic with lethal concentration 50 (LC_{50}s) of over 100,000 ppm. Whole drilling fluids of various formulations of the drilling fluids to be used by Shell in the Chukchi Sea have also been texted for toxicity (M-I SWACO 2014). The KLA-SHIELD basic formula with various additives had acute 96 hr LC_{50}s of 302,000 to 500,000 ppm. A formulation of the abandonment fluid was found to have a 96-hr LC_{50} of 142,000 ppm (M-I SWACO 2014).

Table 4.4.1-1 Toxicity of Drilling Fluid Components

Generic Description	Product Name	96 hr LC_{50}S [1, 2]
Acrylic polymer	IDCAP D	>500,000
Shale/clay inhibitor	EMI-2009	>500,000
Biopolymer	Flowzan	>500,000
Zinc oxide	Sulf-X	117,275
Shale/clay inhibitor	KLA-STOP	345,008
Copolymeric shale stabilizer	POROSEAL	>500,000
Biocide	Busan 1060	>500,000
Vegetable, polymer fiber blend	MI SEAL	206,000
Cellulose fiber	MIX II Fine	>500,000
Cellulose fiber	MIX II MED	>500,000
Graphite	G-SEAL	>1,000,000
Calcium carbonate	SAFECARB-20	>1,000,000
Calcium carbonate	SAFECARB-40	>1,000,000
Calcium carbonate	SAFECARB-250	>1,000,000
Sodium chloride	stock product	178,000
Resinated lignite	RESINEX	>518,766
Sulfonated asphalt	ASPHASOL SUPREME	557,538
Mixture	FORM-A-BLOK	>500,000
Cellulose	FORM-A-SET AK	148,000
Mixture	Pipelax ENV WH	293,000
Mixture	LUBE 945	462,937
Mixture	CLEAN SPOT	161,600
Surfactant	SCREENKLEEN	>500,000
Mixture	SAFE-SCAV HS	>500,000
Hydrogen sulfide scavenger	SAFE-SCAV HS	>500,000
Oxygen scavenger	Sodium Metabisulfite	142,000

[1] Source: M-I SWACO 2014

[2] Method # 2 testing of maximum concentrations

Table 4.4.1-2 Toxicity Rating System (GESAMP 1997 as cited in Patin 1999)

Acute Toxicity [1]	
Rating	**48- to 96-hr LC_{50}S / EC_{50} (mg/L)**
(0) Non-toxic	> 1,000
(1) Practically non-toxic	100 to 1,000
(2) Slightly toxic	10 to 100
(3) Moderately toxic	1 to 10
(4) Highly toxic	0.1 to 1.0
(5) Very highly toxic	0.01 to 0.1
(6) Extremely toxic	<0.01

[1]GESAMP 1997 as cited in Patin 1999, based on system originally developed by International Maritime Consultative Organization (IMO / FAO / UNESCO / WMO / WHO / IAEA / UN / UNEP 1969). The system was recently updated by GESAMP.

Biocides will be used in the drilling fluids in some instances. Micro-organisms, primarily bacteria, build up naturally in untreated mud systems, and the bacteria break down various components of the drilling fluids degrading the drilling fluids. The biocide Busan 1060 has been added as a contingency drilling fluid component to the base fluids of the KLA-SHIELD Inhibited WBM, and as an additive for the abandonment fluids, that will be used to prevent this bacterial growth.

EPA (2008c) has concluded that this biocide is practically non-toxic to birds, slightly to moderately toxic to laboratory mammals, and practically non-toxic to moderately toxic to marine species (fish and invertebrates). A maximum of 0.4 pounds per barrel of Busan 1060 is planned for any water based fluid formulations. Shell's current drilling fluid plan (M-I SWACO 2014) contains the results of toxicity tests on 17 different water based drilling fluid formulations, all of which contain 0.4 lb/bbl of the biocide Busan 1060. Of the 17 tests, six of the fluids had LC50 values >500,000 ppm with the remaining 11 tests ranging between 91,800 ppm and 365,000 ppm.

EPA's NPDES exploration facilities GP requires operators to use drilling fluids have an LC50 value greater than 30,000 ppm and this must be verified and documented by laboratory testing. EPA (2012b) concluded in their Ocean Discharge Criteria Evaluation prepared for the NPDES exploration facilities GP, that such drilling fluids will not result in unreasonable degradation of marine waters, and this included an assessment of persistence and bioaccumulation of the drilling fluids and their components in the Chukchi Sea. The EPA further concluded that the discharges are not likely to affect species protected under the ESA which includes many of the marine mammal species in the area and several species of seabirds.

It should be noted that the toxicity tests referenced above are conducted on the types of organisms (adult and larval crustaceans, fish) that are generally considered to be most sensitive to potentially toxic chemicals, and are conducted with very low dilutions of the drilling fluids. Additionally, as described above in Section 4.2.1, both modeling and discharge monitoring studies have shown that discharged drilling fluids are diluted by magnitudes of 1,000 or more within a very short distance from the outlet and within a couple minutes of discharge when discharged at open ocean water environments within the range of water depths found at Shell's drill sites. At these dilutions there will be no effect on fish and wildlife.

Studies by the National Research Council (NRC 1983), EPA (2006b), and Neff (2005) indicated that although planktonic organisms are extremely sensitive to environmental conditions, such as temperature, light, availability of nutrients, and water quality, there is little or no evidence of effects from exploration drilling fluid discharges. Based on the available studies and information discussed above, discharges of drill cuttings and fluids associated with Shell's exploration drilling activities will have minor effects on phytoplankton.

4.4.5 Impacts of Other Permitted Discharges on Lower Trophic Organisms

The discharge of sanitary and domestic wastes from vessels and drilling units will have little to no effect on lower trophic organisms. Some changes in water quality, such as increases in TSS, BOD, and chemical oxygen demand will occur but will be limited to the area immediately adjacent to the discharge site due to rapid dilution and dispersion into the water column. Discharges of sanitary and domestic wastewaters will increase the amount of organic materials and nutrients in the water, which could result in a brief increase in primary productivity.

Discharge of non-contact cooling water, ballast water, desalination unit wastes, and deck drainage would also have minor effects on water quality such as changes in temperature, salinity, and pH. Effects would be minor due to the limited special extent and their short-term nature. These effects would largely be limited to the area within 328 to 656 ft (100 to 200 m) of the discharge location, and would not be expected to affect plankton or benthos in the area. Cooling water discharges will be only a few degrees above ambient and that difference will likely be reduced by 99 percent or more within 164 ft (50 m) of the discharge location. Some entrainment of meroplankton (larval fish and fish eggs) and zooplankton will occur in the intake, use, and discharge of seawater but entrainment effects would not be sufficient to result in a noticeable change in regional zooplankton or fish populations. Thus, these impacts are considered negligible and short-term, lasting less than one year.

Equipment used during Chukchi Sea activities, and potential bilge water releases of vessels passing through OCS waters could create potential for release of developmental stages of organisms that may survive in Arctic waters with the changes in climate and ice cover in recent years and future projections (Barber et al. 2009; Darnis et al. 2012). Under the United States ballast water management regulations 33 CFR 151 Subpart D, all vessels equipped with ballast water tanks must develop and maintain a Ballast Water Management Plan. In Alaskan waters, 33 CFR 151 requires that vessels traveling from international waters or from one COTPZ to another, undergo a mid-ocean exchange of ballast waters (or federally approved biocide or ozone) before entering the COTPZ to prevent exotic species from being brought from one ocean to another or into coastal waters. Shell's exploration drilling operations will be conducted in compliance with these regulatory mandates, which will minimize the risk of the introduction of exotic species and impacts to lower trophic resources. The potential for introducing exotic and invasive species through minor discharges such as bilge and ballast water are expected to be negligible. The vessels will be at various locations across the Chukchi Sea when in transit and on standby. The Chukchi Sea is a very large open water body of more than 230,000 mi^2 (595,697 km^2) and the Lease Sale 193 Area itself being 53,125 mi^2 (137,593 km^2). The ephemeral impacts associated with vessel discharges are generally limited to the area within 330 ft (100 m) of the vessel. Given the size of the Chukchi Sea and the distribution of the vessels, the increase in the number of support vessels will not appreciably increase the effect of discharges from the support vessels on the lower trophic organisms in the Chukchi Sea.

No significant impacts on lower trophic organisms will occur from discharges of deck drainage, cooling water, ballast water and bilge water from vessels associated with the exploration drilling activities described in EP Revision 2; all such impacts on lower trophic organisms will be negligible.

4.4.6 Impacts of a Small Liquid Hydrocarbon Spill on Lower Trophic Organisms

Section 2.10 of this EIA addresses the potential sources and types of a hydrocarbon spill, Shell's plans for responding to a small spill (defined as 48 bbl or less), and Shell's WCD planning scenario. As explained in Section 2.10, Shell's categories of spill sizes are different from, but not incompatible with, those used by BOEM. The probability of a large (> 48 bbl) liquid hydrocarbon spill, is sufficiently small to conclude it would not occur during the proposed exploration drilling activities. A small spill, such as a release of 48 bbl of diesel fuel, is the most probable type and volume of spill, if any, to occur. Over 99 percent of a small spill (diesel fuel) would evaporate (48 percent) or disperse (51 percent) within 48 hr. Prudent planning and state and federal regulatory requirements require that Shell have comprehensive spill prevention and response plans and capabilities in place. Shell's plans include measures to prevent any spill release from occurring and to respond in the event of a spill, including capabilities for responding to a "worst case" scenario release. In the unlikely event of a spill, implementation of Shell's comprehensive spill response plan would minimize the impacts from the spill and any effects on lower trophic organisms. Response equipment and trained personnel would be available on site to deploy boom and recovery equipment for the control and removal of product spilled into the environment. Additionally, the procedures of Shell's FTP for fuel transfer between vessels would be utilized in accordance with BOEM lease stipulation No. 6, USCG requirements, and Shell's operating procedures.

Petroleum has been shown to have a variety of effects on lower trophic organism ranging from sublethal to lethal. Lethal concentrations of hydrocarbons range from 0.05 to 10 ppm, with sublethal effects at concentrations of 1 ppm down to well below 0.05 ppm (NRC 1985). Lethality is dependent on exposure time, toxicity of the contaminant, and species and life stage of the organism at time of exposure (organisms at earlier life stages are more susceptible) (MMS 2003a). A study by Johansson et al. (1980) indicated that oil spills, or water that is chronically polluted, will affect zooplankton communities; however, the effects appeared to be short-lived. Due to large numbers, wide distribution, rapid regeneration, and high fecundity, communities of zooplankton are likely to recover from exposure to oil spills in open waters (MMS 2008a).

<u>Impacts on Planktonic Organisms</u>

Phytoplankton is found in the water column below the surface so dispersed and/or dissolved oil in the water column has the greatest potential of adversely affecting phytoplankton. Effects of petroleum on phytoplankton range from lethal to sublethal effects such as reduced photosynthesis or growth (Capuzzo 1987). At low concentrations, petroleum has been found to stimulate phytoplankton growth. Most effects have been revealed only in the laboratory with little evidence of effects in the ocean (Teal and

Howarth 1984). Johansson et al. (1980) monitored the effects of the large Tsesis oil spill and found that phytoplankton species composition was not changed by the spill and that the phytoplankton biomass and photosynthesis actually increased. Any acute effects on phytoplankton are generally temporary as phytoplankton regeneration can be as soon as 9 to 12 hr; this along with rapid replacement of phytoplankton from adjacent non-impacted waters would likely preclude any substantial effect on phytoplankton population levels resulting from exposure to oil spills (NRC 1985). Those that are killed after contact with the oil would be replaced quickly due to high reproductive rates (MMS 2008a).

Zooplankton species are more likely to suffer harmful effects from an oil spill than phytoplankton. Both lethal and sub-lethal effects could occur. Sub-lethal effects may include lower reproductive rates, depressed feeding, and changes in behavior. The level of effect depends upon the concentration of the oil, its toxicity, exposure time, and the life stage of the planktonic individual. If a spill were to occur during the summer months in high productivity areas where population levels of zooplankton are already high, it has been estimated that less than one percent of the zooplankton population in the Lease Sale 193 Area would be subject to lethal or sub-lethal effects (MMS 2008a). Johansson et al. (1980) observed zooplankton at spill sites and found that the communities were negatively affected, but the effects were short-term. It is expected that the zooplankton community would recover quickly from harmful effects because of the organism's large distribution, high reproductive rate, and short generation time.

Shell's pre-booming during refueling and other oil spill prevention measures will prevent any uncontrolled release of diesel fuel. Fate and transport information indicates that up to 99 percent of the released diesel fuel would either evaporate or be widely dispersed in the water column within 48 hr of release. Diesel fuel constituents dispersed or dissolved in the water column might affect phytoplankton, by decreasing photosynthesis: however, only a small area that would be affected by such a spill, any such impacts would be negligible. Impacts to phytoplankton would be temporary given the rapid dispersal of the petroleum and the short generation time of phytoplankton.

The scientific literature indicates measurable or long-term effects have not been observed even in the case of large oil spills. Diesel dispersed into the water column would likely have negative impact on zooplankton, including mortality and reduced growth and reproduction. Any such effects would involve a small fraction of the population. A small spill of diesel fuel would have little or no effect on benthic organisms as the diesel would be widely dispersed and found in low concentrations at the seafloor.

Mitigation measures will be in place that will reduce the probability of an uncontrolled release of 48 bbl of diesel fuel occurring, and minimize the environmental effects through containment and cleanup. Shell's FTP requires pre-booming prior to transferring fuel between vessels. Additionally, Shell's oil spill response equipment would be mobilized to contain and clean up any release that was to occur. Even at these levels for an uncontained release, the effects would be short-term and temporary, having a negligible impact on total lower trophic populations.

Impacts on Benthic Organisms

The acute effects of oil spills on offshore benthos have been little studied, perhaps because heavy oil contamination does not occur in these water depths. Kingston et al. (1995) reported little evidence of impact on infaunal macrobenthos five months after the Braer oil spill occurred. A large oil spill would be expected to have an effect on benthic invertebrates, either from short-term exposure to high concentrations of oil or long-term exposure to lower concentrations of oil. Most of the harmful effects on benthic organisms from oil spills would occur where benthos comes into contact with oil that has been mixed into bottom sediments by waves (MMS 2008a). This would likely only occur in shallow water. The organisms most likely to come into contact with the oil, and thus most likely to suffer negative effects, are those that live in shallow water close to shore. The Chukchi Sea, however, does not have a productive intertidal zone because bottomfast ice prevents the colonization of benthic organisms at depths less than 6.6 ft (2 m). Organisms at depths greater than 6.6 ft (2 m) would have a substantially lower chance of coming in direct contact with oil.

Conclusion

Impacts to lower trophic resources will be limited to an extremely small portion of the Chukchi Sea, and the lower trophic resources are widespread; planktonic organisms have short generation times and benthic organisms can re-colonize. Some of Shell's exploration-related activities are expected to have a negligible impact on lower trophic organisms, including ZVSP survey sound, other permitted discharges, and a potential small liquid hydrocarbon spill. Other activities are expected to have a minor impact on lower trophic organisms, including drilling unit mooring and MLC construction and drilling wastes. Overall, based on significance thresholds and level of effect definitions for lower trophic resources determined by BOEM (BOEM 2011a) and analysis provided in Section 4.4, impacts associated with Shell's proposed activities in EP Revision 2 will not be significant and will have a minor impact on lower trophic resources.

4.5 Impacts on Fish and Essential Fish Habitat

EP Revision 2 activities that result in direct and indirect impacts on fish and essential fish habitat (EFH) include: seafloor disturbance by MLC construction, vessel traffic, sounds from drilling and ice management, sounds from the ZVSP survey, drilling waste, other permitting discharges, and a small liquid hydrocarbon spill. In general, the analyses of impacts on fish and EFH for the exploration drilling activities in EP Revision 2 do not differ substantively from the analysis in EIA EP Revision 1; the key changes are drilling unit mooring and MLCs and drilling waste discharge.

The species of fish that occur in the Lease Sale 193 Area are identified in Section 3.5. Fish species most likely to be within the Burger Prospect area during the drilling season are marine species, with the most abundant species being Arctic cod, saffron cod, Bering flounder, capelin, and sculpins. Spawning of most of the common marine fish species occurs under the ice during the winter (Craig 1984b). Shell's EP Revision 2 activities on the Burger Prospect are scheduled for the open water season and would not disturb the spawning habitat when ice covers the Burger Prospect. The following sections discuss potential effects of EP Revision 2 on fish and essential fish habitat.

BOEM has established a significance threshold and definitions for levels of effect for fish as part of BOEM's EA of Shell's EP Revision 1 (BOEM 2011a). The significance threshold and level of effects definitions below are excerpted from Appendix B of the EA:

Significance Threshold

- An adverse impact that results in a decline in abundance and/or change in distribution requiring three or more generations for the indicated population to recover to its former status

Level of Effects

Negligible

- No measurable impacts. Population-level effects are not detectable.
- Localized, short-term disturbance or habitat effect experienced during one season that is not anticipated to accumulate across multiple seasons.
- No mortality or impacts to reproductive success or recruitment are anticipated.
- Mitigation measures are implemented fully and effectively or are not necessary.

Minor

- Population-level effects are not detectable. Temporary, nonlethal adverse effects to some individuals.

- Widespread annual or chronic disturbances or habitat effects not anticipated to accumulate across 1 year, or localized effects that are anticipated to persist for more than 1 year.
- Low mortality levels may occur, measurable in terms of individuals or <1% of the local post-breeding fish populations.
- Mitigation measures may be implemented on some, but not all, impacting activities, indicating that some adverse effects are avoidable.
- Unmitigatable or unavoidable adverse effects are short-term and localized.

Moderate

- Mortalities or disturbances could occur, but not on a scale resulting in population-level effects.
- Widespread annual or chronic disturbances or habitat effects could persist for more than 1 year and up to a decade.
- Some mortality could occur but remains limited to a number of individuals insufficient to produce population-level effects.
- Widespread implementation of mitigation measures for similar activities may be effective in reducing the level of avoidable adverse effects.
- Unmitigatable or unavoidable adverse effects are short-term and widespread, or long-term and localized.

As presented in the analyses below, Shell has concluded that the potential effects on fish and EFH from the exploration activities as described in EP Revision 2 are not significant, and the overall effect of Shell's exploration drilling activities on fish and EFH will be minor (Table 4.5-1).

Table 4.5-1 Potential Effects of Shell's Exploration Drilling Program on Fish and EFH

Resource / Analyzed Activity	EP Revision 2
Fish and EFH (overall)	Minor
From vessel traffic	Negligible
From drilling sound	Negligible
From ZVSP survey sound	Negligible
From drilling unit mooring and MLCs	Minor
From drilling wastes	Minor
From other permitted discharges	Negligible
From small liquid hydrocarbon spills	Minor

4.5.1 Impacts of Vessel Traffic on Fish and EFH

Vessel traffic could potentially impact fish through the generation of underwater sound. There have been no documented cases of mortality to fish from vessel noise (Normandeau & Associates, Inc. 2012). Vessel traffic could, however, briefly disturb and displace fish. Fish have been shown to react when engine and propeller sounds exceeds certain levels (Olsen et al. 1983; Ona 1988; Ona and Godo 1990). Avoidance reactions have been observed in fish such as cod and herring when vessel sound levels were 110 to 130 dB (Nakken 1992; Olsen 1979; Ona and Godo 1990; Ona and Toresen 1988); however, others have reported that fish such as polar cod, herring, and capelin may be attracted to vessels (Rostad et al. 2006). Vessel sound source levels in the audible range for fish are typically 150 to 170 dB re 1 μPa/hertz (Hz) (Richardson et al. 1995a). In calm weather, ambient sound levels in audible parts of the spectrum lie between 60 to 100 dB re 1 μPa. Larval fish appear to have similar hearing ranges and behavioral startle responses to sound as do adults of the species (Hawkins and Popper 2012).

Sound energy levels associated with transit of support vessels as described in EP Revision 2 are provided in Table 2.9-4. Vessels in the exploration drilling activities, including those added as described in EP Revision 2, would be expected to produce levels of 170 to 180 dB when in transit but received sound levels would be reduced to 160 dB within 12 yd (11 m), and to 130 dB within 743 yd (680 m). Based on reported source levels for these types of vessels and ambient sound levels of 80 to 100 dB, there may be some avoidance by fish of the area near Shell's vessels when in transit. Any avoidance reactions will last only minutes longer than the vessel is at a location, and would be limited to a relatively small area (Mitson and Knudsen 2003; Ona et al. 2007). Cavitation of bubbles generated by vessel hull structures and vibrations from vessel pumps could result in barotrauma injury and mortality of epipelagic non-swimming and weak swimming fish life stages and fish prey (Hawkins and Popper 2012). Shell does not anticipate that fish at different life stages will be impacted significantly from the proposed drilling program or experience the type of impacts that Hawkins and Popper (2012) describe related to bubble cavitation.

No especially important spawning habitats are known to occur within the Lease Sale 193 Area. There are anadromous streams or intertidal and subtidal spawning areas that might be used by capelin or herring. Vessel traffic will occur in areas designated as EFH for salmon, Arctic cod, saffron cod, and opilio crab. Although vessel traffic will traverse EFH and could result in brief disturbance of fish, the vessel traffic would have no lasting effect on the habitat. Any impacts from vessel traffic on fish and fish habitat will be temporary, localized, and short-term. These vessels will be at various locations across the Chukchi Sea when in transit and on standby. The Chukchi Sea is a very large open water body of more than 230,000 mi^2 (595,697 km^2) and the Lease Sale 193 Area itself being 53,125 mi^2 (137,593 km^2). Given the size of the Chukchi Sea and the distribution of the vessels, and the available research indicating avoidance behavior is likely, the impacts of vessel traffic under EP Revision 2 on fish and EFH are localized and short-term without expected mortality, and therefore expected to be negligible.

4.5.2 Impact of Drilling and Ice Management Sound on Fish and EFH

Fish are known to hear and react to sounds and some use sound to communicate (Tavolga et al. 1981) and possibly avoid predators (Wilson and Dill 2002). Experiments have shown that fish can sense both the strength and direction of sound (Hawkins 1981). Primary factors determining whether a fish can sense a sound signal, and potentially react to it, are the frequency of the signal and the strength of the signal in relation to the natural background sound level.

Sensitivity of individual sound frequencies and the width of the frequency spectrum also varies depending on the species of fish, but the optimum range for most species is between infrasound <20 Hz (Sand and Karlsen 1986) and 700 Hz (Platt and Popper 1981; Buerkle 1968; Chapman and Hawkins 1973; Offut 1974). A few species have good hearing up to 2,000 Hz (Hawkins 1981). Fish such as mackerel, flatfish and some other bottom-living species, which do not have a swim bladder, have poorer hearing than species such as cod and herring, which have a well-developed swim bladder (Hawkins 1981). It has been shown that cod are most sensitive to sound in the frequency range 60 to 310 Hz (Chapman and Hawkins 1973), with maximum sensitivity at 160 Hz where the hearing threshold is about 80 dB re 1 μPa.

The level of sound at which a fish will react or alter its behavior is usually well above the detection level. Fish have been found to react to sounds when the sound level increased to about 20 dB above the detection level of 120 dB re 1 μPa (Ona 1988); however, the response threshold can depend on the time of year and the fish's physiological condition (Engas et al. 1993). In general, fish react more strongly to pulses of sound rather than a continuous signal (Blaxter et al. 1981), and a quicker alarm response is elicited when the sound signal intensity rises rapidly compared to sound rising more slowly to the same level.

Investigations of fish behavior in relation to vessel sound energy (Olsen et al. 1983; Ona 1988, Ona and Godo 1990) have shown that fish react when the sound from the engines and propellers exceeds a certain level. Avoidance reactions have been observed in fish such as cod and herring when vessels approached close enough that received sound levels were 110 to 130 dB (Nakken 1992; Olsen 1979; Ona and Godo 1990; Ona and Toresen 1988). However, other researchers have found that fish such as polar cod, herring, and capelin are often attracted to vessels (apparently by the sound) and swim toward the vessel (Rostad et al. 2006). Typical sound source levels of vessel sound in the audible range for fish are 150 to 170 dB re 1 μPa/Hz (Richardson et al. 1995a). In calm weather, ambient sound levels in audible parts of the spectrum lie between 60 to 100 dB re 1 μPa.

Popper et al. (2014) developed sound exposure guidelines based on the different ways fish detect sounds. Table 4.5-2 shows the guidelines developed for fish in relation to continuous sounds (Popper et al. 2014 as cited in BOEM 2015).

Table. 4.5-2 Sound Exposure Guidelines for Fish in Relation to Continuous Sounds[1,2]

Type of Animal	Mortality and potential mortal injury	Impairment			Behavior
		Recoverable injury	TTS	Masking	
Fish: no swim bladder (particle motion detection)	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Fish: swim bladder is not involved in hearing (particle motion detection)	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Fish: swim bladder involved in hearing (primarily pressure detection)	(N) Low (I) Low (F) Low	170 dB rms for 48 h	158 dB rms for 12 h	(N) High (I) High (F) High	(N) High (I) Moderate (F) Low
Sea turtles	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) High (I) Moderate (F) Low
Eggs and larvae	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low	(N) Moderate (I) Moderate (F) Low
Notes: rms sound pressure levels dB re 1 μPa. All criteria are presented as sound pressure even for fish without swim bladders since no data for particle motion exist. Relative risk (high, moderate, low) is given for animals at three distances from the source defined in relative terms as near (N), intermediate (I), and far (F).					

[1]For the most part, data in this table are based on knowing that fish will respond to sounds and their hearing sensitivity, but, there are no data on exposure or received leves that enable guideline numbers to be provided (as presented in BOEM 2015).

[2]For fish in relation to shipping and continuous noise from Popper et al., 2014. (as presented in BOEM 2015).

Ice management and anchor handling would be expected to produce the highest level of sounds associated with exploration drilling. Shell's ice management vessels are expected to generate sound levels up to 196 dB when breaking ice. These levels would be reduced to 160 dB within 66 yd (60 m), and to 120 dB within 6.0 mi (9.6 km). Anchor handling is the loudest with received levels of sound of 120 dB likely being experienced out to distances of 8.7 mi (14 km). The drilling units would be expected to generate sound levels up to 185 dB, which would be reduced to 160 dB within <11 yd (<10 m) and to 120 dB within 0.9 mi (1.5 km). Greater sound levels are produced when drilling with the MLC bit, which generates sound levels that would be reduced to 160 dB within 78 yd (71 m) and to 120 dB within 5.1 mi (8.2 km). Expected received levels with distance from these activities are presented in Table 2.9-1 (Austin et al. 2013).

Based on reported source levels and ambient sound levels of 80 to 100 dB, there may be some avoidance by fish of the area near the drilling units during drilling activity on the Burger Prospect, particularly around the anchor handlers and ice management vessels. Any avoidance reactions will last only minutes longer than the vessel is operating at that location or the unit is drilling, and would be limited to a relatively small area within a few miles of the vessel (Mitson and Knudsen 2003; Ona et al. 2007). No important spawning habitats are known to occur at or near the Burger Prospect. The impacts of sound from drilling operations and ice management on fish will therefore be localized, short-term with no population-level effects expected. Based on the significance thresholds and level of effects definitions adopted by BOEM (BOEM 2011a), the direct and indirect impacts of EP Revision 2 sound from the two drilling units, support vessels, and ice management on fish and essential fish habitat is expected to be negligible.

4.5.3 Impact of ZVSP Survey Sound on Fish and EFH

The potential effects of sound energy on fish are described above with regard to exploration drilling and ice management. Fish are known to hear and react to sounds and some use sound to communicate (Tavolga et al. 1981) and possibly avoid predators (Wilson and Dill 2002). Experiments have shown that fish can sense both the strength and direction of sound (Hawkins 1981). Primary factors determining whether a fish can sense a sound signal, and potentially react to it, are the frequency of the signal and the strength of the signal in relation to the natural background sound level.

Several effects and potential effects of airgun sound energy on fish have been identified and studied fairly intensively. The results of these studies, along with an assessment of the fish communities of the Chukchi Sea, indicates that the planned ZVSP surveys may affect individual fish within a few meters of the sound source but would have no population-level impacts (Moulton et al. 2005a; Thomson and Davis 2001).

There is some evidence indicating that releases of energy from airguns can damage eggs and fry of some fish. Eggs and larvae of some fish may apparently sustain sublethal to lethal effects if they are within very close proximity to the seismic-energy-discharge point. These types of effects have been demonstrated by some laboratory experiments using single airguns (e.g., Kosheleva 1992; Matishov 1992; Holliday et al. 1987), while other similar studies have found no significant increases in mortality or morbidity due to airgun exposure (Dalen and Knutsen 1986; Kostyuvchenko 1973). The effects, where they do occur, are apparently limited to the area within 3 to 6 ft (1 to 2 m) from the airgun-discharge ports. In their detailed review of studies on the effects of airguns on fish and fisheries, Dalen et al. (1996) concluded that airguns can have deleterious effects on fish eggs and larvae out to a distance of 16 ft (5.0 m), but that the most frequent and serious injuries are restricted to the area within 5.0 ft (1.5 m) of the airguns. Despite these reports, many authors recommend that seismic surveys, which use much larger airgun arrays than ZVSP surveys, not take place in important spawning grounds when spawning is occurring. Most investigators and reviewers (Gausland 2003; Thomson and Davis 2001; Dalen et al. 1996) have concluded that even seismic surveys with much larger airgun arrays than are used for ZVSP surveys, would have no impact to fish eggs and larvae discernible at the population or fisheries level.

Airgun noises can affect fish at life history stages after the larval stage. Documented effects include benign behavioral responses, emigration, swim bladder rupture, damage to the ear, and death. Studies have shown that intense sounds can affect the auditory system of fishes or, within a few yards of the sound source, other tissues and organs such as swim bladders (Hastings et al. 1996; McCauley et al. 2003; Cook 2005). Seismic surveys using airguns have been found to disturb and displace fishes and interrupt feeding (Pearson et al. 1992), although information suggests that displacement may vary among species, depending on life history strategies (demersal vs. pelagic). Research shows both benthic and pelagic fish exhibit a startle response (McCauley et al. 2000; Wardle et al. 2001); while this response is not harmful to fish, many pelagic fish typically leave the survey area during seismic surveys (Løkkeborg and Soldal 1993, Engas et al. 1996). Studies of the effects of sound on caged or confined fish showed that fish moved away from the sounds and swam faster during the seismic energy test. Fish behavior returned to a pre-exposure state within 30 min after completion of the test. These studies suggest that fish will respond to acoustic energy, but that behavioral changes will be temporary.

Popper et al. (2014) developed sound exposure guidelines based on the different ways fish detect sounds. Table 4.5-3 shows the guidelines developed for fish in relation to seismic airguns (Popper et al. 2014 as cited in BOEM 2015).

Table. 4.5-3 Sound Exposure Guidelines for Fish in Relation to Seismic Airguns[1,2]

Type of Animal	Mortality and potential mortal injury	Impairment			Behavior
		Recoverable injury	TTS	Masking	
Fish: no swim bladder (particle motion detection)	>219 dB SEL_{cum} or >213 dB peak	>216 dB SEL_{cum} or >213 dB peak	>>186 dB SEL_{cum}	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: swim bladder is not involved in hearing (particle motion detection)	210 dB SEL_{cum} or >207 dB peak	203 dB SEL_{cum} or >207 dB peak	>>186 dB SEL_{cum}	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: swim bladder involved in hearing (primarily pressure detection)	207 dB SEL_{cum} or >207 dB peak	203 dB SEL_{cum} or >207 dB peak	186 dB SEL_{cum}	(N) Low (I) Low (F) Moderate	(N) High (I) High (F) Moderate
Sea turtles	210 dB SEL_{cum} or >207 dB peak	(N) High (I) Low (F) Low	(N) High (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
Eggs and larvae	>210 dB SEL_{cum} or >207 dB peak	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low

Notes: peak and rms sound pressure levels dB re 1 µPa; SEL dB re 1 µPa²·s. All criteria are presented as sound pressure even for fish without swim bladders since no data for particle motion exist. Relative risk (high, moderate, low) is given for animals at three distances from the source defined in relative terms as near (N), intermediate (I), and far (F).

[1] Data on mortality and recoverable injury from Halvorsen et al. (2011, 2012a,c) based on 960 sound events at 1.2 s intervals. TTS based on Popper et al. (2005). Note that the same peak levels are used both for mortality and recoverable injury since the same sound exposure levels (SELs) were used throughout the pile driving studies. Thus, the same peak level was derived (Halvorsen et al. 2011)(as presented in BOEM 2015).

[2] SEL is sound exposure level; TTS is temporary threshold shift For fish in relation to seismic airguns from Popper et al. (2014). Reproduced here with permission from the Acoustical Society of America (Publication ASA S3/SC 1.4 TR-2014), and A. Popper. Sept. 2014 (as presented in BOEM 2015).

The proposed ZVSP surveys would be conducted in offshore marine waters. Most of the important marine fish species in the Chukchi Sea spawn in the winter (e.g., Arctic cod, saffron cod, staghorn and fourhorn sculpins, Canadian eelpout, Arctic flounder, and sand lance) or spawn in shallow waters near the beach (e.g., herring, capelin) and have demersal or even adhesive eggs. The ZVSP surveys would take place in mid to late summer and, therefore, would not overlap with the spawning period of the aforementioned marine fish species. Overall, the proposed ZVSP surveys would be expected to have minimal effects on fish eggs and larvae, although a small number of eggs or larvae could be damaged. The effects would be short-term, lasting only minutes or hours after the ZVSP survey is concluded, and there would be no discernible population effects. Adult fish are more mobile and may avoid the area near the sound source. Based on the significance thresholds and level of effects definitions adopted by BOEM (BOEM 2011a) and this analysis, any effects on fish from the ZVSP surveys would be negligible.

4.5.4 Impacts of Drilling Unit Mooring and MLCs on Fish and EFH

There will be direct disturbance of the seafloor on the Burger Prospect from the setting and removal of anchors during mooring of the two drilling units and from the construction of MLCs. Although the Burger Prospect is included near areas of the Chukchi Sea designated as EFH for Arctic cod, saffron cod, and salmon, it is the EFH for Arctic cod that is located at the Burger Prospect. EFH could be affected by mooring and MLC construction because those activities would: (1) affect seafloor sediments on the Burger Prospect and alter seafloor relief; and (2) lower abundance or diversity of benthic organisms, some of which may be fish prey.

Dimensions of the seafloor impacts from drilling unit mooring and MLC construction are provided in Tables 2.3-1, 2.3-2, and 2.3-4 , respectively. Seafloor disturbance from mooring and MLC construction by drill bit or MLC ROV system for EP Revision 2's six drill sites is presented in Table 4.3.1-1. Over the duration of EP Revision 2 (up to six wells), seafloor and benthic organisms on the Chukchi Sea seafloor would be impacted by mooring and MLC construction by a total of 4.01 to 5.28 ac (16,158 to 21,354 m^2), depending on MLC construction by drill bit or by MLC ROV system. The MLC ROV system will result in a higher level of seafloor disturbance.

The seafloor sediments are generally small-grained clays and silts and not suitable for spawning areas so drilling unit mooring and MLC construction would not cause population level effects. Some mortality of fish may occur due to decrease in benthic fish prey. Based on the significance thresholds and level of effects definitions adopted by BOEM (BOEM 2011a) and this analysis, any effects on fish and EFH from mooring and the construction of MLCs would be minor.

4.5.5 Impacts of Drilling Waste on Fish and EFH

Discharges of drill cuttings and drilling fluids could potentially impact fish through chemical or physical toxicological effects or through the alteration of fish habitats; however, any such impacts will be minimal in nature and short-term. The primary effect on fish habitat will be the deposition of drill cuttings and drilling fluids on the seafloor. This will occur at each drill site, all of which are located within Arctic cod EFH and relatively near areas of the Chukchi Sea designated as EFH for saffron cod and salmon. Deposition of these materials on the seafloor will:

- alter seafloor relief;
- change sediment consistency and grain size;
- increase concentrations of some metals in the sediment;
- decrease oxygen in the sediments (anoxia); or
- lower abundance or diversity of benthic organisms some of which may be fish prey.

These types of habitat effects may lower the value of the affected area as fish spawning or feeding habitat. The effects will largely be limited to the area where accumulations of the discharged materials are expected to exceed 0.4 in (1.0 cm). Modeling of the discharges indicates that accumulations of 0.4 in (1.0 cm) or more will be limited to the area within about 623 to 1,689 ft (190 to 515 m) down current of the discharge location, an area of approximately 2.6 to 5.5 ac (1.1 to 2.2 ha) for each well, and about 15.6 to 33.0 ac (6.3 to 13.5 ha) for all six wells in the EP (Fluid Dynamix 2014a,b,c,d). This represents less than 0.000011% to 0.000024% of the seafloor of the Chukchi Sea.

These areas of potential impact are within EFH for Arctic cod. Impacts on fish habitat would be minor because: 1) a very small area would be impacted, 2) existing seafloor sediments are generally small-grained clays and silts and not suitable for spawning areas, and 3) no especially productive fish habitats are known to be in the vicinity of the Burger Prospect. There are no substantial differences in the fish resources in the Burger Prospect area. Important spawning areas have not been identified in the Chukchi Sea, although gravelly areas along the coast are thought to be herring spawning areas. The only kelp beds identified in the northeastern Chukchi Sea are located along Peard Bay more than 100 mi (161 km) from Shell's Burger Prospect. Drill sites in the Burger Prospect are located more than 90 mi (145 km) from the nearest anadromous stream. Shallow hazards surveys (Fugro 1989a, b, 1990 a, b, c, d; GEMS 2009) indicate that surficial sediments at the drill sites range from mud to clay to gravelly clay. Impacts to the fish habitat would be restricted to very small areas of the Chukchi Sea seafloor but may be long-term due to the low energy of the system and few ice keel scours in the 143 to 150 ft (43.7 to 45.8 m) water depths found at Shell's drill sites.

Any toxic effects on fish and fish larvae present within a few feet of the discharge point would be expected to be due solely to the physical effects of suspended solids. Modeling of the cuttings and adhered drilling fluid discharges associated with Shell's exploration drilling activities indicates that suspended solids would be less than 100 ppm within 328 yd (300 m) of the discharge location, and that TSS concentrations would be near ambient levels at a distance of 0.6 mi (1.0 km). As discussed above regarding the effects of MLC construction, these suspended sediment loads are much lower than those reported to be harmful to fish. Material discharged during drilling and construction activities from the seafloor would be similar in composition to naturally-occurring seafloor sediments, and its contribution to turbidity from waves and currents would be about the same as the sediments existing at the seafloor surface before drilling activities (BOEM 2012). Excess cement discharged on the seafloor would also bury benthic habitat. Benthic fish would be exposed to total mercury and monomethyl mercury concentrations in surficial sediments from mercury-sulfide cuttings discharged to the seafloor (BOEM 2012). However, Fox et al. (2014) found no statistical differences in mercury in water or sediments in samples from 58 stations near sites of old exploratory wells in the Leased Area. The NPDES exploration facilities GP, under which the discharges will be authorized, limits the toxicity of drilling fluids (at end of discharge pipe) to a minimum 96-hr LC50 of 30,000 ppm. Recent toxicity testing of the drilling fluid system planned for EP Revision 2 shows a 96-hr LC50 of >500,000 ppm (M-I SWACO 2013). Both modeling and field studies have shown that discharged drilling fluids dilute, disperse and/or diffuse rapidly in receiving waters (Ayers et al. 1980a, 1980b; Brandsma et al. 1980; NRC 1983; O'Reilly et al. 1989; Nedwed et al. 2004; Smith et al. 2004; Neff 2005). Dilution rate is strongly affected by discharge rate; the NPDES exploration facilities GP limits the discharge of cuttings and fluids to 1,000 bbl/hr or less in water depths of 130 ft (40 m) or more. The EPA (2006a) modeled hypothetical 1,000 bbl/hr discharges of drilling fluids in water depths of 130 ft (40 m) in the Chukchi Sea and predicted a minimum dilution of 1,173:1 at 33 ft (100 m) from the discharge point. Modeling of similar discharges offshore of Sakhalin Island predicted a 1,000-fold dilution within ten min and 328 ft (100 m) of the discharge point. The EPA modeled a hypothetical 1,000 bbl/hr discharge of drilling fluids in waters of the Chukchi Sea ranging between 131 to 164 ft (40 to 50 m) in depth and predicted a minimum dilution of 600:1 at 330 ft (100 m) down-current from the discharge point (EPA 2012b). Drilling fluid discharges at Shell's drill sites will be pre-diluted with seawater at a rate of about 11 bbl/min.

In a field study (O'Reilly et al. 1989) of a drilling waste discharge offshore of California, a 56 yd^3 (43 m^3) discharged drilling fluids were found to be diluted 183-fold at 33 ft (10 m) and 1,049-fold at a distance of 328 ft (100 m) from the discharge point. Neff (2005) concluded that concentrations of discharged drilling fluids drop to levels that would have no effect within about two min of discharge and within 16 ft (5 m) of the discharge location. Demersal fish eggs could potentially be smothered if discharges occur in, and the discharged materials are deposited on a spawning area during the spawning period. Many of the most abundant marine fish species in the northeastern Chukchi Sea spawn under the ice during the winter and diadromous fish spawn in freshwater or brackish water near the shoreline. Therefore little or no effect on fish eggs would be expected.

In sum, the localized effects could extend for more than one season, with some temporary nonlethal adverse effects to some individuals but no population-level effects detectable. Based on the significance thresholds and level of effects definitions adopted by BOEM (BOEM 2011a) and this analysis, under EP Revision 2 the level of effects from drilling discharges on fish and EFH is not significant and minor.

4.5.6 Impacts of Other Permitted Discharges on Fish and EFH

The discharges of sanitary and domestic wastes will result in some changes in water quality, such as increases in turbidity, and biological and chemical oxygen demand. These changes would occur in the area immediately adjacent to the discharge site, but would be limited due to rapid dilution and dispersion into the water column. These waste streams are not hazardous (see, e.g., discussion above detailing characteristics of discharges) so impacts to fish, if any, would be temporary and short-term consisting largely of attraction or avoidance. Fish eggs and larval stages of fish would have continued exposure.

Discharge of non-contact cooling water, ballast water, desalination unit wastes, and deck drainage would also have minor effects on water quality such as minor changes in temperature, salinity, and pH. These effects would largely be limited to the area within 328 ft (100 m) of the discharge location, and would not affect fish in the area. Cooling water discharges will be only a few degrees above ambient and will likely reach temperatures very near ambient within about 33 to 820 ft (10 to 250 m) of the outfall (Fluid Dynamix 2014e,f). Some entrainment of juvenile and larval fish and fish eggs could occur in the intake. Entrainment effects would not be sufficient to result in a noticeable change in regional fish populations, given the limited number of ballast water exchanges, and the high natural mortality rates. Any effects of permitted vessel discharges on fish would be negligible and temporary lasting only minutes or hours after the discharge ceases, likely consisting only of displacement of adult fish and some entrainment of eggs and larvae.

A study by Verna (2014) revealed that coastal Alaska receives about 14 million metric tons of ballast water annually from 49 different ecoregions. Crude oil tankers in coastwise trade were identified as the dominant type of vessel traffic discharging ballast-water in Alaska coastal waters. With decreasing sea ice, new trans-arctic shipping routes would increase the potential for introduction of invasive species in northern seas (Smith and Stephenson 2013). Under the United States ballast water management regulations 33 CFR 151 Subpart D, all vessels equipped with ballast water tanks must develop and maintain a Ballast Water Management Plan. In Alaskan waters, 33 CFR 151 requires that vessels traveling from international waters or from one COTPZ to another, undergo a mid-ocean exchange of ballast waters (or federally approved biocide or ozone) before entering the COTPZ to prevent exotic species from being brought from one ocean to another or into coastal waters. Shell’s exploration drilling operations will be conducted in compliance with these regulatory mandates, which will minimize the risk of the introduction of exotic species and impacts to lower trophic resources. The potential for introducing exotic and invasive species through minor discharges such as bilge and ballast water are expected to be negligible.

As described in EP Revision 2, the numbers and total volume of these vessel discharges increase given the increase in the number of support vessels. However, these vessels will be at various locations across the Chukchi Sea when in transit and on standby. The Chukchi Sea is a very large open water body of more than 230,000 mi^2 (595,697 km^2) and the Lease Sale 193 Area itself being 53,125 mi^2 (137,593 km^2). The ephemeral impacts associated with vessel discharges are generally limited to the area within 330 ft (100 m) of the vessel. Given the size of the Chukchi Sea and the distribution of the vessels, the increase in the number of support vessels will not appreciably increase the effect of discharges on fish and EFH in the Chukchi Sea. The impact on fish and EFH from other permitted discharges from vessels associated with the exploration drilling activities will be localized and short-term, with no measurable population-level effects. Based on the significance thresholds and level of effects definitions adopted by BOEM (BOEM 2011a) and this analysis, under EP Revision 2 the level of effects from other permitted discharges on fish and EFH is not significant and negligible.

4.5.7 Impacts of a Small Liquid Hydrocarbon Spill on Fish and EFH

As discussed in Sections 2.10 of this EIA, a small spill, such as a release of 48 bbl of diesel fuel, is the most probable type and volume of spill, if any, to occur as a result of EP Revision 2 activities. Section 2.10 of this EIA addresses the potential sources and types of a hydrocarbon spill, Shell's plans for responding to a small spill (defined as 48 bbl or less), and Shell's WCD planning scenario. As explained in Section 2.10, Shell's categories of spill sizes are different from, but not incompatible with, those used by BOEM. The probability of a large (> 48 bbl) liquid hydrocarbon spill, is sufficiently small to conclude it would not occur during the proposed exploration drilling activities. Prudent planning and state and federal regulatory requirements nevertheless require that Shell have comprehensive spill prevention and response plans and capabilities in place. Shell's plans include measures to prevent any spill release from occurring and to respond in the event of a spill, including capabilities for responding to a "worst case" scenario release. In the unlikely event of a spill, implementation of Shell's comprehensive spill response plan would minimize the impacts from the spill and any effects on sediments. Response equipment and trained personnel would be available on site to deploy boom and recovery equipment for the control and removal of product spilled into the environment. Additionally, the procedures of Shell's FTP for fuel transfer between vessels would be utilized in accordance with BOEM lease stipulation No. 6, USCG requirements, and Shell's operating procedures.

In the unlikely event of a spill, implementation of Shell's comprehensive spill response plan would minimize the impacts from the spill and any effects on fish. Response equipment and trained personnel would be available and on site to deploy boom and recovery equipment for the control and removal of hydrocarbons spilled into the environment. Additionally, the procedures of Shell's FTP for fuel transfer between vessels would be utilized in accordance with BOEM lease stipulation No. 6, USCG requirements, and Shell's operating procedures.

The magnitude of the effects of a small spill, such as a fuel spill, would be determined by a combination of biological, physical, and chemical factors in the time of which the spill occurs. While adult finfish tend to avoid contaminated areas, the behavior may not be characteristic of all fish species in the Chukchi Sea. A fuel spill occurring within offshore waters can be expected to impact some fish eggs and larvae during any season (see discussion above on the expected low numbers of fish eggs expected to be present at drill sites during offshore exploration drilling operations); however, numbers of fish occurring are dependent on season. Diesel fuel spills are more critical for fish in the early life stages due to the toxicity threshold being at a lower level and eggs and larvae cannot avoid oiled waters. Fish assimilate hydrocarbons through their gills when exposed to water-soluble impediments but also ingest hydrocarbons by feeding on oil particles or contaminated prey. Observations at the Exxon Valdez oil spill in Prince William Sound revealed that free-swimming fish are rarely at risk from an oil spill. They typically move away from oil spilled areas, which explains why there has never been a commercially important fish-kill on record from an oil spill (MMS 1998). Similar behavior could be expected if the hydrocarbon were diesel fuel instead of crude oil.

Large numbers of fish eggs and larvae have been killed by liquid hydrocarbon spills. However, because fish typically produce eggs on an enormous scale and the majority of them die at an early stage by predation, even a high death toll caused by a spill has no detectable effect on adult populations. This was confirmed by the Torrey Canyon spill off England's coast and the Argo Merchant spill off of Nantucket, Massachusetts. In both cases, a 90 percent death rate in fish eggs and larvae did not have an impact on the future commercial fisheries of the area (Baker et al. 1991).

Seasons of low and high susceptibility to impacts can be defined for any species. Fuel spill impact levels are most affected by the timing and location of the spill. These two factors, along with winds and currents often shifting spill location, determine the extent of impacts. If a spill should occur, temporary effects can occur at 0.245 to 0.265 ppb such as reduced growth, lower feeding efficiency, and lower swimming speed. When concentrations were greater than 4.1 ppm or more, fish did not recover the ability to feed, even when transported to clean petroleum free water for 24 hr afterward. Chronic exposure levels to fish occurring at 0.50 to 0.100 ppm for 12 to 13 weeks severely affect respiration, osmoregulation, and resistance to disease. Impacts caused by petroleum spills are due primarily to absorption of the more soluble low molecular weight hydrocarbon components.

The probability and effect of small fuel spills occurring will be minimized by implementation of Shell's OSRP and such required measures as pre-booming before any over-water fuel transfer. Given the open ocean location of Shell's Burger Prospect, the duration of any small fuel spill, the opportunity for effect would be very brief. Over 99 percent of a small spill (diesel fuel) would evaporate (48 percent) or disperse (51 percent) within 48 hr. Adult fish would likely avoid the released oil; floating fish eggs or larvae exposed to the oil within 48 hr could be killed or be subject to decreased growth rates, developmental abnormalities, increased risk of disease or predation, and other physiological effects. Any such effects would be restricted to a small area for a brief period of time and would not have an impact on the fish population. Any impact on fish and EFH from a small fuel spill would be temporary with some mortality measurable in terms of individuals. Based on the significance thresholds and level of effects definitions adopted by BOEM (BOEM 2011a) and this analysis, under EP Revision 2 the level of effects from a small liquid hydrocarbon spill on fish and EFH is not significant and the level of effect would be minor.

Conclusion

Based on significance thresholds and level of effect definitions for fish and essential fish habitat determined by BOEM (BOEM 2011a) and analysis provided in this section, impacts associated with Shell's proposed activities in EP Revision 2 will have negligible to minor impacts on fish and EFH. The level of effect on fish and EFH of vessel traffic, sound energy from vessels, drilling sound, ZVSP survey sound, and other permitted discharges was determined to be negligible. Because the localized effects of drilling waste, drilling unit mooring and MLC construction, and a liquid hydrocarbon spill could extend for more than one season, with some temporary nonlethal adverse effects to some individuals but no population-level effects detectable, the level of effect on fish and EFH is analyzed to be minor. Thus, the overall level of effects of activities from EP Revision 2 on fish and EFH is not significant and minor.

4.6 Impacts on Birds

EP Revision 2 exploration drilling activities that could result in direct or indirect environmental impacts on marine and coastal birds in proximity to the Burger Prospect include: vessel presence and noise, air emissions, aircraft presence and noise, avian collisions with structures and vessels, drilling sound, ZVSP survey sound, drilling wastes discharges, other permitted discharges, and a small liquid hydrocarbon spill. In general, the analysis of impacts on birds for the exploration drilling activities in EP Revision 2 does not differ substantively from the analysis in EIA EP Revision 1. The key changes are increased vessel traffic and aircraft activity. Transit and operation of the drilling units and associated support vessels and ZVSP surveys could result in some temporary disturbance of birds found in the offshore waters due to the generation of sound and vessel movement. Aircraft (primarily helicopter) traffic between the Burger Prospect and shorebase could also disturb birds in offshore and coastal waters and onshore habitats along transit routes; however, any such effects would be greatly minimized by Shell's mitigation measures that include a minimum altitude of 1,500 ft (457 m) for support aircraft, unless engaged in marine mammal monitoring flights.

The abundance and distribution of bird species that utilize the Lease Sale 193 Area and adjacent coastal waters are discussed in Section 3.6. The number of species and the abundance of most species decreases offshore. Bird use of these offshore waters, where most of the activities planned in EP Revision 2 would occur, is discussed in Section 3.6.6. The results of baseline bird surveys conducted in the Burger Prospect area during 2008 to 2012 (Tables 3.6.6-1 through 3.6.6-4) supplement historical studies in the same area (Table 3.6.6-1). A total of 34 species of birds were observed in the Burger area during the baseline studies (Gall et al. 2013). The eight most commonly observed species during these surveys were red and red-necked phalaropes, northern fulmar, short-tailed shearwater, black-legged kittiwake, glaucous gull, thick-billed murre, least auklet, and crested auklet. Other species were present in relatively low numbers. The eight most commonly observed bird species and others occur in shallower waters between the prospect and the shoreline, and bird density is generally greater in these coastal waters.

During Shell's 2012 drilling program, some birds sought refuge on a vessel in inclement weather and rested on the vessel until continuing migration. In other cases, exhausted birds alighted on a vessel, but did not survive. BOEM calculated bird encounter rates based on the encounter reports from Shell's 2012 exploration drilling program. These rates may underestimate impacts in that some birds 1) could have struck a vessel but landed overboard and been lost at sea undetected, or 2) alighted, rested, and departed undetected (BOEM 2015). Not all encounters are fatal and, in some cases, crew assistance likely helped some birds survive. The rates are not an index, but simply an estimate of the number of birds encountering vessels during one open-water season. BOEM estimated that birds would encounter drillships at a greater rate (53 birds per season) than smaller support vessels (11 birds per season) (BOEM 2015).

Any disturbance effects would be short-term, lasting only minutes or hours after the vessel or aircraft left the area, and would be minor without demonstrable impact on bird populations. Collisions between birds and the drilling units or other vessels are expected to occur in low numbers due to the relatively low density of birds in the Burger Prospect area, and based on the timing of Shell's exploration drilling season. The potential for bird collisions will be minimized by Shell's mitigation measures, which include implementation of the Bird Strike Avoidance and Lighting Plan (Appendix E of EP Revision 2) that entails shading and minimizing use of high intensity lights on support vessels, following designated travel corridors, and other measures. Drilling unit mooring, MLC construction, air emissions associated with operation of the drilling unit and support vessels, and the expansion of the shorebase in Barrow would likely have no effect on birds. In the unlikely event of a small liquid hydrocarbon spill, birds using marine and coastal waters could suffer mortalities and morbidity depending on the direction of the oil slick, natural spill processes including evaporation and dispersion, and the effectiveness of the oil spill cleanup effort.

In BOEM's EA of Shell's EP Revision 1, BOEM defined a significance threshold and level of effects for impacts on birds (BOEM 2011a). These significance threshold and level of effect definitions are used in the Section 4.6 analyses.

Significance Threshold

- An adverse impact that results in a decline in abundance and/or change in distribution requiring three or more generations for the indicated population to recover to its former status

Level of Effects

Negligible

- Localized short-term disturbance or habitat effect experienced during one season that is not anticipated to accumulate across one year
- No mortality is anticipated
- Mitigation measures implemented fully and effectively or are not necessary

Minor

- Widespread annual or chronic disturbances or habitat effects not anticipated to accumulate across one year, or localized effects that are anticipated to persist for more than 1 year
- Anticipated or potential mortality is estimated or measured in terms of individuals or <1 percent of the local post-breeding population
- Mitigation measures are implemented on some, but not all, impacting activities, indicating that some adverse effects are avoidable
- Unmitigatable or unavoidable adverse effects are short-term and localized

Moderate

- Widespread annual or chronic disturbances or habitat effects anticipated to persist for more than one year, but less than a decade

Overall, the potential effects on birds from EP Revision 2 are determined to be minor (Table 4.6-1). Potential effects on T&E birds are discussed separately in Section 4.8; the potential effects of birds as subsistence resources are discussed separately in Section 4.11.

Table 4.6-1 Potential Effects of Shell's Exploration Drilling Program on Birds

Resource / Analyzed Activity	EP Revision 2
Birds (overall)	Minor
From aircraft traffic	Negligible
From vessel traffic	Negligible (disturbance), Minor (collisions)
From drilling and ice management sound	None
From ZVSP survey sound	Negligible
From air emissions	None
From mooring and drilling waste	Negligible
From other permitted discharges	Negligible
From small liquid hydrocarbon spills	Minor
From shorebase expansion	None

4.6.1 Impacts of Aircraft Traffic on Birds

Operating aircraft can disturb birds, with the potential to flush the birds or create increased movement (Derksen et al. 1992) with potential effects on energetics and body weight (Ward and Stehn 1989), alter habitat use (Belanger and Bedard 1989), or decrease productivity at nesting sites. These effects are thought to be of greatest impact at nesting colonies, or areas where the birds congregate for molting or staging before migration.

Aircraft Disturbance of Staging and Molting Birds

Owens (1977) found that wintering brant were disturbed by fixed-wing aircraft flights at altitudes of less than 1,641 ft (500 m) and lateral distances of less than 1.0 mi (1.4 km). Barry and Spencer (1976) reported that molting snow geese and white-fronted geese run from approaching helicopters, and that geese within 1.5 mi (2.5 km) of the aircraft were disturbed. Mosbech and Glahder (1991) reported that larger Bell 212 model helicopters caused reactions by molting emperor and pink-footed geese at distances possibly as great as 5.6 mi (9.0 km).

Ward and Stehn (1989) observed the responses of staging black brant, Canada geese, and emperor geese in Izembek Lagoon in western Alaska to incidental and experimental flights. Results of the study are summarized in Tables 4.6.1-1 and 4.6.1-2. These data indicate that responses of geese to aircraft are very brief, that geese within a distance of 1.2 mi (1.9 km) or more may be disturbed by helicopter traffic, and that the number of geese that respond generally decreases as altitude increases from 500 to 1,000 ft (152 to 305 m). Their analysis of disturbance patterns indicated that 45 to 50 disturbances per day would be required to prevent weight gain by the brant. Brant exhibited three general levels of response. When brant reacted to the stimulus, their initial response was a raised head and alert posture, followed by flight if stimulus continued. The flocks often returned to the same location if the stimulus passed rapidly. Bird flight responses to aircraft were observed in three increasing levels of flight duration; rise flights lasting an average of 21 sec, circle flights lasting an average of 90 sec, and departure flights lasting about 126 sec. Aircraft caused less response than other stimuli such as people on foot or vessels. The authors suggested that staging and wintering birds might be more tolerant of disturbance than flightless molting birds.

Table 4.6.1-1 Bird Responses to Aircraft Overflights, Izembek Lagoon, Alaska

Bird Species	Aircraft	Birds Responding [1] (percent)	Duration of Response [1] (seconds)	Birds in Flight [1] (percent)	Flight Duration [1] (seconds)
Black Brant	Single engine	52	131	38	82
	Twin engine	25	99	14	92
	Helicopter	57	266	39	93
Canada Geese	Single engine	29	108	9	68
	Twin engine	15	80	4	-
	Helicopter	31	93	8	92

[1] Source: Ward and Stehn 1989

Table 4.6.1-2 Birds Responding to and Flying in Response to Aircraft in Izembek Lagoon, Alaska

Aircraft Type	Aircraft Flight		Canada Geese [1]		Emperor Geese [1]		Black Brant [1]	
	LD [2]	ALT [2]	Response	Flight	Response	Flight	Response	Flight
Single engine	0-0.2	500	80	40	-	-	96	76
	0-0.2	1,000	39	1	75	63	72	41
	0.3-0.7	1,000	8	1	100	0	44	15
	0.8-1.2	1,000	11	11	100	0	25	3
Twin engine	0-0.2	500	31	0	73	0	79	32
	0-0.2	1,000	18	0	27	0	64	14
	0.3-0.7	1,000	22	12	100	0	39	6
	0.8-1.2	1,000	0	0	-	-	1	0
Helicopter	0-0.2	500	57	24	83	83	92	84
	0-0.2	1,000	31	4	83	37	90	74
	0.3-0.7	1,000	24	7	69	18	72	47
	0.8-1.2	1,000	7	5	98	50	38	15

[1] Source: Ward and Stehn 1989
[2] LD = lateral distance (to aircraft in mi)
[3] ALT = altitude (of aircraft in ft)

Derksen et al. (1992) studied the responses of molting black brant on the Alaska North Slope to 140 experimental overflights with a Bell 206 helicopter at altitudes of 500 to 5,000 ft (150 to 1,525 m). Responses of the flightless brant primarily included increased movement, with monitored birds in overflight areas moving at more than five times the rate of birds in control areas. Some response was noted as far as 2.1 to 2.5 mi (3.5 to 4.0 km) laterally from the aircraft The duration of responses to the helicopter overflight varied with altitude (Table 4.6.1-3) but was generally less than six min. There was no evidence of injury or mortality to the birds. The brant did not appear to habituate to the daily experimental flights. Owens (1977) and Madsen (1985) found the same to be true for helicopter disturbance of the pink-footed goose. Modeling and extrapolation of the study results led the authors to believe that helicopter flights in excess of 50 per day could result in weight loss to the birds that could affect their ability to successfully molt and migrate to a staging area.

Table 4.6.1-3 Response Time of Molting Brant to Helicopter Overflights

Altitude		Number of Overflights [1,2]	Average Duration of Response (sec) [1,2]
760 m	2,500 ft	131	325.4
455 m	1,500 ft	28	316.5
Landing	-	40	300.6
Take-off	-	54	204.4
610 m	2,000 ft	18	164.3
150 m	500 ft	22	157.5
305 m	1,000 ft	59	144.6
1,070 m	3,500 ft	3	100.7
915 m	3,000 ft	10	100.4
1,525 m	5,000 ft	6	10.7
1,220 m	4,000 ft	2	0.0

[1] Source: Derksen et al. 1992
[2] Observations recorded near Teshekpuk Lake, Alaska

These studies indicate that the effects of helicopter flights associated with Shell's exploration drilling activities would result in only minimal disturbance effects on a portion of the population of staging and molting waterbirds. Under EP Revision 2 the number of round trip crew change helicopter flights is expected to be up to 40 per week. The helicopter flights associated with the exploration drilling activities may have some disturbance effects on staging and molting birds, but, overall, the impact of such flights on staging and molting birds will consist of limited, brief behavioral responses, with no population effects. The number of flights is much lower than what research has indicated would be required to result in long-term physiological effects on the birds. The planned crew change flights would be at an altitude of 1,500 ft (457 m) or more. The research cited above (Table 4.6.1-2) suggests that overflights at these altitudes would evoke few responses. The flights are also along direct routes (Figure 2.2-2) that avoid areas noted as especially important for staging and molting, such as Peard Bay, Kasegaluk Lagoon, and Ledyard Bay (Table 4.6.1-4). Again some molting or staging birds may be disturbed by these flights but the effects would be temporary lasting only minutes, and resulting in negligible effects on the birds.

Table 4.6.1-4 Distances from Aircraft Flight Corridors to Colonies and Staging/Molting Areas

Cape Lisburne		Nearest Nesting Colony		Kasegaluk Lagoon		Peard Bay		Ledyard Bay	
mi	**km**	**mi**	**km**	**mi**	**km**	**mi**	**km**	**mi**	**Km**
184	296	29	47	67	107	27	44	64	103

[1] Based on flight corridor in Figure 2.2-2 and nesting colonies and other resources in Figure 3.6-1

Aircraft Disturbance of Bird Nesting Colonies

Bird nesting colonies can sometimes be disturbed by aircraft resulting in a loss of productivity (Carney and Sydeman 1999); adult birds flushed from nests can cause displacement of eggs and young from the nest and/or render eggs and young more vulnerable to predation and exposure to weather. However, studies indicate that these types of effects can be avoided if certain altitudes and distances are maintained.

Rojek et al. (2007) observed a relatively low level of disturbance from helicopters at a murre cliff colony and concluded aircraft at altitudes of >1,000 ft (>305 m) would not cause disturbance to breeding sea birds. Fjeld et al. (1988) reported that most aircraft flushing responses at murre colonies was limited to flights within 1.5 mi (2.5 km).

Gollop et al. (1974a) studied the reaction of similar small colonies of arctic terns, glaucous gulls, on spits in the Beaufort Sea and found these colonies / species resistant to displacement from helicopters, especially common eiders. Nesting common eiders exhibited no response to helicopters. The arctic tern was the most sensitive with 100 percent of nesting and non-nesting birds flushing in response to helicopters at altitudes of up to 1,000 ft (305 m), but no response to flights at 1,500 ft (457 m). A few non-nesting gulls flushed from overflights at 1,000 ft (305 m) but the number was not substantial. All observed flushing responses were brief with the birds returning within minutes. The helicopter flights were found to have no apparent effect on reproductive success.

The nearest large cliff-nesting bird colonies are located more than 184 mi (296 km) south of the flight corridors and will therefore not be affected by flights associated with the exploration drilling activities. Four small coastal bird colonies of common eiders, arctic terns, and horned puffins are located between Icy Cape and Barrow shoreward of the prospect area; however, these colonies are located more than 29 mi (47 km) from any planned aircraft corridors (Figure 2.2-2) for the crew changes (Table 4.6.1-4). These flights would there for have no effect on nesting colonies. Shell's minimum altitude requirement of 1,500 ft (457 m) would likely avoid all responses from nesting common eiders and most if not all responses from other species. Any responses that might occur would likely consist of alert postures, head bobbing, increased movement, and/or flushing, but any flushed birds would be expected to return to the nest within seconds or a few minutes.

Based on the significance thresholds and level of effects definitions adopted by BOEM (BOEM 2011a), this analysis, and Shell's mitigation measures (including its minimum altitude requirements of 1,500 ft [457 m]), under EP Revision 2, the impact from aircraft travel on birds, including staging and molting birds and nesting communities, is not significant and the level of effect would be negligible.

4.6.2 Impacts of Vessel Traffic on Birds

Vessel traffic could affect birds though disturbance and displacement of resting, feeding, or nesting birds or by collisions of birds with vessels, as described below.

<u>Avian Disturbance from Vessel Traffic</u>

Vessel traffic can disturb birds and temporarily displace foraging and resting birds. Some species, such as some gulls, are attracted to vessels. Disturbances from vessels are generally limited to the flushing of birds away from vessel pathways. Larger bird species generally have been found to have greater flushing distances and different types of vessels result in different flushing distances. For example, flushing distances for some waterbird species have been shown to be 66 to 164 ft (20 to 50 m) for personal watercraft and 75 to 190 ft (23 to 58 m) for an outboard-powered boat (Rodgers and Schwikert 2002). As a vessel passes an area, birds will likely move some distance away and then soon after continue on with foraging and resting. Disturbances from offshore vessel traffic are generally short-term, lasting only as long as the activity, and restricted to the immediate vicinity of the vessel. While there is some energetic cost associated with bird disturbance, the brief disturbance would have only negligible effect on birds and no effect on bird populations. Lacroix et al. (2003) investigated the effects of a marine seismic survey, including vessel traffic, on molting long-tailed ducks in the Beaufort Sea. The seismic program involved traffic of five vessels with lengths of 75 to 135 ft (23 to 41 m), as well as the use of airguns behind some of these vessels. The survey program was found to have no effect on the movements, diving behavior, or site fidelity of the ducks.

Potential for effects due to vessel incursion is greater near bird nesting colonies where disturbance could result in lowered productivity due to nest abandonment, direct loss of eggs or chicks, increases in predation rates on eggs and chicks, and effects in important habitats where birds are concentrated for feeding, molting, or staging. Rojek et al. (2007) observed the responses of common murres and Brandt's cormorants at a nesting colony in California to commercial fishing boats. Disturbance of these birds occurred when vessels approached within 660 ft (200 m) of the colony, but most such disturbance consisted of head-bobbing and other alert behaviors. Nearly all of the disturbances occurred when vessels approached within 330 ft (100 m) of the colony; 78 percent of the disturbance events occurred when vessels approached to a distance of 164 ft (50 m).

As described in EP Revision 2, Shell's planned exploration drilling activities in the Chukchi Sea involves two drilling units and a number of support vessels, and OSR vessels. As vessels pass an area, birds would likely move some distance away and then soon after, continue on with foraging and resting. Most vessel traffic would take place offshore in the vicinity of the drill sites; the Burger drill sites are more than 64 mi (103 km) from shore where bird densities are relatively low (Table 3.6.6-2). Bird species that will be most commonly encountered by vessels in offshore waters will likely be northern fulmars, short-tailed shearwaters, red and red-necked phalaropes, black-legged kittiwakes, glaucous gulls, thick-billed murres, least and crested auklets. If the vessel transits closer to shore, loons and waterfowl (long-tailed ducks, king eider, common eider) species are likely to be more commonly encountered. Disturbances from the vessel traffic will be short-term lasting only about as long as the activity, and would occur in the immediate vicinity of the vessel and therefore a very small portion of the Chukchi Sea. Vessels will not traverse areas known to be especially important to resting, staging, or molting birds, such as Ledyard Bay or Peard Bay. All efforts will be expended to follow the established offshore travel corridor and avoid the polynya zone where bird densities tend to be higher than in areas further offshore. Disturbances from vessel traffic are not anticipated to result in bird mortality and will not affect birds on a population level.

No disturbance of nesting colonies is expected to occur. The Burger drill sites are located more than 64 mi (103 km) from shore and more than 100 mi (160 km) from the large cliff nesting colonies in the Cape Lisburne area. Birds from these colonies are known to forage as far as 75 mi (120 km) from the colony, so vessel traffic could potentially result in some disturbance of these birds when foraging, but these effects would be negligible due to the small number of vessel trips per season.

Small colonies of arctic terns, glaucous gulls, horned puffins, and common eiders are located on spits and islands along the northeastern Chukchi Sea coastline. Most vessel traffic will occur far offshore. Any vessel traffic between the Burger Prospect and the Wainwright shorebase or the Barrow shorebase would bring the vessel no closer than 12 mi (20 km) of any identified nesting colony along the Chukchi Sea (Table 4.6.2-1) and should therefore have no effect on nesting birds. Based on the significance thresholds and level of effects definitions adopted by BOEM (BOEM 2011a), and this analysis, any disturbance impacts from vessel traffic in EP Revision 2 on birds will be insignificant, localized and brief, therefore, the level of effect is negligible.

Table 4.6.2-1 Distances from Prospect-Shore Vessel Routes to Nearest Nesting Colonies

Vesel Route	Distance from Vessel Route to Nearest Nesting Colonies							
Prospect to Wainwright	**Icy Cape Spit**		**Seahorse Island**		**E. Akoliakatat Pass**		**S.E. Spit Peard Bay**	
	40 mi	65 km	36 mi	57 km	32 mi	51 km	39 mi	62 km
Prospect to Barrow	**Pt Barrow Spit**		**Seahorse Island**		**Cooper Island**		**Deadmans Island**	
	10 mi	16 km	29 mi	47 km	25 mi	40 km	12 mi	20 km

[1] Source: Colony locations from Beringia Seabird Catalog (USFWS 2000)

Avian Collisions from Vessel Traffic

Vessels and structures in open waters pose a collision risk to some species of birds. Growing scientific evidence also indicates some bird species are attracted to certain light sources, increasing the risk of bird strikes. Most studies note that increased darkness, coupled with inclement weather, particularly foggy and misty conditions or low cloud cover, increases the attraction to lighted vessels and structures. Birds drawn to light sometimes become disoriented and collide with these structures, resulting in injury and death. Little information is currently available on the cause and effect of light-induced bird strikes. The most relevant studies in the Arctic Ocean are those assessing the behavior of birds at the Endicott and Northstar facilities: oil production facilities located on artificial islands in nearshore waters of the Alaskan Beaufort Sea (Day et al. 2005). A study on the effects of anti-collision lighting systems on Northstar Island for eiders and other birds in the Beaufort showed a significant slowing of flight speeds at night and movement away from the island when strobe lights (40 flashes per min) were used (Day et al. 2003; Day et al. 2005). The lights did not cause other bird species to avoid the island but seemed to attract them. Effectiveness of the lighting then was questionable. Lease stipulation 7 requires Shell to make efforts to reduce light radiating from EP Revision 2 vessels and facilities.

Table 4.6.2-2 Bird Strikes with Shell's Vessels in the Chukchi Sea in 2012

Bird Strikes [1]					
Alcid	**Passerine [2]**	**Seaduck [3]**	**Shorebird [4]**	**Tubenose [5]**	**Total**
1	47	23	5	3	79

[1] Source: d'Entremont et al. 2013
[2] Passerines included arctic warbler, northern wheatear, unidentified
[3] Sea ducks included long-tailed duck, common eider, king eider
[4] Shorebirds included red-necked phalarope
[5] Tubenoses included short-tailed shearwaters, storm-petrels

During Shell's 2012 drilling program, some birds sought refuge on a vessel in inclement weather and rested on the vessel until continuing migration. In other cases, exhausted birds alighted on a vessel, but did not survive. BOEM calculated bird encounter rates based on the encounter reports from Shell's 2012 exploration drilling program. These rates may underestimate impacts in that some birds 1) could have struck a vessel but landed overboard and been lost at sea undetected, or 2) alighted, rested, and departed undetected (BOEM 2015). Not all encounters are fatal and, in some cases, crew assistance likely helped some birds survive. The rates are not an index, but simply an estimate of the number of birds encountering vessels during one open-water season. BOEM estimated that birds would encounter drillships at a greater rate (53 birds per season) than smaller support vessels (11 birds per season) (BOEM 2015).Potential bird strikes from EP Revision 2 would have no effect on local or regional bird populations as the numbers of mortalities are minute compared to overall population numbers and mortality rates experienced by these populations due to natural causes and hunting. The effects of avian collisions on bird populations would therefore be temporary with no effect on bird populations. Based on the significance thresholds and level of effects definitions adopted by BOEM (BOEM 2011a), this analysis, and Shell's mitigation measures (including Shell's Bird Strike Avoidance and Lighting Plan in Appendix E of EP Revision 2), under EP Revision 2, the impacts from avian collisions on birds, is not significant and the level of effect would be minor.

4.6.3 Impacts of Exploration Drilling and Ice Management Sound on Birds

No studies investigating the impacts of sound levels produced by exploration drilling and ice management on birds were found in the literature, but it is unlikely that sound energy from these activities will have any impact on birds. Such studies may have not been collected due to the expected low impacts to bird populations and viability due to the effects of sound energy produced by exploration drilling and ice management on birds. Studies on the effects of seismic surveys on birds present some indication of how exploration drilling and ice management sounds could affect birds. Seismic surveys produce underwater sound (source levels of approximately 220 to 250 dB) that is generally much stronger than what is produced from exploration drilling and ice management.

Exploration drilling sounds include those from drilling, MLC construction, support vessels in DP mode, and anchor handling. Expected received levels with distance from these activities are presented in Table 2.9-1. Drilling itself is expected to generate sound levels up to 185 dB at the drilling unit, but received sound levels from drilling which would be reduced to 160 dB within 11 yd (10 m) and to 120 dB within 0.9 mi (1.5 km). Greater sound levels are produced when drilling with the MLC bit, which generates sound levels that would be reduced to 160 dB within 78 yd (71 m) and to 120 dB within 5.1 mi (8.2 km).

Vessels engaged in ice management will generate sound levels up to 196 dB at the vessel. These levels would be reduced to 160 dB within 66 yd (60 m), and to 120 dB within 6.0 mi (9.6 km). Anchor handling is the loudest with received levels of sound of 120 dB likely being experienced out to distances of 18.02 mi (29 km). However, the 18.02 mi (29 km) measurement is considered an anomaly in the modeling process, and 8.7 mi (14 km) has been determined to be more realistic estimate of a single vessel. Based on this analysis, under EP Revision 2, no effects from drilling sounds are expected on birds.

4.6.4 Impacts of ZVSP Survey Sound on Birds

Studies on the effects of seismic surveys on birds provide some indication of how the sound energy generated by ZVSP surveys could affect birds. Both seismic surveys and ZVSP surveys use airguns as the energy source; however, the airgun arrays used in seismic surveys are typically much larger, and ZVSP survey airgun arrays are stationary while seismic survey airgun arrays are typically towed behind vessels. Evans et al. (1993) evaluated the effects on marine birds from operating seismic vessels in the North Sea and found no observable difference in bird behavior. Birds did not show differences in behavior when close or far from the active survey vessels, and birds were neither repelled nor attracted to the vessels. Similarly, studies in the Canadian Arctic (Webb and Kempf 1998) and Wadden Sea (Stemp 1985) found no statistical differences in bird distribution with and without on-going seismic surveys. Lacroix et al. (2003) investigated the effects of a marine seismic survey on molting long-tailed ducks in the Beaufort Sea and found that the survey program had no effect on the movements, diving behavior or site fidelity of the ducks.

These studies indicate that the use of an airgun array during ZVSP surveys will have little if any effect on birds or bird distribution. Any effects would likely consist of temporary behavioral responses such as the flushing of birds from the vicinity of the drilling unit, would likely last only minutes to a few hours at the most, and would have no effect on bird populations. Based on the significance thresholds and level of effects definitions adopted by BOEM (BOEM 2011a), and this analysis, under EP Revision 2 the impacts from ZVSP surveys on birds would not be significant and the level of effects would be negligible.

4.6.5 Impacts of Air Emissions on Birds

The planned exploration drilling will be conducted at drill sites located a minimum of 64 mi (103 km) offshore. As described in Section 3.1.3, air quality in the Lease Sale 193 Area and onshore on the North Slope is classified by the EPA as good. The exploration drilling activities will emit air pollutants, largely through the use of combustion engines, which are discussed in Sections 2.8 and 4.1. The emissions of primary interest from the Shell exploration drilling activities include NO_2, CO, SO_2, small-diameter PM, and VOC.

Emissions from Shell's planned exploration drilling activities are expected to have no impacts on coastal and marine birds. Dispersion of the air emissions associated with the drilling activities has been modeled. Maximum predicted concentrations of the criteria pollutants at the shoreline were found to under both the primary and secondary standards in the NAAQS. The NAAQS are designed by EPA to protect human health and flora and fauna from excessive long- and short-term exposure to ambient levels of six pollutants: CO, NO_2, PM, SO_x, ozone, and Pb. Primary standards set limits to protect public health. Secondary standards set limits to protect public welfare, including, inter alia, animals and vegetation. Modeling indicates that offshore the pollutant concentrations meet more productive standards than OSHA's exposure standards. These exposure based offshore air quality standards consider the characteristics of the region and activities of the population that accesses the region, such as the transient behavior of the populations offshore, the remoteness and inaccessibility of a region such as the Chukchi Sea OCS, and the affected environment and background air quality. Any impacts to air quality will be short-term, lasting only as long as the drilling units and support vessels are in the Chukchi Sea, therefore the impacts from offshore air emissions should have no effect on birds.

4.6.6 Impacts of Drilling Unit Mooring, MLC Construction, and Drilling Wastes on Birds

The physical manifestations of anchor disturbances associated with mooring the two drilling units (3.7 ac, [14,923 m^2]) would attenuate after removal over time by the natural movement of seafloor sediments and ice scour. The physical effects of mooring and MLC construction would be restricted to a very small portion of the Chukchi Sea seafloor area (4.01 to 5.28 ac [16,158 to 21,354 m^2]), depending on MLC construction by drill bit or by MLC ROV system. The MLC ROV system results in the larger disturbance area. Benthic organisms within the area directly affected by MLC construction and anchor mooring would likely be buried or decimated due to the weight and force of the anchors and MLC drill bit or subsequent displacement. The seafloor area of lower trophic benthic habitat that would be directly disturbed would be small, but re-colonization by lower trophic benthic communities could take a number of years. This could be important for benthic feeders, but as explained below, bird species that are benthic feeders are not prevalent in the Burger Prospect. The seafloor disturbance by mooring and MLC construction is localized, temporary, short-term, and represents a very small proportion of the total seafloor of the Chukchi Sea.

As discussed in Section 3.6.6 and Section 4.6, densities of bird species on the Burger Prospect that are benthic feeders are very low. Few if any birds would be expected to be in the area during these activities. Only temporary displacement would occur during these activities mainly due to the presence of project equipment, not the generated disturbances to the seafloor.

The discharge of drill cuttings and drilling fluids will have no direct effect on birds. All drill cuttings and drilling fluids will be discharged to the Chukchi Sea under the conditions and limitations of the required NPDES exploration facilities GP (Table 4.2.1-1). Under this permit, there can be no discharge of oil, which could impact birds. The EPA (2012b) in their required assessment of the effects of discharges associated with the permit similarly concluded that such discharges would not have noteworthy effects on birds either through direct contact or indirectly by affecting prey species availability.

The discharge of drill cutting and drilling fluids will affect water quality parameters, primarily increasing TSS. Most of these effects will be limited to the area within 820 ft (250 m) of the discharge location and would last only a few minutes to a few hours after the discharge is stopped (Table 4.2.1-3) (Fluid Dynamix 2014a,b,c,d). These water quality effects would have no direct effect on birds, and little or no indirect effect on birds through effects on prey species such as zooplankton and fish.

Drill cuttings and drilling fluids will settle rapidly onto the seafloor, and within areas of heavy seafloor accumulation there will some temporary diminution of the density and abundance of benthic invertebrates, and therefore potential for indirect impact to benthic feeding seabirds such as eiders and long-tailed ducks. However, the Burger Prospect area is not heavily utilized by these species due to water depths and distance from shore. The area that would be affected is also very small. Modeling of these discharges indicates that these discharged materials may settle to a thickness of 0.4 in (1.0 cm) or more over a total of approximately 2.7 to 5.5 ac (1.1 to 2.2 ha) for each well, and about 16 to 32.6 ac (6.6 to 13.2 ha) for all six wells in the EP (Fluid Dynamix 2014a,b,c,d). This represents less than 0.000011 to 0.000024 percent of the seafloor of the Chukchi Sea.

Concentrations of heavy metals may be slightly elevated within this area, but these effects will be minimized by the NPDES exploration facilities GP restrictions on metal concentrations in barite used in the drilling fluids. Metal concentrations would not be elevated to levels that would have ecological effects (Shell Global Solutions 2009). Research has shown that these metals have low bio-availability and that there is little bio-accumulation of the metals (Neff et al. 1989a, 1989b, and 1989c; Leuterman et al. 1997; Neff 2010).

Indirect effects of discharges from drilling wastes include the smothering of benthic invertebrates and slight elevation in the concentration of some metals. Based on the significance thresholds and level of effects definitions adopted by BOEM (BOEM 2011a), and this analysis, under EP Revision 2, the impacts of drilling waste discharges on marine birds would not be significant and have at most a negligible impact on marine birds.

4.6.7 Impacts of Other Permitted Discharges on Birds

Other permitted discharges include the discharge of bilge or ballast water, non-contact cooling water, desalination wastes, domestic and sanitary wastes, bilge water, ballast water, boiler blowdown, fire control system test water, and deck drainage from the drilling units (Tables 2.7-4 and 2.7-5), and lesser but similar wastewaters from the support vessels (Table 2.7-6). Discharges from the drilling units will be conducted under the conditions and limitations of the required NPDES exploration facilities GP (Tables 4.2.1-1 and 4.2.1-2). Under these limitations, there will be no discharge of free oil, floating solids, or trash that could potentially affect marine birds. Food wastes, which could potentially attract birds, will not be discharged from the drilling units and vessels; these wastes will be incinerated on the drilling unit and many vessels. Discharges associated with the support vessels will be conducted under MARPOL and USCG regulations in the OCS and the EPA's VGP when in State waters. With respect to support vessels, there will be no discharge of free oil, floating solids, or trash that could potentially oil, entangle, or otherwise affect marine birds; only sanitary wastes treated in a MSD will be discharged.

Permitted discharges will result in slight changes in pH, temperature, TSS, and BOD in the water column, but these effects would be limited in scope and limited to the immediate vicinity of the discharge due to rapid dispersion in the open ocean conditions and would have no effect on birds. The discharges would also be expected to have no effect on lower trophic organisms and fish and therefore no indirect effects on bird prey. Any effect on the habitat would be negligible and short-term, lasting only as long as the discharge is ongoing. The permitted discharges would have little or no direct effect on individual birds or bird populations. Other permitted discharges associated with the exploration drilling activities will not affect bird populations, and any indirect effects on bird prey or habitat would be short-term, lasting only as long as the discharge is ongoing. Based on the significance thresholds and level of effects definitions adopted by BOEM (BOEM 2011a), and this analysis, under EP Revision 2, the impacts of other permitted discharges on birds would not be significant and would be negligible.

4.6.8 Impacts of Shorebase Expansion on Birds

Potential impacts of construction on birds typically include habitat loss or loss of access to habitat, disturbance and displacement, and collisions (USFWS 2012). Use of Shell's proposed shorebase facilities, including the expansion of Barrow facilities, are not expected to affect birds in the area. All shorebase expansions planned for EP Revision 2 would occur on existing gravel pads. Therefore, there will be no additional loss of habitat or loss of access to habitat. Birds in the area are expected to be habituated to human presence on the site and are not expected to be disturbed, displaced, or at a greater risk of collision beyond the level occurring prior to Shell's proposed activities. Furthermore, construction-related impacts are not expected to affect birds because noise and fugitive dust related to construction will be minimal and temporary.

4.6.9 Impacts of Small Liquid Hydrocarbon Spills on Birds

As discussed in Sections 2.10 of this EIA; a small spill, such as a release of 48 bbl of diesel fuel, is the most probable type and volume of spill, if any, to occur as a result of EP Revision 2 activities. Section 2.10 of this EIA addresses the potential sources and types of a hydrocarbon spill, Shell's plans for responding to a small spill (defined as 48 bbl or less), and Shell's WCD planning scenario. As explained in Section 2.10, Shell's categories of spill sizes are different from, but not incompatible with, those used by BOEM. The probability of a large (> 48 bbl) liquid hydrocarbon spill, is sufficiently small to conclude it would not occur during the proposed exploration drilling activities. Prudent planning and state and federal regulatory requirements nevertheless require that Shell have comprehensive spill prevention and response plans and capabilities in place. Shell's plans include measures to prevent any spill release from occurring and to respond in the event of a spill, including capabilities for responding to a "worst case" scenario release. In the unlikely event of a spill, implementation of Shell's comprehensive spill response plan would minimize the impacts from the spill and any effects on impacted sediments to which foraging birds could come into contact. Response equipment and trained personnel would be available on site to deploy boom and recovery equipment for the control and removal of product spilled into the environment. Additionally, the procedures of Shell's FTP for fuel transfer between vessels would be utilized in accordance with BOEM lease stipulation No. 6, USCG requirements, and Shell's operating procedures.

In the unlikely event of a spill, implementation of Shell's comprehensive spill response plan would minimize potential impacts from a small spill on coastal and marine birds. Response equipment and trained personnel would be available on site to deploy boom and recovery equipment for the control and removal of product spilled into the environment. Additionally, the procedures of Shell's FTP for fuel transfer between vessels would be utilized in accordance with BOEM lease stipulation No. 6, USCG requirements, and Shell's operating procedures.

Bird morbidity or mortality can occur through direct contact with a liquid hydrocarbon spill (crude oil or diesel fuel; MMS 2003a). Oiled feathers can result in a loss in water repellency, thermal insulation, buoyancy, and the ability to forage and fly. Consequently, oiled birds can die of hypothermia and starvation. When a bird encounters oil, oil sticks to its feathers, causing them to separate and mat. Instinctively, birds try to remove the oil through preening which then leads to oil ingestion. Oil ingestion can result in severe damage to the internal organs and mortality (MMS 2003a). The extent of the above-referenced potential effects on birds from a small hydrocarbon spill would be influenced by the amount of oil spilled, effectiveness of containment, and densities of bird species present in the area of the spill. These factors are discussed below.

Under the small spill scenario, the most probable liquid hydrocarbon spill type, although very unlikely from statistical or operational standpoints, would be a 48 bbl spill of diesel fuel that would occur during re-fueling efforts. Such a release could result in morbidity or mortality to any birds that come into contact with the released petroleum (MMS 2003a). An uncontrolled spill could quickly result in a slick that encompasses 20 to 200 ac (0.08 to 0.81 km^2) if not contained by booms and quickly recovered; however, fate and transport information indicates that up to 99 percent of the released diesel fuel would either evaporate or be widely dispersed in the water column within 48 hr. of release (Section 2.10 and Table 2.10-2). Average and maximum densities of birds recorded in the Burger Prospect area in 2008 and 2009 are listed below in Table 4.6.9-1.

Table 4.6.9-1 Observed Bird Densities in the Burger Prospect Area in 2008 and 2009

Year	Late Summer [1]		Early Fall [1]		Late Fall [1]	
	Average	Maximum	Average	Maximum	Average	Maximum
2008	0.8/mi^2	1.3/mi^2	7.0/mi^2	9.1/mi^2	6.0/mi^2	7.8/mi^2
	0.3/km^2	0.5 /km^2	2.7/km^2	3.5/km^2	2.3/km^2	3.0/km^2
2009	105.7/mi^2	122.8/mi^2	118.9/mi^2	147.1/mi^2	5.7/mi^2	6.7/mi^2
	40.8/km^2	47.4/km^2	45.9/km^2	56.8/km^2	2.2/km^2	2.6/km^2

[1] Based on Gall and Day 2009

Given a slick size of up to 200 ac (0.8 km^2), as many as 50 or more birds could be affected by the spill. Common birds in the area of Shell's Burger Prospect include phalaropes, northern fulmar, short-tailed shearwater, black-legged kittiwake, glaucous gull, thick-billed murre, least auklet, and crested auklet. Mortality of 50 or more birds from a spill of this size would be considered a discernible event; however, there would be no population effects.

The above assessment is based on an uncontained spill. Shell's FTP requires pre-booming prior to transferring fuel between vessels. Additionally, Shell's oil spill response equipment would be mobilized to contain and clean up any such release. These mitigation measures should greatly reduce the probability of a slick of this size, and the exposure of birds to that slick. The ADIOS model estimates a fuel spill would be almost entirely (99 percent) dispersed or evaporated within 48 hr with the potential of impact to shoreline resources being very low. The above assessment of effects is therefore considered to be a maximum.

Even at these levels for an uncontained release, the effects on birds would be short-term and temporary. While there could be mortality of individual birds, there is unlikely to be any noticeable impact on total bird populations of any species exposed to the spilled fuel. Based on the significance thresholds and level of effects definitions adopted by BOEM (BOEM 2011a), and this analysis, under EP Revision 2, the impact of a small liquid hydrocarbon spill on marine and coastal birds is not significant and considered to be minor.

4.6.10 Conclusion

Any disturbance effects from vessel and aircraft traffic would be localized and short-term, lasting only minutes or hours after the vessel or aircraft leaves the area and would have no habitat effect that would accumulate across a year. The potential for bird collisions will be minimized by Shell's mitigation measures, which include implementation of the Bird Strike Avoidance and Lighting Plan (Appendix E of EP Revision 2) that entails shading and minimizing use of high intensity lights on support vessels, following designated travel corridors, and other measures. Disturbance effects from aircraft and vessel traffic would be negligible. Collisions between birds and the drilling units or other vessels are expected to occur in low numbers due to the relatively low density of birds in the Burger Prospect area, and based on the experience from Shell's 2012 exploration drilling activities on Burger Prospect; however, the impacts from vessel collisions are minor, given bird collisions and some potential mortality measured in terms of individuals or <1 percent of the local post-breeding population.

The discharge of drill cuttings and drilling muds, other permitted discharges, and ZVSP survey sound are expected to result in negligible impacts. Drilling unit mooring, MLC construction, air emissions and shorebase expansion were considered, but are anticipated to have no effect on birds. In the unlikely event of a small liquid hydrocarbon spill, birds using marine and coastal waters could suffer mortalities and morbidity depending on the direction of the oil slick, natural spill mitigation including evaporation and dispersion, and the effectiveness of the oil spill cleanup effort; the level of effect of impact of small liquid hydrocarbon spill on birds is minor.

Based on significance thresholds and level of effect definitions for birds determined by BOEM (BOEM 2011a) and analysis provided in Section 4.6, impacts associated with Shell's proposed activities in EP Revision 2 will not be significant and will have minor impacts on marine and coastal birds.

4.7 Impacts on Marine Mammals

Marine mammals potentially occurring near the Chukchi Sea program area are identified and described in Section 3.7 of this document. An assessment of the impacts on these non-ESA listed marine mammal species from the planned exploration drilling activities as described in EP Revision 2 is provided below. The potential impacts specific to T&E marine mammal species (polar bear, bowhead whale, humpback whale, fin whale, North Pacific right whale, and ringed seal) and candidate species (Pacific walrus and bearded seal) are analyzed in Section 4.8.

In EP Revision 2, Shell proposes to drill up to six exploration wells on six identified locations within the Burger Prospect using two drilling units: the *Discoverer* and the *Polar Pioneer*. This is an expansion in the level of potential activity from EP Revision 1, which was approved by BOEM (BOEM 2011a). In that approved EP, Shell proposed to drill at the same well locations using one drilling unit, the *Discoverer*. The additional drilling unit, the *Polar Pioneer*, is a non-self-propelled, semi-submersible drilling unit. Descriptions of these two drilling units are included in Section 1.0 of the EP, and in the Preface and Section 2.0 of this EIA. These drilling units are accompanied by an expanded number of support vessels, aircraft, and oil spill response vessels. Descriptions of these vessels, aircraft, and response assets are included in Sections 1.0 and 13.0 of the EP and in the Preface and Section 2.0 of this EIA.

The scope of activities analyzed in this Section includes the transit of two drilling units and support vessels to and from the Burger Prospect more than 64 mi (103 km) offshore of the Chukchi Sea coastline. Specifically, Shell will mobilize both of its drilling units, the *Discoverer* and the *Polar Pioneer*, and support vessels through the Bering Strait on or about 1 July each drilling season, reaching the Burger Prospect as early as 4 July, as ice conditions permit.[10] Shell will moor and stabilize the two drilling units (anchor handling) at their designated locations (Section 2.3). EP Revision 2 anticipates two drilling units operating simultaneously. The minimum distance between any two well sites on the Burger Prospect (Burger A and Burger F) is 2.0 mi (3.2 km), and the maximum distance (Burger S to Burger V) is 13.7 mi (22.0 km) (Figure 2.1-1). The most likely drilling scenario would place the two drilling units from 7 to 10 mi (11.3 to 16.1 km) apart. A MLC will be constructed at each drill site.

For the first time, Shell is including the option of utilizing a MLC ROV system to construct MLCs; this option would increase the time the drilling units are available for drilling the wells. Therefore, MLCs could be constructed using either the conventional method with the drilling units or by the newly-proposed MLC ROV system (Section 2.3).

Additional activities associated with the program include ice management, drilling operations for two drilling units, helicopter support for crew rotations and logistics, air operations in Barrow, ice reconnaissance flights using fixed-wing aircraft, discharge monitoring, and marine mammal monitoring (see Section 2.5). Shell also proposes to conduct one geophysical survey, or ZVSP survey, at each of the six drill sites after the well is drilled (Section 2.4). Each ZVSP survey, which relies upon an airgun array to gather geophysical information at various depths, typically takes 10 to 14 hr.

In addition to these offshore activities, onshore support facilities will be used in Barrow and Wainwright. Shell anticipates expansion of its air support shorebase in Barrow to lease an additional 40-person accommodation. Shell also anticipates expanding air and shorebase facilities at Wainwright to include additional storage yard space. Additional descriptions of these shorebases are included in Sections 1.0 and 14.0 of the EP and in the Preface and Section 2.0 of this EIA.

Each season, drilling will cease on or around 31 October. Shell will demobilize the drilling units and support vessels out of the Chukchi Sea at the end of each drilling season. The exploration drilling activities under EP Revision 2 are anticipated to occur over multiple drilling seasons.

Impact Factors

The main sources of potential disturbance to marine mammals associated with the exploration drilling activities proposed in this EP Revision 2 will be from aircraft traffic, the drilling units, and support vessels. Vessels, anchor handling, drilling equipment and operations, including ZVSP survey operations and ice management, emit low-frequency sound energy into the water that may alter marine mammal behavior and could affect marine mammals' hearing abilities.

Acoustic impacts are the primary concern for marine mammals. Shell has calculated the estimated aggregate exposures of marine mammals from the low-level continuous sound generated during exploration drilling operations, ice management activities, and impulse sound generated during a short-duration ZVSP survey, which would occur at or near the end of drilling at each well. In addition to sounds generated during exploration drilling, ice management, and ZVSP survey, new sound categories have been added: sound generated while constructing the MLC, sounds due to anchor handling, and sounds made by support vessels while on DP when tending to the drilling unit. The inclusion of these new sound categories in the pre-season aggregate exposure estimates, along with the additional drilling unit and associated support vessels, increases the estimated total of marine mammal exposures from that estimated

[10] *See supra* note 2.

in 2012. It is often difficult to separate the effects of visual and acoustic disturbance; therefore, these are discussed as one below. Impacts from sound energy associated with exploration drilling, ice management, and vessel traffic are most likely to cause some temporary avoidance of the immediate area by marine mammals.

Additional impacts could result from sediment-impacts, discharges, and air emissions. Increased vessel traffic associated with the expanded exploration drilling activities also increases the potential for vessel strikes, but the likelihood of a vessel strike remains considerably low. On-site vessel mooring and MLC construction could alter sediment characteristics that potentially influence prey density of some mammal species. Small hydrocarbon spills and various permitted discharges could alter water quality, thus affecting marine mammal prey species, the animals themselves, or cause avoidance of the area. As discussed herein, the potential impacts of program air emissions on marine mammals (Section 4.7.6) are expected to be negligible.

Finally, oil spills could potentially impact marine mammals. A large oil spill, such as a crude oil release from a blowout, is an extremely rare event and not considered reasonably foreseeable for this exploration drilling activities (Section 6.0). A small spill, such as a release of fuel, could affect marine mammals, but any impacts would affect only a small percentage of the total species population for all marine mammals, if any, and would be fleeting because of the limited duration of spills of this size. Any potential effects from a spill would be mitigated by the swift implementation of Shell's comprehensive OSRP.

Mitigation measures designed to limit potential impacts from operations on marine mammals will be in place throughout the exploration drilling activities. Potential impacts to marine mammals (ESA-listed and non-listed species) will largely be mitigated by implementation of Shell's 4MP. Shell's 4MP (Revision 2, Appendix B) is an integral part of Shell's planned exploration drilling activities. Shell's 4MP serves multiple purposes: it protects marine mammal resources; fulfills reporting requirements of BOEM, NMFS and USFWS; and establishes a means of collecting scientific data on marine mammals on which to base future planning. The principal components of the 4MP are summarized here.

Shell's 4MP integrates marine mammal monitoring and real-time mitigation measures through the use of vessel-based observers, acoustic recorders deployed at the seafloor, and an aerial monitoring program. Dedicated personnel onboard each drilling unit and transiting vessel involved with this program will actively monitor the surrounding waters for the presence of marine mammals. The PSOs will be trained, experienced field observers, including both biologists and Alaska Native personnel. Throughout the period of operations, PSOs will be stationed on the drilling units and transiting support vessels in locations that maximize their view of the waters surrounding the activities.

PSOs collect data on the numbers and species of marine mammals observed during operations, as well as the distances at which animals are seen and their behavior, including their reactions to the operations. Reports describing the data and interactions of the animals with the exploration drilling activities will be prepared and available to agencies. Importantly, PSOs will initiate mitigation measures when appropriate. For example, for vessels in transit, PSOs will assist the vessel in maintaining the required exclusion zone around polar bears and walruses and vessels must also reduce speed and avoid course changes when observed within specific distances of whales. It is a goal to staff each support vessel with at least one Alaska Native PSO, subject to the availability of qualified, trained personnel and scheduling limitations. Alaska Native PSOs will also facilitate outreach and communication with hunters and the local communities. These activities will coordinate with Shell's broader POC to avoid impacts to subsistence resources and avoid unreasonable interference with subsistence activities.

Vessel-based PSOs will conduct monitoring, at a minimum, aboard drilling units, and transiting support vessels such as OSVs, ice management and anchor handling vessels. The vessel-based PSO monitoring program is designed to ensure that disturbance to marine mammals and subsistence hunts is minimized, that potential effects on marine mammals from exploration drilling activities are documented, and to collect data on the occurrence and distribution of marine mammals in the project area.

Modeling of Air Emissions, Discharges, and Sound Profile

Some of the impact factors identified above are associated with a single well and the total impact for the exploration drilling activities is simply the sum of the impacts from all the wells in the program with no synergistic effects between wells due to separation in time and space. Other types of impacts have the potential to be synergistic if the impacting activities were conducted simultaneously or in such close geographical proximity that their effects overlap. Shell identified the following components of its exploration drilling activities that could possibly have synergistic effects: sound generation associated with drilling activity (including the drilling units, MLC construction, anchor handling, support vessels, ice management, and ZVSP surveys), air emissions from various sources, drilling waste discharges, and other permitted vessel discharges. Modeling of air emissions, some discharges, and sound have been conducted for EP Revision 2. These modeling efforts take into account Shell's entire exploration drilling program, and make numerous conservative assumptions that result in an overestimate of likely program impacts. The following section describes the modeling completed for the assessment of sound impacts from the exploration drilling activities described in EP Revision 2. Section 4.0 includes a summary of the modeling completed for air emissions and discharges.

Shell conducted sound modeling in order to predict the noise footprint of drilling and related activities to support this EIA and its request for MMPA authorization for the non-lethal taking of whales and seals in conjunction with EP Revision 2. Shell's sound propagation modeling consisted of multiple steps. The first was to determine the sound footprint for each discrete noise generating activity at the Burger Prospect, and then to determine the aggregate sound footprint for simultaneous activities.

Shell determined the appropriate sound footprint for each relevant activity including drilling, support vessels in DP mode, MLC construction, anchor handling, ice management activities, and ZVSP surveys. When available, Shell used actual measured sound levels to determine the extent of sound propagation for the activity. For example, Shell relied upon its 2012 sound measurements of the *Discoverer* drilling at the Burger Prospect; its 2013 sound measurements of the *Nordica* in DP mode to represent support vessels; its 2012 sound measurements of the *Discoverer* while constructing the MLC at Burger A; its 2012 sound measurements for the *Tor Viking* while conducting anchor handling on the Burger Prospect; and its 2012 sound measurements for the *Tor Viking* while conducting ice management on the Burger Prospect. In those limited instances when sound measurements were not available for the activity, Shell relied on a sound propagation model and available data to estimate the sound footprint. For example, Shell estimated the sound footprint for the *Polar Pioneer* by combining a source level derived from acoustic measurements of several comparable semi-submersible drilling units with an estimate of sound propagation from the MONM (Austin et al. 2013). The MONM was also used to determine the sound footprint of ZVSP survey activities, assuming different airgun array configurations. Shell adopted the following conservative assumptions to account for model uncertainty, measurement variability, and provide precautionary sound exposure estimates:

- A radii safety factor increase of 1.3 or 1.5 was applied to each activity sound estimate. This had the effect of increasing the estimated exposure area.
- Because measured sound levels for a separate MLC ROV system were not available, the sound footprint for MLC construction was defined from measurements of the MLC construction from the Discoverer in 2012. Sounds from a separate MLC ROV system could be expected to be quieter.

Based on these individual activity measurements, Shell modeled aggregate sound under several likely "activity scenarios" that combined different activities assumed to occur simultaneously. That is, the sound propagation modeling assumes multiple, concurrently-operating sound sources from different possible activity combinations. With this method, Shell estimated the total areas ensonified to continuous sound levels sounds ≥120 dB rms under nine distinct, likely activity scenarios. These scenarios were derived from a realistic operational timeline that considered various combinations of continuous sound sources that may operate at the same time at one or more sites (drill sites) or locations (ice management). The following nine representative activity scenarios were modeled to estimate areas exposed to continuous sounds ≥120 dB rms:

- Drilling at one site using the *Discoverer* (used as the sound source for the single site drilling-only scenario as a conservative measure because it is expected to be the louder of the two drilling units)
- Drilling at one site using the *Discoverer* with one support vessel in DP mode
- Drilling at two sites: with the *Polar Pioneer* and one support vessel in DP mode at one site and the *Discoverer* and one support vessel in DP mode at a second site
- Constructing a MLC at two different sites
- Anchor handling at one site
- Drilling at one site using the *Polar Pioneer* with one support vessel in DP mode and anchor handling at a second site
- Constructing a MLC at two different sites and anchor handling at a third site
- Two vessels conducting ice management activities
- Four vessels conducting ice management activities

The concurrent ice management activity scenarios (8 and 9) were modeled and assessed separately from non-ice management scenarios due to the temporal and spatial variability of ice conditions relative to the other activities. It is possible that ice management and drilling activities could have overlapping acoustic footprints, however, it is difficult to meaningfully quantify the countless ways in which this could occur due to the temporal and spatial variability of ice conditions. Additionally, ice management could occur at distances from the drill sites that would result in independent, non-overlapping acoustic footprints with respect to continuous sound sources operating at or near exploration drill sites. For these reasons, concurrent ice management activity scenarios were modeled separately from non-ice management scenarios, and results from each were summed together to conservatively estimate the maximum total area ensonified to continuous sound levels ≥120 dB re 1 µPa rms.

The ice management activity scenarios assumed either two or four vessels engaged in concurrent operations. The two-vessel scenario assumed a single ice management vessel positioned 1,640 ft (500 m) to the northeast of two different drill sites. The four-vessel scenario assumed ice management associated with two different drill sites with one vessel located 1,640 ft (500 m) to the northeast of each site and a second vessel positioned 1.2 mi (2 km) to the northeast of each site.

Finally, a tenth scenario was included for ZVSP survey activities, which would be completed in the fall after the completion of a well, and would last a relatively short period of time (10 to 14 hr). For this scenario Shell modeled the footprint of the pulsed sounds emitted by the airgun array to estimate the area ensonified at levels ≥160 dB rms.

These representative activity scenarios were modeled for different drill site combinations and, as a conservative measure, the combinations corresponding to the largest ensonified area were chosen to represent the given activity scenario. The scenarios that involved anchor handling and ice management resulted in the largest estimated areas ensonified at levels ≥120 dB rms. The largest area estimated to be exposed to continuous sounds ≥120 dB rms during a single activity scenario resulted from concurrent MLC construction at two different sites and anchor handling at a third site (scenario 7). Scenarios that involved drilling and/or DP vessel operations produced the smallest acoustic footprints. The smallest area estimated to be ensonified by continuous sounds ≥120 dB rms during a single activity scenario resulted from one drilling unit (the *Discoverer*) alone at a single drill site (scenario 1). Combining the highest activity scenario (scenario 7) with the four-vessel ice management scenario (scenario 9) resulted in the maximum total area that might be ensonified to ≥120 dB rms. While this combined scenario resulted in the highest sound, it would occur for only brief periods of time relative to the entire exploration drilling activities. Detailed modeling results were used to calculate the areas (in km^2) ensonified at levels ≥120 dB rms (continuous) and ≥160 dB rms (pulsed). The potential impacts on whales and seals that may result from these modeled sounds are discussed below.

Offshore aerial wildlife monitoting photographic surveys for marine mammals, which were completed in 2012, will complement the acoustic monitoring and vessel-based observer programs. These aerial surveys will begin when the vessels arrive at or near the drill sites and will continue until the drilling related vessels have left the drill sites. The aerial surveys will be conducted daily, weather permitting. The survey flights will be conducted in a grid pattern covering the area within 31 mi (50 km) of the drill sites within the Burger Prospect. Analysis of the digital photographs will be completed as quickly as possible and to the extent possible, results from imagery will be used to assess the distribution of marine mammals in the project area and inform operational plans in a way that minimizes potential impacts. Photographic surveys may also be conducted in a sawtooth pattern within 23 mi (37 km) of the coast from Barrow to Point Hope if nearshore priorities are identified. Nearshore photographic surveys were designed to collect data on marine mammal distribution and movements in coastal regions, including areas used by Pacific walruses for terrestrial haulouts in recent years.

These monitoring measures have proven effective at minimizing impacts to marine mammals, particularly when monitoring data from different platforms were integrated. The data gathered is used to monitor the effectiveness of operational mitigation measures, satisfy regulatory reporting obligations and collect valuable scientific data on marine mammals that otherwise would not be collected.

<u>Definitions Adopted to Determine Significance Impacts and Effect Levels</u>

In BOEM's NEPA analysis of Shell's EP Revision 1, BOEM evaluated the level of effects of Shell's proposed exploration activities for each resource (BOEM 2011a). BOEM established a "significance threshold" to determine whether a particular activity has a significant (or not significant) impact on that resource. Required mitigation measures could reduce otherwise "significant" impacts to a level of "not significant." A finding of no significant effect does not mean that there is no effect. Next, BOEM established a four-category scale (i.e., negligible, minor, moderate or major) to describe the relative degree or anticipated level of effect of an activity on a specific resource.

This is the first opportunity for Shell to review the significance threshold and level of effects definitions that BOEM adopted when it completed the EA for Shell's EP Revision 1. BOEM's definitions provide useful guidance for capturing and defining significance and levels of effects that was not available when Shell prepared the EIA for EP Revision 1.

<u>Significance Threshold and Levels of Effect</u>

The significance threshold is an adverse impact that results in a decline in abundance and/or change in distribution requiring three or more generations for the indicated population to recover to its former status.

<u>Levels of Effect</u>

Negligible

- Localized, short-term disturbance or habitat effect experienced during one season that is not anticipated to accumulate across multiple seasons. Temporary, nonlethal adverse effects to a few individuals are possible.
- May cause brief behavioral reactions such as temporary avoidances of or deflections around an area. No mortality or population-level effects are anticipated.

- Mitigation measures are implemented fully and effectively or are not necessary.
- Unmitigable or unavoidable adverse effects are difficult to measure or observe.

Minor

- Localized, disturbance or habitat effects experienced during one season may accumulate across subsequent seasons, but not over one year.
- Temporary, nonlethal adverse effects to some individuals. May cause behavioral reactions such as avoidances of or deflections around a localized area. Mortality or population-level effects are not anticipated.
- Mitigation measures are fully implemented or are not necessary.
- Unmitigatable or unavoidable adverse effects are short-term and localized.

Moderate

- Widespread annual or chronic disturbances or habitat effects could persist for more than 1 year and up to a decade.
- Mortalities or disturbances could occur, but would be below the estimated Potential Biological Removal (PBR). Population-level effects are not anticipated.
- Widespread implementation of mitigation measures for similar activities may be effective in reducing the level of avoidable adverse effects. Unmitigable or unavoidable adverse effects are short-term and widespread, or long-term and localized.

Potential Effects of Shell's EP Revision 2 on Marine Mammals

As presented in the analyses below, Shell has concluded that the overall potential effects on marine mammals from the exploration activities as described in EP Revision 2 will be negligible to minor and short-term (Table 4.7-1). The level of effects determinations assume there is a replacement of marine mammals every day; this is the assumption utilized in Shell's estimate of exposures to whales and seals in Section 10 of the EP and Table 4.7.3-1 in this Section.

Table 4.7-1 Potential Effects of Shell's Exploration Drilling Program on Non-Threatened or –Endangered Marine Mammals

Resource / Analyzed Activity	EP Revision 2
Marine Mammals (overall)	Minor
From aircraft traffic	Negligible
From vessel traffic	Negligible
From drilling & ice management sound	Negligible
From ZVSP survey sound	Negligible
From drilling unit mooring and MLCs	Negligible
From air emissions	Negligible
Drilling wastes	Negligible
From other permitted discharges	Negligible
From small liquid hydrocarbon spills	Minor

4.7.1 Impacts of Aircraft Traffic on Marine Mammals

Helicopter and fixed-wing aircraft overflights may disturb marine mammals as sound sources or visual cues. Levels and duration of sounds received by marine mammals underwater from a passing helicopter or fixed-wing aircraft are a function of the type of aircraft, orientation and altitude of the aircraft, depth of the animal, and water depth. Aircraft sounds are detectable underwater at greater distances when the receiver is in shallow rather than deep water. Generally, sound levels received underwater decrease as the altitude of the aircraft increases (Richardson et al. 1995a). Aircraft sounds are audible for much greater distances in air than in water.

Helicopters will be used for personnel and equipment transport to and from the two drilling units. Under calm conditions, rotor and engine sounds are coupled into the water within a 26-degree cone beneath the aircraft Some of the sound will transmit beyond the immediate area, and some sound will enter the water outside the 26º area when the sea surface is rough. However, scattering and absorption will limit lateral propagation in shallow water. Dominant tones in noise spectra from helicopters are generally below 500 Hertz (Hz) (Greene and Moore 1995). Because of Doppler shift effects, the frequencies of tones received at a stationary site diminish when an aircraft passes overhead. The apparent frequency is increased while the aircraft approaches and is reduced while it moves away.

Aircraft flyovers are not heard underwater for very long, especially when compared to how long they are heard in air as the aircraft approaches an observer. Helicopters flying to and from the drilling units will generally maintain straight-line routes at altitudes of 1,500 ft (457 m) ASL or greater, thereby limiting the received levels at and below the surface.

The nature of sounds produced by aircraft activities above the surface of the water does not pose a direct threat to the hearing of marine mammals that are in the water; however, short-term behavioral responses of cetaceans to aircraft have been documented in several locations, including Arctic waters (Richardson et al. 1985a, b Patenaude et al. 2002).

As discussed below, given the timing and location of the proposed exploration drilling operations, as well as the mitigation measures that will be implemented as a part of the program, any impacts from aircraft traffic on marine mammals associated with the exploration drilling activities as described in EP Revision 2 will be localized and temporary with no anticipated population level effects. Based on the significance thresholds and level of effects definitions adopted by BOEM (BOEM 2011a), the effects of aircraft traffic associated with the exploration activities will not be significant and will have negligible impacts on marine mammals.

<u>Impacts of Aircraft Traffic on Cetaceans</u>

Cetacean reactions to aircraft depend on several variables including the animal’s behavioral state, activity, group size, habitat, and the helicopter flight pattern, among other variables (Richardson et al. 1995a). This section presents potential impacts on non-–endangered baleen whales. Information on potential impacts on bowhead, fin, and humpback whales are provided in Section 4.8, Impacts on Threatened or Endangered Species. Gray whales may show avoidance behavior in response to air traffic sound energy. The Scientific Research Association (1988) reported that gray whales usually exhibited avoidance behavior when helicopters flew lower than 1,198 ft (365 m). Mothers with calves appear to be more sensitive to air traffic (Clarke et al. 1989). Some gray whales have been observed reacting to sound energy generated by helicopters flying within 328 ft (100 m) of the whales (Malme et al. 1984). As a mitigation measure, Shell helicopters will be flying at altitudes above 1,500 ft (457 m) except during take-offs and landings and when weather conditions force an altitude reduction for safety reasons. Any changes in gray whale behavior due to aircraft traffic will therefore be temporary, lasting only minutes or hours at the most. Given these findings, aircraft traffic associated with Shell’s exploration drilling activities as described in the EP Revision 2 will have negligible impact on gray and minke whales and will not have any effect on gray whale populations.

Richardson et al. (1995b) observed some belugas exhibiting avoidance behaviors in reaction to aircraft flying at altitudes less than or equal to 820 ft (250 m), most; however, showed no reaction to aircraft flying at altitudes greater than or equal 492 ft (150 m). The amount of time that belugas may be affected by low-flying aircraft is usually only seconds (Stewart et al. 1982). In one study, most reactions of beluga whales have been observed (Patenaude et al. 2002) reacting to helicopter sound via deflection when exposed to helicopters occurred when the helicopter approached within 820 ft (250 m). These brief encounters with aircraft are not expected to have any more than a brief effect on belugas (Richardson et al. 1991a; Richard et al.1998), and any potential deflection or displacement would likely be temporary. Shell's mitigation measure of requiring an altitude of 1,500 ft (457 m) or more for all helicopter flights will therefore avoid most or all effect on belugas. Given these findings, aircraft traffic associated with Shell's exploration drilling activities as described in EP Revision 2 will have negligible impact on belugas and other odontocetes, such as the harbor porpoise and killer whale, and will have no effect on the populations of these species.

Conclusion

In conclusion, short-term and localized adverse effects on individual cetaceans may include alterations in swimming and diving behavior, avoidance, or deflection around a localized area resulting from aircraft traffic supporting Shell's proposed activities as described in Section 2.0. These non-lethal effects would only last until the aircraft noise becomes inaudible and are not anticipated to accumulate across multiple seasons. Mortality or population-level effects are not anticipated. Mitigation measures will be fully implemented requiring aircraft to fly along predetermined routes at altitudes at least 1,500 ft (457 m) except during take-offs, landings, marine mammal monitoring, and when conditions force an altitude reduction for personnel safety reasons. Furthermore, flights between Barrow and Wainwright will occur along a corridor 5.0 mi (8 km) inland to minimize effects on subsistence and subsistence resources including marine mammals. Based on the level of effects definitions determined by BOEM (2011) and provided in Section 4.7, effects on whales from aircraft flights associated with the proposed activities will not be significant and are expected to be negligible.

Impact of Aircraft Traffic on Pinnipeds

Few systematic studies of pinniped reactions to aircraft overflights have been conducted. Documented reactions range from simply becoming alert and raising the head, to escape behavior such as hauled out animals rushing to the water. This section presents potential impacts on non-threatened pinnipeds. Information on potential impacts on ringed seals and walruses are provided in Section 4.8, Impacts on Threatened or Endangered Species. Brueggeman et al. (1992a) reported that about 6.6 percent of 552 seals (ringed, bearded, and spotted seals but primarily ringed seals) observed while monitoring previous exploration drilling efforts in the Chukchi Sea reacted to a twin otter airplane flown at an altitude of 1,000 ft (305 m). Reactions included diving in the water resulting in a splash, or escaping from ice into the water. Ringed seals hauled out on the surface of the ice have shown behavioral responses to helicopter overflights with escape responses most probable at lateral distances <656 ft (<200 m) and overhead distances <492 ft (<150 m; Born et al. 1999). Spotted seals showed immediate reaction to the presence of aircraft during surveys by Rugh et al. (1997). They observed disturbances of spotted seals at altitudes up to 4,500 ft (1,370 m). Concentrations of animals hauled out on land seem to react more severely than the scattered small groups found on the sea ice in spring. Disturbances of seals by Shell's aircraft will be temporary and localized. Shell's identified flight corridors (Figure 2.2-2), where both the increased crew change flights and the helicopter shuttle flights would take place, avoid all known spotted seal haulouts and minimizes the portion of flights that would be over coastal waters. Known spotted seal haulout locations in Kasegaluk Lagoon are more than 70 mi (113 km) from the identified flight corridors. Shell's mitigation measures require a minimum altitude of 1,500 ft (457 m), which should reduce the disturbance to spotted seals and ribbon seals.

Conclusion

Effects on seals may include alterations in swimming behavior, avoidance, or deflection around a localized area. Disturbances of seals by aircraft supporting Shell's proposed operations as described in Section 2.0 will be temporary and localized to small numbers of seals hauled out on remnant ice floes or already in the water. These non-lethal effects would only last until the aircraft noise becomes inaudible and are not anticipated to accumulate across multiple seasons. The potential impacts on seals from aircraft traffic will be minimized by fully implemented mitigation measures including flying along predetermined routes at altitudes of at least 1,500 ft (457 m) except during take-offs, landings, marine mammal monitoring, and when conditions force an altitude reduction for personnel safety reasons by the proposed flight corridor. The predetermined flight paths minimize the portion of flights over coastal waters. Furthermore, flights between Barrow and Wainwright will occur along a corridor 5 mi (8 km) inland to minimize effects on subsistence and subsistence resources including marine mammals. For these reasons, based on the significance thresholds and level of effects definitions determined by BOEM (BOEM 2011a), and provided in this section, aircraft traffic associated with Shell's proposed activities will not be significant and will have a negligible effect on non-listed seals.

4.7.2 Impacts of Vessel Traffic on Marine Mammals

It is likely that some marine mammals will be present in the Burger Prospect area when the exploration drilling operations are on-going. The most common occurrences of marine mammals that are not listed as T&E, or candidate species, will likely be spotted seals and gray whales. Small numbers of ribbon seals, beluga whales, harbor porpoise, killer whales, and minke whales may also be present. Increased vessel traffic in the Chukchi Sea associated with the proposed exploration drilling activities as described in EP Revision 2 may potentially impact marine mammals by collisions of the vessels with animals in the water or by effects of the sounds from the vessels entering the water.

Vessel Strikes – Most marine mammals actively avoid ships that are under way. Few vessel strikes of marine mammals have been reported in the Chukchi Sea, but increased numbers of vessels working in an area could increase the likelihood of vessel strikes of marine mammals. To minimize the potential for strikes, all Shell transiting vessels will have PSOs onboard to assist in spotting marine mammals. The PSOs' observations will be used to help avoid marine mammals and possible vessel strikes. Vessels will reduce speed and avoid course changes within 900 ft (274 m) of whales. Shell has successfully operated a large number of vessels in the Chukchi Sea since 2006 without any marine mammal strikes. Further, George et al. (1994) examined subsistence-harvested bowheads and quantified how many of them had scars that appeared to have been inflicted by vessels. Among 236 whales examined between 1976 and 1992, they found two whales that exhibited evidence of past interactions with vessels, and one with questionable scarring. One carcass was reported more recently that appeared to have been struck by a vessel (Rosa 2009). In light of the success of Shell's historic marine mammal observer program in preventing ship strikes and Shell's commitment to continuing the program (now called a PSO program), it is unlikely that a ship strike of a marine mammal would occur during this project. Even if a ship strike occurred, it would impact an individual animal, but would not affect animal populations in the project area.

Vessel Sounds – In addition to the drilling units, various types of vessels will be used in support of the operations including OSVs, ice management vessels, anchor handlers, and OSR vessels. Sounds from boats and vessels have been reported extensively (Greene and Moore 1995; Blackwell and Greene 2002, 2005, 2006). Numerous measurements of underwater vessel sounds have been performed in support of recent industry activity in the Chukchi and Beaufort seas. Results of these measurements have been reported in various 90-day and comprehensive reports since 2007. For example, Warner and Hannay (2009) estimated sound pressure levels of 100 dB at distances ranging from approximately 1.5 to 2.3 mi (2.4 to 3.7 km) from various types of barges. MacDonald et al. (2008) estimated higher underwater sound pressure levels from the seismic vessel *Gilavar* of 120 dB at approximately 13 mi (21 km) from the source, although the sound level was only 150 dB at 85 ft (26 m) from the vessel. Like other industry-generated sound, underwater sound from vessels is generally at relatively low frequencies.

The primary sources of sounds from all vessel classes are propeller cavitation, propeller singing, and propulsion or other machinery. Propeller cavitation is usually the dominant noise source for vessels (Ross 1976). Propeller cavitation and singing are produced outside the hull, whereas propulsion or other machinery noise originates inside the hull. There are additional sounds produced by vessel activity, such as pumps, generators, flow noise from water passing over the hull, and bubbles breaking in the wake. Icebreakers contribute greater sound levels during ice-breaking activities than ships of similar size during normal operation in open water (Richardson et al. 1995a). This higher sound production results from the greater amount of power and propeller cavitation required when operating in thick ice.

Various marine mammal species have been reported to avoid vessels that are under way. It is often not clear if the animals avoid vessels because of the sound of the vessel or if visual cues are also important. Information below describes studies that have examined marine mammal interactions with vessels. Included below are studies that have looked at T&E species, considered in more detail later in Section 4.8, Impacts on Threatened or Endangered Species, as well as species that do not occur in the Chukchi Sea, or specifically in the area of the Burger Prospect. Additionally, not all of these studies have occurred in Arctic waters, but they all provide information that may be important to understanding how marine mammals react to ships and other vessels when they are present.

Vessel Disturbances of Baleen Whales

The results of six years of vessel-based marine mammal surveys in the CSESP study areas in the northeastern Chukchi Sea are presented in Table 3.7-6 and 3.7-7. This section presents potential impacts on non–endangered baleen whales. Information on potential impacts on bowhead, fin, and humpback whales are provided in Section 4.8, Impacts on Threatened or Endangered Species. Sighting rates for baleen whales based on the CSESP surveys within the Burger Study Area are presented below in Table 4.7.2-1. Based on these and other data, the most common occurrences of baleen whales in the area where vessel traffic will take place will likely be gray whales and bowhead whales; however, all whales would be expected to be encountered by vessels at very low frequencies. Small numbers of minke whales may also be encountered but would not be expected. Vessel traffic in the Chukchi Sea associated with EP Revision 2 could potentially result in behavioral disturbances of a small number of these whales.

Table 4.7.2-1 Baleen Whale Sighting Rates in the CSESP Burger Study Area 2008 - 2012[1]

Common Name	Units	Sighting Rates by Year in July-October [1]				
		2008	2009	2010	2011	2012
Bowhead whale	Sightings/1,000 km	0.72	0.73	6.79	4.14	11.36
	Sightings/1,000 mi	1.16	1.17	10.93	6.66	18.28
Gray whale	Sightings/1,000 km	0.36	0.37	0.36	0	0.87
	Sightings/1,000 mi	0.58	0.60	0.58	0.00	1.40
Fin whale	Sightings/1,000 km	0	0	0	0	0
	Sightings/1,000 mi	0	0	0	0	
Minke whale	Sightings/1,000 km	0	0	0	0	0.87
	Sightings/1,000 mi	0	0	0	0	1.40
Unidentified whale	Sightings/1,000 km	0	0.37	0.71	1.66	9.61
	Sightings/1,000 mi	0.00	0.60	1.14	2.67	15.47
Survey Effort	Sightings/1,000 km	2,500 km	2,686 km	2,714 km	1,031 km	1,144 km
	Sightings/1,000 mi	1,553 mi	1,669 mi	1,686 mi	641 mi	711 mi

[1]Similar sighting rates were not presented in the 2013 annual report

Source: Aerts et al. 2012, 2013

Bogoslovskaya et al. (1981) observed avoidance behaviors by gray whales when vessels came within 980 ft (300 m), but saw no reaction to vessels further away. During a study by Schulberg et al. (1989), many gray whales showed no deflection or change of behavior until vessels came within 98 ft (30 m). Underwater sound may also elicit a response in whales to avoid vessels moving within their immediate area. Any avoidance responses due to vessel traffic are expected to be minimal and temporary. Gray whales may be present in and around the project area throughout the drilling season; however, concentrations of gray whales are often seen along the Alaskan Chukchi Sea coast near Icy Cape, particularly in the Peard Bay area. Gray whales also frequent areas near Hanna Shoal to the north of the Burger Prospect and use the area for feeding (Moore et al. 2000), although heavy use of this area has not been observed in recent years. These gray whale concentration areas are north and east of the drill sites and Wainwright and therefore would be expected to receive little vessel traffic. Vessels conducting contingency vessel-based crew changes (Figure 2.2-1) may traverse portions of these areas; however, this vessel traffic is only for contingency purposes and will therefore occur at very low frequencies, if at all. It is unlikely that vessel traffic in the area will disturb feeding whales or cause avoidance of this area.

Palka and Hammond (2001) analyzed line transect census data in which the orientation and distance off transect line were reported for large numbers of minke whales. Minor changes in locomotion speed, direction, and/or diving profile were reported at ranges from 1,847 to 2,352 ft (563 to 717 m) at received levels of 110 to 120 dB re 1µPa rms. Based on past observations (Table 4.7.2-1) it is unlikely that minke whales will be encountered by vessels associated with the exploration drilling activities as described in EP Revision 2; however, if such encounters occur they are expected to be in very low numbers and result in only temporary behavioral disturbances.

Conclusion

Based on the frequencies of observations from vessel-based surveys as presented above, few whales would be expected to be encountered by vessels during the exploration drilling activities. Encounters that do occur could potentially result in brief behavioral disturbances such as temporary avoidance or deflection as described above. These non-lethal effects are not anticipated to accumulate across multiple seasons. Effects on baleen whales from vessel traffic would incrementally increase due to the addition of vessels to support two drilling units operating simultaneously; however, any effects on the few baleen whales from vessel traffic will last only minutes or hours after the vessel has passed. Effects would be minimized by fully implementing mitigation measures that require vessels associated with the drilling activities that are underway to reduce speed, avoid separating members from a group of whales and avoid multiple course changes when within 900 ft (274 m) of whales. Vessel speed also will be reduced during inclement weather conditions in order to avoid collisions with whales and other marine mammals. These mitigation measures should prevent any measureable disruptions to baleen whales at the Burger Prospect or areas transited beyond the prospect. Based on the significance thresholds and level of effects definitions determined by BOEM (BOEM 2011a) and provided above in Section 4.7, vessel traffic associated with Shell's proposed activities will not be significant and will have a negligible effect on non listed baleen whales.

Vessel Disturbances of Toothed Whales

Harbor porpoise are known to tolerate ships and may approach moving ships to bow ride (Richardson et al. 1995a). This species is present, but not common, in the Chukchi Sea and any impacts from vessel traffic would likely only affect a few individuals (Table 4.7.2-2). Similarly, only a few individuals of killer whales are likely to encounter Shell operations in the Chukchi Sea (Table 4.7.2-2).

Fraker et al. (1978) observed startle responses in belugas when vessels moved through areas with a high concentration of whales. Reactions of beluga whales to vessels will likely vary among individuals. The amount of avoidance exhibited by an individual beluga would depend upon the amount of previous exposure to moving vessels, and the level of need for the beluga to be in the same area as vessel traffic (Finley and Davis 1984). In some studies, more intense reactions to large vessels have been noted, but these observations were made in deep water (Finley et al. 1990; LGL and Greeneridge 1996), and it is not clear that the intensity of the reaction was specifically related to the size of the ship.

Vessel traffic related to the exploration drilling activities as described in EP Revision 2 may encounter beluga whales, but the numbers encountered are expected to be few, if any. No belugas were observed in the vicinity of Shell's Burger Prospect during historical exploration drilling programs in the Chukchi Sea (Brueggeman et al. 1990, 1991b, 1992a), and no belugas were observed during baseline marine mammal surveys conducted across a broad area of the northeastern Chukchi Sea (including the Burger Prospect) in

July to October 2008-2012 (Table 4.7.2-2). Most beluga whales move north during spring before drilling operations in the Chukchi Sea are planned to begin. Some beluga whales migrate north during April through June (Moore et al. 1993), while others congregate in nearshore areas of the Chukchi Sea near Omalik and Kasegaluk lagoons in late June and early July (Huntington et al. 1999; Suydam et al. 2001) before moving north. Additionally, most belugas migrate relatively close to shore during the spring, and therefore would be approximately 40 to 50 mi (approximately 64 to 80 km) from Shell's area of exploration drilling operations, though the specific routes and timing depends on the extent and location of sea ice (MMS 2003a). Most beluga whales continue north into the Beaufort Sea and remain offshore near the continental shelf break or continue into the Canadian Beaufort Sea and Amundsen Gulf where they spend the summer. Evidence indicates that beluga whales occupy areas near or beyond the continental shelf break during summer in the eastern Chukchi Sea, often near the pack ice margin or in areas of dense ice (Suydam et al. 2005a). Moore et al. (2000) identified the importance of deeper water for belugas in areas sloping downward from the continental shelf. These preferred habitats are well north of the EP Revision 2 drill sites. In late September through October and into November beluga whales move back into and through the Chukchi Sea. This fall movement back through the Chukchi Sea is more spread out than during spring and animals migrate through waters farther from shore. Beluga whales are most likely to encounter Shell's operations during this period. Vessels conducting contingency vessel-based crew changes (Figure 2.1-1) may traverse areas where beluga are more common; however, this vessel traffic is only for contingency purposes and will therefore occur at very low frequencies if at all.

Because belugas do not follow a specific corridor during the fall migration, avoidance of the Shell drilling operations by some individuals is unlikely to have more than a short-term behavioral effect on some individuals in the population.

The results of six years of vessel-based marine mammal surveys in the CSESP study areas in the northeastern Chukchi Sea are presented in Table 3.7-6 and 3.7-7. Sighting rates for toothed whales based on the vessel-based CSESP surveys within the Burger Study Area are presented below in Table 4.7.2-2. Based on these and other data, few, if any, toothed whales would be encountered by vessels during the exploration drilling activities.

Table 4.7.2-2 Odontocete Sighting Rates in the CSESP Burger Study Area 2008-2012[1]

Common Name	Units	Sighting Rates by Year in July-October [2]				
		2008	2009	2010	2011	2012
Harbor porpoise	Sightings/1,000 km	0	0	0	0	0
	Sightings/1,000 mi	0	0	0	0	0
Dall's porpoise	Sightings/1,000 km	0	0	0	0	0
	Sightings/1,000 mi	0	0	0	0	0
Killer whale	Sightings/1,000 km	0	0	0	0	0
	Sightings/1,000 mi	0	0	0	0	0
Beluga whale	Sightings/1,000 km	0	0	0	0	0
	Sightings/1,000 mi	0	0	0	0	0
Survey Effort	Sightings/1,000 km	2,500 km	2,686 km	2,714 km	1,031 km	1,144 km
	Sightings/1,000 mi	1,553 mi	1,669 mi	1,686 mi	641 mi	711 mi

[1]Similar sighting rates were not presented in the 2013 annual report

[2] Source: Aerts et al. 2013

Conclusion

Based on the frequencies of observations from vessel-based surveys as presented above (Table 4.7.2-2), few toothed whales are expected to be encountered by vessels during Shell's exploration drilling activities. Encounters that do occur could potentially result in brief behavioral disturbances, such as temporary avoidance or deflection, as described above. These non-lethal effects are not anticipated to accumulate across multiple seasons. Effects on toothed whales from vessel traffic could incrementally increase due to the addition of vessels to support two drilling units operating simultaneously; however, any effects on the few toothed whales from vessel traffic will last only minutes or hours after the vessel has passed. Effects would be minimized by fully implementing mitigation measures that require vessels associated with the drilling program that are underway to reduce speed, avoid separating members from a group of whales, and avoid multiple course changes when within 900 ft (274 m) of whales. Vessel speed also will be reduced during inclement weather conditions in order to avoid collisions with whales and other marine mammals. These mitigation measures should prevent any measureable disruptions to toothed whales occurring near project activities. Based on the significance thresholds and level of effects definitions determined by BOEM (BOEM 2011a) and provided in Section 4.7, vessel traffic associated with Shell's proposed activities will not be significant and will have a negligible effect on toothed whales.

Vessel Disturbances of Pinnipeds

Ringed, bearded, and spotted seals and walruses are the most commonly observed marine mammals in the project area and would be expected to be encountered by vessels associated with the exploration drilling activities. The results of six years of vessel-based marine mammal surveys in the CSESP study areas in the northeastern Chukchi Sea are presented in Table 3.7-6 and 3.7-7. Sighting rates for seals during the vessel-based CSESP surveys within the Burger Study Area are presented below in Table 4.7.2-3. Based on these data, spotted seals will likely be encountered by vessels. Very small numbers of ribbon seals may also be encountered. This section discusses potential impacts on non-threatened pinnipeds, but references to studies on T&E species do appear here as well. Non-listed species are expected to act similarly to T&E species. Information on potential impacts on ringed and bearded seals and walruses are provided in Section 4.8, Impacts on Threatened or Endangered Species.

Available data and reported responses of seals to vessels as well as to other noisy human disturbances (Richardson et al. 1995a) suggest that seals often show considerable tolerance of vessels. Brewer et al. (1993) reported observations of ringed seals following ice management vessels in the Beaufort Sea, apparently feeding on fish and plankton in the disturbed waters. Blees et al. (2010) reported that the most common reaction of seals to seismic survey monitoring vessels near the Burger Prospect were looking at the vessel (63 percent) or no reaction whatsoever (39 percent), while about nine percent exhibited reactions of increasing swim speed, changing direction, or splashing.

Table 4.7.2-3 Seal Sighting Rates in the CSESP Burger Study Area 2008-2012[1]

Common Name	Units	Sighting Rates by Year in July-October [2]				
		2008	2009	2010	2011	2012
Ringed/spotted seal	Sightings/1,000 km	8.0	9.0	4.0	4.0	23.0
	Sightings/1,000 mi	12.9	14.5	6.4	6.4	37.0
Ringed seal	Sightings/1,000 km	4.0	4.0	0.0	1.0	10.0
	Sightings/1,000 mi	6.4	6.4	0.0	1.6	16.1
Spotted seal	Sightings/1,000 km	5.0	1.0	1.0	2.0	3.0
	Sightings/1,000 mi	8.0	1.6	1.6	3.2	4.8
Bearded seal	Sightings/1,000 km	16.0	7.0	13.0	7.0	36.0
	Sightings/1,000 mi	25.7	11.3	20.9	11.3	57.9
Ribbon seal	Sightings/1,000 km	1.0	0.0	0.0	0.0	0.0
	Sightings/1,000 mi	1.6	0.0	0.0	0.0	0.0
Unidentified seal	Sightings/1,000 km	15.0	6.0	8.0	9.0	33.0
	Sightings/1,000 mi	24.1	9.7	12.9	14.5	53.1
	Sightings/1,000 mi	0.00	0.60	1.14	2.67	15.47
Survey Effort	Sightings/1,000 km	2,500 km	2,686 km	2,714 km	1,031 km	1,144 km
	Sightings/1,000 mi	1,553 mi	1,669 mi	1,686 mi	641 mi	711 mi

[1] Similar sighting rates were not presented in the 2013 annual report

[2] Source: Aerts et al. 2013

Conclusion

Spotted and ribbon seals are associated with sea ice, and most sea ice is absent from the prospect area during the open water season. Effects on seals present near Shell's proposed activities may include temporary avoidance responses such as slipping off of ice and into the water, diving, or briefly avoiding approaching vessels within a localized area. Disturbances of seals by vessels supporting Shell's proposed operations as described in Section 2.9 will be temporary and localized to small numbers of seals hauled out on remnant ice floes or already in the water. Effects on seals from vessel traffic would incrementally increase due to the addition of vessels to support two drilling units operating simultaneously; however, any effects would last only minutes or hours after the vessel has passed are not anticipated to accumulate across multiple seasons. Effects would be minimized by fully implementing mitigation measures that require vessels associated with the drilling program that are underway to reduce speed, and avoid multiple course changes when in the vicinity of marine mammals, including seals. Vessel speed also will be reduced during inclement weather conditions in order to avoid collisions with seals and other marine mammals. These mitigation measures should prevent any measureable disruptions to seals occurring near project activities. Based on the significance thresholds and level of effects definitions determined by BOEM (BOEM 2011a) and provided in Section 4.7, vessel traffic associated with Shell's proposed activities will not be significant and will have a negligible effect on seals occurring near Shell's proposed activities.

4.7.3 Impacts of Continuous Sounds from Drilling, Ice Management, and Other Support Activities on Marine Mammals

Sound levels expected to be generated by drilling, including MLC construction, vessels in DP mode, anchor handling, and ice management are provided in Section 2.9. The sound energy generated by drilling operations varies with the sound energy from vessels supporting the drilling in DP mode or performing anchor handling or ice management being greater than that generated by the drilling units alone. Some of these activities may occur simultaneously. Section 4.0 describes the acoustic modeling Shell performed, and Table 4.0-3 summarizes the ten scenarios analyzed and the size of the modeled ensonified areas associated with each.

Potential exposures based on the estimated areas that might be ensonified by all these activities, and calculated densities of marine mammals in the northeastern Chukchi Sea, were calculated for a drilling season (Table 4.7.3-1). These are estimates for all sound sources, including drilling (which includes MLC construction), vessels in DP mode, ice management, anchor handling, and ZVSP surveys. An estimate is provided in which the populations are assumed to be moving such that there is a complete turnover of the animals within the ensonified area each day, with the exception of bowhead whales. The bowhead whale exposures assume whales move out and different whales move into the area and are exposed every two days. The following table of the calculated numbers of whales and seals potentially exposed to sound levels related to Shell's proposed activities that could result in NMFS-defined "harassment" is best interpreted as conservatively high (Table 4.7.3-1).

Table 4.7.3-1 Potential Whales & Seals Exposures to In-Water Sound Levels >120 or >160 dB re 1µPa rms

Species	Number of Exposures to In-Water Sound Levels > 120 dB or >160 dB re 1µPa rms [1,2,3]
	Considering Population Turnover [4]
Beluga	974
Narwhal	1
Killer whale	14
Harbor porpoise	294
Bowhead whale	2,582
Fin whale	14
Gray whale	2,581
Humpback whale	14
Minke whale	41
Bearded seal	1,722
Ribbon seal	96
Ringed seal	50,433
Spotted seal	1,007

[1] Not all marine mammals will change their behavior when exposed to these sound levels
[2] Source: Unpublished Data from LGL
[3] Exposures > 160 dB re 1µPa rms are for impulsive sound sources (ZVSP surveys) only, 120 dB re 1µPa rms for continuous sound sources (e.g. drilling, DP, ice management)
[4] Assumes mammals move out and different mammals move into the area and are exposed in each 24 hr period the activity occurs. Bowhead whale exposures assume whales move out and different whales move into the area and are exposed in each 48 hr period the activity occurs.

None of the equipment planned for use will produce continuous sounds loud enough to cause detrimental physical effects (e.g., temporary reduction in hearing sensitivity or permanent hearing damage) in marine mammals unless the animals enter the area immediately adjacent to the drilling units during operations and remain there for an extended period of time, which is unlikely given their tendency to avoid such areas. Consequently, mitigation, as described for seismic activities including ramp ups, power downs, and shut downs, should not be necessary for exploration drilling and other support activities emitting continuous sounds. However, Shell plans to use PSOs onboard the drilling units, OSVs, ice management, and anchor handling vessels to monitor marine mammals and their responses to industry activities, in addition to initiating mitigation measures should in-field sound measurements indicate conditions that may present a threat to the health and well-being of marine mammals. Sound energy from drilling ice management, and other support activities associated with Shell's exploration drilling activities as described in EP Revision 2 could result in behavioral disturbance of marine mammals and may mask marine mammal communication and other sounds in the natural environment; however, only short-term and localized behavioral disturbances are anticipated. Southall et al. (2007) reviewed a number of papers describing the responses of marine mammals to non-pulsed sound. In general, little or no response was observed in animals exposed at received levels from 90 to 120 dB re 1μPa rms. Probability of avoidance and other behavioral effects increased when received levels were 120 to 160 dB re 1μPa rms.

Ice management vessels produce more noise than ships of comparable size due primarily to the sounds of the propeller cavitation (Richardson et al. 1995a). Ice management vessels typically ram into heavy ice until losing momentum, then back off to build momentum before ramming again. The highest noise levels usually occur while backing full astern in preparation to ram forward. Overall, the noise generated by an ice management vessel pushing ice was 10 to 15 dB re 1μPa rms greater than the noise produced by the ship underway in open water (Richardson et al. 1995a).

A MLC will be constructed at each drill site using either a large diameter bit operated by hydraulic motors and suspended from the *Discoverer* or *Polar Pioneer* or with an excavator on a ROV system. The MLC ROV would excavate the MLC using implements such as a bucket, grinder, or rock hammer on the ROV sled. Use of a MLC ROV system would require an additional OSV type vessel from which the ROV would be transported, deployed and operated. This specific technology has not been put to use for construction of MLC's, but similar technology has been used for very similar work elsewhere.

Sounds from construction of an MLC during Shell's 2012 exploration drilling activities in the Chukchi Sea were recorded by hydrophones moored to the seafloor at distances of 0.6, 1.2, 2.5 and 4.9 mi (1, 2, 4, and 8 km). JASCO (Austin et al. 2013) calculated that these sounds diminished below the 120 dB rms threshold at 5.3 mi (8.2 km) from the drill site. The MLC in the 2012 program was constructed using the drilling unit. If Shell constructs MLCs using the ROV system, emitted sounds would be expected to be quieter than when using the drilling unit. Sound profile modeling, as described in Section 4.0, was conducted using the louder option of constructing a MLC using a drilling unit in the scenarios to be conservative.

Baleen Whales and Continuous Sounds

Baleen whales are likely to respond to drilling sounds by avoiding the area of operations. Most information on the response of baleen whales to continuous sounds is drawn from studies of gray whales and bowhead whales. This section discusses the potential impacts of continuous sound on non-endangered baleen whales, specifically gray and minke whales.

Gray whales are expected to occur throughout the eastern Chukchi Sea until their fall migration to Baja California begins (Funk et al. 2010; Blees et al. 2010; Brueggeman 2010). However, given the transient nature of whales, relatively few gray whales or minke whales are expected to be exposed to continuous sounds from drilling and support activities.

Malme et al. (1986) observed the behavior of feeding gray whales during four experimental playbacks of drilling sounds (50 to 315 Hz; 21-min overall duration and 10 percent duty cycle; source levels 156 to 162 dB re 1μPa rms). In two cases for received levels of 100 to 110 dB re 1μPa rms, no behavioral reaction was observed. Avoidance behavior was observed in two cases where received levels were 110 to 120 dB re 1μPa rms.

Frankel & Clark (1998) conducted playback experiments with wintering humpback whales using a single speaker producing a low-frequency "M-sequence" (sine wave with multiple-phase reversals) signal in the 60 to 90 Hz band with output of 172 dB re 1μPa rms. For 11 playbacks, exposures were between 120 and

130 dB re 1µPa rms and included sufficient information regarding individual responses. During eight of the trials, there were no measurable differences in tracks or bearings relative to control conditions, whereas on three occasions, whales either moved slightly away from (n = 1) or towards (n = 2) the playback speaker during exposure. The presence of the source vessel itself had a greater effect than did the M-sequence playback.

Bowhead whale response to drilling sounds has been studied more thoroughly, and these studies are reviewed in Section 4.8.6. In general, these studies indicate that there could be some avoidance, by bowhead, or baleen whales, of the areas ensonified by continuous sound sources such as drilling and ice management within the areas ensonified to > 120 dB re 1µPa rms, but these effects would be slight and brief in duration. Furthermore, available data suggest baleen whales avoid ice management vessels. Migrating bowhead whales appeared to avoid an area around a drill site by >16 mi (>25 km) where an icebreaker was working in the Beaufort Sea. There was intensive icebreaking daily in support of the drilling activities (Brewer et al. 1993). Migrating bowheads also avoided a nearby drill site at the same time of year when little icebreaking was being conducted (LGL and Greeneridge 1987). It is unclear whether the drilling activities, icebreaking operations, or the ice itself might have been the cause for the whales' diversion. Non-listed baleen whales are expected to act similarly to listed species.

It is possible that the simultaneous operation of two drilling units at the Burger Prospect and associated activities contemplated in EP Revision 2 may cause whales to temporarily deflect farther north than they normally would until they are past the drilling operations in the Chukchi Sea before they head south into the Bering Sea. Alternatively, data suggest they may in fact stay closer to shore and travel south along the Alaskan coast. A deflection to the north would potentially increase the distance a whale would travel as it moves through the Chukchi Sea. Recordings from the drilling ship *Explorer II* were projected in the Canadian Beaufort Sea during the drilling season (Richardson et al. 1985a). Changes in behavior in response to the sounds were observed. Some whales showed avoidance behavior, but the deflection away from the sound was considered weak (Richardson et al. 1985a). During the same study, Richardson et al. (1985a) observed whales between 2.5 mi and 12.4 mi (4 and 20 km) while drilling activity was occurring, and he concluded that the whales were undisturbed. In a similar study where recordings from the drilling unit *Kulluk* were projected, no deflection was seen until sound pressure levels reached 120 dB re 1 µPa rms or higher (Wartzok et al. 1989).

Numbers of gray and minke whales expected to be exposed to sounds (continuous *and* pulsed) associated with Shell's proposed activities that may illicit behavioral reactions constituting NMFS-defined "harassment" - temporary avoidance or deflection behaviors - are presented in Table 4.7.3-1. The number of potentially exposed individuals represent only a small proportion of their respective populations.

Conclusion

In conclusion, reactions of gray and minke whales to continuous sounds from drilling, icebreaking and other support activities are expected to include temporary (short-term) disturbance consisting of avoidance of or deflection around a localized area. No mortality or population-level effects are anticipated. Effects on non-endangered baleen whales from program-related continuous sounds would incrementally increase above levels described in EP Revision 1 due to the addition of an ice management vessel and two drilling units operating simultaneously at the Burger Prospect; however, any effects are not anticipated to accumulate across multiple seasons. Effects would be minimized by fully implementing mitigation measures with PSOs stationed on drilling units, OSVs, ice management vessels, and anchor-handling vessels to apply real-time mitigation, if necessary. These mitigation measures should prevent any measureable disruptions to baleen whales occurring near project activities. Based on the significance thresholds and level of effects definitions determined by BOEM (BOEM 2011a) and provided in Section 4.7, continuous sounds from drilling and ice management associated with Shell's proposed activities will not be significant and will have a negligible effect on non-listed baleen whales occurring near Shell's proposed activities.

Toothed Whales and Continuous Sound

Most toothed whales have the greatest hearing sensitivity at frequencies much higher than that of baleen whales and may be less responsive to low-frequency sound commonly associated with industry activities. Richardson et al. (1995a) reported that beluga whales did not show any apparent reaction to playback of underwater drilling sounds at distances greater than 656 to 1,312 ft (200 to 400 m). Reactions included slowing down, milling, or reversal of course after which the whales continued past the projector, sometimes within 164 to 328 ft (50 to 100 m). The authors concluded (based on a small sample size) that playback of drilling sound had no biologically significant effects on migration routes of beluga whales migrating through pack ice and along the seaward side of the nearshore lead east of Pt. Barrow in spring.

In reviewing responses of cetaceans with best hearing in mid-frequency ranges, which includes toothed whales, Southall et al. (2007) reported that combined field and laboratory data for mid-frequency cetaceans exposed to non-pulse sounds did not lead to a clear conclusion about received levels coincident with various behavioral responses. In some settings, individuals in the field showed profound behavioral responses to exposures from 90 to 120 dB re 1µPa rms, while others failed to exhibit such responses for exposure to received levels from 120 to 150 dB re 1µPa rms. Contextual variables other than exposure received level, and probable species differences, are the likely reasons for this variability. Context, including the fact that captive subjects were often directly reinforced with food for tolerating noise exposure, may also explain why there was great disparity in results from field and laboratory conditions—exposures in captive settings generally exceeded 170 dB re 1µPa rms before inducing behavioral responses. Relevant material reviewed by Southall et al. (2007) is summarized below.

Awbrey and Stewart (1983) played back semi-submersible drilling unit sounds (source level: 163 dB re 1µPa rms) to belugas in Alaska. They reported avoidance reactions at 984 and 4,921 ft (300 and 1,500 m) and approach by groups at a distance of 11,483 ft (3,500 m) (received levels approximately 110 to 145 dB re 1µPa rms over these ranges assuming a 15 log R transmission loss). Similarly, Richardson et al. (1990a) played back drilling platform sounds (source level: 163 dB re 1µPa rms) to belugas in Alaska. They conducted aerial observations of eight individuals among approximately 100 spread over an area several hundred meters to several kilometers from the sound source and found no obvious reactions. Moderate changes in movement were noted for three groups swimming within 656 ft (200 m) of the sound projector.

Several researchers conducting laboratory experiments on hearing and the effects of non-pulse sounds on hearing in mid-frequency cetaceans have reported concurrent behavioral responses. Nachtigall et al. (2003) reported that noise exposures up to 179 dB re 1µPa rms and 55-min duration affected the trained behaviors of a bottlenose dolphin participating in a temporary threshold shift (TTS) experiment. Finneran and Schlundt (2004) provided a detailed, comprehensive analysis of the behavioral responses of belugas and bottlenose dolphins to 1-s tones (received levels 160 to 202 dB re 1µPa rms) in the context of TTS experiments. Romano et al. (2004) investigated the physiological responses of a bottlenose dolphin and a beluga exposed to these tonal exposures and demonstrated a decrease in blood cortisol levels during a series of exposures between 130 and 201 dB re 1µPa rms. Collectively, the laboratory observations suggested the onset of behavioral response at higher received levels than did field studies. The differences were likely related to the very different conditions and contextual variables between untrained, free-ranging individuals vs. laboratory subjects that were rewarded with food for tolerating noise exposure. In general, these studies indicate that there could be some avoidance by toothed whales, of the areas ensonified by continuous sound sources such as drilling and ice management within the areas ensonified to > 120 dB re 1µPa rms, but any such effects would be minor and brief. Simultaneous operation of two drilling units at the Burger Prospect and associated activities in 2015 may influence whales to stay farther north than they normally would. Alternatively, they may stay closer to shore and travel along the Alaskan coast. A deflection to the north would potentially increase the distance a whale would travel as they move through the Chukchi Sea. At distances greater than 660-1,300 ft (200-400 m), recorded sounds from drilling activities did not have biologically significant effects on beluga whales even though the sound energy level and frequency were such that it could be heard several kilometers away (Richardson et al. 1995b). This exposure did result in minor deflection from the sound energy and temporary changes in behavior. These changes are not expected to affect whale populations (Richardson et al. 1991; Richard et al. 1998). NMML determined exploration drilling operations are unlikely to affect beluga whales, considering the distances between the Lease Area and beluga whale habitat during the open-water season (Clarke et al., 2011, 2012, 2013, 2014).

Numbers of toothed whales expected to be exposed to sounds (continuous *and* pulsed) associated with Shell's proposed activities that may illicit behavioral reactions constituting NMFS-defined "harassment" temporary avoidance or deflection behaviors - are presented in Table 4.7.3-1. The number of potentially exposed individuals represent only a small proportion of their respective populations.

<u>Conclusion</u>

In sum, reactions of toothed whales to continuous sounds from drilling, icebreaking and other support activities are expected to include temporary (short-term) disturbance consisting of avoidance of or deflection around a localized area. No mortality or population-level effects are anticipated. Effects on toothed whales from program-related continuous sounds would incrementally increase above levels described in EP Revision 1 due to the addition of an ice management vessel and two drilling units operating simultaneously at the Burger Prospect; however, any effects are not anticipated to accumulate across multiple seasons. Effects would be minimized by fully implementing mitigation measures with PSOs stationed on drilling units, OSVs, ice management vessels, and anchor-handling vessels to apply real-time mitigation, if necessary. These mitigation measures should prevent any measureable disruptions to toothed whales occurring near project activities. Based on the significance thresholds and level of effects definitions determined by BOEM (BOEM 2011a), and provided in Section 4.7, continuous sounds from drilling and ice management associated with Shell's proposed activities will not be significant and will have a negligible effect on toothed whales occurring near Shell's proposed activities.

<u>Seals and Continuous Sound</u>

Reactions of pinnipeds to drilling and related activities have not been studied extensively. Pinnipeds generally seem to be less responsive to exposure to industrial sound than most cetaceans. Ringed seals were often seen near drilling units in the Arctic during earlier exploration drilling programs (Ward and Pessah 1986; Brueggeman et al. 1991a; Gallagher et al. 1992; Brewer et al. 1993; Hall et al. 1994). In spring, some ringed and bearded seals approached and dove within 164 ft (50 m) of an underwater sound projector broadcasting steady low frequency drilling sounds (Richardson et al. 1990, 1991a). Received sound levels at the locations of the seals were estimated to be approximately 130 dB re 1µPa rms. Frost and Lowery (1988) reported reduced densities of ringed seals within 2.3 mi (3.7 km) of artificial islands, on some of which drilling was under way.

Southall et al. (2007) reviewed literature describing responses of pinnipeds to non-pulsed sound and reported that the limited data suggest exposures between approximately 90 and 140 dB re 1uPa rms generally do not appear to induce strong behavioral responses in pinnipeds exposed to non-pulse sounds in water; no data exist regarding exposures at higher levels. It is important to note that among these studies of pinnipeds responding to non-pulse exposures in water, there are some apparent differences in responses between field and laboratory conditions. In contrast to the mid-frequency odontocetes, captive pinnipeds responded more strongly at lower levels than did animals in the field. Again, contextual issues are the likely cause of this difference.

Brueggeman et al. (1992a) reported the reactions of seals to an icebreaker during activities at two prospects in the Chukchi Sea. Reactions of seals to the icebreakers varied between the two prospects. Most (67 percent) seals did not react to the icebreaker at either prospect. Reaction at one prospect was greatest during icebreaking activity followed by general vessel activity (running/maneuvering/jogging) and was lowest while the vessel was at anchor or drifting. Frequency of reaction was greatest for animals within 0.14 mi (0.23 km) of the vessel and lowest for animals beyond 0.58 mi (0.93 km). At the second prospect, seal reaction was lowest during icebreaking activity with higher and similar levels of response during general (non-icebreaking) vessel operations and when the vessel was at anchor or drifting. The frequency of seal reaction generally declined with increasing distance from the vessel except during general vessel activity where it remained consistently high to about 0.29 mi (0.46 km) from the vessel before declining. Kanik et al. (1980 in Richardson et al. 1995a) reported that most ringed seals and harp seals within 0.6 to 1.2 mi (1 to 2 km) from an icebreaker remained on ice but that seals closer to the icebreaker often dove into the water.

Shell's proposed activities would occur during the open-water season, after sea ice retreats north of the prospect areas and after all of the fast-ice has melted way. Furthermore, whelping and molting seasons for all seal species occurring near the Burger Prospect will have ended before commencement of activities associated with the proposed exploration drilling activities. Sighting rates observed during CSESP vessel-based marine mammal surveys collected over five years (2008-2012) are provided in Table 4.7.2-3. Similar sighting rates were not presented in the annual report for 2013. Based on frequencies of observations, few seals are expected to linger in the area after the sea ice has retreated north.

Conclusion

In conclusion, seals in the Chukchi Sea are associated with sea ice, and most sea ice is absent from the prospect area during the open water season. Effects on seals present near Shell's proposed activities may include temporary avoidance responses such as slipping off of ice and into the water, diving, or briefly avoiding approaching vessels within a localized area. Disturbances of seals by continuous sounds emitted from drilling and support activities as described in Section 2.0 will be temporary and localized to small numbers of seals hauled out on remnant ice floes or already in the water. Effects on seals from continuous sound would increase above those expected in Shell's EP Revision 1, because the proposed activities include two drilling units operating simultaneously at the Burger Prospect and an increase in associated support activities; however, any effects would be short-term are not anticipated to accumulate across multiple seasons. Effects would be minimized by fully implementing mitigation measures with PSOs stationed on drilling units, OSVs, ice management vessels, and anchor-handling vessels to apply real-time mitigation, if necessary. These mitigation measures should prevent any measureable disruptions to seals occurring near project activities. Based on the significance thresholds and level of effects definitions determined by BOEM (BOEM 2011a), and provided in Section 4.7, effects from continuous sound associated with Shell's proposed activities will not be significant and will have a negligible effect on seals occurring near Shell's proposed activities.

Overall Conclusion on Impacts of Continuous Sound

No lasting impacts to marine mammals from the sound energy that will be created by exploration drilling and ice management activities in the Chukchi Sea are expected. The most likely effects of these activities are temporary avoidance of the area by most marine mammals. Avoidance of the area is likely to last as long as operations are ongoing, but is unlikely to persist once activities cease.

Species composition and the number of individual marine mammals observed in the Burger Prospect area, and adjacent areas of the Chukchi Sea, shows considerable seasonal and inter-annual variation. Gray whales were the cetacean most frequently sighted from seismic and support vessels during surveys conducted on the Burger Prospect from 2006 through 2008 (Funk et al. 2010); however, they were relatively uncommon in the area during more recent surveys, especially after September (Brueggeman et al. 2009; Reiser et al. 2010; Blees et al. 2010). Gray whales have been the most frequently sighted cetacean during the 2008-2012 CSESP studies in the areas surrounding the Burger Prospect (Table 3.7-6). Very few humpback, fin, or minke whales have been cited in the area (Table 3.7-6).

Gray whales have been reported to use Hanna Shoal, located approximately 37 mi (60 km) from the Burger Prospect, as a feeding area; however, much of this evidence is from historical records rather than recent observations (Clarke et al. 2011). There is no indication that gray whales feed in the Burger Prospect area. Gray whales have been shown to interrupt feeding in response to airgun pulses (Malme et al. 1986, 1988), but the distance to Hanna Shoal from the Burger Prospect area makes it very unlikely that drilling sounds would interrupt gray whales that might be feeding near the shoal. Currents in the Chukchi Sea often cause ice to accumulate around Hanna Shoal and the waters between Hanna Shoal and the Burger Prospect may be an area where active ice management is required. Malme et al. (1986) reported that approximately 50 percent of gray whales exposed to pulsed sounds of 173 dB re 1µPa rms interrupted feeding and that approximately 10 percent interrupted feeding at received levels of 163 dB re 1µPa rms. Studies of western gray whales off Sakhalin Island demonstrated considerable tolerance to an operating seismic vessel offshore of the feeding area (Johnson et al 2007b), although there were subtle behavioral responses (Gailey et al. 2007) and some movement of whales within the feeding area in response to the seismic activity (Yazvenko et al. 2007). Sounds produced by vessels managing the ice (Table 2.9-1) during Shell's 2012 drilling activities were recorded and the distance to the 120 dB re 1 µPa rms isopleth was calculated to occur at 9.6 km (JASCO and Greeneridge 2014). It is unlikely that gray whales feeding near Hanna Shoal would be displaced from the feeding area unless ice management occurred very near the Shoal. Feeding western gray whales in the Sakhalin Islands that showed displacement from feeding areas due to sound generally remained within the overall feeding area and reoccupied preferred sights once the noise producing activity ceased (Yazvenko et al. 2007). Any displacement of gray whales near the project area would likely be short-term lasting only as long as operations were ongoing in the immediate area of the displacement.

Beluga whales regularly use the Chukchi Sea but tend to remain north of the project area during the summer when most of the planned activities will take place. Beluga whales may interact with the exploration drilling activities during their fall migration when they move south through the Chukchi Sea; however, very few have been observed in the prospect area in July-October in six years of intensive baseline marine mammal surveys. Beluga whales would probably avoid the drilling operations, but impacts of that avoidance would be minimal because most animals would be moving through the area and going a slightly greater distance around the operations would have little or no impacts on their energy requirements. Beluga whales primarily use high-frequency sounds to communicate and locate prey; therefore, masking by low-frequency sounds associated with drilling activities is not expected to occur (Gales 1982). If the distance between communicating whales does not exceed their distance from the drilling activity, the likelihood of potential impacts from masking would be low (Gales 1982). Cetaceans that use lower frequencies to call could experience masking of their calls in close proximity to the drilling operation. Any such effects are expected to be minimal as most cetaceans will avoid the operations.

Harbor porpoises and killer whales could be present in the project area. In general, only a few individuals of these species would be present if they were in the area at all and no impacts beyond short–term avoidance would likely occur. No impacts to the populations of these animals would occur.

Non-listed pinniped species that could be encountered in the study area include spotted seals and ribbon seals. Most pinnipeds are unlikely to react to continuous sounds until they are much stronger than 120 dB re 1µPa rms (the zone of disturbance recognized by NMFS for continuous sounds), so it is probable that only a small percentage of these animals would actually be disturbed. Only short-term avoidance of the immediate area around the drilling operations is expected to occur. Spotted seals could be present in the area. The closest spotted seal haulouts are along the Chukchi Sea coast near Icy Cape which is approximately 60 mi (96 km) away.

Effects of the sound generated by exploration drilling and ice management are expected to result in only slight short-term behavioral disturbance. Based on the modeled sound propagation and transmission loss associated with exploration drilling and the densities of marine mammals in the Burger Prospect area, a small number of beluga, gray whales, and spotted and ringed seals are likely to be exposed to drilling sound levels that might elicit such reactions (Table 4.7.3-1). All such effects would be negligible. Shell does not expect any lasting impacts to marine mammals from sounds created during exploration drilling activities in the Chukchi Sea.

4.7.4 Impacts of ZVSP Survey Sound Generation on Marine Mammals

As described in EP Revision 2, Shell plans to conduct a geophysical activity referred to as a ZVSP survey at each Chukchi drill site. During ZVSP survey operations, a string of geophones (receivers) will be hung in the wellbore to record the sonic waves created by the firing of a sound source (airgun array), which is suspended from the deck of the drilling unit into the water adjacent to the riser (Figure 2.4-1). The geophones will be relocated in the wellbore after each firing of the sound source until the entire wellbore has been surveyed. Each ZVSP survey will take approximately 10 to 14 hr to complete; the majority of that time will involve relocating the geophones in the wellbore. The sound source will be triggered approximately 216 times over the course of each survey.

A two-airgun (2×250 in.^{3} airguns) or three-airgun array (3×150 in.^{3}) will likely be used to perform each ZVSP survey. The estimated source level used to model sound propagation from the airgun array is approximately 239 to 241 dB re 1µPa m rms (Table 2.4-1). Modeled radii to various sound isopleths are provided in Table 2.9-5.

Airguns function by venting high-pressure air into the water. The pressure signature of an individual airgun consists of a sharp rise and then fall in pressure, followed by several positive and negative pressure excursions caused by oscillation of the resulting air bubble. Typical high-energy airgun arrays emit most energy at 10 to 120 Hz. However, the pulses contain energy up to 500 to 1,000 Hz and some energy at higher frequencies (Goold and Fish 1998; Potter et al. 2007).

The effects of sounds from airguns on marine mammals might include one or more of the following: tolerance, masking of natural sounds, behavioral disturbance, and, at least in theory, the possibility of temporary or permanent hearing impairment, or non-auditory physical effects (Richardson et al. 1995a). Given the brief duration and moderate size of the sound sources planned for each survey, no marine mammal species are expected to experience temporary or permanent hearing impairment, or non-auditory physical effects. Some marine mammal species could demonstrate behavioral disturbance at longer distances than auditory physical effects. However, Shell will implement a number of mitigation measures to minimize any potential effects and avoid harm to any marine mammals.

Shell's mitigation program includes a comprehensive 4MP (Attachment B of EP Revision 2). Airgun arrays will be ramped up slowly during ZVSP surveys to warn cetaceans and pinnipeds in the vicinity of the airguns and provide time for them to leave the area and avoid potential injury or impairment of their hearing abilities. Ramp ups from a cold start when no airguns have been firing will begin by firing the smallest airgun in the array. A ramp up to the required airgun array volume will not begin until there has been a minimum of 30-min of observation of the safety zone by PSOs to assure that no marine mammals are present. The safety zone is the extent of the 180 dB re 1µPa rms radius for cetaceans and 190 dB re 1µPa rms for pinnipeds. The entire safety zone must be visible during the 30-min lead-in to an array ramp up. If a marine mammal(s) is sighted within the safety zone during the 30-min watch prior to ramp up, ramp up will be delayed until the marine mammal(s) is sighted outside of the safety zone or the animal(s) is not sighted for at least 15 to 30 min: 15 min for small odontocetes (beluga, harbor porpoise) and pinnipeds (spotted seals), or 30 min for baleen whales (gray whales and minke whales).

NMFS is currently in the process of revising and updating its marine mammal acoustic thresholds in order to incorporate new science and utilize improved methods (NOAA 2013c). The thresholds currently being revised include: 1) thresholds for injury (Level A Harassment) of whales and seals that would be applied to all (impulsive and continuous) sound sources; and 2) the behavioral (Level B Harassment) thresholds to be applied to mobile and impulsive sounds (NOAA 2013c). To date NMFS has released detailed information only on the thresholds for injury; the agency released a document entitled Draft Guidance for

Assessing the Effects of Anthropogenic Sound on Marine Mammals: Acoustic Threshold levels for Onset of Permanent and Temporary Threshold Shifts (NOAA 2013c) for public review and comment on 27 December 2013. However, NMFS has yet to issue draft guidance concerning revised Level B behavioral harassment thresholds.

The draft guidance document reviewed much of the new information on marine mammal hearing consistent with the findings of Southall et al. 2007. NMFS categorized marine mammals into functional hearing groups (Table 4.7.3-1), but altered the hearing ranges slightly from what has been published in the past. The agency also adopted / established weighting function parameters for each functional hearing group. When applied to auditory weighting functions, the parameters take into consideration the functional hearing group's sensitivities to different frequencies. The acoustic threshold criteria are in draft and have not been implemented; therefore, the criteria have not been utilized in this assessment.

<u>Tolerance</u>

Numerous studies have shown that pulsed sounds from airguns are often readily detectable in the water at distances of many kilometers. Numerous studies have shown that marine mammals at distances more than a few kilometers from operating seismic vessels often show no apparent response. That is often true even in cases when the pulsed sounds must be readily audible to the animals based on measured received levels and the hearing sensitivity of the particular mammal group. Although various baleen whales, toothed whales, and (less frequently) pinnipeds have been shown to react behaviorally to airgun pulses under some conditions, at other times mammals of all three types have shown no overt reactions. In general, pinnipeds, and small odontocetes, seem to be more tolerant of exposure to airgun pulses than are baleen whales.

<u>Masking</u>

Masking effects of pulsed sounds (even from large arrays of airguns) on marine mammal calls and other natural sounds are expected to be limited, although there are very few specific data of relevance. Some whales 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). Although there has been one report that sperm whales cease calling when exposed to pulses from a very distant seismic ship (Bowles et al. 1994), a more recent study reports that sperm whales off northern Norway continued calling in the presence of seismic pulses (Madsen et al. 2002). That has also been shown during recent work in the Gulf of Mexico (Tyack et al. 2003).

<u>Disturbance Reactions</u>

Disturbance includes a variety of effects, including subtle changes in behavior, more conspicuous changes in activities, and displacement. Based on conclusions reported by NMFS (2001), we assume that simple exposure to sound, or brief reactions that do not disrupt behavioral patterns in a potentially significant manner, do not constitute harassment or "taking." By potentially significant, we mean "in a manner that might have deleterious effects to the well-being of individual marine mammals or their populations".

Reactions to sound, if any, depend on species, state of maturity, experience, current activity, reproductive state, time of day, and many other factors. If a marine mammal does react briefly to an underwater sound by changing its behavior or moving a small distance, the impacts of the change are unlikely to be significant to the individual, let alone the stock or the species as a whole. However, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period, impacts on the animals could be significant. Given the many uncertainties in predicting the quantity and types of impacts of noise on marine mammals, it is common practice to estimate how many mammals were present within a particular distance of industrial activities, or exposed to a particular level of industrial sound. This practice likely overestimates the numbers of marine mammals that are affected in some biologically-important manner.

The sound criteria used to estimate the number of marine mammals that might be disturbed to some biologically-important degree by Shell's ZVSP surveys are based on behavioral observations during studies of several species.

Baleen Whales – Baleen whales generally tend to avoid operating airguns, but distances of avoidance radii are quite variable. Whales are often reported to show no overt reactions to pulses from large arrays of airguns at distances beyond a few kilometers, even though the airgun pulses remain well above ambient noise levels out to much longer distances. However, baleen whales exposed to strong noise pulses from airguns often react by deviating from their normal migration route and/or interrupting their feeding and moving away. In the case of the migrating gray and bowhead whales, the observed changes in behavior appeared to be of little or no biological consequence to the animals. They simply avoided the sound source by displacing their migration route to varying degrees, while remaining within the natural boundaries of the migration corridors.

Studies of gray, bowhead, and humpback whales have determined that received levels of pulses in the 160 to 170 dB re 1 μPa rms range seem to cause obvious avoidance behavior in a substantial fraction of the animals exposed. In many areas, seismic pulses from large arrays of airguns diminish to those levels at distances ranging from 2.8 to 9.0 mi (4.5 to 14.5 km) from the source. Received sound energy levels generated by the planned ZVSP surveys are expected to diminish to 160 dB re 1μPa rms within 2.3 mi (3.7 km) of the source (Table 2.9-5). A substantial proportion of the baleen whales within those distances may show avoidance or other strong disturbance reactions to the airgun array. Subtle behavioral changes sometimes become evident at somewhat lower received levels, and recent studies have shown that some species of baleen whales, notably bowhead and humpback whales, at times show strong avoidance at received levels lower than 160 to 170 dB re 1 μPa rms. Bowhead whales migrating west across the Alaskan Beaufort Sea in autumn, in particular, are unusually responsive, with substantial avoidance occurring out to distances of 12.4 to 18.6 mi (20 to 30 km) from a medium-sized airgun source (Miller et al. 1999; Richardson et al. 1999). However, more recent research on bowhead whales (Miller et al. 2005; Christie et al. 2010) corroborates earlier evidence that, during the summer feeding season, bowheads are not as sensitive to seismic sources. In summer, feeding bowheads typically begin to show avoidance reactions at a received level of about 150 to 160 dB re 1 μPa rms (Richardson et al. 1986; Ljungblad et al. 1988; Miller et al. 1999, Christie et al. 2010). Shell's ZVSP surveys may be conducted at least partially during fall migration in the area of the known bowhead migration corridor. Recent evidence suggests that some bowheads feed during migration and feeding bowheads might be encountered in the project area (Lyons et al. 2009; Christie et al. 2010). The primary bowhead summer feeding grounds; however, are far to the east in the Canadian Beaufort Sea and the primary feeding area used during fall migration is near Barrow though bowheads fed near Shell's seismic programs in Camden Bay in both 2007 and 2008. Shell anticipates that some baleen whales may exhibit minor, short-term disturbance responses to underwater sounds from airguns. Any potential impacts on baleen whale behavior would be localized within the activity area and would not result in population-level effects.

Malme et al. (1986, 1988) studied the responses of feeding eastern gray whales to pulses from a single 100 in.^{3} airgun off St. Lawrence Island in the northern Bering Sea. They estimated, based on small sample sizes, that 50 percent of feeding gray whales ceased feeding at an average received pressure level of 173 dB re 1 μPa on an (approximate) rms basis, and that 10 percent of feeding whales interrupted feeding at received levels of 163 dB re 1μPa rms. Those findings were generally consistent with the results of experiments conducted on larger numbers of gray whales that were migrating along the California coast, and on observations of Western Pacific gray whales feeding off Sakhalin Island, Russia (Johnson 2002).

Two drilling units operating simultaneously at the Burger Prospect in the northeastern Chukchi Sea, which are close to Hanna Shoal would increase the potential for gray whales to be disturbed enough by activities to interrupt feeding, particularly if ice management was required in close proximity to the shoal. Studies of western gray whales off Sakhalin Island demonstrated considerable tolerance to an operating seismic vessel offshore of the feeding area (Johnson et al 2007b) and may suggest that gray whales would be unlikely to abandon the feeding area altogether, but some whales could be displaced from preferred feeding habitat over short periods of time. Many gray whales feed along the Chukchi Sea coast north of Icy Cape, particularly in the Peard Bay area (Thomas et al. 2010), and it is likely that any temporary displacement from the Hanna Shoal area would not result in impacts to whales over longer periods due to a lack of feeding habitat since abundant feeding habitat exists relatively close by.

Data on short-term reactions (or lack of reactions) of cetaceans to impulsive noises do not necessarily provide information about long-term effects. However, gray whales continued to migrate annually along the west coast of North America despite intermittent seismic exploration and much ship traffic in that area for decades (Malme et al. 1984). Bowhead whales have continued to travel to the eastern Beaufort Sea each summer despite seismic exploration in their summer and autumn range for many years (Richardson et al. 1987; Funk et al. 2010). Populations of both gray whales and bowhead whales grew substantially during this time. In any event, the brief exposures to sound pulses from the proposed ZVSP survey airgun source are highly unlikely to result in any prolonged effects on individual baleen whales or their populations.

Toothed Whales – Few studies similar to the more extensive baleen whale/seismic pulse work summarized above have been reported for toothed whales. However, systematic work on sperm whales is underway (Tyack et al. 2003), and there is an increasing amount of information about responses of various odontocetes to seismic surveys based on monitoring studies (e.g., Stone 2003; Smultea et al. 2004; Moulton and Miller 2005).

Finneran and Jenkins (2012) analyzed acoustic thresholds for TTS and PTS for pulsed noises. They found that mid-frequency cetaceans including killer whales and beluga whales occurs in the 150 Hz – 160 kHz range (Finneran and Jenkins 2012). High-frequency cetacean group, which includes harbor porpoises, uses a 200 Hz – 180 kHz frequency range according to Finneran and Jenkins (2012).

Seismic operators sometimes see dolphins and other small toothed whales near operating airgun arrays, but in general there seems to be a tendency for most delphinids to show some limited avoidance of seismic vessels operating large airgun systems. However, some dolphins seem to be attracted to the seismic vessel and floats, and some ride the bow wave of the seismic vessel even when large arrays of airguns are firing. Nonetheless, there have been indications that small toothed whales sometimes move away, or maintain a somewhat greater distance from the vessel, when a large array of airguns is operating than when it is silent (e.g., Goold 1996a,b,c; Calambokidis and Osmek 1998; Stone 2003). Aerial surveys during seismic operations in the southeastern Beaufort Sea recorded much lower sighting rates of beluga whales within 6.2 to 12.4 mi (10 to 20 km) of an active seismic vessel. These results were consistent with the low number of beluga sightings reported by observers aboard the seismic vessel, suggesting that some belugas might be avoiding the seismic operations at distances of 6.2 to 12.4 mi (10 to 20 km) (Miller et al. 2005). Similarly, aerial surveys conducted in 2007 and 2008 during Shell seismic programs in the Beaufort Sea generally reported beluga whale sightings out near the shelf break well away from the seismic operations; however, this may simply be the whales preferred habitat and not be a reaction to the seismic program.

Similarly, captive bottlenose dolphins and beluga whales exhibit changes in behavior when exposed to strong pulsed sounds similar in duration to those typically used in seismic surveys (Finneran et al. 2000, 2002); however, the animals tolerated high received levels of sound (pk–pk level >200 dB re 1 μPa) before exhibiting aversive behaviors.

Odontocete reactions to large arrays of airguns are variable and, at least for small odontocetes, seem to be confined to a smaller radius than has been observed for mysticetes. A ≥170 dB re 1μPa rms disturbance criterion (rather than ≥160 dB re 1μPa rms) may be more appropriate for small odontocetes (and pinnipeds) which tend to be less responsive than other cetaceans; however, based on the limited existing evidence, belugas should not be grouped with delphinids in the “less responsive” category.

Pinnipeds – Pinnipeds are not likely to show a strong avoidance reaction to the small-sized airgun source that will be used for the ZVSP surveys. Visual monitoring from seismic vessels has shown only slight (if any) avoidance of airguns by pinnipeds, and only slight (if any) changes in behavior. Pinnipeds frequently do not avoid the area within a few hundred meters of operating airgun arrays (e.g., Miller et al. 2005; Harris et al. 2001). However, initial telemetry work suggests that avoidance and other behavioral reactions to small airgun sources may at times be stronger than evident to date from visual studies of pinniped reactions to airguns (Thompson et al. 1998). Even if reactions of the species occurring in the proposed survey area are as strong as those evident in the telemetry study, reactions are expected to be confined to relatively small distances and durations, with no long-term effects on pinniped individuals or populations.

Hearing Impairment and Other Physical Effects

Temporary or permanent hearing impairment is a possibility when marine mammals are exposed to very strong sounds, but there has been no specific documentation of this for marine mammals exposed to sequences of airgun pulses. Current NMFS policy regarding exposure of marine mammals to high-level sounds is that cetaceans and pinnipeds should not be exposed to impulsive sounds ≥180 and 190 dB re 1 μPa (rms), respectively (NMFS 2000). These exposure levels have also been applied by the USFWS to walruses and polar bears, respectively. Those criteria have been used in defining the safety (shutdown) radii planned for the proposed ZVSP survey operations. However, those criteria were established before there were any data on the minimum received levels of sounds necessary to cause temporary auditory impairment in marine mammals:

- the 180 dB re 1μPa rms criterion for cetaceans is probably quite precautionary, i.e., lower than necessary to avoid TTS, let alone permanent auditory injury, at least for belugas and delphinids.
- the minimum sound level necessary to cause permanent hearing impairment is higher, by a variable and generally unknown amount, than the level that induces barely-detectable TTS.
- the level associated with the onset of TTS is often considered to be a level below which there is no danger of permanent damage.

Several aspects of the planned monitoring and mitigation measures for this project (Section 2.11) are designed to detect marine mammals before they approach the exclusion zone, and to avoid exposing them to sound pulses that might cause hearing impairment. In addition, many cetaceans are likely to show some avoidance of the area with high received levels of airgun sound. In those cases, the avoidance responses of the animals themselves will reduce or (most likely) avoid any possibility of hearing impairment.

Non-auditory physical effects might also occur in marine mammals exposed to strong underwater pulsed sound. Possible types of non-auditory physiological effects or injuries that theoretically might occur in mammals close to a strong sound source include stress, neurological effects, bubble formation, resonance effects, and other types of organ or tissue damage. It is possible that some marine mammal species (i.e., beaked whales) may be especially susceptible to injury and/or stranding when exposed to strong pulsed sounds. However, beaked whales do not occur in the vicinity of the Burger Prospect, and, as discussed below, there is no definitive evidence that any of these effects occur, even for marine mammals in close proximity to large arrays of airguns. It is unlikely that any effects of these types would occur during the present project given the brief duration of exposure of any given mammal, and the planned monitoring and mitigation measures. The following subsections discuss in more detail the possibilities of TTS, PTS, and non-auditory physical effects.

Temporary Threshold Shift – TTS is the mildest form of hearing impairment that can occur during exposure to a strong sound (Kryter 1985). While experiencing TTS, the hearing threshold rises and a sound must be stronger in order to be heard. TTS can last from minutes or hours to (in cases of strong

TTS) days. For sound exposures at or somewhat above the TTS threshold, hearing sensitivity recovers rapidly after exposure to the noise ends.

For toothed whales exposed to single short pulses, the TTS threshold is, to a first approximation, a function of the energy content of the pulse (Finneran et al. 2005, 2002). Given the available data, the received level of a single seismic pulse might need to be approximately 210 dB re 1 μPa rms (approximately 221 to 226 dB re 1μPa rms peak-to-peak [pk–pk]) in order to produce brief, mild TTS. Exposure to several seismic pulses at received levels near 200 to 205 dB re 1μPa rms might result in slight TTS in a small odontocete, assuming the TTS threshold is, to a first approximation, a function of the total received pulse energy. Seismic pulses with received levels of 200 to 205 dB re 1μPa rms or more are usually restricted to a radius of no more than 656 ft (200 m) around a seismic vessel operating a large array of airguns.

For baleen whales, there are no data, direct or indirect, on levels or properties of sound that are required to induce TTS. However, no cases of TTS are expected given the moderate size of the source, and the strong likelihood that baleen whales would avoid the area of operations (or vessel) before being exposed to levels high enough for there to be any possibility of TTS.

In pinnipeds, TTS thresholds associated with exposure to brief pulses (single or multiple) of underwater sound have not been measured. Initial evidence from prolonged exposures suggested that some pinnipeds may incur TTS at somewhat lower received levels than do small odontocetes exposed for similar durations (Kastak et al. 1999; Ketten et al. 2001; *cf*. Au et al. 2000). For harbor seal, which is closely related to the ringed seal, TTS onset apparently occurs at somewhat lower received energy levels than for odontocetes.

A marine mammal within a radius of ≤328 ft (≤100 m) around a typical large array of operating airguns might be exposed to a few seismic pulses with levels of ≥205 dB re 1μPa rms, and possibly more pulses if the mammal moved with the seismic vessel. The received sound levels will be reduced for the proposed array to be used during the current survey compared to larger arrays, thus reducing the potential for TTS for the proposed survey. (As noted above, most cetacean species tend to avoid operating airguns, although not all individuals do so.) However, a couple of the considerations that are relevant in assessing the impact of typical seismic surveys with airgun arrays are directly applicable here:

- "Ramping up" (soft start) is standard operational protocol during startup of airgun arrays. Ramping up involves starting the airguns in sequence, usually commencing with a single airgun and gradually adding additional airguns. This practice will be employed when the airgun array is operated during the proposed survey.
- With a large array of airguns, TTS would be most likely to occur in odontocetes that bow-ride or otherwise linger near the airguns. Harbor porpoises occur in the Chukchi Sea; however, as discussed above, harbor porpoise are unlikely to be in the project area in large numbers if at all.

NMFS (1995, 2000) concluded that cetaceans and pinnipeds should not be exposed to pulsed underwater noise at received levels exceeding, respectively, 180 and 190 dB re 1 μPa (rms). These sound levels are ***not***, however, considered to be the levels above which TTS might occur. Rather, they are the received levels above which, in the view of a panel of bioacoustics specialists convened by NMFS before TTS measurements for marine mammals started to become available, one could not be certain that there would be no injurious effects, auditory or otherwise, to marine mammals. As discussed above, data that are now available imply that TTS is unlikely to occur unless odontocetes are exposed to airgun pulses much stronger than 180 dB re 1 μPa rms. Given the timing and location of Shell's proposed exploration drilling activities, the brief duration of ZVSP surveys as well as the procedures to be followed when completing these surveys, it is unlikely such effects will be realized.

Permanent Threshold Shift – When PTS occurs, there is physical damage to the sound receptors in the ear. In some cases, there can be total or partial deafness, whereas in other cases, the animal has an impaired ability to hear sounds in specific frequency ranges. There is no specific evidence that exposure to pulses of airgun sound can cause PTS in any marine mammal, even with large arrays of airguns. However, given the possibility that mammals close to an airgun array might incur TTS, there has been further speculation about the possibility that some individuals occurring very close to airguns might incur PTS. Single or occasional occurrences of mild TTS are not indicative of permanent auditory damage in terrestrial mammals. Relationships between TTS and PTS thresholds have not been studied in marine mammals, but are assumed to be similar to those in humans and other terrestrial mammals. PTS might occur at a received sound level at least several decibels above that inducing mild TTS if the animal were exposed to the strong sound pulses with very rapid rise time.

It is highly unlikely that marine mammals could receive sounds strong enough (and over a sufficient duration) to cause permanent hearing impairment during a project employing the medium-sized airgun sources planned here. For the proposed project, marine mammals are unlikely to be exposed to received levels of seismic pulses strong enough to cause TTS. Marine mammals would probably need to be within 328 to 656 ft (100 to 200 m) of the airguns and be exposed for some time period for TTS to occur. Given the higher level of sound necessary to cause PTS, it is even less likely that PTS could occur. In fact, even the levels immediately adjacent to the airgun may not be sufficient to induce PTS, especially because a mammal would not be exposed to more than one strong pulse unless it remained immediately alongside the airgun for a period longer than the inter-pulse interval. Baleen whales generally avoid the immediate area around operating seismic vessels. The planned ZVSP survey monitoring and mitigation measures, including visual monitoring, power downs, and shut downs of the airguns when mammals are seen within the “safety radii”, will minimize the already-minimal probability of exposure of marine mammals to sounds strong enough to induce PTS.

<u>Non-auditory Physiological Effects</u> – Non-auditory physiological effects or injuries that might occur in marine mammals exposed to strong underwater sound include stress, neurological effects, bubble formation, and other types of organ or tissue damage. However, studies examining such effects are very limited. If any such effects do occur, they probably would be limited to unusual situations when animals might be exposed at close range for unusually long periods. It is doubtful that any single marine mammal would be exposed to strong seismic sounds for a sufficient period of time that physiological stress would develop. That is especially so in the case of the proposed project where the airgun configuration is moderately sized and the survey will occur for only a short period of time.

Available data suggest that the effects of seismic survey sounds, if they occur at all, would be limited to short distances and probably to projects involving large arrays of airguns. However, the available data do not allow for meaningful quantitative predictions of the numbers (if any) of marine mammals that might be affected in those ways. Marine mammals that show behavioral avoidance of seismic vessels, including most baleen whales, some odontocetes (including belugas), and some pinnipeds, are especially unlikely to incur auditory impairment or other physical effects. Also, Shell’s planned ZVSP survey monitoring and mitigation measures include shut downs of the airguns, which will reduce any such effects that might otherwise occur.

<u>Strandings and Mortality</u>

Marine mammals close to underwater detonations of high explosive can be killed or severely injured, and their auditory organs are especially susceptible to injury (Ketten et al. 1993; Ketten 1995). Airgun pulses are less energetic and have slower rise times, and there is no proof that they can cause serious injury, death, or stranding even in the case of large airgun arrays. However, the association of mass strandings of beaked whales with naval exercises and, in one case, an L-DEO seismic survey, has raised the possibility that beaked whales exposed to strong pulsed sounds may be especially susceptible to injury and/or behavioral reactions that can lead to stranding.

Seismic pulses and mid-frequency sonar pulses are quite different. Sounds produced by airgun arrays are broadband with most of the energy below 1 kilohertz (kHz). Typical military mid-frequency sonars operate at frequencies of 2–10 kHz, generally with a relatively narrow bandwidth at any one time. Thus, it is not appropriate to assume that there is a direct connection between the effects of military sonar and seismic surveys on marine mammals. However, evidence that sonar pulses can, in special circumstances, lead to physical damage and mortality (NOAA and USN 2001; Jepson et al. 2003; Fernández et al. 2005), even if only indirectly, suggests that caution is warranted when dealing with exposure of marine mammals to any high-intensity pulsed sound.

In May 1996, 12 Cuvier's beaked whales stranded along the coasts of Kyparissiakos Gulf in the Mediterranean Sea. That stranding was subsequently linked to the use of low- and medium-frequency (250 to 3,000 Hz) active sonar by a North Atlantic Treaty Organization (NATO) research vessel in the region (Frantzis 1998). In March 2000, a population of Cuvier's beaked whales being studied in the Bahamas disappeared after a U.S. Navy task force using mid-frequency tactical sonars passed through the area; some beaked whales stranded (Balcomb and Claridge 2001; NOAA and USN 2001).

In September 2002, a total of 14 beaked whales of various species stranded coincident with naval exercises in the Canary Islands (Martel n.d.; Jepson et al. 2003; Fernández et al. 2003). Also in September 2002, there was a stranding of two Cuvier's beaked whales in the Gulf of California, Mexico, when the L-DEO vessel *Maurice Ewing* was operating a 20-airgun, 8,490 in.^{3} array in the general area. The link between the stranding and the seismic surveys was inconclusive and not based on any physical evidence (Hogarth 2002; Yoder 2002). Nonetheless, that plus the incidents involving beaked whale strandings near naval exercises, suggests a need for caution in conducting seismic surveys in areas occupied by beaked whales. However, no beaked whales are found within the vicinity of the Burger Prospect, and the planned ZVSP survey monitoring and mitigation measures are expected to minimize any possibility for injury or mortality of other species.

Airgun arrays that will be used for the ZVSP surveys are much smaller in volume than those used in the above-referenced seismic surveys, which represent a more extreme scenario than that proposed in EP Revision 2. Many seismic surveys have been conducted in the Chukchi Sea and Beaufort Sea, with no reported strandings. The ZVSP surveys would not be expected to result in any such events.

Conclusion

The airgun arrays that will be used for the ZVSP surveys are much smaller in volume than those used in the above-referenced seismic surveys, which represent a more extreme scenario. Most airgun noise is focused beneath the airgun array, though some noise radiates horizontally from firing airgun arrays. Horizontally radiated noise quickly attenuates in the ocean, with decibel levels dropping from source levels to much lower levels in a few tens of meters (Blackwell et al. 2013). Reactions of gray whales to the sound energy generated by ZVSP surveys may be similar to those described above but would likely be limited to a much smaller area. Based on average densities and modeled sound energy radii, few gray whales, belugas, and spotted seals would be expected to be exposed to sound levels of > 160 dB re 1µPa rms (Table 4.7.3-1). Although the airgun arrays used for ZVSP surveys are considerably smaller than those employed in seismic surveys, these studies indicate there is potential for temporary behavioral effects on marine mammals, including startle reactions, deflection, and avoidance. Such disturbances could be expected if the animals approach areas that are ensonified to received sound energy levels of 160 dB re 1µPa rms or more. Sound profile modeling indicated that ensonification to this level would be limited to the area within approximately 7.42 mi (11.96 km) of the source.

Shell will implement a number of ZVSP survey mitigation measures to minimize these effects and avoid harm to any marine mammals, including an extensive 4MP. Airgun arrays will be ramped up slowly during ZVSP surveys to warn cetaceans and pinnipeds in the vicinity of the airguns and provide time for them to leave the area and avoid potential injury or impairment of their hearing abilities. Ramp ups from a cold start when no airguns have been firing will begin by firing a single airgun in the array. A ramp up to the required airgun array volume will not begin until there has been a minimum of 30 min of observation of the safety zone by PSOs to assure that no marine mammals are present. The safety zone is the extent of the 180 dB re 1µPa rms radius for cetaceans and 190 dB re 1µPa rms for pinnipeds. The entire safety zone must be visible during the 30-min lead-in to an array ramp up. If a marine mammal(s) is sighted within the safety zone during the 30-min watch prior to ramp up, ramp up will be delayed until the marine mammal(s) is sighted outside of the safety zone or the animal(s) is not sighted for at least 15 to 30 min: 15 min for small odontocetes (beluga, harbor porpoise) and pinnipeds (spotted seals), or 30 min for baleen whales (gray whales, minke whales).

Given the moderate size of the sound sources planned for the planned ZVSP survey activity, the very short duration it will be conducted at each drillsite, and mitigation measures to be applied, it is unlikely that there would be any cases of temporary or permanent hearing impairment, or non-auditory physical effects in any marine mammal species that would be found in the project area. More likely, behavioral disturbance - including temporary avoidance or deflection reactions - could occur at longer distances than auditory physical effects. These non-lethal effects are not anticipated to last beyond minutes to hours after the ZVSP survey activities are complete and will not accumulate across multiple seasons. Effects would be minimized by fully implementing mitigation measures described above as part of the 4MP, including ramp-up and shut down procedures. Based on the significance thresholds and level of effects definitions determined by BOEM (BOEM 2011a) and provided in Section 4.7, ZVSP survey activities associated with Shell's proposed program as described in Section 2.0 will not be significant and will have a negligible effect on non-–listed marine mammals.

4.7.5 Impacts of Drilling Unit Mooring and MLCs on Marine Mammals

Most marine mammals would likely avoid the immediate areas where drilling unit mooring, installation of mooring buoys, or MLC construction are occurring, so these activities would have no direct impact on marine mammals. Direct disturbance of the seafloor from the setting and removal of anchors during mooring of the drilling unit and from the construction of MLCs will impact benthic organisms that marine mammals prey on and their habitat, but these types of indirect impacts would be limited to a very small portion of the available habitat. Over the duration of the Chukchi Sea EP Revision 2 (up to six wells), a total of approximately 4.01 to 5.28 ac (16,158 to 21,354m^2) of benthic habitat on the Chukchi Sea seafloor would be impacted by mooring and MLC construction, depending on whether MLC construction is done by drill bit or by MLC ROV system. Recolonization of benthic communities would occur within one year, but growth of benthic organisms such as mollusks or polychaetes to size ranges that would be utilized by benthic foragers such as walruses would take several years. Impacts of mooring and MLC construction on benthic organisms are discussed in Section 4.4.3. Impacts of sound associated with mooring and MLC construction are discussed in Section 4.7.3.

Conclusion

The relative spatial extent of impacts on benthic organisms that some marine mammals feed upon is small compared to the benthic habitat available to marine mammals. Based on the significance thresholds and level of effects definitions determined by BOEM (BOEM 2011a), and provided in Section 4.7, effects of drilling unit mooring and MLC construction associated with Shell's proposed activities will not be significant and will have a negligible effect on marine mammals occurring near Shell's proposed activities.

4.7.6 Impacts of Air Emissions on Marine Mammals

The planned exploration drilling will be conducted at drill sites located a minimum of 64 mi (103 km) offshore. As described in Section 3.1.3, air quality in the Lease Sale 193 Area and onshore on the North Slope is classified by the EPA as good. The exploration drilling activities will emit air pollutants, largely through the use of combustion engines, which are discussed in Sections 2.8 and 4.1. The emissions of primary interest from the Shell exploration drilling activities include NO_2, CO, SO_2, small-diameter PM, and VOC.

Section 4.1 discussed the air quality impacts expected from Shell's EP Revision 2 and concludes that the overall impacts on air quality will be minor and that impacts on offshore air quality resulting from drilling and vessel emissions will be minor.

In BOEM's (2011) EA on Shell's EP Revision 1, the agency did not explicitly assess the impacts of air emissions on marine mammals; however, potential impacts to marine mammals have been examined in a programmatic analysis of exploration drilling conducted by NOAA and BOEM (in the role of cooperating agency). The document considers the effects of oil and gas activities in the Arctic Ocean which includes the Chukchi Sea (Effects of Oil and Gas Activities in the Arctic Ocean Draft Supplemental EIS, NOAA, 2013b). The programmatic analysis of exploration drilling provided in the NOAA Supplemental Draft EIS concludes that air quality impacts would be negligible or minor for Level 2 Exploration Activity (representing two exploratory drilling programs in the Beaufort Sea and two exploratory drilling programs in the Chukchi Sea per year). The NOAA Supplemental Draft EIS finds that exploration drilling impacts to marine mammal species would primarily be due to disturbance and displacement resulting from temporary and local increases in noise and boat traffic.

<u>Conclusion</u>

These types of effects indicate that marine mammals are likely to not remain in the close vicinity of the exploration activity where potential elevated emissions may occur. Furthermore, marine mammals are not expected to be exposed to potential elevated levels of air emissions for an extended period of time because they are transitory, moving through the area. In areas further from drilling activities where subsistence hunting and fishing occurs closer to shore, an analysis of air quality impacts reveals that emissions associated with the project are expected to have negligible to minor impacts on humans in the area (see Section 4.11.9 and Attachment C). For these reasons, air emissions from the project are expected to have negligible impact on marine mammals.

4.7.7 Impacts of Drilling Wastes on Marine Mammals

Drill cuttings and drilling fluid discharges are regulated by the EPA's NPDES exploration facilities GP. Discharges related to Shell's EP Revision 2 are expected to be well below both the discharge and toxicity limits established in that permit. EPA's NPDES exploration facilities GP establishes discharge limits for drilling fluids (at the end of a discharge pipe) to a maximum of 1,000 bbl/hr (159 m^3/hr) in receiving waters with a depth of 130 ft (40 m) or more. Actual discharge rates during Shell's exploration drilling operations are expected to be between 72 to 88 bbl/hr when drilling. At the end of each well, Shell may discharge drilling fluids remaining in a reserve pit at a rate up to, but not more than 1,000 bbl/hr. All discharged fluids are required to meet strict toxicity limits with a minimum 96-hr LC_{50} of 30,000 ppm. The most recent toxicity testing on the drilling fluid planned for use in Shell's exploration drilling activities indicated the fluid has a 96-hr LC50 of >500,000 ppm.

Both modeling and field studies have shown that discharged drilling fluids are diluted rapidly in receiving waters (Ayers et al. 1980a, 1980b; Brandsma et al. 1980; NRC 1983; O'Reilly et al. 1989; Nedwed et al. 2004; Smith et al. 2004; Neff 2005). The EPA modeled a hypothetical 1,000 bbl/hr discharge of drilling fluids in 130 ft (40 m) of water in the Chukchi Sea and predicted a minimum dilution of 1,173:1 at 330 ft (100 m) down-current from the discharge point. In a field study (O'Reilly et al. 1989) of a drilling waste discharge offshore of California, a 56 yd^3 (43 m^2) discharge of drilling fluids was found to be diluted 183-fold at 33 ft (10 m) and 1,049 at 328 ft (100 m). Neff (2005) concluded that concentrations of discharged drilling fluids drop to levels that would have no effect within about two min of discharge and within 16 ft (5 m) of the discharge location.

Gray whales will more than likely avoid exploration drilling activities and not come into close contact with drilling fluid and cuttings. However, gray whales are benthic feeders and the area of seafloor that will be covered by discharge will be unavailable to the whales for foraging purposes. This is not expected to impact individual whales or the gray whale population, because the areas of disturbance on the seafloor covered with drill cuttings is so small in relation to the area available to the whales for foraging. Modeling of the discharges indicates that accumulations of 0.4 in (1.0 cm) or more will be limited to the area within about 820 ft (250 m) of the discharge location, an area of approximately 5.4 ac (2.2 ha) for each well, and about 32.6 ac (13.2 ha) for all six wells (Table 4.3.2-2) in EP Revision 2 (Fluid Dynamix 2014a,b,c,d). This represents less than 0.000011% to 0.000024% of the seafloor of the Chukchi Sea. Dunton et al. (2009) investigated the benthic communities at the historic Hammerhead exploration wells in the Beaufort Sea, and concluded that they could not discern any measureable changes in benthic community structure at Hammerhead as a result of drilling activities that took place over 20 years ago. They further stated that if the benthic community was impacted during drilling operation for the Hammerhead well, it had progressed well towards recovery. Seals would not be expected to be impacted by drilling fluid or cuttings. It is unlikely that seals would remain near the discharge point for an extended time period, so exposure to discharged fluid and cuttings would limit any impacts to these highly mobile species. Discharge of drilling fluid and cuttings would likely result in some loss of benthic invertebrates on and in the seafloor due to the smothering. This loss would have negligible effects on pinniped species, even those that feed primarily on benthic organisms, such as bearded seals and walruses, because of the small area likely to be affected. This area, compared with the total area of feeding habitat available to seals, is very small. Any direct effects from the discharge on seal prey would have a negligible effect on the seals.

Conclusion

In conclusion, under EPA guidelines, concentrations of drilling fluids drop below levels that would affect marine mammals within a few minutes, and are diluted within a few hundred meters. Furthermore, the areas affected by drilling discharges would be small, recover quickly, represent a small portion of benthic habitat available to marine mammals, and would be in the general proximity of activities causing enough noise to discourage visitation by marine mammals. Based on the significance thresholds and level of effects definitions determined by BOEM (BOEM 2011a) and provided in Section 4.7, effects of the discharge of drilling waste on marine mammals would be negligible.

4.7.8 Impacts of Other Permitted Discharges on Marine Mammals

Other permitted discharges associated with the drilling units, as described in Section 2.7, will be conducted as authorized by the EPA under the NPDES exploration facilities GP. Discharges associated with the vessels will be conducted under MARPOL and USCG regulations. There will be no discharge of free oil, floating solids, or trash that could potentially oil, entangle, or otherwise affect marine mammals. Shell plans to have an MSD onboard each vessel. Food wastes, which could potentially attract marine mammals, will not be discharged; all food wastes will be incinerated. Discharges will result in slight changes in pH, temperature, TSS, and BOD within the immediate vicinity of the vessel, but these water quality effects would have no effect on marine mammals.

The potential for introducing exotic and invasive species through minor discharges such as bilge and ballast water are also expected to be negligible. The USCG CFR 151 subpart D requires that mid-ocean exchange of ballast water occur. Further discharges authorized under the NPDES exploration facilities GP or the EPA’s VGP and will result in only minor, temporary changes in water quality, such as temporary increases in TSS and BOD.

Discharges will increase incrementally compared to that determined for EP Revision 1 due to two drilling units operating simultaneously at the Burger Prospect and an associated increase in supporting activities; however, all discharges will be managed according to NPDES permit requirements and MARPOL and USCG regulations.

Conclusion

Direct effects on marine mammals from discharges are not expected. Areas affected by other permitted discharges would be small, recover quickly, represent a small portion of habitat available to marine mammals, and would be in the general proximity of activities causing enough noise to discourage visitation by marine mammals. Any indirect effects on marine mammal prey or habitat would be negligible and short-term in a localized area, lasting only as long as the discharge is ongoing. Permit and regulation requirements and described mitigation measures will minimize any impacts on marine mammals. Based on the significance thresholds and level of effects definitions determined by BOEM (BOEM 2011a), and provided in Section 4.7, effects of other permitted discharges on marine mammals will be negligible.

4.7.9 Impacts of a Small Liquid Hydrocarbon Spill on Marine Mammals

Section 2.10 of this EIA analyzes in detail the potential sources of a hydrocarbon spill, the probability of various types of spills occurring, Shell's plans for responding to a small spill (defined as 48 bbl or less), and Shell's WCD planning scenario. As explained in Section 2.10 Shell's categories of spill sizes are different from, but not incompatible with, those used by BOEM. The probability of a large (>48 bbl) liquid hydrocarbon spill is sufficiently small to conclude it would not occur during the proposed exploration drilling activities. Prudent planning and state and federal regulatory requirements nevertheless require that Shell have comprehensive spill prevention and response plans and capabilities in place. Shell's plans include measures to prevent any spill release from occurring and to respond in the event of a spill, including capabilities for responding to a "worst case" scenario release. In the unlikely event of a spill, implementation of Shell's comprehensive spill response plan would minimize the impacts from the spill on marine mammals. Response equipment and trained personnel would be available on site to deploy boom and recovery equipment for the control and removal of product spilled in the environment. Additionally, the procedures of Shell's FTP for fuel transfer between vessels would be utilized in accordance with BOEM lease stipulation No. 6, USCG requirements, and Shells operating procedures.

The literature on the effects of oil spills on marine mammals has been reviewed and synthesized by Geraci and St. Aubin (1982, 1985, 1990), Richardson et al. (1989), and others. The following section summarizes some of this literature, and provides an assessment of potential effects of a small spill (48 bbl diesel fuel) on marine mammals.

Thermoregulatory Effects of Oil on Marine Mammals

Contact with oil has been found to negatively impact the ability of some animals to thermo regulate by matting and wetting the hair, fur, or feathers, with a consequent loss of insulation. Marine mammals found in the Lease Sale 193 Area, including whales and seals, use a thick layer of blubber as insulation. It has been shown that contact with oil would have little or no effect on species that use a blubber layer for insulation (Kooyman et al. 1976; Geraci and Smith 1976). However, within two to four weeks of birth, oiling of the fur can be detrimental to newborn ringed seal and spotted seal pups, which at this time have a special thick fur called lanugos that keep them warm until they can build up enough blubber. Oiling of the lanugos could cause heat loss and hypothermia (St. Aubin 1988). The period of time that ringed seal and spotted seal pups are vulnerable to liquid hydrocarbon spills is very brief (2 to 4 weeks) and exploration drilling in the program area would occur long after pups are born and have shed their lanugo coat. Bearded seals are typically are born with their juvenile coat after molting their lanugo prior to birth (Burns 2009).

Toxicological Effects of Oil on Marine Mammals – Contact, Ingestion, and Inhalation

The epidermis of whales has been found to be largely impenetrable by oil (Geraci and St. Aubin 1985). However, eyes and mucous membranes could be affected when contact with oil is made. Oil can also affect seal and walrus membranes that are not covered by fur. In a study by Geraci and Smith (1976), seals immersed in oil-covered water exhibited irritation of the eyes, swollen noses, ulcers, and scratches on the cornea. Another study by the same scientists later found no tissue damage to ringed seals after being immersed in oil-covered water for 24 hr (Geraci and Smith 1976).

Ingestion of oil is another concern. Aromatics and other toxic molecules from oil that are ingested can enter the bloodstream via the intestinal wall and be transferred to major body organs. St. Aubin (1988) found that high levels of toxins would be needed before detrimental effects would be seen. He concluded that it would take ingestion of 0.26 gal (1.0 liter) of crude oil by a seal that was 110 lb (50 kg) in order to see these effects. Ingestion of oil over time has the potential to cause long-term effects on phocids (St. Aubin 1988). Crude oil residues can be stored in lipids inside the body, but there has been no evidence of resulting metabolic or physiologic effects. Because walruses are benthic feeders, it is unlikely that they would feed on prey contaminated by oil. Therefore, ingestion of oil is highly unlikely by walruses. Baleen whale prey could also carry contaminants that could be ingested by whales (Würsig 1990). In an experiment involving dolphins, Caldwell and Caldwell (1982) fed small amounts of hydraulic oil to dolphins for three months, and found no detectable effects in the dolphins. These studies indicate that, if ingestion of oily material occurred, effects on seals and walruses would likely be minimal. Ingestion of oil by marine mammals is unlikely and not expected because of the low probability of a large liquid hydrocarbon spill.

The respiratory system of marine mammals in the area, if any, could be compromised by the inhalation of vapors from a large liquid hydrocarbon spill. Other effects of vapor inhalation could potentially include neurological disorders and liver damage (Geraci 1990). Toxins could affect seals, walruses or whales if they inhaled from vapors rising from the oil directly after the spill occurs.

There is no evidence of whale mortality from a liquid hydrocarbon spill according to Richardson et al. (1989) from any or all of these pathways.

Impact of a Small Liquid Hydrocarbon Spill (48 bbl diesel) on Marine Mammals

While the probability of any spill occurring is remote due to the implementation of rigorous spill control policies and procedures, a small spill (defined as 48 bbl or less), such as a spill incidental to a refueling operation, has been determined to be the most likely spill scenario during an exploration drilling activities. An uncontrolled release of 48 bbl of diesel fuel during such an event could result in a slick that encompasses 10 to 200 ac (0.1 to 0.8 m^2) if not contained by booms and quickly recovered. However, fate and transport information indicates that up to 99 percent of the released diesel fuel would either evaporate or be widely dispersed in the water column within 48 hr. of release. Given the small area that would be affected by such a spill, the short duration of a slick, the density of marine mammals in the area, and avoidance of the immediate area around vessels by marine mammals, there would be limited opportunity for marine mammals to contact the slick. It is unlikely that any marine mammal deaths, disability, or loss of fitness or reproductive potential would result if marine mammals were to contact the slick. The scientific literature indicates that both whales and seals are relatively resistant to the environmental effects of petroleum.

Seals and whales that directly contact a slick at a small spill could experience irritation of the eyes and other mucosal membranes, swollen noses, ulcers, and scratches on the cornea (Geraci and Smith 1976). Given the volume of the release and the short duration of the slick, it is extremely unlikely that marine mammals could ingest sufficient quantities (St. Aubin 1988) of the petroleum to impact their health. Ingestion of small amounts would likely have no acute effects. A release of diesel would result in volatilization of hazardous air pollutants and could present an inhalation hazard to marine mammals. However, given the size of the slick, its short duration and the open, windy, high-energy conditions in the Chukchi Sea, it is doubtful that the concentration of the vapors would reach levels that would be harmful to marine mammals. Even if high concentrations were reached, these components usually evaporate within a few hours of the spill.

Such a small spill would be insufficient to produce any population level effects on marine mammals in the Chukchi Sea. Oil generally poorly adheres to the skin of mysticete whales, and cetaceans are believed to have the ability to detect and avoid oil spills (Geraci, 1990; St. Aubin 1990). Furthermore, the weathering process should act to quickly break up or dissipate oil/fuel through the local environment to harmless residual levels that would eventually become undetectable. Toothed whales are unlikely to be in the vicinity of the drillship or associated vessels due to noise. Because toothed whales are likely to avoid and disperse from areas with lots of human activity (such as cleanup crews or drilling operations), it is likely that they would avoid the area of the spill as long as cleanup activities were ongoing. Ice seals are believed to have the ability to detect and avoid oil spills (Geraci, 1990; St. Aubin 1990).

Conclusion

In conclusion, such a small spill would be insufficient to produce any population level effects on small or large groups of marine mammals. Mitigation measures will be fully implemented that will reduce the probability of such spills occurring, and minimize the environmental effects through containment and cleanup. Shell's FTP requires pre-booming prior to transferring fuel between vessels. Additionally, Shell's OSR equipment would be mobilized to contain and clean up any release that was to occur. The above assessment of the effects of a small spill is therefore considered to be the maximum, most-likely spill event. Even at these levels for an uncontained release, the effects would be temporary. Based on the significance thresholds and level of effects definitions determined by BOEM (BOEM 2011a), and provided in Section 4.7, effects of a small liquid hydrocarbon spill on marine mammals would be minor.

4.8 Impacts on Threatened and Endangered Species

In Section 3.8, Shell identified the T&E species that could potentially be affected by the activities proposed in EP Revision 2. These include:

- two species of waterfowl: Steller's eider and spectacled eider;
- polar bear;
- three species of endangered baleen whales: bowhead, fin and humpback; and
- three species of pinnipeds: ringed seal, bearded seal (listing vacated, treated as candidate for listing), and Pacific walrus (candidate for listing).

Steller sea lions and North Pacific right whales are resident in the Bering Sea and could theoretically encounter project vessels as they transit to the Chukchi Sea, but past analyses have concluded that any effects to these species would be discountable (NMFS 2013b).

In EP Revision 2, Shell proposes an expanded level of activity stemming primarily from two drilling units operating simultaneously, and the additional support and activity required for the exploration drilling activities. EP Revision 2 exploration drilling activities that could result in direct or indirect environmental impacts on T&E species include: increased aircraft traffic; increased vessel traffic; sound energy generated from exploration drilling activities (including ice management); sound energy from ZVSP surveys; air emissions; drilling unit mooring, MLC construction and permitted drilling waste discharges; other permitted discharges; and a small hydrocarbon spill.

In BOEM's EA for Shell's EP Revision 1, the agency established significance thresholds and definitions for levels of effect specifically for T&E species (BOEM 2011a). These are different from BOEM's criteria for all birds (Section 4.6) and its criteria for all marine mammals (Section 4.7). The following definitions are those BOEM established for T&E species, and they have been adopted for use in the following analysis of potential impacts from Shell's proposed drilling operations at the Burger Prospect.

Significance Threshold

An adverse impact that results in a decline in abundance and/or change in distribution requiring one or more generations for the indicated population to recover to its former status.

Levels of Effect

Negligible

- The action is not anticipated to affect threatened T&E species or critical habitat under the ESA of 1973.

Minor

- The action may adversely affect threatened T&E species or critical habitat under the ESA of 1973.

Moderate

- The action is likely to adversely affect threatened T&E species or critical habitat under the ESA of 1973.

As presented in the analyses below, Shell has concluded that the overall potential effects on T&E species from the activities described in EP Revision 2 would range from negligible to minor (Table 4.8-1).

Table 4.8-1 Potential Effects of Shell's Exploration Drilling Program on T&E Species

Resource / Analyzed Activity **Threatened and Endangered Species (overall)**	**Birds**	**Polar Bears**	**Seals & Walruses**	**Whales**
Overall (by species)	Minor	Minor	Minor	Minor
From aircraft traffic	Minor	Minor	Minor	Minor
From vessel traffic	Minor (disturbance) Minor (collisions)	Minor	Minor	Minor
From drilling, ice management, and MLC construction sound	Minor	Minor	Minor	Minor
From ZVSP survey sound	Minor	Minor	Minor	Minor
From air emissions	Negligible	Negligible	Negligible	Negligible
From wastes generated by drilling unit mooring, MLC construction, and drilling	Minor	Negligible	Minor	Negligible
From other permitted discharges	Minor	Negligible	Negligible	Negligible
From shorebase expansion	Minor	Negligible	None	None
From small liquid hydrocarbon spills	Minor	Minor	Minor	Minor

4.8.1 Impacts on Threatened and Endangered Birds

In Section 3.8, Shell identified the T&E birds that could potentially be affected by the activities proposed in EP Revision 2. They include: Steller's eider (*Polysticta stelleri*), and spectacled eider (*Somateria fischeri*);Important here, the presence and abundance of these species in and near the offshore waters near Shell's Burger Prospect is limited. Steller's eiders and spectacled eiders, are all found in the Burger Prospect, although in low numbers, as well as in the waters between the prospect and the coastline. Avian surveys conducted as part of the CSESP studies in and around Shell's Burger Prospect confirm that the spectacled eider and Steller's eider are rarely observed (see Table 4.8.1-1). The frequency of observations of spectacled eiders and yellow-billed loons during 7,125 mi (11,467 km) of vessel-based surveys in the Burger Study Area over the Burger Prospect is provided below in Table 4.8.1-1. No Steller's eiders were observed during the surveys. The small number of birds observed and their low density near the Burger Prospect during the drilling period suggest the total number of T&E birds affected to be low.

Table 4.8.1-1 Frequency of Observation of T&E Birds in the CSESP Burger Study Area 2008-2012

Year	**Spectacled Eider birds observed / 1,000 mi (km)**			
	Burger [1,2]		**Total** [1,3]	
	km	**mi**	**km**	**mi**
2008	0.0	0.0	0.0	0.0
2009	0.4	0.6	1.2	2.0
2010	0.6	1.0	1.0	1.7
2011	0.0	0.0	2.0	3.2
2012	0.0	0.0	2.6	4.2
All	0.3	0.4	1.4	2.2

[1] Source: Gall et al. 2013
[2] Birds observed within 984 ft (300 m) of vessel on and off transects on Burger Study Area July-October 2008-2012
[3] Birds observed within 984 ft (300 m) of vessel on and of transects on all Study Areas July-October 2008-2012

Information on the distribution, life history, and abundance of these four T&E birds is summarized below; additional information is provided in Section 3.8. In addition, Section 4.6 provides an analysis of the impacts of Shell's EP Revision 2 on other birds, and much of that general information is also relevant here.

As discussed in Section 3.8, the Alaska breeding population of Steller's eiders has been listed as threatened by the USFWS. The Steller's eider is primarily confined to the Arctic Coastal Plain of Alaska's North Slope, with a concentration around Barrow. Survey data indicates that few, if any, Steller's eiders are expected to be within the Burger Prospect area during the drilling period. In six years (2008-2013) of intensive surveys conducted around the Burger Prospect during July – October, no Steller's eiders were observed in the Burger Prospect area (Gall and Day 2010, 2011, 2012; Gall et al. 2013; Gall et al. 2014).

No critical habitat has been designated for the Steller's eider in the Chukchi Sea. Critical habitat for Steller's eider has been designated in Southwestern Alaska on the Yukon-Kuskokwim Delta and in adjacent marine waters. Steller's eiders migrate northward along the Western Alaska coast in spring, but the majority of the world's population breeds in Siberia and nests only in very low densities on the Arctic Coastal Plain of Alaska (Hodges and Eldridge 2001; Larned et al. 2009). They make use of coastal areas along the Chukchi Sea coast from Barrow to Cape Lisburne following the breeding season (BLM 2003), and would not be expected in the Burger Prospect area in sufficient numbers during any period of the year.

The spectacled eider is listed as threatened throughout its range, as discussed in Section 3.8. The Alaska breeding population of spectacled eider is found in higher densities in the western portion of the Alaska Coastal Plain and gradually decreases to the east (Larned et al. 2006). Critical habitat has been designated for spectacled eiders in Alaska within Ledyard Bay in the Chukchi Sea LBCHU; however, the northern boundary of this habitat is approximately 50 mi (80 km) from the southern extent of the Burger Prospect areas. In six years (2008-2013) of intensive surveys conducted around the Burger Prospect during July – October, no spectacled eiders were observed in 2008, 2010, 2011, 2012, and 2013; a single spectacled eider was observed in 2009 (Gall et al. 2013). Very few spectacled eiders are expected to be within the Burger Prospect area during the drilling period.

The discussion of potential direct and indirect impacts from Shell's EP Revision 2 considers Steller's eiders and spectacled eiders in the same subsection, as well as the LBCHU which has been designated as critical habitat for the spectacled eider. Potential impacts on these two eider species are expected to be the same because their range and distribution indicate that very few individuals from either species are expected in the offshore area of Shell's project. The Arctic Coastal Plain of Alaska provides important nesting habitat for the threatened Steller's and spectacled eiders, and a small portion of this habitat has been altered by oil and gas development. The area affected by Shell's planned Chukchi Sea exploration drilling activities is small and far offshore where few Steller's and spectacled eiders would be expected to be found during the drilling season (July – October).

USFWS 2012 Biological Opinion and Consultation Opinion

BOEM and BSEE and their predecessor agencies have engaged in consultations with the USFWS on the impacts of oil and gas leasing and exploration in the Arctic. Pursuant to Section 7 of the ESA of 1973, BOEM Alaska OCS consulted with the USFWS regarding the potential effects of Lease Sale 193 on T&E species. The resulting BO (USFWS 2007) concluded that the lease sales and subsequent exploration drilling activities (including seismic, vessel transit, and exploration drilling) were not likely to jeopardize the continued existence of the spectacled or Steller's eider, and are not likely to destroy or adversely modify designated critical habitat.

BOEM's most recent consultation regarding these T&E birds and their critical habitat was an incremental step consultation under Section 7 of the ESA that was concluded on 8 May 2012 (USFWS 2012). USFWS issued one analysis that serves as a BO considering the effects of oil and gas leasing, exploration, and development in the Beaufort and Chukchi Seas on spectacled eiders, spectacled eider critical habitat, and Alaska-breeding Steller's eiders. Activities considered include lease sales, deep penetration surveys, high-resolution seismic surveys, exploration drilling, and all vessel and air traffic associated with these surveys and exploratory drilling. Relevant to Shell's EP Revision 2, the USFWS analysis assumed up to two exploratory drilling programs per sea would operate simultaneously during the each open-water season. The two drilling units would each operate 30 to 90 days, typically from July through November, with each drilling unit drilling two but possibly up to six wells annually. USFWS assumed that drilling operations would be supported with helicopter flights from base camp up to three times per day and support vessel trips up to three times per week. USFWS further assumed that a drilling unit would be supported by 1 to 2 ice-breakers, 1 anchor handler, 1 to 2 oil spill response barges and tugs, 1 tank vessel for spill storage, and 2 to 3 small support vessels. Relevant here, USFWS contemplates more activity than proposed here by Shell (as it also includes extensive survey efforts that are unlikely to be contemporaneous with Shell's drilling) and assumes many of the same important mitigation measures (e.g., 1,500 ft [457 m] altitude for aircraft, lighting protocols) that Shell adopts.

USFWS identified the following potential effects to listed and candidate birds: habitat loss, disturbance and displacement, collisions, increased predation, and small spills. USFWS identified habitat loss from abandoned wells and equipment on the sea floor as a potential issue as the listed eiders forage on the sea floor. USFWS concluded that because these capped wells have an extremely small footprint, any permanent habitat loss would be extremely minor. USFWS also identified the contamination of benthic and other food sources for avian species resulting from drilling muds and cuttings as a possible harm but notes that the NPDES exploration facilities GP places limits on the location, volume and materials discharged from exploratory drilling. USFWS found that recovery of benthic communities would likely occur within up to two years of the completion of a well but that given the small impact area, the low number of wells to be drilled, and the NPDES permitting limits, only minor impacts to the four species of birds would occur from any contamination resulting from discharges of drilling mud and cuttings.

USFWS also considered the severity of the disturbance and displacement that would occur as a result of a proposed two drilling unit exploration scenario in the Chukchi Sea. With respect to aircraft, USFWS assumed fixed-wing aircraft would be used for crew changes and up to three helicopter flights per day for each drilling operation would be used to transport personnel and supplies between drilling units and land. (This level of aircraft travel—42 round trip flights per week—is similar to that proposed by Shell in EP Revision 2.) The agency noted that specific information on the listed eiders' responses to aircraft is lacking; however, they are likely to have a similar response as King eiders. In a study in Greenland, nearly all King eiders dove when survey aircraft approached (Mosbech and Boertmann 1999). Their response varied with time of day, and increased with decreasing plane altitude; however, over 50 percent remained submerged until the plane passed (USFWS 2012). With the low number of anticipated fixed-wing flights, low density of birds expected, and additional protection provided to these avian species through the flight altitude mitigation measures (1,500 ft [457 m]), USFWS concluded that impacts from aircraft disturbance on listed eiders or candidate species were not expected to disturb or adversely affect listed and candidate species (USFWS 2012). For helicopter trips, which would also avoid flying below 1,500 ft (457 m) over the LBCHU during the open water season, USFWS determined that given the number of flights, any impacts on the listed eiders or candidate species from aircraft disturbance would be infrequent, minor, or short-term (USFWS 2012).

USFWS also discussed the impacts associated with vessels transiting and operating in the area, noting that impacts include displacing the birds, as well as vessel collisions. USFWS found that vessels transiting through spring leads (in 1 April – 10 June, prior to Shell's activities in the area) may cause short-term minor disturbance for birds, but effects are likely to be limited due to the brief duration of vessel transit, and low numbers of vessels. While exploration drilling has the potential to disturb and displace listed and candidate species, USFWS noted that the listed and candidate birds are unlikely to be present at the drill site, the drilling activities are stationary and disturb a very small area, and birds are likely to either habituate to the activity or move away to an undisturbed area. Given this, USFWS concluded that the species may not be disturbed by vessel traffic. USFWS also analyzed the impact of collisions between vessels/exploration drilling units and listed and candidate species, and noted that the risk of collision increases when visibility is impaired. Flight behavior of listed eiders and the candidate species puts them at risk of colliding with human-built structures. Any collisions would be episodic in nature, rendering quantification of the collision risk difficult. USFWS found that mitigation measures, such as BOEM's requirements regarding lighting protocols for vessels, will likely reduce collision risk. Based on the best information, USFWS determined that despite these measures, it expects a few listed eiders may die from collisions during the first incremental step and thus adverse effects could occur.

With respect to small oil spills, USFWS reviewed the harm that exposure to oil can cause in birds, including the loss of waterproof properties that could lead to hypothermia and potentially drowning; mortality of embryos; ingestion of oil-contaminated foods that could result in sub-lethal health effects; and mortality after exposure. USFWS found that it is highly unlikely that there would be any significant effects to listed eiders or candidate avian species given the low volume of oil; that oil is likely to evaporate, weather, or be mostly recovered; and the low density of these species in the area. As a result, only a few birds are likely to encounter any oil from small spills or disturbance from OSR activities.

Finally, USFWS considered the impacts to the LBCHU, which is important to migrating and molting spectacled eiders. Of relevance here, USFWS analyzed the impacts of a small spill on this area. The USFWS noted that a small spill should be of low volume and largely recoverable, although it could temporarily contaminate a small area of within the LBCHU. Any effects would be minimized through oil evaporation, weathering, and recovery efforts therefore no long-term effects would be expected to diminish the value of the LBCHU for molding spectacled eiders.

The USFWS concluded that that the impacts to listed Steller's and spectacled eiders, the LBCHU, and avian candidate species from the exploration drilling activities, taken together with cumulative effects, are not likely to jeopardize the continued existence of any species, would not appreciably reduce the likelihood of survival and recovery of the species, and are not likely to destroy or adversely modify spectacled eider critical habitat.

The exploration drilling activities contemplated under EP Revision 2 are described in detail in Section 2.0. The activities that could result in direct or indirect environmental impacts on T&E birds and their critical habitats include: increased aircraft traffic; increased vessel traffic; sound energy generated from exploration drilling activities (including ice management); sound energy from ZVSP surveys; air emissions; drilling unit mooring, MLC construction and permitted drilling waste discharges; other permitted discharges; and a small hydrocarbon spill. Disturbance and temporary displacement of listed eiders and yellow-billed loons, are the most likely responses from Shell's proposed activities. The severity of any response depends upon the duration, frequency, and timing of the activity causing the disturbance (USFWS 2012). Disturbance that results in agitated behavior, flushing, or other movements can increase energy costs. Birds could also potentially be displaced from preferred habitats to areas where resources are less abundant or are of lower quality. The analysis and conclusions in USFWS's 2012 BO and Conference Opinion—which were not available when Shell submitted EP Revision 1 and when BOEM approved that EP—inform the analysis and conclusions within this section.

Impacts of Aircraft Traffic on Threatened and Endangered Birds

Aircraft traffic under EP Revision 2 will increase above those levels proposed in Shell's EP Revision 1 in order to support two drilling units operating simultaneously. Aircraft traffic consists of approximately 40 round trip helicopter flights weekly between the Burger Prospect and shorebase facilities at Barrow; this is an increase from EP Revision 1 which estimated 12 round trips weekly. Potentially two fixed-wing aircraft will be used for PSO overflights and ice reconnaissance, on a daily basis when possible. In addition to this routine aircraft traffic between the Burger Prospect and Barrow, aerial surveys for marine mammals will be conducted along a standardized route, attempted daily, for the duration of the exploration drilling activities as part of the 4MP (Appendix B of the Chukchi Sea EP Revision 2). A portion of these surveys will be conducted over the LBCHU, where a minimum flight altitude of 1,500 ft (457 m) will be maintained per requirements of Shell's 4MP. While the levels of aircraft travel have increased under EP Revision 2, the following analysis demonstrates why aircraft travel remains unlikely to result in any more than temporary disturbance to a very small number of T&E birds.

In general, helicopter and fixed wing aircraft flights can disturb and displace birds, with the potential to flush the birds, create increased movement (Derksen et al. 1992) with potential effects on energetics and body weight (Ward and Stehn 1989), alter habitat use (Belanger and Bedard 1989), or decrease productivity at nesting sites. These effects are thought to be of greatest impact at nesting colonies, or areas where the birds congregate for molting or staging before migration. As described below, for all species considered, any effects from aircraft would be brief, consisting of momentary behavioral disturbance or displacement. Given the low frequency with which these birds are encountered, flights would affect very few T&E birds. Any effects are not expected to persist from one year to the next.

Numerous steps will be taken by Shell to minimize the impact of aircraft on T&E birds, particularly birds that are nesting or molting. Shell's fully implemented effective mitigation measures include requiring aircraft to fly at altitudes of at least or above 1,500 ft (457 m) except during take-offs, landings, marine mammal monitoring, and when conditions force an altitude reduction for personnel safety reasons. Planned helicopter flights would follow a direct and approved flight corridor between the Barrow Airport, which is adjacent to the Chukchi Sea, and the Burger Prospect. The aircraft corridor avoids areas such as the LBCHU and Kasegaluk Lagoon, which are known to be used heavily by eider species, further minimizing the likelihood of impacts. Furthermore, flights between Barrow and Wainwright will occur along a corridor 5.0 mi (8.0 km) inland to minimize effects on subsistence and subsistence resources including birds.

Disturbance effects to Steller's and spectacled eiders from aircraft traffic will be similar to other marine and coastal birds as described in detail in Section 4.6.1. The greatest potential for aircraft traffic to impact the birds would occur when the birds are nesting or molting (flightless), or if the disturbance displaced the birds from important habitats to less productive habitats.

The potential for aircraft to disturb nesting birds will be greatly minimized by Shell's implementation of mitigation measures. First, nesting spectacled eiders have been observed to exhibit some tolerance to aircraft by nesting within 820 to 2,460 ft (250 to 750 m) of the Deadhorse airport (TERA 1996; Martin 1997). Other eider species have been found to show great tolerance to aircraft For example, Gollop et al. (1974a) observed that common eiders exhibited no response to overflights with a helicopter at altitudes of 20 to 3,000 ft (6 to 914 m) and a fixed wing (Cessna 185) aircraft at altitudes of 125 to 1,000 ft (38 to 305 m). The minimum altitude of 1,500 ft (457 m) for operations of helicopters (except during take-offs and landings, marine mammal surveys and in emergency situations) would greatly reduce disturbance from flights over nesting eiders and likely avoid responses from nesting and molting spectacled eiders. Second, planned helicopter flights would follow a direct and approved flight corridor between the Barrow Airport, which is adjacent to the Chukchi Sea, and the Burger Prospect. Therefore there is almost no opportunity to effect nesting eiders. The Barrow area is an important nesting area for Steller's eiders, but nests are located to the south and east of the airport (Rojek and Martin 2003; Rojek 2005, 2006, 2007, 2008). It is unlikely that flights would occur directly over nesting Steller's or spectacled eiders; however, if use of contingency routes from Barrow to Wainwright were necessary, those flights could fly over nesting birds. And, in some instances flights may be diverted by weather or emergency.

Aircraft may also disturb molting (flightless) and flight capable eiders. The flight corridor from Barrow to the Burger Prospect traverses coastal waters that could be used by molting, staging, feeding, or resting eiders. However, the flight corridor does not traverse any areas of particular importance to either threatened eider species, such as the LBCHU, Kasegaluk Lagoon and Peard Bay where Steller's or spectacled eiders congregate in large numbers to molt or stage. In fact, these areas would be avoided by more than 27 mi (44 km) (Table 4.6.1-4). The potential for any disturbance to molting Steller's and spectacled eiders will be greatly reduced by the mitigation measures implemented by Shell, including minimum altitude of 1,500 ft (457 m) and an aircraft corridor that avoids areas such as the LBCHU and Kasegaluk Lagoon, which are known to be used heavily by these species. Flights are expected to have little opportunity to affect molting or staging spectacled eiders in the LBCHU and any disturbance effects on threatened eiders are therefore expected to be temporary.

The USFWS came to a similar conclusion in their 2009 and 2012 BOs. USFWS (2009c) analyzed aircraft impacts associated with an oil and gas exploration in the Beaufort and Chukchi Sea, and stated that marine mammal survey flights in the LBCHU with a fixed-wing plane at an altitude of 1,500 ft (457 m) are unlikely to disturb or adversely affect spectacled or Steller's eiders. A similar conclusion was also reached in USFWS's more recent 2012 BO. USFWS determined that, given the low number of anticipated flights, low density of birds expected, and additional protections (e.g., flight altitude mitigation measures), impacts from aircraft disturbance on listed eiders or candidate species are expected to be infrequent, minor, short-term (USFWS 2012).

<u>Conclusion</u>

For both T&E bird species, any effects from aircraft traffic associated with EP Revision 2 will, at most, result in temporary, short-term behavioral disturbance or displacement (e.g., flushing). In addition, the scarcity of these species in and around the Burger Prospect ensures that flights will affect only a small number of individuals, if any. There will no effect on the populations of these species as aircraft travel is not likely to cause mortality or reductions in reproductive success. Shell's extensive mitigation measures include minimum flight altitudes and the flight corridors chosen to minimize any impacts from aircraft travel. As a result, there is almost no opportunity to affect nesting or molting Steller's or spectacled eiders. Based on conclusions in prior BOs (USFWS 2007; USFWS 2012), T&E birds may be affected by aircraft flights. Therefore, given the significance thresholds and level of effects definitions determined by BOEM (2011a), the applicable level of effect is minor, and the impacts will not be significant.

Impacts of Vessel Traffic on Threatened and Endangered Birds

Vessel traffic associated with EP Revision 2 is higher than the levels proposed in Shell's EP Revision 1 in order to support two drilling units operating simultaneously. New vessels include use of a second drilling unit, the MLC ROV System vessel that could be used to construct MLCs instead of the drilling units, and science vessels to support monitoring requirements under the NPDES exploration facilities GP. The drilling units will be supported by additional vessels for ice management, anchor handling, resupply, and crew transport, as well as oil spill response vessels and barges staged near the drilling units, with a full complement of crew and oil spill response equipment. The expected frequency of OSV visits to the drilling units has been increased from 17 round trips/season to 30 round trips/season.

Avian Disturbance from Vessel Traffic

In general, disturbances to T&E birds would be similar to other birds as described in Section 4.6.2. Routine vessel traffic has limited potential to briefly disturb birds and could temporarily move them a short distance to another location. Some marine and coastal birds, including Steller's eiders, have the potential to habituate to regular vessel traffic (Schwemmer et al., 2011; USACE 2000d; USFWS 2012), and some birds are attracted to vessels. In this case, transiting vessels may not flush eiders unless there is direct competition for space. Therefore, tolerance to nearby vessels would reduce any impact from vessel traffic. Any effects that do occur—such as flushing and short-term disturbances that last as long as the activity and are restricted to the immediate vicinity—would be reduced with tolerance, and are not anticipated to persist from one year to the next.

Another important factor is the low numbers and density of the listed eiders and candidate species. All of these species are found in the Burger Prospect and surrounding areas in low numbers. Densities of these birds during 7,125 mi (11,467 km) of vessel-based surveys in the CSESP Burger Study Area over the Burger Prospect are provided above in Table 3.6.6-2. In general, given the low frequency with which these birds are encountered offshore, vessel traffic would affect very few birds.

Effects on T&E birds from routine vessel support associated with the drilling operation will be minimized by fully implemented effective mitigation measures requiring vessels to use the shortest route between the shorebase and offshore drilling facilities. Planned vessel traffic will follow the outlined and approved vessel corridors that are designed to avoid known fragile ecosystems and the LBCHU and therefore located more than 30 mi (48.3 km) from LBCHU. Vessel traffic associated with EP Revision 2 is prohibited by Lease Stipulation 7 from entering the LBCHU during 1 July – 15 November. Shell's plans to reduce vessel speed in inclement weather to minimize impacts on marine mammals could also decrease the chance of avian collisions. Given the low density of the two eider species outside the LBCHU and of the candidate species, the vessel locations and their routes are likely to encounter these species in very small numbers and have no biological impact at the population level.

Sea ducks appear to be relatively tolerant of vessels in harbor areas of the Alaskan Aleutian Islands (USACE 2000a, 2000b, and 2000c). Steller's eiders exhibit tolerance to vessel traffic and readily habituate to vessels and human activity. USACE (2000d) reported that vessels moving through flocks of Steller's eider during arrival to or departure from the Trident Seafood plant dock in the Aleutians do not flush the eiders unless there is direct competition for space. In those cases, the eiders typically fly only a short distance before landing. Tolerance to nearby vessels would reduce any potential impacts on threatened eiders from vessel traffic.

Steller's and spectacled eiders nest in coastal and inland terrestrial habitats in the area, and would not be affected by offshore vessel traffic associated with Shell's exploration drilling activities. Exploration drilling activity and most vessel activity occurs more than 64 mi (103 km) offshore. Molting flocks of spectacled eiders gather in shallow waters off the coast in water usually less than 120 ft (36 m) deep and travel along the coast up to 31 mi (50 km) offshore (USFWS 2005). Not including Ledyard Bay during the molt period, the density of eiders in areas of the Chukchi Sea is expected to be relatively low, where vessels would operate beyond the coastal areas occupied by most eiders (MMS 2007b). Most vessel traffic associated with the exploration drilling activities will occur more than 64 mi (103 km) offshore where staging and molting in numbers is not known to occur, and where few eiders will be present, if any. Shell's identified vessel route (Figure 2.2-1) between Wainwright shorebase facilities and the Burger Prospect traverses waters that are likely used by spectacled eiders in low numbers; however, it does not traverse any reported important habitats such as Ledyard Bay, Kasegaluk Lagoon, or Peard Bay where Steller's or spectacled eiders congregate in large numbers to molt or stage. No vessel traffic would be expected in the spectacled eider LBCHU except during an emergency. To further reduce the potential for disturbance, PSOs aboard all transiting vessels will watch for molting flocks of threatened eiders and recommend that vessels alter course around the birds. This measure will increase the distance between vessels and birds, and mitigate potential impacts from birds interacting with vessels.

<u>Conclusion regarding Vessel Traffic Disturbance</u>

T&E bird species may react to vessel traffic. The reactions are expected to be limited to a few birds and consist of brief behavioral disturbance (flushing) or temporary displacement that lasts for minutes or hours. Because these impacts are limited to a short-term disturbance they will have no biological impact at the population level. Moreover, some birds habituate to vessels. The listed eiders and candidate species are found in low densities in offshore waters, and Shell has adopted numerous mitigation measures that will further minimize any impacts on T&E birds (e.g., vessel corridors, PSOs who will have vessel change course if birds identified). Based on the analysis above, T&E birds may be affected by vessel traffic disturbance. Therefore, given the significance thresholds and level of effects definitions determined by BOEM (2011a), the applicable level of effect is minor, and the impacts will not be significant. .

<u>Avian Collisions with Vessels</u>

Steller's eiders and spectacled eiders are found in areas that would experience some vessel traffic associated with the exploration drilling activities. As noted, these birds are found in very low densities in most offshore areas (Table 4.8.1-1), including the Burger Prospect and surrounding areas. This low density is due to the distance from shore and the water depth at which the drilling activities would take place.

Shell monitored vessel surface areas for bird strikes during the 2012 exploration drilling activities in the Chukchi Sea and the Beaufort Sea. A total of 79 bird strikes were recorded at the drilling unit and support vessels while in the Chukchi Sea during the 2012 (Table 4.6.2-2). Not all strikes resulted in fatalities; approximately 28 percent of the birds were alive when discovered and returned to the sea. None of these strikes involved T&E species.

Shell has adopted mitigation measures that will decrease the likelihood of avian collisions for all listed species. Shell's Bird Strike Avoidance and Lighting Plan (Appendix E of EP Revision 2) instructs to minimize light output and unnecessary lighting on vessels and the drilling units to minimize the potential for bird strikes. High intensity lights (which have the potential to disorient birds and increase the risk of collision) on support vessels and drilling units will be shaded or used only during certain critical operations for safety reasons. Thus, reduced use of high-intensity lights will reduce the risk of threatened eiders striking project vessels. Shell will also monitor conditions to assess risk and reduce the chance of bird strikes. Any strike that was to occur would likely result in injury or mortality to the bird, but would have no effect on the population level effects.

BOEM's NEPA analysis of EP Revision 1 discussed the impact of avian collisions on spectacled and Steller's eiders. BOEM noted that these birds have some tendency to strike vessels and structures because they fly low and fast over the ocean and often do not or cannot react in time to avoid them. BOEM reviewed Shell's lighting-related mitigation measures under Stipulation 7, but noted that these efforts cannot be assumed to be totally effective and there is still the potential for some bird collision mortality. BOEM calculated non T&E bird encounter rates based on the encounter reports from Shell's 2012 exploration drilling program. These rates may underestimate impacts in that some birds 1) could have struck a vessel but landed overboard and been lost at sea undetected, or 2) alighted, rested, and departed undetected (BOEM 2015). Not all encounters are fatal and, in some cases, crew assistance likely helped some birds survive. The rates are not an index, but simply an estimate of the number of birds encountering vessels during one open-water season. BOEM estimated that birds would encounter drillships at a greater rate (53 birds per season) than smaller support vessels (11 birds per season) (BOEM 2015). As noted above, the USFWS 2012 BO determined that any impacts related to exploration drilling are limited to at most the death of a very low number of individuals through collisions (<1 Steller's eider and up to 13 spectacled eiders over a total of 14 years) (USFWS 2012). BOEM noted that no ESA-listed eiders have been reported to collide with exploration structures or vessels to date. Even considering the increased vessel activity under EP Revision 2, the collision rates are so low and the lighting-related mitigation measures will further reduce impacts therefore any impacts should be considered a minor level of effect.

Potential impacts on threatened eiders from strikes with project vessels would be unlikely to result in population-level effects and would be similar to those for other birds, as discussed in detail in Section 4.6.2. Day et al. (2005) suggested that eiders are particularly susceptible to collisions with offshore structures as they fly low and at relatively high speeds (approximately 45 mph [72 km/hr]) over water. Eiders (king, common, and Steller's) observed at the Northstar facilities in coastal waters of the Beaufort Sea were observed to fly at altitudes of 3 to 164 ft (1 to 50 m) with an average of 19.7 ft (6.0 m). Johnson and Richardson (1982) reported that 88 percent of eiders they observed migrating in the Beaufort Sea flew below an altitude of 33 ft (10 m) and >50 percent flew below 17 ft (5 m). These data indicate that collisions between spectacled and Steller's eiders and the drilling units or support vessels could occur; however, the potential is low and would be unlikely to involve a significant proportion of their respective populations. In four years of monitoring the much larger Northstar facilities, which is also in coastal waters that are more heavily utilized by eiders, no collisions with spectacled or Steller's eiders were observed (Day et al. 2005).

Bird strikes are not expected during the northward migration of spectacled and Steller's eiders because the northern migration occurs in May, before the drilling units and support vessels enter the Chukchi Sea. Bird strikes are also not expected during the months of July and August. There is almost 24 hr of daylight during which reduces the potential for bird strikes by reducing any attraction or disorientation effects of lights and improving visibility. Shell's mitigation measures discussed above, including its use of lighting, will minimize the potential for bird strikes during periods of reduced daylight, including clouds and fog.

After August, all exploration drilling and most activities will be in areas that are at least 64 mi (103 km) offshore. During this time, spectacled eiders tend to be concentrated in Ledyard Bay, in waters from 12 to 30 mi (19 to 48 km) offshore (Petersen et al. 1999 cited in USFWS 2006b). Project vessels are not expected to enter Ledyard Bay, and very few threatened eiders are expected to use the offshore areas where exploration drilling will occur. In six years (2008-2013) of intensive surveys conducted around the Burger Prospect during July – October, no Steller's eiders were observed in the Burger Prospect area and only one spectacled eider was observed (Gall and Day 2010, 2011, 2012; Gall et al. 2013, 2014).

No bird strikes or avian collisions involving the drilling units or support vessels and spectacled or Steller's eider mortalities are anticipated. The low probability of such events occurring as well as any potential disorientation of migrating eiders will be reduced by implementation of a number of mitigation measures. These potential impacts will be minor and temporary due to the low probability of such occurrence and the lack of population effects if a strike occurred.

Conclusions Regarding Vessel Traffic and Avian Collisions

Eiders have some tendency to strike vessels and structures, but as noted above, this is not anticipated. The timing of vessel travel and Shell's lighting-related mitigation measures under Stipulation 7 decrease the likelihood of strikes. Moreover, while there were bird strikes during Shell's exploration drilling activities in the Chukchi Sea in 2012, there were no strikes of T&E species given their low occurrence in the area during the open water season. Based on the analysis above, T&E birds may be affected by vessel-avian collisions. Therefore, given the significance thresholds and level of effects definitions determined by BOEM (2011a), the applicable level of effect is minor, and the impacts will not be significant.

Impacts of Drilling and Ice Management Sound on Threatened and Endangered Birds

Section 4.0 describes the new sound measurements and modeling that Shell conducted for EP Revision 2 (Table 4.0-3). There is an increased level of simultaneous activity associated with EP Revision 2—which includes two drilling units drilling simultaneously and potentially in conjunction with ice management, anchor handling, OSVs on DP at either drilling units, and construction of an MLC using the drilling unit or the newly-proposed MLC ROV system. Disturbance effects to listed eiders and candidate avian species from sound energy generated by ice management, exploration drilling, OSVs, and construction of the MLCs, as described in EP Revision 2, will be similar to those on other marine and coastal birds as described in detail in Section 4.6.3. Eiders and the candidate avian species exposed to sound energy from exploration drilling and ice management activities would either move from the area or show little reaction. Studies on the effects of seismic surveys, which generate more intense sound pressure levels than exploration drilling and ice management, have revealed little effect on marine birds (Evans et al. 1993; Stemp 1985; Webb and Kempf 1998). Any potential effects would be biologically insignificant to their respective populations.

Disturbance effects to Steller's and spectacled eiders from sound energy generated by ice management and exploration drilling will be similar to those on other marine and coastal birds as described in detail in Section 4.6.3. Sound energy generated by exploration drilling and ice management is anticipated to have negligible to no impact on Steller's and spectacled eiders. Exploration drilling activities will not start until July, after the spring migration, and the program activities will take place outside areas regularly used by these species. Steller's and spectacled eiders critical habitats also would not be affected by sound energy from exploration drilling and ice management because these designated habitats are at least 54 mi (87 km) from the Burger Prospect.

Conclusion

In conclusion, any effects from sound energy from exploration drilling and ice management on T&E birds would be brief behavioral disturbances, and temporary, lasting only minutes or hours after the activity ceases. None of these effects would result in population-level impacts on T&E birds. These non-lethal effects are not anticipated to last beyond minutes to hours after the activities are complete and will not accumulate across multiple seasons. Based on analysis above, T&E birds may be affected by the sound from drilling, OSVs, MLC construction, and ice management activities associated with Shell's proposed program as described in Section 2.0. Therefore, given the significance thresholds and level of effects definitions determined by BOEM (2011a), the applicable level of effect is minor, and the impacts will not be significant.

Impacts of ZVSP Survey Sound on Threatened and Endangered Birds

As described in EP Revision 2, Shell plans to conduct a geophysical activity referred to as a ZVSP survey at each Chukchi Sea drill site. During ZVSP survey operations, a string of geophones (receivers) will be hung in the wellbore to record the sonic waves created by the firing of a sound source (airgun array), which is suspended from the deck of the drilling unit into the water adjacent to the riser (Figure 2.4-1). The geophones will be relocated in the wellbore after each firing of the sound source until the entire wellbore has been surveyed. Each ZVSP survey will take approximately 10 to 14 hr to complete; the majority of that time will involve relocating the geophones in the wellbore. The sound source will be triggered approximately 216 times over the course of each survey.

A two-airgun (2×250 in.^{3} airguns) or three-airgun array (3×150 in.^{3}) will likely be used to perform each ZVSP survey. The estimated source level used to model sound propagation from the airgun array is approximately 239 to 241 dB re 1μPa m rms (Table 2.4-1). Modeled radii to various sound isopleths are provided in Table 2.9-4.

Airguns function by venting high-pressure air into the water. The pressure signature of an individual airgun consists of a sharp rise and then fall in pressure, followed by several positive and negative pressure excursions caused by oscillation of the resulting air bubble. Typical high-energy airgun arrays emit most energy at 10 to 120 Hz. However, the pulses contain energy up to 500 to 1,000 Hz and some energy at higher frequencies (Goold and Fish 1998; Potter et al. 2007).

Potential effects to listed eiders and candidate species from sound energy generated by ZVSP surveys will be similar to other marine and coastal birds as described in detail in Section 4.6.4. These potential effects would be biologically insignificant to their respective populations. Little effect, if any, has been reported by studies that investigated the effects of sound from underwater airguns on marine birds (Stemp 1985; Evans et al. 1993; Webb and Kempf 1998; Lacroix et al. 2003). ZVSP surveys are conducted for a much shorter period than typical seismic surveys, and utilize a much smaller airgun array than is used for typical seismic surveys. These studies indicate that the use of an airgun array during ZVSP surveys will have little or no effect on T&E birds in the area.

Given the moderate size of the sound sources planned for the planned ZVSP survey activity, the very short duration it will be conducted at each drill site, and studies showing limited effects on birds from airguns, it is unlikely that there would be any impacts beyond temporary behavioral disturbance such has flushing of birds that may cause the bird to move a short distance to another location. These non-lethal effects are not anticipated to last beyond minutes to hours after the ZVSP survey activities are complete and will not accumulate across multiple seasons.

Potential effects to Steller's and spectacled eiders from sound energy generated by ZVSP survey will be similar to other marine and coastal birds as described above, and in detail in Section 4.6.4. The planned ZVSP surveys (one at each drill site) would be limited to about 10 to 14 hr at each exploration drill site, and would take place in offshore areas where no Steller's eiders and only small numbers of spectacled eiders are expected to occur. Spectacled and Steller's eiders critical habitats also would not be affected by sound energy from ZVSP survey because these designated areas are at least 54 mi (87 km) from the Burger Prospect.

Conclusion

Given the moderate size of the sound sources planned for the planned ZVSP survey activity, the very short duration it will be conducted at each drill site, and studies showing limited effects on birds from airguns, impacts will consist of temporary behavioral disturbance or displacement to another nearby location. These effects are not anticipated to last beyond minutes to hours, resulting in no measurable impact. Based on analysis above, T&E birds may be affected by the ZVSP survey activities associated with Shell's proposed program as described in Section 2.0. Therefore, given the significance thresholds and level of effects definitions determined by BOEM (2011a), the applicable level of effect is minor, and the impacts will not be significant.

Impacts of Air Emissions on Threatened and Endangered Birds

The planned exploration drilling will be conducted a minimum of 64 mi (103 km) offshore. As described in Section 3.1.3, air quality in the Lease Sale 193 Area and onshore on the North Slope is classified by the EPA as good. The exploration drilling activities will emit air pollutants, largely through the use of combustion engines. Potential effects to listed eiders and candidate species from air emissions associated with EP Revision 2 will be similar to other marine and coastal birds as described in detail in Section 4.6.5.

Shell has conducted dispersion modeling of air pollutants emissions associated with Shell's planned exploration drilling activities under EP Revision 2; this modeling and its conclusions are discussed in Sections 2.8 and 4.1. Shell created NEPA emissions inventories based on Shell's proposed sources and activities, including the two drilling units, MLC ROV system, support vessels, and oil spill response assets. The air pollutants addressed include: NO_X, CO, PM_{10}, $PM_{2.5}$, VOC, SO_2, Pb, and GHG. Shell specifically considered the impact of vessel and drilling emissions at both onshore areas and the offshore areas used for subsistence hunting and fishing. The details of that air emissions analysis are provided in Attachment B (onshore) and Attachment C (offshore subsistence) to this EIA. In addition, Attachment A to this EIA describes Shell's development of offshore criteria that are appropriate for determining significance under NEPA; a summary of this information is also provided in Section 4.1 on air quality. As described in Sections 4.0 and 4.1 and in Attachment C, the NEPA emission inventories adopted a number of conservative assumptions that result in an overestimate of the actual onshore and offshore emissions associated with EP Revision 2.

As summarized in Section 4.6.5 on marine and coastal birds, maximum predicted concentrations of the criteria pollutants at the shoreline met both primary and secondary NAAQS standards, and offshore pollutant concentrations meet the occupational health standards developed by Shell (Attachment A). Compliance with these criteria should ensure no project impacts to these birds. To the extent that a listed eider or candidate species is in the immediate vicinity of the drilling units or vessels, air emissions could have a temporary, short-term impact but that is highly unlikely.

Potential effects to Steller's and spectacled eiders from air emissions associated with EP Revisions 2 will be similar to other marine and coastal birds as described above, and in detail in Section 4.6.5.

Conclusion

The expected emissions of air pollutants are not expected to have an effect on the listed eiders, or designated critical habitat for spectacled eiders, particularly given their low density in the area. Based on analysis above, air emissions are not expected to affect T&E birds. Therefore, given the significance thresholds and level of effects definitions determined by BOEM (2011a), the applicable level of effect is negligible, and the impacts will not be significant.

Impacts of Drilling Unit Mooring, MLC Construction, and Drilling Wastes on Threatened and Endangered Birds

As discussed in Section 4.2 on water quality, Shell modeled the discharge of drilling wastes from the Burger Prospect wells to predict the dispersion and deposition of the discharged drill cuttings, water-based drilling fluids, and cement; the resulting volumes and rates are presented in Section 2.0, Table 2.7-3. All drill cuttings and drilling muds will be discharged below the sea surface under the conditions and limitations of EPA's NPDES exploration facilities GP. The permit limits and conditions placed on the discharge content, volume, and rate, which ensure they do not result in undue degradation of water quality, are provided in Table 4.2.1-1. The deposition area of drill cuttings and fluids and discharge plumes is in Table 4.2.1-3. Discharge modeling performed for both the *Discoverer* and the *Polar Pioneer*, based on maximum prevailing current speeds of 98.4 in./s (25 cm/s), shows that sedimentation depth of muds and cuttings at greater than 1 cm thickness will occur within approximately 1,641 ft

(500 m) of the drilling unit discharge point (Fluid Dynamix 2014a,b,c,d). Concentrations of total suspended solids, a transient feature of the discharge, are modeled to be below 15 mg/L at distances approximately 3,281 ft (1,000 m) from the drilling unit discharge point. Consistent with discussion of discharge modeling in Section 4.0, no overlapping impacts are associated with the two drilling units operating simultaneously at the Burger Prospect given the size of the plumes and location of even the two closest well sites. As a result, the increased level of activity associated with EP Revision 2 should not affect the impact conclusions associated with these discharges.

Most of the effects from drilling wastes will be limited to the area within 820 ft (250 m) of the discharge location and would last only a few minutes to a few hours after the discharge is stopped (Table 4.2.1-3). The total area that would be affected is also very small. Modeling of these discharges indicates that these discharged materials may settle to a thickness of 0.4 in (1.0 cm) or more over a total of approximately 5.4 ac (2.2 ha) for each well, and about 32.6 ac (13.2 ha) for all six wells in the EP (Fluid Dynamix 2014a,b,c,d). This represents less than 0.000011 to 0.000024 percent of the seafloor of the Chukchi Sea.

The physical manifestations of anchor disturbances associated with mooring the two drilling units (3.7 ac, 14,923 m^2) would attenuate after removal over time by the natural movement of seafloor sediments and ice scours. The physical effects of mooring and MLC construction would be restricted to a very small portion of the Chukchi Sea seafloor area (4.01 to 5.28 ac [16,158 to 21,354 m^2]), depending on MLC construction by drill bit or by MLC ROV system. The MLC ROV system results in the larger disturbance area. Benthic organisms within the area directly affected by MLC construction and anchor mooring would likely be buried or decimated due to the weight and force of the anchors and MLC drill bit or subsequent displacement. Approximately 10 additional acres (0.04 km^2) may be indirectly impacted by the re-deposition of cuttings from MLC construction and drilling to thickness of 0.4 in. (1.0 cm) or more resulting in the smothering of benthic organisms. The seafloor area of lower trophic benthic habitat that would be directly or indirectly disturbed would be small, but re-colonization by lower trophic benthic communities could take a number of years. This could be important for benthic feeders, but as explained below, bird species that are benthic feeders (including the listed eiders) are not prevalent in the Burger Prospect area. The seafloor disturbance by mooring and MLC construction is localized, temporary, short-term, and represents a very small proportion of the total seafloor of the Chukchi Sea.

The impacts on T&E birds from drilling unit mooring, MLC construction, and drilling wastes will be similar to those discussed for marine and coastal birds in Section 4.6.6. Only temporary displacement would occur during these activities mainly due to the presence of project equipment, not the generated disturbances to the seafloor. Drilling unit mooring and MLC construction will take place in areas with limited use by T&E birds, thus the potential for disturbance and other behavioral effects is low and would not involve population-level impacts. All drill cuttings and drilling muds will be discharged below the sea surface under the conditions and limitations of the required NPDES exploration facilities GP.

As discussed in Section 4.2 and 4.6.6, concentrations of heavy metals from permitted discharges could be slightly elevated, but these effects will be minimized by adherence with the NPDES exploration facilities GP restrictions on metal concentrations in barite used in the drilling fluids. Metal concentrations could result in limited contamination of benthic and other food sources of avian species. However, metal concentrations would not be elevated to levels that would have ecological effects (Shell Global Solutions 2009), and these metals have low bio-availability and there is little bio-accumulation of the metals (Neff et al. 1989a, 1989b, and 1989c; Leuterman et al. 1997; Neff 2010). Moreover, the recovery of any benthic communities that are harmed is likely to occur within two years or less of the completion of the well (USFWS 2012).

In USFWS's BO (2012) for oil and gas activities in the Beaufort and Chukchi Sea Planning Areas, the agency analyzed the potential effects on avian species from habitat loss and disturbance resulting from exploration drilling activities for a maximum of 36 wells each for the Chukchi Sea and Beaufort Sea. USFWS determined that given the relatively small impact area from structures associated with exploration drilling in relation to the size of the Chukchi Sea Planning Area, the low number of wells that are likely to be drilled in the area, and the limits on the discharges enforced through the NPDES permit process, only minor impacts are expected to listed eiders or yellow-billed loons from toxic contamination resulting from discharges of drilling mud and cuttings. In BOEM's EA (2011) for Shell's EP Revision 1, drilling unit mooring and MLC construction was not identified as one of the most important impact producing factors associated with the proposed activities. Because the total area affected is still small relative to the Chukchi Sea Planning Area, this remains the case with the proposed simultaneous drilling by two drilling units at the Burger Prospect.

Potential effects of drilling waste discharges on marine birds are described in detail in Section 4.6.6 and would be similar to the potential effects on Steller's and spectacled eiders. All drill cuttings and drilling muds will be discharged below the sea surface under the conditions and limitations of the required NPDES exploration facilities GP. The discharge of drill cuttings and drilling muds would have no direct effect on Steller's and spectacled eiders. The discharge of drill cutting and drilling fluids will affect water quality parameters, primarily increasing TSS. The discharge of drill cuttings and drilling muds could have an indirect effect on Steller's or spectacled eiders. The proposed discharges will likely result in some smothering effects on benthic organisms, some of which are potential food items for threatened eiders. The proposed discharge could also contain some elevated metal levels that could also affect benthic organisms; however that contamination would occur in a very small area. Further, even though the listed eiders are benthic feeders, the offshore areas affected are not regularly used by eiders for feeding.

As discussed in Section 3.6.6 and Section 4.6, densities of bird species on the Burger Prospect that are benthic feeders, such as Steller's and spectacled eiders, are very low. Few if any birds would be expected to be in the area during these activities. Only one spectacled eider was observed (in 2009) at the Burger Prospect during six years of CSESP surveys (Gall et al. 2013, 2014). No Steller's eiders were observed at the Burger Prospect (Gall et al. 2013, 2014). Because of the low likelihood of presence of eiders at the Burger Prospect and the relatively small area potentially affected by drilling unit mooring and MLC construction, adverse impacts on Steller's and spectacled eiders are not anticipated. Mooring of the two drilling units, MLC construction, and exploration drilling will not disturb any eider designated critical habitat, all of which is located in northwestern and southwestern Alaska far from the project area.

The areas affected by drilling discharges would be small, recover quickly, and represent a small portion of benthic habitat available to threatened or endangered birds. Given the size of the impact area and the low density of eiders in the Burger Prospect, any effects are not anticipated to accumulate across multiple seasons. Spectacled and Steller's eiders critical habitats also would not be affected by drilling waste discharges because these designated areas are at least 50 mi (80 km) from the Burger Prospect.

Conclusion

No direct impacts are anticipated to either of the two species are expected from drilling unit mooring, MLC construction, or drilling discharges. Indirect effects, if any, from the mooring, MLC construction, and discharges would be on spectacled and Steller's eiders (not the candidate species) as this activity could affect their prey. Any effects on these eiders would be negligible and short-term, not measurable, and insignificant to their respective populations. These T&E birds are not prevalent near the Burger Prospect, and the relative area affected compared to the habitat available for these birds is very small. Based on analysis above, T&E birds may be affected by indirect impacts from mooring, MLC construction, and drilling discharges. Therefore, given the significance thresholds and level of effects definitions determined by BOEM (2011a), the applicable level of effect is minor, and the impacts will not be significant. This finding is consistent with USFWS recent assessment of the potential impacts of these discharges on listed eiders.

Impacts of Other Permitted Discharges on Threatened and Endangered Birds

Other permitted discharges include the discharge of bilge or ballast water, non-contact cooling water, desalination wastes, domestic and sanitary wastes, bilge water, ballast water, boiler blowdown, fire control system test water, and deck drainage from the drilling units (Tables 2.7-4 and 2.7-5), and lesser but similar wastewaters from the support vessels (Table 2.7-6). Discharges from the drilling units will be conducted under the conditions and limitations of the required NPDES exploration facilities GP (Tables 4.2.1-1 and 4.2.1-2). Under these limitations, there will be no discharge of free oil, floating solids, or trash that could potentially affect marine birds.

Potential effects of other permitted discharges on marine birds are described in detail in Section 4.6.7; the potential effects on listed eiders and candidate species would be similar. Other permitted discharges are anticipated to have no direct effects on T&E birds. The discharges result in slight changes in pH, temperature, TSS and BOD, in the water column, but these effects would be limited to the immediate vicinity of the discharge due to rapid dispersion in the open ocean. The discharges could have an effect on bird prey or habitat. However, the discharges would take place in areas that are not heavily used by these birds, and the NPDES permit limits should significantly curtail any impacts. Any indirect effects on bird prey or habitat availability would last only as long as the discharge is ongoing.

Impacts of other permitted discharges are anticipated to have effects on Steller’s and spectacled eiders similar to those discussed above, and for other marine birds in Section 4.6.7. The discharges would take place in areas that are not heavily used by spectacled and Steller’s eiders and would be conducted per requirements of the NPDES exploration facilities GP, which prohibits the discharge of free oil. The only potential for impacts are indirect through their prey. Additionally, spectacled and Steller’s eiders critical habitats would not be affected by other permitted is charges because these designated areas are at least 50 mi (80 km) from the Burger Prospect.

Conclusion

While no direct impacts are associated with these permitted discharges, there is a possibility that discharges could have an effect on bird prey or habitat. Because the discharges would take place in areas that are not heavily used by these birds, and the NPDES permit limits should significantly curtail any impacts, any indirect effects on bird prey or habitat availability would last only as long as the discharge is ongoing. Any impacts, if they were to occur, are not measurable. Based on analysis above, T&E birds may be affected by indirect impacts from other permitted discharges. Therefore, given the significance thresholds and level of effects definitions determined by BOEM (2011a), the applicable level of effect is minor, and the impacts will not be significant.

Impacts of Shorebase Expansion on T&E Birds

Potential impacts of construction on T&E birds typically include habitat loss or loss of access to habitat, disturbance and displacement, and collisions (USFWS 2012). Use of Shell’s proposed shorebase facilities, including the expansion of Barrow facilities, are not expected to affect T&E birds in the area. All shorebase expansions planned for EP Revision 2 would occur on existing gravel pads. Therefore there will be no additional loss of habitat or loss of access to habitat. T&E birds in the area are expected to be habituated to human presence on the site and are not expected to be disturbed, displaced, or at a greater risk of collision beyond the level occurring prior to Shell’s proposed activities. Furthermore, construction-related impacts are not expected to affect T&E birds because noise and fugitive dust related to construction will be minimal and temporary. Based on the significance thresholds and level of effects definitions determined by BOEM (BOEM 2011a) and provided above, T&E birds are not expected to be adversely affected from shorebase expansion. Therefore, the impacts associated with shorebase expansion will not be significant and will have a minor effect on T&E birds.

Impacts of Small Liquid Hydrocarbon Spills on Threatened and Endangered Birds

As discussed in Section 2.10, a small spill, such as a release of 48 bbl of diesel fuel, is the most probable type and volume of spill, if any, to occur as a result of EP Revision 2 activities. Section 2.10 addresses the potential sources and types of a hydrocarbon spill. Shell’s plans for responding to a small spill (defined as 48 bbl or less), and Shell’s WCD planning scenario. Shell’s categories of spill sizes are different from, but not incompatible with, those used by BOEM. The probability of a large (> 48 bbl) liquid hydrocarbon spill, is sufficiently small to conclude it would not occur during the proposed exploration drilling activities. Prudent planning and state and federal regulatory requirements nevertheless require that Shell have comprehensive spill prevention and response plans and capabilities in place. Shell’s plans include measures to prevent any spill release from occurring and to respond in the event of a spill, including capabilities for responding to a “worst case” scenario release. Under Shell’s FTP, fuel transfer vessels will be pre-boomed prior to fuel transfer operations and would be utilized in accordance with BOEM lease stipulation No. 6, USCG requirements, and Shell’s operating procedures, eliminating most or all potential fuel releases.

The duration of a small spill and opportunity for effect would be very brief. Nearly 100 percent of a small spill (diesel fuel) would evaporate (48 percent) or disperse (51 percent) within 48 hr. Given that nearly 100 percent of the spill would disperse within 48 hr, it is likely that little diesel if any would reach these waters and there would be little or no opportunity for impact on listed eiders and candidate avian species. Opportunity for such impacts will be further reduced by Shell’s response measures in its OSRP and FTP. In the unlikely event of a spill, implementation of Shell’s comprehensive spill response plan would minimize the impacts from the spill and any effects on sediments. Response equipment and trained personnel would be available on site to deploy boom and recovery equipment for the control and removal of product spilled into the environment. Additionally, the procedures of Shell’s FTP for fuel transfer between vessels would be utilized in accordance with BOEM lease stipulation No. 6, USCG requirements, and Shell’s operating procedures.

Bird morbidity or mortality can occur through direct contact with a liquid hydrocarbon spill (crude oil or diesel fuel; MMS 2003a). Oiled feathers can result in a loss in water repellency, thermal insulation, buoyancy, and the ability to forage and fly. Consequently, oiled birds can die of hypothermia and starvation. When a bird encounters oil, oil sticks to its feathers, causing them to separate and mat. Instinctively, birds try to remove the oil through preening which then leads to oil ingestion. Oil ingestion can result in severe damage to the internal organs and mortality (MMS 2001). The extent of the above-referenced potential effects on birds from a small hydrocarbon spill would be influenced by the amount of oil spilled, effectiveness of containment, and densities of bird species present in the area of the spill.

The effects of a small spill on birds are described in detail in Section 4.6.8 and would be identical to those on Steller’s and spectacled eiders, except these birds are found at much lower densities than others. Impacts, including mortality, could result from a small hydrocarbon spill; however, population-level effects on these species would be highly unlikely. In BOEM’s EA analyzing Shell’s EP Revision 1 and the associated impacts of the same sized spill, BOEM agreed, finding that few T&E birds are anticipated to occur in the project area and few could be exposed to an accidental spill. Moreover, many offshore birds would likely avoid spill response activities. BOEM concluded that consecutive years of activity would not have an additive effect and that an accidental small spill that is immediately contained would have a negligible level of effect on T&E birds. BOEM further discussed the impacts if a small accidental spill (<48 bbl) were to escape containment or response measures. BOEM determined it would not persist very long (<3 days), resulting in few opportunities to contact many T&E birds. BOEM noted that Shell’s spill response measures include immediate attention to the LBCHU, located about halfway between the drilling sites and shore, and where spectacled eiders and other (flightless) molting birds would be most vulnerable after mid-July. BOEM noted that vessel activity associated with spill response could have limited success in keeping keep molting seaducks away from a spill because the birds are flightless. BOEM also indicated that later in the open-water season, new migrants could arrive in a spill area on a regular basis, making hazing more difficult. BOEM agreed with Shell's conclusions that there would be limited mortality from a small spill, resulting in a minor level of effect.

The USFWS more recently considered the impacts of a small hydrocarbon spill on this same species. After reviewing the harm that exposure to oil can cause in birds, USFWS found that it is highly unlikely that there would be any significant effects to listed eiders or candidate avian species given the low volume of oil; that oil is likely to evaporate, weather, or be mostly recovered; and the low density of these species in the area. As a result, only a few birds are likely to encounter oil from small spills and most individuals will displace away from spill sites due to disturbance from oil spill response activities.

The effects of a small spill on birds are described in detail in Section 4.6.8 and would be identical to those on Steller's and spectacled eiders. Eider contact with the slick associated with a release of diesel fuel could result in the morbidity or mortality to the birds. An uncontrolled diesel fuel spill could result in a slick that encompasses 20 to 200 ac (0.1 to 0.8 km^2) if not contained by booms and quickly recovered; however, fate and transport information indicates that up to 99 percent of the released diesel fuel would either evaporate or be widely dispersed in the water column within 48 hr of release. Given the small area of the Chukchi Sea that would be affected, and the low density of spectacled eiders and Steller's eiders in the areas of the Chukchi Sea in which the exploration drilling activities would occur, it is likely that no or very few spectacled or Steller's eiders would come into contact with the uncontained diesel slick. If any eiders were to contact the oil a small number of bird mortalities could result.

Spectacled and Steller's eiders' critical habitats likely would not be affected by a small hydrocarbon spill because these designated areas are at least 50 mi (80 km) from the Burger Prospect. Shell's OSR equipment would be mobilized to contain and clean up any release that was to occur, and would focus on protection on LBCHU if that area was at risk. The USFWS recently considered impacts to the LBCHU from a small spill, because of this area's importance to migrating and molting spectacled eiders (USFWS 2012). USFWS determined that, in the unlikely event that impacts reached the LBCHU, those effects would be minimized through oil evaporation, weathering, and recovery efforts and no long-term effects would be expected to diminish the value of the LBCHU for molding spectacled eiders.

Conclusion

Such a small spill would be insufficient to produce any population level effects on threatened or endangered birds. Mitigation measures will reduce the probability of such spills occurring, and minimize the environmental effects through containment and cleanup. Even the effects of an uncontained release would be temporary and would not accumulate across multiple seasons. Furthermore, the density of these species is low in the Burger Prospect. Based on analysis above, given the small chance of mortality, T&E birds may be affected by a small liquid hydrocarbon spill. Therefore, given the significance thresholds and level of effects definitions determined by BOEM (2011a), the applicable level of effect is minor, and the impacts will not be significant.

4.8.2 Impacts on Polar Bears

The polar bear was listed by USFWS as a threatened species under the ESA on 14 May 2008 (73 FR 28212-2833). Although the USFWS designated approximately 187,000 mi^2 (484,328 km^2) of critical habitat for polar bears within Alaska, on 10 January 2013 the U.S. District Court for the District of Alaska, vacated and remanded the Final Rule to the USFWS. There is currently no designated critical habitat for polar bears. In addition to the summary information provided below, the natural history and seasonal distributions of polar bears are discussed in further detail in Section 3.8.3.

Polar bears require sea ice habitats as year-round habitat (Durner et al. 2004). In winter, they can be found on landfast ice (Durner et al. 2004). Polar bears move with the pack ice to hunt seal as summer nears and the sea ice is retreating. Polar bears select areas of high ice concentration in spring and summer and thus generally are found far offshore as nearshore ice melts. Polar bears then return shoreward with rapid ice formation in the fall (Durner et al. 2004). These patterns and dependence on sea ice habitat suggest polar bears may be present near the planned exploration drill sites during summer, if the pack ice is nearby. However, exploration drilling activities will not take place in heavy ice, limiting the opportunity for encounters.

Offshore exploration drilling activity will be concluded on or about 31 October before the Chukchi Sea is solidly iced over and winter sets in. Therefore, denning polar bears will not be affected since polar bears den during the winter season.

USFWS Biological Opinions

Under the MMPA, the USFWS has promulgated regulations for authorizing small takes of polar bears in the Chukchi Sea that might take place incidental to conducting oil and gas exploration. Prior to issuing regulations in 2008, the USFWS (2008c) evaluated the effects of authorizing such takes on polar bears, and released a Programmatic BO. Before issuing incidental take regulations, the USFWS must determine that the total taking will have a negligible impact on the species and will not have an immitigable adverse impact on the availability of the species for subsistence uses. In their evaluation, the USFWS considered that as many as three drilling units could be operating simultaneously in the Chukchi Sea, each with 1 to 2 supporting ice management vessels, supply barge and tug, and OSR vessels, and serviced with 1 to 2 helicopter flights per day and 1 to 2 supply boat trips per week. They assumed that each drilling unit might drill up to four wells per drilling season. The USFWS concluded that authorizing these activities would result in a small number of takes and that they would have a negligible effect on polar bears, and would not have an unmitigable adverse impact on the availability of the species for subsistence uses. The agency reached this conclusion on:

- The biological and behavioral characteristics of the animals
- Nature of the oil and gas industry
- Potential effects of oil and gas exploration drilling activities
- The documented impacts of industry activities on the species
- Potential impacts of climate change
- Mitigation measures that minimize industry impacts

The agency determined that the takes that would occur under the above described level of oil and gas exploration would be small due to the small footprint of exploration and the low numbers of polar bears using open water habitats. The USFWS also stated that routine aircraft traffic has little to no effect on polar bears, but added that extensive or repeated overflights could disturb polar bears, noting that the behavioral reactions of nondenning bears should be limited to short-term changes in behavior and would have no effect on individual bears or the population. They also reported that vessel traffic could similarly result in short-term behavioral disturbance of polar bears, but added that the vessel would be more likely to attract bears if operating near the pack ice.

BOEM and BSEE, and their predecessor agencies, have also engaged in consultations with the USFWS on the impacts of oil and gas leasing and exploration in the Arctic. Pursuant to Section 7 of the ESA of 1973, USFWS conducted an incremental step consultation under Section 7 of the ESA to consider the potential effects oil and gas leasing, exploration, and development in the Beaufort and Chukchi Seas on polar bears and polar bear critical habitat. That BO was issued on 8 May 2012 (USFWS 2012). Given the court decision to vacate and remand the designation of critical habitat for the polar bear, this analysis focuses on the USFWS's results regarding the species and not the critical habitat.

Activities considered in the USFWS 2012 BO include lease sales, deep penetration surveys, high-resolution surveys, exploration drilling, and all vessel and air traffic associated with these surveys and exploratory drilling. Relevant to Shell's EP Revision 2, the USFWS analysis assumed up to two drilling rigs units per sea would operate simultaneously during the each open-water season. The units would operate 30 to 90 days, typically from July through November, with each drilling unit drilling two but possibly up to six wells annually. USFWS assumed that drilling operations would be supported with helicopter flights from base camp up to three times per day and support vessel trips up to three times per week. USFWS further assumed that each exploration drilling unit would be supported by 1 to 2 ice-breakers, 1 anchor handler, 1 to 2 OSR barges and tugs, 1 tank vessel for spill storage, and 2 to 3 small support vessels. Relevant here, USFWS's BO contemplates significantly more activity than proposed here by Shell (as it also includes extensive survey efforts that are unlikely to be contemporaneous with Shell's drilling and concurrent drilling in the Beaufort Sea) and considers the same important mitigation measures (e.g., 1,500 ft [457 m] altitude for aircraft, lighting protocols) that Shell proposes.

USFWS identified the following potential effects to polar bear: human-polar bear interactions, disturbance and displacement due to noise and aircraft, and small spills. USFWS identified human-polar bear interactions from exploration drilling activities as an area of possible concern. USFWS noted that due to melting of sea ice, the fact that no polar bear were observed during Shell's seismic surveying in 2008, and the location of the proposed activities, the agency expects very few human encounters with polar bears. USFWS estimated that 22 polar bears may be seen from each exploration drilling operation annually. USFWS also noted polar bear interactions with were much more likely to occur in the Beaufort Sea than the Chukchi Sea and concluded that disturbance of denning polar bear in the Chukchi Sea is unlikely to occur.

Next, the USFWS considered the impacts from sound associated with vessel engines and ice breaking. USFWS noted that a swimming bear may be able to hear engine noise (though such an encounter would occur rarely) and the result could be minor disturbance with the bear swimming faster or changing course. Polar bears on ice may be able to hear activities near or on the ice and might run away; fleeing from a vessel would likely have minimal effect if the event is temporary and the animal is unstressed, but on a warmer day the effect could be more adverse if the polar bear became overheated and there would be more of an impact. In general, USFWS indicated that polar bears would most likely respond to exploration drilling activities by moving from their original position or jumping into the water if on ice in order to avoid such activities. USFWS acknowledged the important mitigation measures imposed by the Chukchi Sea ITRs (e.g., PSOs), and concluded that it is unlikely a polar bear would be exposed to strong underwater seismic sounds long enough for significant impacts to occur.

With respect to aircraft, USFWS noted that extensive overflights of helicopter and fixed wing aircraft could disturb polar bears, and mostly likely in the fall when there are more likely to be bears looking for ice or searching for den sites. The USFWS (2012) concluded in its BO that, given the relatively low number of operations and the size of the Chukchi Sea, the low density of polar bears where activities during exploration drilling would likely take place, and implementation of mitigation measures, the number of potential helicopter overflights an individual polar bear may experience is extremely low. The agency concluded that they expect these occasional overflights would cause only minor, short-term behavioral changes—no population level effects were anticipated. It was noted that any reactions of non-denning bears would be limited to short-term changes in behavior before bears resumed their normal activity.

With respect to small spills, USFWS reviewed the harm that exposure to oil can cause to polar bears, including oil ingestion through consumption of contaminated prey or nursing, and fouling of fur which reduces insulation and can damage skin and impair thermoregulation, and exposure to harmful vapors. This exposure could have short-term impacts, sub-lethal injuries, or result in death. USFWS found polar bears are unlikely to encounter a small spill in the first place given their low density, and the small area in which the spill would occur. Moreover, mitigation measures would be employed to contain the spill, any oil would weather quickly, and hazing would be employed to reduce any impacts to polar bears. USFWS concluded that the chance of a polar bear contacting a small spill was extremely low and the effects would be expected to be short-term, localized, and at most affect only a very small number of individuals. USFWS concluded these effects would be minor.

On 20 May 2013, the USFWS completed a BO that examined the potential effects of take of polar bear incidental to Chukchi Sea oil and gas exploration (USFWS 2013b). This opinion was issued in conjunction with USFWS's reissuance of the MMPA incidental take regulations. The analysis and conclusions in this opinion were very similar to the 2012 BO issued one year earlier for activities in both the Chukchi and Beaufort seas. This BO carried forward the same level of activity as the prior ITR analysis, considering up to three operators drilling up to eight wells annually in the Chukchi Sea, as well as several support vessels and aircraft It considered other offshore activities occurring simultaneously as well, including seismic programs, shallow hazards surveys, marine geophysical surveys, geotechnical surveys, and offshore environmental studies. Given the similarities to the 2012 analysis described above, the conclusions are summarized here.

- Noise and vessel traffic that disturb polar bears (e.g., noise from vessel engines, drilling, ice breaking) would result in only non-lethal, minor, short-term behavioral changes. Such impacts would meet the definition of Level B harassment under the MMPA and are estimated to number up to 25 annually (for all the activities considered, not just exploration drilling).
- The likelihood of disturbances from aircraft overflights is extremely low given the low numbers of operations, size of the Chukchi Sea leasing area, low density of polar bear, and mitigation measures (e.g., minimum altitude restrictions). If overflights do encounter polar bears the anticipated effect is minor, short-term behavioral changes that do not result in injury.
- Mitigation measures, including observers to ensure vessels are at least ½ mile from observed polar bears and reporting of encounters, will reduce impacts to those that are minor and temporary in nature.
- Only in extremely rare cases, would deterrence activities be necessary that could cause harm to individual bears. Deterrence activities could result in fewer than 5 polar bear annually subject to direct contact from projectiles and less than one lethal impact annually. This issue is addressed in a subsequent 2014 BO (USFWS 2014b).
- Small oil spills may occur and if polar bears contact oil they may become injured by it; however, the chance of a bear encountering a spill is very small. There could be additional disturbance, and potential disturbance, associated with cleanup of a small spill. Only a very low number of polar bears, are likely to contact oil or chemicals from a small spill.

The USFWS 2012 and 2013 analyses are based on up to two drilling units (up to six wells) and three drilling units (up to eight wells), respectively, operating simultaneously each year in the Chukchi Sea. They provide a level of activity that is greater than that proposed by Shell in EP Revision 2, and are useful guidelines in assessing the impacts associated with Shell's EP Revision 2. Mitigation measures considered in the BOs include: an oil spill prevention and response plan, site specific monitoring program for marine mammal subsistence resources, conflict avoidance mechanisms, and other measures, all of which are part of Shell's EP Revision 2. Shell has prepared and will implement a Shell's Polar Bear Avoidance and Interaction Plan (submitted to USFWS on September 18 2014) to minimize interaction and any resulting impacts. This plan and EP Revision 2 contain mitigation measures designed to avoid contacts and incidental takes of polar bears. Shell applied for an MMPA authorization for incidental harassment of polar bears, which will require mitigation measures to avoid impacts to species or subsistence activities. Shell has adopted mitigation measures from prior authorizations into EP Revision 2 (EP Section 12) as well as other measures including the following:

- Aircraft over land or sea shall not operate below 1,500 ft (457 m) altitude unless engaged in marine mammal monitoring, approaching, landing or taking off, in poor weather (fog or low ceilings), or in an emergency situation.

- Aircraft engaged in marine mammal monitoring shall not operate below 1,500 ft (457 m) in areas of active whaling; such areas to be identified through communications with the Com Centers and SAs.
- Except in an emergency, aircraft will not operate at an altitude lower than 1,500 ft (457 m) within 0.5 mi. (0.8 km) of polar bears when observed on land or ice.
- Helicopters will not operate at an altitude lower than 3,000 ft (914 m) within 1 mi (1.6 km) of walrus groups observed on land, and fixed-wing aircraft will not, except in an emergency, operate at an altitude lower than 1,500 ft (457 m) within 0.5 mi (805 m) of walrus groups observed on ice, or within 1 mi (1,610 m) of walrus groups observed on land.
- If aircraft must be operated below 1,500 ft (457 m) because of weather, the operator will avoid areas of known walrus and polar bear concentrations and will take precautions to avoid flying directly over, or within 0.5 mi (805 m), of these areas.
- PSOs will be aboard the drilling unit(s) and transiting support vessels.
- Except in an emergency, vessels will not approach within 0.5 mi (0.8 km) of walruses or polar bears when observed on ice.
- Vessels will maintain the maximum distance possible from concentrations polar bears.
- Except in an emergency, vessels will not approach within an 0.5 mi (805-m) radius polar bears observed on ice.
- Except in an emergency, vessels will not approach within a 0.5 mi (805-m) radius of polar bears observed on land.
- Vessel speed will be reduced during inclement weather conditions in order to avoid collisions with marine mammals.
- Shell will communicate and coordinate with the Com Centers regarding all vessel transit.
- A polar bear culvert trap has been constructed in anticipation of oil spill response needs and will be available prior to exploration drilling.

The timing of Shell's activities will also minimize polar bear interactions and disturbance. Shell intends to start its exploration drilling operations on or about 4 July. Shell's proposed activities would occur during the open-water season, after sea ice retreats north of the prospect areas and after all of the fast-ice has melted way. Starting after ice recedes will further reduce the likelihood of encounters with polar bears and other marine mammals that rely on sea ice habitats. Polar bears in the Chukchi Sea are associated with sea ice, and most sea ice is absent from the prospect area during the open water season. Shell's ice management plan is to avoid pack ice by moving the drilling units offsite if necessary. Although this is for the safety of the drilling units and crew, it also reduces the likelihood of a need for icebreaking or encounters with polar bears. Shell's intention is to wait to enter the Chukchi Sea until about 1 July when the ice has receded north of the drill site. During transit into the Chukchi Sea, Shell may encounter some broken melting ice. During transit out of the Chukchi Sea, Shell may encounter some first year ice. Based on frequencies of observations, few polar bears are expected to linger in the area after the sea ice has retreated north, or appear during the end of the season as drilling units and vessels depart. Therefore, in reviewing Shell's EP Revision 1, BOEM determined it was unlikely that open-water exploration drilling in the northeastern Chukchi Sea will impact polar bears or the abundance and availability of ringed and bearded seals, which are the primary prey of polar bears (BOEM 2011a).

EP Revision 2 exploration drilling activities are described in detail in Section 2.0. The activities that could result in direct or indirect environmental impacts on T&E polar bear include: increased aircraft traffic;

increased vessel traffic; sound energy generated from exploration drilling activities (including ice management); sound energy from ZVSP survey; air emissions; drilling unit mooring, MLC construction and permitted drilling waste discharges; other permitted discharges; and a small hydrocarbon spill. The impacts on polar bears that are associated with each of these activities are discussed below.

Impacts of Aircraft Traffic on Polar Bears

Aircraft traffic under EP Revision 2 will increase above those levels proposed in Shell's EP Revision 1 in order to support two drilling units operating simultaneously. Aircraft traffic consists of approximately 40 round trip helicopter flights weekly between the Burger Prospect and shorebase facilities at Barrow; this is an increase from EP Revision 1 which estimated 12 round trips weekly. Potentially two fixed-wing aircraft will be used for PSO overflights and ice reconnaissance, on a daily basis when possible. In addition to this routine aircraft traffic between the Burger Prospect and Barrow, aerial surveys for marine mammals will be conducted along a standardized route, attempted daily, for the duration of the exploration drilling activities as part of the 4MP (Appendix B of the Chukchi Sea EP Revision 2).

Overflights could potentially result in some human disturbance of polar bears but any such impacts would be brief and would affect few polar bears. Effects on polar bears may include alterations in swimming behavior, avoidance, or deflection around a localized area. Denning does not occur during the time period when the flights would be conducted, and flights would not prohibit polar bear movements along the coast.

Shell will implement multiple measures designed to mitigate potential effects of aircraft traffic on polar bears. The potential impacts on polar bears from aircraft traffic will be minimized by flying along predetermined corridors (Figure 2.2-2), which will reduce the spatial area potentially disturbed. Polar bears on ice or in the water are not stationary and are very mobile, thus the same bears would not be disturbed by flights along the corridor. The predetermined flight paths minimize the portion of flights over coastal waters. The Barrow helicopter crew change route transits polar bear denning and barrier island habitat; however, given the infrequency of trips and minimum altitude requirements, and timing of flights not overlapping with denning, effects on polar bears would be negligible and there would be no known physical impacts on habitat. Furthermore, flights between Barrow and Wainwright will occur along a corridor 5.0 mi (0.8 km) inland to minimize effects on subsistence activity and subsistence resources including marine mammals. Aircraft will maintain a 1,500 ft (457 m) except during take-offs, landings, marine mammal monitoring, and when weather or other conditions force an altitude reduction for personnel safety reasons by the proposed flight corridor. Except in an emergency, aircraft will not operate at an altitude lower than 1,500 ft (457 m) within 0.5 mi. (0.8 km) of polar bears when observed on land or ice. If aircraft must be operated below 1,500 ft (457 m) because of weather, the operator will avoid areas of known polar bear concentrations and will take precautions to avoid flying directly over or within 0.5 mi (805 m) of these areas.

The USFWS (2012) concluded in its Programmatic BO that, given the relatively low number of operations and the size of the Chukchi Sea leasing area, the low density of polar bears where activities during exploration drilling would likely take place, and implementation of mitigation measures, the number of potential helicopter overflights an individual polar bear may experience is extremely low. The agency concluded that they expect these occasional overflights would cause only minor, short-term behavioral changes—no population level effects were anticipated. It was noted that any reactions of non-denning bears should be limited to short-term changes in behavior before bears resumed their normal activity. In its subsequent BO supporting issuance of ITRs in the Chukchi Sea, USFWS (2013b) concluded that given the relatively low number of operations likely in the Chukchi Sea and their limited size, the low density of polar bears, and mitigation measures (including minimum altitude restrictions), the potential for disturbance of polar bears from aircraft overflights would be extremely low. USFWS further determined that even if overflights encounter polar bears, only limited, short-term behavioral changes that would not result in injury are expected.

Conclusion

Despite the increased number of aircraft and helicopter flights supporting Shell's exploration drilling activities as described in EP Revision 2, the impacts to polar bear from aircraft travel are not expected to increase. Given the limited size and number of exploration drilling operations in the Chukchi Sea, the low density of polar bears, and Shell's mitigation measures, the potential for disturbance of polar bears from aircraft overflights would be extremely low. If disturbances of polar bears by aircraft do occur, the impacts will be temporary and localized to small numbers of polar bears on shore near the coast, in the water, or on remnant ice floes. These non-lethal effects would only last until the aircraft noise becomes inaudible and are not anticipated to accumulate across multiple seasons. Based on analysis above, polar bears may be affected by aircraft traffic. Therefore, given the significance thresholds and level of effects definitions determined by BOEM (2011a), the applicable level of effect is minor, and the impacts will not be significant.

Impacts of Vessel Traffic on Polar Bears

Vessel traffic associated with EP Revision 2 is higher than the levels proposed in Shell's EP Revision 1 in order to support two drill units operating simultaneously. New vessels include use of a second drilling unit, the MLC ROV System vessel that could be used to construct MLCs instead of the drilling units, and science vessels to support monitoring requirements under the NPDES exploration facilities GP. The drilling units will be supported by additional vessels for ice management, anchor handling, resupply, and crew transport, as well as OSR vessels and barges staged near the drilling unit, with a full complement of crew and OSR equipment. The expected frequency of OSV visits to the drilling units has been increased from 17 round trips / season to 30 round trips/ season.

Most vessel operations associated with the proposed exploration drilling activities would take place far offshore and in open water and are not expected to encounter polar bears. Impacts on polar bears from vessels would likely be limited to short-term disturbance and displacement from the immediate area of activity, resulting in some expenditure of energy. Shell will fully implement a Polar Bear Avoidance and Interaction Plan (submitted to USFWS on September 17, 2014) to mitigate encounters with polar bears. These plans have proven effective in avoiding encounters with polar bear (and other species) and minimizing the impacts of the few encounters that do occur. As part of Shell's mitigation measures, vessels will not approach closer than 0.5 mi (800 m) to polar bears observed in water, on land or ice during travel status. Vessel speed also will be reduced during inclement weather conditions in order to avoid collisions with polar bears, avoid separating members of groups of polar bears, avoid multiple changes in direction in the water, or on ice.

The USFWS (2008b) concluded in its Programmatic BO that vessel traffic could result in short-term behavioral disturbance of polar bears or attract animals if in pack ice. Polar bears exposed to vessel traffic are anticipated to move away, show curiosity, or show no effect. Polar bears are known to be attracted to vessels on occasion (Harwood et al. 2005), likely due to curiosity. Brueggeman (1991a) reported that polar bears reacted to icebreakers during oil and gas exploration in the Chukchi Sea by walking toward, stopping, looking, and walking/swimming away from the vessel. These reactions, however, were brief and would not be expected to result in any long-term effects. Potential impacts on polar bears from vessel traffic would not result in a biologically significant impact at the population level.

In USFWS's BO for Oil and Gas Activities in the Beaufort and Chukchi Sea Planning Areas (2012), the agency concluded that during exploration drilling activities, in the rare event a polar bear is encountered, only minor, short-term behavioral changes by non-denning polar bears would likely result from vessel disturbances. Furthermore, in USFWS's BO for ITRs in the Chukchi Sea (2013b), the agency's interpretation of industry-submitted monitoring reports was that the large majority of interactions would result in only minor, short-term behavioral changes.

Conclusion

Based on the frequencies of observations from vessel-based surveys (Table 3.7-6), few polar bears would be expected to be encountered by vessels during the exploration drilling activities. Effects would be minimized by the vessel-based mitigation measures, which should prevent any measureable disruptions to polar bears. Any effects on polar bears from vessel traffic will be short-behavioral changes that last only minutes or hours after the vessel has passed. Effects are not anticipated to accumulate across multiple seasons. Based on analysis above, polar bears may be affected by vessel traffic. Therefore, given the significance thresholds and level of effects definitions determined by BOEM (2011a), the applicable level of effect is minor, and the impacts will not be significant.

Impacts of Continuous Sounds from Drilling, Ice Management, and Other Support Activities on Polar Bears

Section 4.0 describes the new sound measurements and modeling that Shell conducted for its for EP Revision 2 (Table 4.0-3). There is an increased level of simultaneous activity associated with EP Revision 2—which includes two drilling units drilling simultaneously and potentially in conjunction with ice management, anchor handling, and construction of an MLC using the drilling unit or the newly-proposed MLC ROV system. Continuous sounds from exploration drilling, MLC construction, ice management and other support activities will have little effect on polar bears. Effects on polar bears present near Shell's proposed activities may include temporary avoidance responses or briefly avoiding approaching vessels within a localized area. Polar bears encountering drilling operations may be temporarily deflected from their chosen path, and some may choose to return where they came from; however, any interruption is likely to be brief in duration. At most, polar bears have demonstrated curiosity when encountering vessels and will approach them on occasion (Harwood et al. 2005). And, given the vast geographical area over which polar bears travel and their dispersed distribution, the number of individuals affected would be small. Polar bears can be drawn to areas of human activity, but implementation of Shell's Polar Bear Avoidance and Interaction Plan (submitted to USFWS on September 17, 2014) will minimize encounters and potential impacts from interactions by increasing the distance between vessels and polar bears.

Disturbances of polar bears by continuous sounds emitted from drilling and support activities as described in Section 2.0 will be temporary and localized to small numbers on remnant ice floes or in the water. Polar bears traveling by swimming in the water do so with their heads out of the water. Sensitive body parts such as the sensory organs in the ears are therefore not exposed to the sound levels. Sound levels received by polar bears in the water would be attenuated because polar bears generally do not dive much below the surface.

Effects on polar bears from continuous sound could increase above those expected in Shell's EP Revision 1, because the proposed activities include two drilling units operating simultaneously at the Burger Prospect and an increase in associated support activities. However, given the small numbers expected to be encountered and the short-term nature of any effects, impacts and are not anticipated to accumulate across multiple seasons. Effects would be minimized by fully implementing mitigation measures imposing vessel distance restrictions when polar bear are on water or ice, and with PSOs stationed on drilling units, OSVs, ice management vessels, and anchor-handling vessels to apply real-time mitigation, if necessary. These mitigation measures should prevent any measureable disruptions to polar bears occurring near project activities.

Conclusion

As noted, only a small number of polar bears are likely to be encountered, and they will have limited exposure to the drilling sounds. Any reaction will be short-term and further decreased by Shell's mitigation measures aimed and limited interactions with polar bear. Based on analysis above, polar bears may be affected by continuous sound associated with Shell's proposed activities. Therefore, given the significance thresholds and level of effects definitions determined by BOEM (2011a), the applicable level of effect is minor, and the impacts will not be significant.

Impact of ZVSP Survey Sound on Polar Bears

As described in EP Revision 2, Shell plans to conduct a geophysical activity referred to as a ZVSP survey at each Chukchi Sea drill site. During ZVSP survey operations, a string of geophones (receivers) will be hung in the wellbore to record the sonic waves created by the firing of a sound source (airgun array), which is suspended from the deck of the drilling unit into the water adjacent to the riser (Figure 2.4-1). The geophones will be relocated in the wellbore after each firing of the sound source until the entire wellbore has been surveyed. Each ZVSP survey will take approximately 10 to 14 hr to complete; the majority of that time will involve relocating the geophones in the wellbore. The sound source will be triggered approximately 216 times over the course of each survey.

A two-airgun (2×250 in.^{3} airguns) or three-airgun array (3×150 in.^{3}) will likely be used to perform each ZVSP survey. The estimated source level used to model sound propagation from the airgun array is approximately 239 to 241 dB re 1µPa m rms (Table 2.4-1). Modeled radii to various sound isopleths are provided in Table 2.9-5.

Airguns function by venting high-pressure air into the water. The pressure signature of an individual airgun consists of a sharp rise and then fall in pressure, followed by several positive and negative pressure excursions caused by oscillation of the resulting air bubble. Typical high-energy airgun arrays emit most energy at 10 to 120 Hz. However, the pulses contain energy up to 500 to 1,000 Hz and some energy at higher frequencies (Goold and Fish 1998; Potter et al. 2007).

Observations recorded during seismic surveys, which use airgun arrays similar to, but larger than, ZVSP surveys as the energy source, indicate that many polar bears do not react at all and others show such reactions as either moving away or approaching the seismic vessel apparently out of curiosity (USFWS 2013b).

Polar bears in the vicinity of any ZVSP survey would not be exposed to high sound energy levels. Polar bears observed near drill sites are most commonly out of the water and on ice floes, where they would not be exposed to the sound energy generated by the ZVSP survey sound source located 10 to 23 ft (3 to 7 m) below the sea surface. Bears traveling by swimming in the water do so with their heads out of the water. Sensitive body parts such as the sensory organs in the ears are therefore not exposed to the sound levels. Received levels of airgun sounds are reduced near the surface because of the pressure release effect at the water's surface (Greene and Richardson 1988; Richardson et al. 1995a). Sound levels received by polar bears in the water would be attenuated because polar bears generally do not dive much below the surface. There is no evidence that airgun pulses can cause serious injury, or death, even in the case of large airgun arrays (USFWS 2009c).

The planned ZVSP survey duration will be about 10 to 14 hr at each drill site. The potential for exposure of polar bears to sound energy from the ZVSP surveys is low given the density of polar bears in the Chukchi Sea and the frequency of observations at historical exploration drilling operations, and the short duration of ZVSP surveys. The 4MP includes shutdown requirements if polar bears are observed within the area ensonified by the ZVSP survey. The USFWS (2009c), in their BO for seismic surveys and drilling in the Chukchi Sea, similarly concluded that seismic surveys would likely result in only short-term behavioral changes in polar bears. Shell's proposed stationary, brief ZVSP surveys may have similar effects, but because they are conducted over a shorter period of time and use much smaller airgun arrays, the effects would be restricted a much smaller area and effect fewer polar bears for a shorter duration. In addition, ZVSP survey sound energy will have no effect on the overall abundance of the principal prey species (ringed seal and bearded seal). These prey species may avoid the immediate area surrounding the drilling unit and sound source, but any such avoidance would be temporary.

Conclusion

Given the moderate size of the sound sources for the planned ZVSP survey activity, the very short duration it will be conducted at each drill site, and mitigation measures to be applied, it is unlikely that there would be any cases of temporary or permanent hearing impairment, or non-auditory physical effects in polar bears. More likely, behavioral disturbance - including temporary avoidance or deflection reactions - could occur at longer distances than auditory physical effects. These non-lethal effects are not anticipated to last beyond minutes to hours after the ZVSP survey activities are complete and will not accumulate across multiple seasons. Effects would be minimized by mitigation measures described above as part of the 4MP, including ramp-up and shut down procedures. Based on analysis above, polar bears may be affected by ZVSP survey activities associated with Shell's proposed activities. Therefore, given the significance thresholds and level of effects definitions determined by BOEM (2011a), the applicable level of effect is minor, and the impacts will not be significant.

Impacts of Air Emissions on Polar Bears

Shell has conducted dispersion modeling of the air emissions associated with Shell's planned exploration drilling activities under EP Revision 2. Shell created NEPA emissions inventories based on Shell's proposed sources and activities, including the two drilling units, MLC ROV system, support vessels, and OSR assets, and the emission units on each. The air pollutants addressed include: NO_X, CO, PM_{10} and $PM_{2.5}$, VOC, SO_2, Pb, and GHG. Shell specifically considered the impact of vessel and drilling emissions onshore, and in the offshore areas used for subsistence hunting and fishing. The details of that analysis are provided in Attachment B (onshore) and Attachment C (offshore subsistence) to this EIA. In addition, Attachment A to this EIA describes Shell's development of criteria that are appropriate for determining significance under NEPA; a summary of this information is also provided in Section 4.1 on air quality. As described in Sections 4.0 and 4.1 and in Attachment C, the NEPA emission inventories adopted a number of conservative assumptions that result in an overestimate of the actual offshore emissions associated with EP Revision 2.

To evaluate the potential effect of the offshore project's air emissions on offshore subsistence use air quality, Shell made conservative assumptions about the locations of the sources of air emissions. Air quality dispersion modeling simulations were used to estimate ambient concentrations attributable to emission units associated with the exploration program and CALPUFF was used to model the offshore air quality emissions within the subsistence use areas. Maximum offshore one-hr concentrations, background concentration, and design concentrations (project emissions plus background concentrations) for each criteria pollutant - NO_2, PM_{10}, $PM_{2.5}$, CO, and SO_2 - are predicted using CALPUFF to calculate the maximum 1-hr concentrations of each pollutant.

As discussed in Attachment A, the NAAQS are not appropriately applied to this offshore environment. Instead, Shell developed offshore subsistence use criteria after reviewing scientific evidence and OSHA state and federal standards (Attachment A). The criteria adopted are more protective than OSHA's exposure standards, and thus have a built-in margin of safety. The criteria are set at levels expected to avoid significant impacts to marine life and other environmental resources present in the offshore regions of the Arctic Ocean.

Maximum predicted offshore design concentrations in the offshore subsistence area are compared to the offshore impact criteria. As shown in Table 4.1.2-1, the total cumulative concentrations of all of the offshore air pollutants associated with the exploration drilling activities as described in EP Revision 2 are expected to be less than 50 percent of the significance criteria. Thus, the air emissions should ensure no project impacts to polar bear, particularly given that emissions will be short-term lasting only as long as there is exposure to the limited exploration activity.

Conclusion

The emissions of air pollutants are not expected to have an effect on polar bear and no effect on their sea ice. The primary constituent element of this habitat is sea ice over waters that support adequate prey resources. Limited pack ice expected during exploration drilling renders encounters with polar bear within and near the Burger Prospect unlikely, or severely limited. These emissions, which meet Shell's criteria, are not expected to have any effect on the overall abundance of the principal prey species (ringed seal and bearded seal), and therefore no effect on polar bear or their sea-ice habitat.

Based on the analysis above, polar bears are not expected to be affected by air emissions. Therefore, given the significance thresholds and level of effects definitions determined by BOEM (2011a), the applicable level of effect is negligible, and the impacts will not be significant.

Impacts of Drilling Unit Mooring, MLC Construction, and Drilling Wastes on Polar Bear

As discussed in Section 4.2 on water quality, Shell modeled the discharge of drilling wastes from the Burger Prospect wells to predict the dispersion and deposition of the discharged drill cuttings, water-based drilling fluids, and cement; the resulting volumes and rates are presented in Section 2.0, Table 2.7-3. All drill cuttings and drilling muds will be discharged below the sea surface under the conditions and limitations of EPA's NPDES exploration facilities GP. The permit limits and conditions placed on the discharge content, volume, and rate, which ensure they do not result in undue degradation of water quality, are provided in Table 4.2.1-1. The deposition area of drill cuttings and fluids and discharge plumes is in Table 4.2.1-3. Discharge modeling performed for both the *Discoverer* and the *Polar Pioneer*, based on maximum prevailing current speeds of 9.84 in/s (25 cm/s), shows that sedimentation depth of muds and cuttings at greater than 1 cm thickness will occur within approximately 500 m of the drilling unit discharge point (Fluid Dynamix 2014a,b,c,d). Concentrations of total suspended solids, a transient feature of the discharge, are modeled to be below 15 mg/L at distances approximately 3,281 ft (1,000 m) from the drilling unit discharge point. Consistent with discussion of discharge modeling in Section 4.0, no overlapping impacts are associated with the two drilling units operating simultaneously at the Burger Prospect given the size of the plumes and location of even the two closest drill sites. As a result, the increased level of activity associated with EP Revision 2 should not affect the impact conclusions associated with these discharges.

Most of the effects from drilling wastes will be limited to the area within 820 ft (250 m) of the discharge location and would last only a few minutes to a few hours after the discharge is stopped (Table 4.2.1-3). The total area that would be affected is also very small. Modeling of these discharges indicates that these discharged materials may settle to a thickness of 0.4 in (1.0 cm) or more over a total of approximately 5.5 ac (2.2 ha) for each well, and about 32.6 ac (13.2 ha) for all six wells in the EP (Fluid Dynamix 2014a,b,c,d). This represents less than 0.000011 to 0.000024 percent of the seafloor of the Chukchi Sea.

The physical manifestations of anchor disturbances associated with mooring the two drilling units (3.7 ac, 14,923 m^2) would attenuate after removal over time by the natural movement of seafloor sediments and ice scours. The physical effects of mooring and MLC construction would be restricted to a very small portion of the Chukchi Sea seafloor area (4.01 to 5.28 ac [16,158 to 21,354 m^2]), depending on MLC construction by drill bit or by MLC ROV system. The MLC ROV system results in the larger disturbance area.

Drill cuttings and drilling mud discharges will not impact polar bears in the Burger Prospect area. All drill cuttings and drilling muds will be discharged to the Chukchi Sea under the conditions and limitations of the NPDES exploration facilities GP (Table 4.2.1-1). Under this permit there can be no discharge of oil, which could impact polar bears. The discharge of drill cutting and drilling muds from the upper and lower well sections, including the excavation of the MLC, will affect water quality parameters, primarily increasing TSS. Most of these effects will be limited and would last only a few minutes to a few hours after the discharge is stopped. Even if the MLC is constructed using the MLC ROV system, which will result in a larger area of disturbance (Table 4.3.1-1), the additional area disturbed by use of the MLC ROV will not result in further impacts on polar bears. Drill cuttings and drilling muds will settle rapidly onto the seafloor.

Concentrations of heavy metals may be slightly elevated within this area, but the effects will be minimized by adherence to the NPDES exploration facilities GP restrictions on metal concentrations in barite used in the drilling fluids. Metal concentrations would not be elevated to levels that would have ecological effects (Shell Global Solutions 2009). Research has shown that there is little bio-accumulation of metals (Neff et al 1989c; Leuterman et al. 1997). These water quality effects would have no effect on polar bears near the surface. Polar bears will not be impacted by biologically non-significant levels of heavy metals from drill cuttings and drilling mud discharges.

Conclusion

Discharge of drilling fluids and cuttings during exploration drilling activities is not expected to cause impacts on polar bears or their sea ice habitat, either directly through contact or indirectly by affecting prey species. Any effects would be localized primarily around the exploration drilling site because of the rapid dilution/deposition of these materials. Effects from drilling discharges are expected to be localized to a small proportion of available marine mammal habitat. Based on the analysis above, polar bears are not expected to be affected by the discharge of drilling fluids and cuttings during exploration drilling activities. Therefore, given the significance thresholds and level of effects definitions determined by BOEM (2011a), the applicable level of effect is negligible, and the impacts will not be significant.

Impacts of Other Permitted Discharges on Polar Bears

Other permitted discharges include treated bilge water, ballast water, non-contact cooling water, desalination wastes, domestic and treated sanitary wastes, excess cement slurry, BOP fluids, and treated deck drainage. These discharges will be conducted under the conditions and limitations of the NPDES exploration facilities GP. Under permit limitations, discharges of free oil, floating solids, or trash that could potentially affect polar bears are not allowed. Although these discharges could result in minor and localized changes in pH, temperature, TSS, and BOD in the water column, they disperse and dilute rapidly in open ocean conditions. Indirect effects on polar bear prey or habitat will last only as long as the discharge is ongoing and will be negligible and have no effect on the polar bears.

The minor impacts on water quality will be limited to the area within about 328 ft (100 m) of the discharge location. These discharges permitted under the NPDES exploration facilities GP, will have no effect on the overall abundance of the principal prey species (ringed seal and bearded seal), and therefore no effects on sea-ice habitat or distribution of seals would result.

Consistent with discussion of discharge modeling in Section 4.0, no overlapping impacts are associated with the two drilling units operating simultaneously at the Burger Prospect given the size of the plumes and location of even the two closest well sites. As a result, the increased level of activity associated with EP Revision 2 should not affect the impact conclusions associated with these discharges. Further, all discharges will be managed according to NPDES permit requirements and MARPOL and USCG regulations. Direct effects on polar bears from discharges are not expected. Areas affected by other permitted discharges would be small, recover quickly, represent a small portion of habitat available to polar bears, and would be in the general proximity of activities causing enough noise to discourage visitation by polar bears.

Conclusion

No direct effects on polar bear are expected from other permitted discharges, and any indirect effects on polar bear prey or habitat would be short-term in a localized area, lasting only as long as the discharge is ongoing. Permit and regulation requirements and described mitigation measures will further minimize any impacts on polar bears. Based on the analysis above, polar bears are not expected to be affected by other permitted discharges during exploration drilling activities. Therefore, given the significance thresholds and level of effects definitions determined by BOEM (2011a), the applicable level of effect is negligible, and the impacts will not be significant.

Impacts of Shorebase Expansion on Polar Bears

Most polar bears occur in the active ice zone, far offshore, hunting throughout the year, although they spend a limited time on land to feed or move to other areas (USFWS 2012). Polar bears present onshore in the vicinity of Shell's shorebase operations could be affected, however adverse impacts are not expected. To prevent human-polar bear interactions that may lead to the injury or killing of a bear in defense of human life, Shell requested authorization to deter polar bears away from facilities (e.g., shorebase facilities). If deterrence events were to occur, most are not likely to involve contact with the bear and would likely cause only minor, temporary behavioral changes (e.g., a bear runs or swims away) (USFWS 2012). While deterring a polar bear will affect its short-term behavior, it is unlikely to significantly reduce the animal's survival (USFWS 2012). All shorebase expansions planned for EP Revision 2 would occur on existing gravel pads, and would have no effect on polar bears or polar bear habitat, because the land has been previously disturbed and human presence already exists at the sites. Polar bears generally do not den along coastal areas of the Chukchi Sea (USFWS 2012). Furthermore, the proposed activities will occur during the open water season when polar bears are not in dens. Construction is not expected to affect polar bears because noise related to construction will be minimal and temporary.

Conclusion

No direct effects or indirect effects on polar bears or polar bear habitat are expected from shorebase expansion. Permit and regulation requirements and described mitigation measures will further minimize any impacts on polar bears. Based on the significance thresholds and level of effects definitions determined by BOEM (BOEM 2011a), polar bears are not expected to be affected by shorebase facilities associated with Shell's EP Revision 2. Therefore, the impacts associated with the expansion of shorebase facilities will not be significant and will have a negligible effect on polar bears.

Impacts of a Small Liquid Hydrocarbon Spill on Polar Bears

Section 2.10 of this EIA analyzes in detail the potential sources of a hydrocarbon spill, the probability of various types of spills occurring, Shell's plans for responding to a "small" spill (defined as 48 bbl or less), and Shell's WCD planning scenario. As explained in Section 2.10, Shell's categories of spill sizes are different from, but not incompatible with, those used by BOEM. The probability of a large (> 48 bbl) liquid hydrocarbon spill, such as diesel fuel or crude oil, is sufficiently small to conclude it would not occur during the proposed exploration drilling activities. Prudent planning and state and federal regulatory requirements nevertheless require that Shell have comprehensive spill prevention and response plans and capabilities in place. Potential impacts of a small spill on polar bears are analyzed below.

Shell's plans include measures to prevent any spill release from occurring and to respond in the event of a spill, including capabilities for responding to a WCD scenario. In the unlikely event of a spill, implementation of Shell's comprehensive spill response plan would minimize the impacts from the spill and any effects on polar bear. Response equipment and trained personnel would be available and on site to deploy boom and recovery equipment for the control and removal of hydrocarbons spilled into the environment. Additionally, the procedures of Shell's FTP for fuel transfer between vessels would be utilized in accordance with BOEM lease stipulation No. 6, USCG requirements, and Shell's operating procedures.

Estimating the number of polar bears that could be directly affected by an accidental fuel spill depends on weather and ice conditions, time of year, and polar bear densities among other factors. Englehardt (1983) reported that thermal stress resulting from oiled fur was a primary threat to polar bears from oil spills. Thermal stress results in an increased metabolism and energy demands and a decreased body temperature. It was also reported (Englehardt 1983) that oil can be absorbed through the skin of polar bears and also ingested through inhalation and consuming oiled prey. The severity of thermal stress and oil ingestion on any affected polar bears would be determined by the extent of exposure to hydrocarbons.

Indirect effects of oil include a reduction in prey and ingestion of oil-contaminated prey. Oil could kill multiple organisms that make up the food chain in the Chukchi Sea. A reduction of a lower trophic organism such as fish may have subsequent negative effects on seals and polar bears.

Whether polar bears come into contact with oil depends on the location, timing, and magnitude of a spill and the ice conditions, and effectiveness of cleanup activities. Shell will have an agency-approved OSRP in place prior to commencing operations in the Chukchi Sea. Spill prevention is paramount to Shell's OSRP. In addition, Shell will have all necessary OSR vessels in the program vicinity with fully trained response personnel and equipment as an additional precautionary measure.

Small spills pose a risk to polar bears; however, the impacts of such a spill are expected to be minimal because of the open ocean location of Shell's Burger Prospect and short-lived nature of a diesel spill in this environment, implementation of Shell's prevention tactics (e.g. FTP), an immediate spill response with equipment already on site, and relatively few polar bears anticipated in the project area. The most likely small spill (still an unlikely event), quantified as a <48-bbl diesel fuel spill, impacts from a spill of this size would be minimized by implementation of Shell's OSR plan and maintenance of preventative measures including pre-booming before over-water fuel transfers. Given the open ocean location of Shell's program locations and the brief duration of a small fuel spill in the environment, the exposure time on polar bear would be brief and the impacts would be negligible. Nearly 100 percent of a small spill (diesel fuel) evaporates (48 percent) or disperses (51 percent) within 48 hr.

It would be anticipated that polar bears would avoid spilled fuel due to their keen sense of smell and human activity associated with fuel spill cleanup activities. A small oil spill could impact small numbers of polar bears, but any such effects would be unlikely to impact this species at the population level. Shell anticipates that, given the few polar bears anticipated in the project area and proposed spill preventative measures, such a small spill would be insufficient to produce any population level effects on polar bears in the Chukchi Sea. The weathering process should act to quickly break up or dissipate oil/fuel through the local environment to harmless residual levels that would eventually become undetectable. Given the dispersed distribution of polar bears, it is likely that a small spill persisting for less than 2 to 30 days would affect few polar bears.

Conclusion

A small spill would be insufficient to produce any population level effects on polar bears. Mitigation measures will reduce the probability of such spills occurring, and minimize the environmental effects through containment and cleanup. Based on the significance thresholds and level of effects definitions determined by BOEM (BOEM 2011a), polar bears may be affected by a small liquid hydrocarbon spill associated with Shell's proposed activities. Given the small likelihood that polar bears would encounter a spill, particularly in light of Shell's mitigation measures, the risk is discountable. Based on analysis above, polar bears may be affected by a small liquid hydrocarbon spill. Therefore, given the significance thresholds and level of effects definitions determined by BOEM (2011a), the applicable level of effect is minor, and the impacts will not be significant.

4.8.3 Impacts on Threatened Seals and Walruses

The activities associates with EP Revision 2 may affect the following protected pinnipeds: the ringed seal, the bearded seal, and the Pacific walrus. The Arctic population of the ringed seal is listed as a threatened species. NMFS listed the Beringia distinct population segment of the bearded seal as threatened in 2012, but that decision was vacated and remanded to the agency in a judicial decision. For purposes of this analysis, Shell will treat the bearded seal as a candidate species. Vessels transiting through the Bering Sea could encounter Steller sea lions. The Steller sea lion is listed as an endangered species and has designated critical habitat around rookeries. As noted in Section 3.8 although transiting vessels in the Bering Sea could encounter the Steller sea lion, transit to the Chukchi Sea was not included as part of the exploration drilling project activities at the Burger Prospect. Regardless, Shell does address impacts to the Steller sea lion in this section where applicable. Finally, the Pacific walrus is a candidate species.

<u>Prior Analysis of Impacts on Ringed Seals, Bearded Seals, and Steller Sea Lions</u>

Bearded and ringed seals are abundant throughout the Alaskan Arctic. The listing rule for the ringed seal estimated the Arctic subspecies in the millions (77 FR 76705-76738 28 December 2012). The listing rule for the bearded seal estimated the population at 155,000 (77 FR 76740-76768 28 December 2012). Insignificant fractions of each respective seal population will be found in the project area, and therefore, any effects from Shell's exploration drilling in the Chukchi Sea will be negligible to these two species, though individuals of each species may be affected by the proposed exploration drilling activities. Any impacts to individuals would be temporary and minor at most. Steller sea lions are not found in the project area and would be encountered, if at all, in transit to through the Bering Sea.

BOEM and BSEE and their predecessor agencies have engaged in consultations with NMFS on the impacts of oil and gas leasing and exploration in the Arctic. The most recent consultation concluded on 2 April 2013, with a BO analyzing the effects of authorizing oil and gas leasing and exploration in the Arctic on these three species (the bearded seal was listed as threatened at the time of the analysis) and associated critical habitat for the 14-year period beginning March 2013 and ending March 2027 (NMFS 2013b).

As relevant to Shell's EP Revision 2, NMFS assumed up to two exploration drilling units per sea per drilling season, with each unit capable of drilling up to four wells per year. Drilling operations were expected to take 30 to 90 days per well, with the drilling season extending a maximum of 120 days. NMFS assumed a typical exploration well depth of 10,000 ft (3,048 m). NMFS assumed that drilling operations would be supported with helicopter flights from base camp up to three times per day and support vessel trips up to three times per week. NMFS further assumed that each exploration drilling unit would be supported by 1 to 2 ice-breakers/anchor handlers, up to three waste control vessels, 1 to 2 OSR barge and tug, 1 tank vessel for spill storage, and 2 to 3 small support vessels.

NMFS concluded that leasing and exploration operations in the Beaufort and Chukchi seas over the 14-year period and related cumulative impacts would not jeopardize the continued existence of these species. Specifically with regard to the impacts of exploration drilling on these species, NMFS concluded that only bearded and ringed seals have the potential for exposure to the drilling operations. NMFS examined all seismic activity in the aggregate and determined that it was not likely to appreciably reduce the likelihood of these species surviving or recovering in the wild. Finally, NMFS concluded that the likelihood of a large or very large oil spill was so low as to make the risk of impacts from such an event negligible.

NMFS concluded that the probability of a BOEM authorized ship striking a ringed or bearded seal was sufficiently small as to be discountable and seals were well-adapted to respond to any displacement that might occur resulting from a passing ice-breaker. NMFS assumed that standard mitigation measures applied to air traffic would keep aircraft at a high enough altitude to prevent harassment to marine mammals. NMFS noted that these seals have demonstrated some tolerance for oil and gas activities.

As to the Steller sea lion, NMFS determined that the only stressor form the project could affect the species was transit through the Bering Sea. NMFS concluded that, while it was possible that Steller sea lions may be exposed to vessels in transit, the probability of a BOEM authorized vessel striking an endangered western Steller sea lion in the Bering Sea is sufficiently small as to be discountable (NMFS 2013b). As to the designated critical habitat of the Steller sea lion, NMFS noted that the population is increasing at approximately 3% per year in the Dutch Harbor area, indicating that vessel traffic does not affect breeding, feeding, and resting locations nearby. NMFS concluded that the combination of a 3 nmi (5.5 km) buffer zone around rookeries and standard mitigation measures, including a PSO on vessels were sufficient such that that vessel traffic associated with Arctic oil and gas operations that passes through Steller sea lion critical habitat would not likely destroy or adversely modified the designated critical habitat.

To reach these conclusions, NMFS identified three categories of anticipated project stressors:

- Sound fields produced by active acoustic devices (including devices for seismic exploration), vessels and aircraft traffic, and drilling operations;
- The risk of collisions between vessels and marine mammals;
- The risk of pollution from unauthorized oil spills.

These project-specific stressors were analyzed in combination with other stressors affecting the species including subsistence harvest of bearded seals and ringed seals, ambient Arctic noise, including natural noise and anthropogenic noise, vessel collisions, increases in shipping activity, potential contamination, and climate change.

With this information, NMFS then analyzed whether members of a species would be exposed to a project-stressor and potential responses. Finally, NMFS concluded an integration and synthesis for each stressor and each species, each time focusing on the “critical question” of how the species is likely to respond upon being exposed to the stressor.

The NMFS analysis, which is based on up to two drilling units operating simultaneously in the Chukchi Sea and an expanded level of activity, is a useful guideline in assessing the impacts associated with Shell’s EP Revision 2. NMFS assumed that mitigation measures that have been required in past IHAs would be included in its future authorizations. For exploration drilling, NMFS identified the following mitigation measures:

- PSOs observers on all drill structures, ice management vessels, and other vessels exceeding NMFS acoustic thresholds;
- aircraft shall not fly within 305 m (1,000 ft) of marine mammals or below 1,500 ft (457 m) above ground level (AGL) or above sea level (ASL); and
- notify BOEM or BSEE and NMFS if any equipment that could pose a risk to marine mammals is lost.

For seismic exploration, NMFS identified the following as standard mitigation measures: PSOs on all vessels that may result in incidental take through acoustic exposure, establishment and monitoring of radii association with received sound level thresholds for shutdown/power down at 190 dB for pinnipeds, and use of start-up and ramp-up procedures for airgun arrays. All of these measures have been included in Shell’s prior authorizations, were included within Shell’s EP Revision 1, and are continued in EP Revision 2. Shell maintains a 4MP, which is described in more detail in Section 4.7.

In reviewing Shell’s EP Revision 1, BOEM determined that acoustic impacts from exploration drilling in the northeastern Chukchi Sea would have a negligible impact on bearded and ringed seals due to the short duration of the proposed activities, the unremarkable site characteristics, and the observed effects of offshore drilling on seals (BOEM 2011a). BOEM expected brief and minor impacts to seals due to vessel traffic and negligible impacts due to aircraft traffic (BOEM did not analyze potential impacts on the Steller sea lion). BOEM expected ice-breaking to result in negligible impacts to seals, resulting only in temporary avoidance in open water. BOEM estimated that a maximum of three ZVSP surveys would be conducted, for a maximum of 42 hr a season in which the airguns would discharge. With appropriate mitigation measures applied, BOEM expected a negligible impact on seal species within the vicinity of any discharging airguns. BOEM concluded that impacts due to permitted discharges were unlikely because the affected areas are so small and would recover quickly (BOEM 2011a). It concluded that the impacts of a small fuel spill would be negligible.

Prior Analysis of Impacts on Pacific Walruses

The USFWS recently determined that the Pacific walrus (76 FR 7634-7679 10 February 2011) warranted listing under the ESA, but the listing was precluded by higher priorities and therefore the Pacific walrus is currently considered a candidate species. The current size of the Pacific walrus population is not known with any confidence, nor has there ever been a reliable population estimate for this stock. Aerial surveys between 1975 and 1990 produced population estimates that ranged from 201,039 to 234,020 individuals (Allen and Angliss 2014). These estimates are considered conservative with large confidence intervals (Gilbert et al. 1992, Gilbert 1999, Hills and Gilbert 1994). Differences between survey methodologies make comparing these estimates tenuous. The population inhabits a large geographic area in remote regions, which makes conducting a thorough survey difficult. Walruses, however still inhabit the entirety of their historic range and there have been no specific reports of declining observations across their range or changes in subsistence harvests that would indicate a serious decline in the population. Walruses are common throughout the Chukchi Sea during summer and the number of walruses present in the project area could range from a few to several thousand depending on the time of year and the amount of ice that is present in and near the project area.

Under the MMPA, the USFWS has promulgated ITRs for authorizing small takes of Pacific walruses in the Chukchi Sea that might take place incidental to conducting oil and gas exploration. Prior to issuing ITRs, the USFWS evaluated the effects of authorizing such takes on Pacific walruses and released a Conference Opinion on 20 May 2013 (USFWS 2013b). Before issuing ITRs, the USFWS must determine that the total taking will have a negligible impact on the species and will not have an immitigable adverse impact on the availability of the species for subsistence uses.

In their evaluation, the USFWS considered that up to three operators (and three drilling units total) could be operating simultaneously in the Chukchi Sea during the open water season (July to November), each with 1 to 2 supporting ice management vessels, supply barge and tug, and OSR vessels, and serviced with 1 to 2 helicopter flights per day and 1 to 2 supply boat trips per week. The USFWS estimated that each operator would drill up to eight wells per season. In addition to exploration drilling, USFWS considered other offshore activities occurring simultaneously as well, including seismic programs, shallow hazards surveys, marine geophysical surveys, geotechnical surveys, and offshore environmental studies.

The analysis and conclusions in this opinion with respect to impacts from exploration drilling activity are summarized here.

- Industry will likely encounter walruses during open water season. Each encounter at sea could range from a few individuals to concentrations of over 1,000 animals. During open water season, walruses are more likely to occupy coastal haulouts away from offshore activity, and are likely to be on broken pack ice that industry is likely to avoid. The frequency of encounters will depend on the location of activities relative to ice floes and the summer ice edge.

- Responses of walruses to disturbance stimuli are variable. Individual walruses that are hauled out are more sensitive to disturbance than swimming individuals. For that reason, USFWS analyzed walruses swimming in open water separately from walruses hauled out on ice or land.

- Noise from industry activities, including aircraft and vessel encounters, has the potential to disturb swimming walruses, including masking communication among individuals and displacing them from preferred foraging areas. However, walruses often tolerate noise: 2012 data indicated that only 5 percent of industry-walrus aircraft encounters resulted in behavioral change meeting the definition of Level B harassment and only 2 percent of industry-walrus vessel encounters constituted Level B harassment.
- Noise from vessels, ice management, and aircraft have the potential to effect hauled-out walruses.
    - Noise from aircraft has the potential to cause walrus groups to flee land or ice and potentially "stampede" into the water, which could cause injury and cow-calf separation. Mitigation measures in past MMPA authorizations (minimum altitude requirements, distance requirements from hauled-out walruses) are effective at minimizing these impacts and USFWS concluded effects of aircraft on hauled-out walruses would be minor.
    - Noise from ice management can displace walrus groups; however, most hauled out groups showed little reaction beyond 0.5 mi (800 m). Monitoring has shown these effects to be limited in time and geographical scale, with only a small proportion of the total population affected. USFWS concluded that mitigation measures required under MMPA authorizations (distance requirements from hauled-out walruses) would minimize effects.
- Walruses feed primarily on benthic invertebrates, therefore dredging and drilling could bury, displace, or kill some prey. Because the area disturbed by these activities is extremely small, the effect on walruses from this disturbance of benthic prey is expected to be very small.
- Walruses can be attracted to equipment and infrastructure. Mitigation measures in MMPA authorizations are expected to minimize any disturbance so that attraction to industry infrastructure will occur rarely and then have only a minor effect on walruses.
- Small oil spills may occur and, in the marine environment, the likelihood of walruses being exposed, and the number of walruses contacting that spill are both low. If contact occurs, walruses may experience irritation of skin and eyes but lethal impacts are not expected. Small spills are expected to have minor, if any, impact on walruses.
- Only in extremely rare cases would deterrence activities be necessary that could cause harm to individual walruses. Deterrence activities are likely to result in short-term behavioral changes (walruses swimming away) that would affect very few individuals. This issue is addressed in a subsequent 2014 BO (USFWS 2014b).

The USFWS concluded that authorizing these activities would result in small number of takes and that no population-level impacts would occur.

In reviewing Shell's EP Revision 1, BOEM determined that exploration drilling in the northeastern Chukchi Sea would displace Pacific walruses from the immediate area of operations, but would have a relatively small footprint compared to available habitat and would therefore have a minor impact. BOEM noted mitigation measures would reduce contacts and avoid incidental takes of Pacific walruses resulting from vessel traffic. It further concluded that, as OCS industry flights are directed away from concentrations of walruses, aircraft traffic would have a negligible impact. BOEM expected ice-breaking would have the greatest potential to disturb walruses, particularly females with young calves. BOEM estimated that a maximum of three ZVSP surveys would be conducted, for a maximum of 42 hr a season in which the airguns would discharge. With appropriate mitigation measures applied, BOEM expected a negligible impact on walruses. BOEM concluded that impacts due to permitted discharges were unlikely because the affected areas are so small and would recover quickly. It concluded that the impacts of a small fuel spill would be minor.

Mitigation Measures

The USFWS (2013b) analysis and NMFS (2013b) analysis both examine impacts from a larger suite of activities than that proposed by Shell in EP Revision 2, but they provide a useful guideline in assessing the impacts associated with Shell's EP Revision 2.

EP Revision 2 contains mitigation measures designed to avoid contacts and incidental takes of walruses and seals. Shell will apply for MMPA authorization for incidental harassment marine mammals, which will require mitigation measures to avoid impacts to species or subsistence activities. Shell will adopt mitigation measures from prior MMPA authorizations and other measures including the following:

- Aircraft over land or sea shall not operate below 1,500 ft (457 m) altitude unless engaged in marine mammal monitoring, approaching, landing or taking off, in poor weather (fog or low ceilings), or in an emergency situation.
- If aircraft must be operated below 1,500 ft (457 m) because of weather, the operator will avoid areas of known walrus and polar bear concentrations and will take precautions to avoid flying directly over or within 0.5 mi (805 m) of these areas. Helicopters will not operate at an altitude lower than 3,000 ft (914 m) within 1 mi (1.6 km) of walrus groups observed on land, and fixed-wing aircraft will not, except in an emergency, operate at an altitude lower than 1,500 ft (457 m) within 0.5 mi (805 m) of walrus groups observed on land.
- PSOs will be aboard the drilling unit(s) and transiting support vessels.
- Vessels will maintain the maximum distance possible from concentrations of walruses.
- Except in an emergency, vessels will not approach within an 0.5 mi (805-m) radius of observed on ice.
- Except in an emergency, vessels will not approach within 1 mi (1,610 m) of groups of walruses observed on land.
- Vessel operators will take every precaution to avoid harassment of concentrations of feeding walruses when a vessel is operating near these animals.
- Vessels will not operate in such a way as to separate members of a group of walruses from other members of the group.
- Vessels will take all reasonable precautions (i.e., reduce speed, change course heading) to maintain a minimum operational exclusion zone of 0.5 mi (805 m) around groups of 12 or more walruses in the water.
- Vessel speed will be reduced during inclement weather conditions in order to avoid collisions with marine mammals.
- Shell will communicate and coordinate with the Com Centers regarding all vessel transit.
- Airgun arrays will be ramped up slowly during ZVSP surveys to warn pinnipeds in the vicinity of the airguns and provide time for them to leave the area and avoid potential injury or impairment of their hearing abilities. Ramp ups from a cold start when no airguns have been firing will begin by firing a single airgun in the array. A ramp up to the required airgun array volume will not begin until there has been a minimum of 30 min of observation of the safety zone by PSOs to assure that no marine mammals are present. The safety zone is the extent of the 190 dB for pinnipeds. The entire safety zone must be visible during the 30-min lead-in to an array ramp up. If a marine mammal(s) is sighted within the safety zone during the 30-min watch prior to ramp up, ramp up will be delayed until the marine mammal(s) is sighted outside of the safety zone or the animal(s) is not sighted for 15 min for pinnipeds.

- Shell has developed and will implement an Adaptive Approach to Ice Management in Areas Occupied by Pacific Walruses (Appendix J of EP Revision 2).

Summary of Impacts

EP Revision 2 exploration drilling activities are described in detail in Section 2.0. Section 4.7 discusses the changes in the program from EP Revision 1 and associated impact factors that are relevant to marine mammals. The main sources of potential disturbance to marine mammals associated with the exploration drilling activities proposed in this EP Revision 2 will be acoustic impacts from aircraft traffic, the drilling units, and support vessels. Vessels, anchor handling, drilling equipment and operations, including ZVSP survey operations and ice management, emit low-frequency sound energy into the water that may alter marine mammal behavior and could affect marine mammals' hearing abilities. Additional impacts include collision, sediment-impacts, and discharges, and air emissions. The impacts on T&E seals and walruses that are associated with each of these activities are discussed below.

In summary, consistent with conclusions drawn by NMFS, USFWS, and BOEM, Shell expects the effects on the ringed seal, bearded seal, and Pacific walrus to be minor and temporary and consist primarily of behavioral responses (avoidance). Below, Shell analyzes the potential effects of activities under EP Revision 2. For additional information, including the estimated number of individual seals that are expected to be impacted, refer to Table 4.7.3-1.

Impacts of Aircraft Traffic on Threatened and Endangered Seals and Walruses

The impact of aircraft traffic on pinnipeds is discussed in Section 4.7.1. It is likely that some ringed seals, bearded seals, and walruses will be present in the Burger Prospect area when the exploration drilling operations are ongoing. Helicopters will be used for personnel and equipment transport to and from the drilling units. Few systematic studies of pinniped reactions to aircraft overflights have been conducted. Documented reactions range from simply becoming alert and raising the head, to escape behavior such as hauled out animals rushing to the water. Ringed seals out on the surface of the ice have shown behavior responses to helicopter overflights with escape response most probable at lateral distance of <656 ft (<200 m) and overhead distances <492 ft (< 150 m) (Born et al. 1999).

Brueggeman et al. (1991a) evaluated walrus reactions to survey aircraft flying at an altitude of 305 m (1,000 ft) over the pack ice and 152 m (500 ft) in water. They observed that 17 percent of the walrus groups on ice and none in water reacted to the aircraft. Walruses reacted to flights between 197 and 492 ft (60 and 150 m) above sea level within 0.62 mi (1 km) lateral distance by either orienting towards the aircraft or escaping into the water (Brueggeman et al. 1990). It appeared that walruses that had hauled out on land or ice were more sensitive to overflights (Brueggeman et al. 1990). In recent years, walruses have moved to terrestrial haulout sites along the Chukchi Sea coast when ice has retreated far offshore beyond the continental shelf break and preferred feeding areas. Stampedes at these large haulouts can result in deaths of animals, particularly smaller juveniles and calves as happened in 2009. Shell will use its aerial monitoring capability, communications via SAs with local communities, and communications with the various agencies and villages to monitor the locations of terrestrial haulouts that may occur along the Chukchi Sea coast during the duration of the exploration drilling activities. Flight paths to and from the drilling units will be altered if necessary to avoid areas with large numbers of hauled out walruses. Helicopters will not operate at an altitude lower than 3,000 ft (914 m) within 1 mi (1.6 km) of walrus groups observed on land, and fixed-wing aircraft will not, except in an emergency, operate at an altitude lower than 1,500 ft (457 m) within 0.5 mi (805 m) of walrus groups observed on land. If aircraft must be operated below 1,500 ft (457 m) because of weather, the operator will avoid areas of known walrus concentrations and will take precautions to avoid flying directly over or within 0.5 mi (805 m) of these areas.

Conclusion

Effects of aircraft traffic on threatened seals and walruses may include alterations in swimming behavior, avoidance, or deflection around a localized area. Disturbances of seals and walruses by aircraft supporting Shell's proposed operations as described in Section 2.0 will be temporary and localized to small numbers hauled out on remnant ice floes or already in the water. These non-lethal effects would only last until the aircraft noise becomes inaudible and are not anticipated to accumulate across multiple seasons. The potential impacts on seals and walruses from aircraft traffic will be minimized by fully implemented mitigation measures including flying along predetermined routes at altitudes of at least 1,500 ft (457 m) except during take-offs, landings, marine mammal monitoring, and when conditions force an altitude reduction for personnel safety reasons by the proposed flight corridor. The predetermined flight paths minimize the portion of flights over coastal waters. Furthermore, flights between Barrow and Wainwright will occur along a corridor 5.0 mi (8.0 km) inland to minimize effects on subsistence and subsistence resources including threatened seals and walruses. Furthermore, aircraft must remain a minimum of 0.5 mi (0.8 km) or 1 mi (1.6 km) from groups of walruses on ice or at terrestrial haul outs, respectively. These mitigation measures will reduce the potential for disturbance. Based on analysis above, T&E seals and walruses may be affected by aircraft traffic. Therefore, given the significance thresholds and level of effects definitions determined by BOEM (2011a), the applicable level of effect is minor, and the impacts will not be significant.

Impacts of Vessel Traffic on Threatened Seals and Walruses

It is likely that some ringed seals, bearded seals, and walruses will be present in the Burger Prospect area when the exploration drilling operations are on-going. Additionally, Steller sea lions will be present in the Bering Sea when project vessels transit to the Chukchi Sea. Impacts of vessel traffic on any of these marine mammals will be minor and short-term, consisting only of temporary displacement.

Ringed, bearded, and spotted seals appear to be fairly tolerant of vessel traffic. Brewer et al. (1993) reported observations of ringed seals following ice management vessels in the Beaufort Sea, apparently feeding on fish and plankton in the disturbed waters.

Walruses have been observed during the CSESP marine mammal surveys in and near the Burger Prospect (Tables 3.7-6, 3.8.9-1), and relatively large numbers have been observed during past drilling operations (Table 3.7-2). They are strongly associated with pack ice and would be expected when ice is present. The ice management vessels associated with the exploration drilling activities as described in EP Revision 2 would therefore be the most likely vessels to encounter walruses. Documented reactions of walruses to vessels include waking up, head raising, and entering the water (Richardson et al. 1995a). Reaction distance depends on ship speed and sound, and is likely influenced by sight of the ship as well (Fay et al. 1984). Brueggeman (1990, 1991a, 1992b) also found that the probability and type of reactions exhibited by walruses hauled out on ice depended on distance from the vessel. Walruses in open water appear to be less responsive than those on ice, showing little reaction unless the ship was very near to the animals (Fay et al. 1984). Brueggeman et al. (1990, 1991a) monitored the behavior of walruses in response to vessels associated with exploration drilling at the Burger Prospect in 1989 and 1990. They reported that none of the observed groups of walruses exhibited escape behavior in response to anchored or drifting vessels, while responses to moving vessels varied, ranged from nothing to approaching the vessel or escape behavior, and varied with distance (Table 4.8.3-1); most reactions occurred when the vessel approached within about 550 yd (500 m) of the walruses.

Table 4.8.3-1 Walrus Reactions to Transiting Support Vessels in the Chukchi Sea

Distance	Number of Walrus Groups Exhibiting Response by Distance [1,2]							
	None		Approached		Head Raise		Escape	
	1989	1990	1989	1990	1989	1990	1989	1990
0.0 to 0.14 m (0.0 to 0.23 km)	3	4	0	1	0	-	4	3
0.14 to 0.28 mi (0.23 to 0.46 km)	2	11	0	0	0	-	4	1
0.28 to 0.58 mi (0.46 to 0.93 km)	0	33	0	1	0	-	2	1
>0.58 mi (>0.93 km)	0	18	0	0	0	-	1	1

[1] Brueggeman et al. 1990a, 1991a
[2] Number responding out of 16 observations in 1989 and 74 observations in 1990

Historically, walruses have not been known to use terrestrial haulouts along the Chukchi Sea, but in recent years, walruses have hauled out along the Chukchi Sea shoreline apparently in response to lack of pack ice. In 2007, 2009-2011, and 2013, they were also observed hauling out in large numbers with mixed sex and age groups along the Chukchi Sea coast of Alaska in late August, September, and October (USFWS 2013a). At least 20,000 to 30,000 walruses were observed hauled out approximately 3 mi (4.8 km) north of the Native Village of Point Lay, Alaska in 2010 and 2011 (Garlich-Miller et al. 2011a in USFWS 2013a). Walruses were not observed hauled out on the Chukchi Sea coast during 2012. Disturbance of large groups of hauled out walruses can sometimes lead to stampedes with resulting injuries and mortalities, especially to walrus calves. Such a mortality event was documented along the Chukchi Sea near Icy Cape in 2009 (Fischbach et al. 2009). Although the cause of the disturbance was not determined, 131 walrus carcasses were observed, apparently the result of stampedes. Salter (1979) reported no detectable response by walruses at a terrestrial haulout site to approach by outboard motorboats at distances of 1.1 to 4.8 mi (1.8 to 7.7 km). The vessel traffic associated with the exploration drilling activities will primarily be located offshore, where it cannot affect walruses at shoreline haulouts. Vessels conducting contingency vessel-based crew changes (Figure 2.2-1) could by definition approach the shoreline, but not likely anywhere other than Barrow, which is not known to be used as a walrus haulout. In addition, this vessel traffic is only for contingency purposes and will therefore occur at very low frequencies if at all. It is unlikely that vessel traffic along this route would result in disturbance of hauled out walruses.

The identified vessel routes between the prospect and Barrow traverse the southern portion of the HSWUA (Figure 2.2-1). This area was identified by USFWS and delineated based on high utilization of the area by tagged walruses. HSWUA changes by month through the June-September seasonal time frame. For much of the drilling season the extent of the HSWUA will be smaller than that shown on Figure 3.9-1 and the vessel route will lie outside its boundary. Further, Shell developed the Adaptive Approach to Ice Management in Areas Occupied by Pacific Walruses (Appendix J, EP Revision 2) ahead of the 2012 exploration drilling season and has updated again. This document provides for real-time consultation between USFWS and vessels while operating in the presence of ice where walruses may be present. Mitigation measures, as described below, plus the adaptive plan will minimize the potential for any walrus disturbance due to vessel traffic in this area, or beyond.

Potential effects on seals and walruses from vessel traffic associated with the exploration drilling activities will be avoided or minimized with implementation of Shell’s mitigation measures. These measures prohibit vessels from operating within 0.5 mi (800 m) of walruses when observed on ice, and 1.0 mi (1.6 km) of groups of walruses observed on land. Vessels underway must reduce vessel speed and avoid multiple course changes when seals are present in the water, or on ice to avoid separating members from a group. Vessel speed will also be reduced during inclement weather conditions in order to avoid accidental collisions with seals or walruses. Given these mitigation measures and pinniped tolerance of vessels, any impacts of vessel traffic on seals and walruses will be minor and short-term, consisting only of temporary displacement or temporary deflection away from the vessel. In general, seals and walruses may leave the ice, make hasty dives or move away from the area. Brueggeman et al. (1991a) noted that the behavioral effect on walruses was very brief, with displaced walruses occasionally re-occupying ice floes as soon as the vessel passed.

Separately, the only stressor from Shell's proposed activities that could affect Steller sea lions is the transit of project vessels through the Bering Sea. While it is possible that individual animals could be exposed to the vessels in transit, that exposure is unlikely to elicit a response that would adversely affect the population (NMFS 2014). Additionally, Shell's vessels will comply with all proximity limitations related to rookeries such that no impact of Steller sea lion critical habitat in Dutch Harbor and elsewhere is anticipated. Shell plans to have PSOs onboard vessels transiting the Bering Strait between Dutch Harbor and the Chukchi Sea.

Conclusion

Threatened seals and walruses are associated with sea ice, and most sea ice is absent from the prospect area during the open water season. Effects on seals and walruses present near Shell's proposed activities may include temporary avoidance responses such as slipping off of ice and into the water, diving, or briefly avoiding approaching vessels within a localized area. Disturbances of seals and walruses by vessels supporting Shell's proposed operations as described in Section 2.0 will be temporary and localized to those hauled out on remnant ice floes or already in the water. Effects on seals and walruses from vessel traffic would incrementally increase due to the addition of vessels to support two drilling units operating simultaneously; however, any effects would last only minutes or hours after the vessel has passed are not anticipated to accumulate across multiple seasons. Effects would be minimized by fully implementing mitigation measures that require vessels associated with the drilling program that are underway will reduce speed, and avoid multiple course changes when seals or walruses are present. Vessel speed also will be reduced during inclement weather conditions in order to avoid collisions with marine mammals. Shell will also implement its Polar Bear and Pacific Walrus Interaction and Avoidance Plan, which includes a 0.5 mi (800 m) vessel exclusion zone around walruses observed on ice. Additionally, vessels will take every precaution to avoid harassment of concentrations of feeding walruses and will maintain a minimum 0.5 mi (805 m) operational exclusion zone around groups of 12 or more walruses encountered in the water. These mitigation measures should prevent any measureable disruptions to seals and walruses occurring near project activities. Finally, vessel transit in the Bering Sea may affect but is not likely to adversely affect Steller sea lions and is expected to have no impact on critical habitat for the species.

Based on analysis above, T&E seals, Steller sea lions, and walruses may be affected by vessel traffic. Therefore, given the significance thresholds and level of effects definitions determined by BOEM (2011a), the applicable level of effect for T&E seals, Steller sea lions, and walruses is minor, and the impacts for all listed pinnipeds will not be significant.

Impacts of Drilling and Ice Management Sound on Threatened Seals and Walruses

Potential effects of sound energy from drilling and ice management on ringed and bearded seals and walruses would be similar to those discussed in detail for pinnipeds in Section 4.7.3. Studies conducted during previous drilling programs in the Alaskan Arctic have reported tolerance of offshore drilling (Brewer et al. 1993; Gallagher et al. 1992) and icebreaking (Brewer et al. 1993; Brueggeman et al. 1991a) by seals and walruses.

Avoidance behavior by marine mammals in response to sound energy, such as temporary deflection during feeding and migration, is the most likely behavioral response expected as a result of Shell's exploration drilling activities in the Chukchi Sea. Ringed seals have been found to have very limited response to exploration drilling activities. While monitoring marine mammal distribution and reaction to exploration drilling in the Beaufort Sea with the *Kulluk*, Brewer et al. (1993) observed ringed seals approaching within 33 ft (10 m) of the drilling unit and concluded that seals were not disturbed by drilling activity. Bearded seals are expected to respond similarly to ringed seals. While monitoring marine mammals at another historical Beaufort Sea drill site, Gallagher et al. (1992) observed seals within 115 ft (35 m) of the drillship *Explorer II* indicating a high level of tolerance to such sounds and activities.

Brueggeman et al. (1992a) reported the reactions of seals to an icebreaker during activities at two prospects in the Chukchi Sea. Reactions of seals to the icebreakers varied between the two prospects. Most (67 percent) seals did not react to the icebreaker at either prospect. Reaction at one prospect was greatest during icebreaking activity followed by general vessel activity (running/maneuvering/jogging) and was lowest while the vessel was at anchor or drifting. Frequency of reaction was greatest for animals within 0.14 mi (0.23 km) of the vessel and lowest for animals beyond 0.58 mi (0.93 km). At the second prospect however, seal reaction was lowest during icebreaking activity with higher and similar levels of response during general (non-icebreaking) vessel operations and when the vessel was at anchor or drifting. The frequency of seal reaction generally declined with increasing distance from the vessel except during general vessel activity where it remained consistently high to about 0.29 mi (0.46 km) from the vessel before declining. Kanik et al. (1980 in Richardson et al. 1995a) reported that most ringed seals and harp seals within 0.6 to 1.2 mi (1 to 2 km) from an icebreaker remained on ice but that seals closer to the icebreaker often dove into the water.

Walruses commonly react to moving vessels, but most reports indicate relatively little reaction to sound energy from drilling (Richardson et al. 1995a). While monitoring marine mammals during exploration drilling in the Chukchi Sea in 1989-1991 Brueggeman et al. (1990) noted that walruses near moving ice breakers exhibited some avoidance behavior (Table 4.8.3-2). Most reactions of walruses to moving vessels occurred when the vessels approached to within 0.3 mi (0.5 km) of the walrus. During ice-breaking activities, walruses moved 12.4 to 15.5 mi (20 to 25 km) from the operations where sound energy levels were 11 to 19 percent above ambient sound level (Table 4.8.3-2). Thus, walruses were temporarily displaced away from vessels to areas where sound levels approached ambient levels.

Table 4.8.3-2 Walrus Reactions to Vessels While Ice Breaking, Chukchi Sea, 1989-1990

Distance	Number of Walrus Groups Exhibiting Response by Distance [1,2]							
	None		Approached		Head Raise		Escape	
	1989	1990	1989	1990	1989	1990	1989	1990
0.0 to 0.14 m (0.0 to 0.23 km)	1	1	0	0	1	-	15	14
0.14 to 0.28 mi (0.23 to 0.46 km)	2	2	0	0	0	-	11	3
0.28 to 0.58 mi (0.46 to 0.93 km)	5	6	0	0	3	-	3	6
>0.58 mi (>0.93 km)	13	65	0	0	4	-	6	2

[1] Source: Brueggeman et al. 1990, 1991a
[2] Number responding based on 60 observations in 1989, 99 observations in 1990

Pacific walruses did not exhibit an avoidance reaction when vessels were anchored or drifting and did not appear to be affected by exploration drilling sounds. Many walruses moved through the Burger Prospect area during the previous exploration drilling activities with the pack ice, and low numbers of walruses summered within the prospect area. With the retreat of the pack ice, walruses inhabited the drilling areas for only a short period of time. Walrus density, mean group size, association with ice cover, distance from the ice edge, and distance from the Burger Prospect were compared before and after drilling to evaluate responses of walruses to the exploration drilling operations (Brueggeman et al. 1990). Walrus density and group size before and during drilling were found not to differ but distribution did change. Walruses showed no preference for a particular amount of ice cover before operations but preferred areas of moderate ice cover during operations, particularly operations involving ice-breaking activities. The walruses were fairly evenly distributed across the pack ice and from the ice edge and Burger Prospect before operations, but they became more distant and clumped during ice-breaking operations. Once icebreaking activities stopped, walruses once again became more evenly distributed, indicating that any effects were brief and that walruses may adjust to operational or drilling sounds.

Disturbance by vessels or ice management of walruses at haulouts could potentially result in stampedes as they rush to the water to escape. These types of disturbances have been known to result in walrus injuries or fatalities or abandonment of young. A number of documented cases of walrus disturbances resulting in stampedes with subsequent walrus deaths and injuries have been reported in the literature. However, all such reviewed reports concerned disturbances of large terrestrial walrus haulouts – no such documented cases regarding disturbance of walruses in ice were found in the literature. Abandonment of young walruses has been reported to have occurred after disturbance of walrus groups hauled out on ice. Fay et al. (1984) calculated that one out of 100 disturbances of walrus groups on ice may have resulted in abandonment of a young walrus.

The probability of encountering walruses during exploration drilling or ice management operations is highly dependent on the presence of ice in the area. The presence or absence of pack ice in the area cannot be predicted at this time. During historic exploration drilling in the Chukchi Sea, ice was present in some years and not in others, with many more walruses being found in the Burger Prospect area when ice was near. If pack ice is located within 10 to 20 mi (16 to 32 km) of the drilling unit, walruses would likely be affected. The Hanna Shoal area has a rich benthic community and is a preferred feeding area for walruses. Currents in the Chukchi Sea often cause ice to accumulate around Hanna Shoal and the waters between Hanna Shoal and the Burger Prospect may be an area where active ice management is required. Effects would probably be limited to slight changes in distribution with some walruses avoiding the area or retreating to the center of the ice floe. All such effects would be minor and temporary, lasting only as long as the ice and walruses, which are moving with wind and current, are in the area. However, the rapid retreat of ice during recent years has at times resulted in large numbers of walruses occupying relatively small pieces of ice, as occurred during Shell's seismic program in 2008. Disturbance of walruses in this situation could result in trampling, particularly of small juveniles and calves, if walruses rushed to enter the water in response to disturbance such as ice management. The likelihood of this occurring is small given the various mitigation measures that will be implemented by Shell, but weather and ice conditions are unpredictable.

In recent years, walruses have moved to terrestrial haulout sites along the Chukchi Sea coast when ice has retreated far offshore beyond the continental shelf break and preferred feeding areas. When walruses abandon the ice they are able to remain in the water for several weeks before they move to land based haulout sites (Funk et al. 2010). They appear to remain in areas of preferred feeding habitat. Animals have been seen in large rafts of a thousand or more individuals during late August in the project area. As with gray whales, the area around Hanna Shoal to the north of the project area appears to be preferred feeding habitat and many walruses may occur in the water in large rafts in this general area if ice retreat during any drilling season is rapid. These animals may then swim through the project area on their way to beach haulout sites along the Alaskan Chukchi Sea coast. Acoustic recordings of walruses (Martin et al. 2010) indicate that walruses swim from beach haulouts out to feeding areas further offshore and then return to the haulout sites. These movements could also cause walruses to move through the area of operations. Such groups of walruses could be displaced from the area of operations and potentially large rafts of walruses could be separated as they moved away from or around the area toward the Alaskan Chukchi Sea coast. In general, these movements would not be expected to cause more than temporary displacement of animals, but if large rafts are encountered it could affect 1,000 or more animals. Movements to and from shore by walruses would probably avoid operations causing little or no impact.

A MLC will be constructed at each drill site using either a large diameter bit operated by hydraulic motors and suspended from the *Discoverer* or *Polar Pioneer* or with an excavator on a ROV system. The MLC ROV would excavate the MLC using implements such as a bucket, grinder, or rock hammer on the ROV sled. Use of a MLC ROV system would require an additional OSV type vessel from which the ROV would be transported, deployed and operated. This specific technology has not been put to use for construction of MLC's, but similar technology has been used for very similar work elsewhere.

Sounds from construction of an MLC during Shell's 2012 exploration drilling activities in the Chukchi Sea were recorded by hydrophones moored to the seafloor at distances of 0.6, 1.2, 2.5, and 4.9 mi (1, 2, 4, and 8 km). JASCO (Austin et al. 2013) calculated that these sounds diminished below the 120 dB rms threshold at 5.1 mi (8.2 km) from the drill site. The MLC in the 2012 program was constructed using the drilling unit. If Shell constructs MLCs using the ROV system, emitted sounds would be expected to be quieter than when using the drilling unit. Sound profile modeling, as described in Section 4.0, was conducted using the louder option of constructing a MLC using a drilling unit in the scenarios to be conservative.

Sound pressure levels that are expected to be generated by exploration drilling and ice management during Shell's planned exploration drilling activities are described in Section 2.9. Sound profile modeling as described in Section 4.0 indicated that the largest area estimated to be exposed to continuous sounds ≥120 dB re 1µPa rms during a single activity scenario was 2,046.3 km^2 and resulted from concurrent mudline cellar construction at two different sites and anchor handling at a third site. Shell's estimated the number of ringed seals and bearded seals that might be exposed to sound levels of greater than 120 dB re 1µPa rms from exploration drilling are included in the exposures identified in Table 4.7.3-1. These data indicate that only a small number of seals would be exposed to the low sound energy level of 120 dB re 1µPa rms. Shell's mitigation measures restrict vessels under normal operating conditions, including ice management vessels, from operating within 0.5 mi (800 m) of walruses when observed on land or ice. Vessels underway must reduce speed and avoid multiple course changes when seals are in the water to avoid separating members from a group. Vessel speed will also be reduced during inclement weather conditions in order to avoid accidental collisions with seals and walruses. Masking can interfere with the detection of important natural sound sources. Underwater drilling sounds could possibly mask environmental sounds (Terhune 1981) or communication between marine mammals (Perry and Renouf 1987). However, in a study conducted by Cummings et al. (1984), in which breeding ringed seals were subjected to recordings of industrial sounds, there were no documented effects on ringed seal vocalizations. Masking is poorly understood in pinnipeds. Masking effects would remain as long as operations were ongoing and the pinnipeds being affected remained within the area where sound levels were great enough to cause masking. There are no definitive studies to suggest how big the area of masking around a drilling unit might be for most animals but it would likely extend some distance beyond the 120 dB re 1µPa rms sound pressure level isopleth recognized by NMFS as the behavioral reaction zone around continuous sound sources. Any masking impacts that occur will be restricted to a relatively small area when compared to available seal and walrus habitat in the Chukchi Sea.

Shell's proposed activities would occur during the open-water season, after sea ice retreats north of the prospect areas and after all of the fast-ice has melted way. The probability of encountering walruses during exploration drilling or ice management operations is highly dependent on the presence of ice in the area. Furthermore, whelping and molting seasons for all ringed seals occurring near the Burger Prospect will have ended before commencement of activities associated with the proposed exploration drilling activities. Sighting rates observed during CSESP vessel-based marine mammal surveys collected over five years (2008-2012) are provided in Table 4.7.2-3. Similar sighting rates were not presented in the annual report for 2013. Based on frequencies of observations, few ringed and bearded seals are expected to linger in the area after the sea ice has retreated north.

<u>Conclusion</u>

In conclusion, ringed seals, bearded seals, and walruses in the Chukchi Sea are associated with sea ice, and most sea ice is absent from the prospect area during the open water season. Effects on seals present near Shell's proposed activities may include temporary avoidance responses such as slipping off of ice and into the water, diving, or briefly avoiding approaching vessels within a localized area. Disturbances of ringed seals, bearded seals and walruses by continuous sounds emitted from drilling sound, ice management and support activities as described in Section 2.0 will be temporary and localized. Effects on ringed seals, bearded seals, and walruses from continuous sound would increase above those expected in Shell's EP Revision 1, because the proposed activities include two drilling units operating simultaneously at the Burger Prospect and an increase in associated support activities; however, any effects would be short-term are not anticipated to accumulate across multiple seasons. Effects would be minimized by fully implementing mitigation measures with PSOs stationed on drilling units, ice management vessels, and anchor-handling vessels to apply real-time mitigation, if necessary. Except in an emergency, vessels, including ice management vessels under normal operating conditions, will not approach within 0.5 mi (800 m) of walruses when observed on ice or within 1.0 mi (1.6 km) of groups of walruses when observed on land. Ice scouting and management activities by ice management vessels will be conducted under the guidance of Adaptive Approach to Ice Management in Areas Occupied by Pacific Walruses. The adaptive approach includes real-time consultation with USFWS when walruses are suspected of being present. These mitigation measures should prevent any measureable disruptions to ringed seals, bearded seals and walruses occurring near project activities. Based on analysis above, threatened seals and walruses may be affected by continuous sound. Therefore, given the significance thresholds and level of effects definitions determined by BOEM (2011a), the applicable level of effect is minor, and the impacts will not be significant.

<u>Impacts of ZVSP Survey Sound on Threatened Seals and Walruses</u>

The potential effects of the sound energy generated by ZVSP surveys on marine mammals are discussed above in Section 4.7.4. Effects on ringed and bearded seals and walruses would be similar to those described for other pinnipeds in that section. The effects are summarized below.

There have been few detailed studies of reactions by seals to sound generated by airgun arrays (Richardson et al. 1995a). However, studies have shown that ringed seals exhibit little or no reaction to industrial or construction activities, such as pipe-driving, that produce underwater sounds 1.0 to 6.0 mi (1.6 to 10.0 km) from the source (Moulton et al. 2003, 2005b; Blackwell et al. 2004). Pinnipeds will tolerate strong noise pulses from non-explosive and explosive scaring devices, especially if attracted to the area for feeding or reproduction (Mate and Harvey 1987, Reeves et al. 1996).

Ringed and bearded seals and walruses would need to remain in the high-noise field for extended periods of time to sustain any permanent injury. Existing evidence also suggests that while seals may be capable of hearing sounds from airgun arrays, they appear to tolerate intense pulse sounds produced by airgun arrays with little effect if there is no danger associated with the noise. Harris et al. (2001) studied aspects of seal behavior in relation to open water seismic surveys in the Beaufort Sea. They observed an equal number of seals from the vessel whether the airguns were firing or not, but the seals tended to be farther from the vessel. They concluded that there was partial avoidance of the area within 492 ft (150 m) of the vessel when the survey was in progress, but added that the seals did not move much beyond 656 ft (200 m) from the vessel. They found no significant differences in relative frequencies of a set of behaviors by the seals with and without airgun operation, indicating little or no effects on seals from the survey.

Potential harm to ringed and bearded seals and walruses will be avoided by the mitigation measures that will be implemented during ZVSP surveys. Airgun arrays will be ramped up slowly during ZVSP surveys to warn seals and walruses in the vicinity of the airguns and provide time for them to leave the area and avoid potential injury or impairment of their hearing abilities. Ramp ups from a cold start when no airguns have been firing will begin by firing a single airgun in the array. A ramp up to the required airgun array volume will not begin until there has been a minimum of 30 min of observation of the safety zone (190 dB re 1µPa rms radius) by PSOs to assure that no seals or walruses are present.

Conclusion

Given the moderate size of the sound sources for the planned ZVSP survey activity, the very short duration it will be conducted at each drill site, and mitigation measures to be applied, it is unlikely that there would be any cases of temporary or especially permanent hearing impairment, or non-auditory physical effects in any marine mammal species that would be found in the project area. More likely, behavioral disturbance - including temporary avoidance or deflection reactions - could occur at longer distances than auditory physical effects. These non-lethal effects are not anticipated to last beyond minutes to hours after the ZVSP survey activities are complete and will not accumulate across multiple seasons. Effects would be minimized by fully implementing mitigation measures described above as part of the 4MP. A very small area is predicted to be ensonified to received sound levels > 190 dB re 1µPa rms, but this is the safety radius within which the airgun arrays cannot operate if a seal or walrus is observed, and cannot be fired unless no seals or walruses have been observed in the area for 30 min. Airgun arrays must also be ramped up slowly, to warn the animals and allow time for them to leave. With this mitigation measures in place, seals and walruses are not expected to be adversely affected by ZVSP surveys. Based on analysis above, threatened seals and walruses may be affected by ZVSP survey activities. Therefore, given the significance thresholds and level of effects definitions determined by BOEM (2011a), the applicable level of effect is minor, and the impacts will not be significant.

Impacts of Air Emissions on Threatened Seals and Walruses

The impacts of project air emissions associated with Shell's planned exploration drilling activities on air quality are discussed in Section 4.1, and the effect of such emissions on marine mammals are discussed in Section 4.7.6. Emissions associated with Shell's EP Revision 2 are expected to have a minor impact on air quality overall and a minor impact on offshore air quality. In areas further from drilling activities where subsistence hunting and fishing occurs closer to shore, an analysis of air quality impacts reveals that emissions associated with the project are expected to have negligible to minor impacts on humans in the area (see Section 4.11.9 and Attachment C).

Conclusion

Ringed seals, bearded seals, and walruses are likely to remain close to ice and avoid open water areas near the drilling sites, so they are not likely to be exposed to potentially elevated levels of emissions for extended periods. Project emissions will have negligible to minor impacts on air quality in subsistence use areas where these species are more likely to be found. Because these species are transitory, they are not likely to be exposed to air quality impacts related to the project emissions for extended periods, resulting in no measureable impact. Based on analysis above, threatened seals and walruses will not be affected by air emissions associated with Shell's planned exploration drilling activities. Therefore, given the significance thresholds and level of effects definitions determined by BOEM (2011a), the applicable level of effect is negligible, and the impacts will not be significant.

Impacts of Drilling Unit Mooring, MLC Construction and Drilling Wastes on Threatened Seals and Walruses

The impacts of seafloor disturbance from drilling unit mooring and early phases of drilling on marine mammals are discussed in Section 4.7.5. Seafloor disturbance from MLC construction or drilling unit mooring would have only a localized and temporary effect and would not be expected to affect ringed seals, bearded seals, or walruses directly. Drilling unit mooring and MLC construction will also have little indirect effect on threatened seals or walruses. Setting and recovering the anchors require use of the anchor handling vessel, which could result in avoidance of the area by seals or walruses as described for vessel traffic. The activity would occur within the anchor radii and therefore to the area within about 3,609 ft (1,100 m) of each drilling unit. The physical manifestations of anchor disturbances associated with mooring the two drilling units (3.7 ac, 14,923 m^2) would attenuate after removal over time by the natural movement of seafloor sediments and ice scours. The physical effects of mooring and MLC construction would be restricted to a very small portion of the Chukchi Sea seafloor area (4.01 to 5.28 ac [16,158 to 21,354 m^2]), depending on MLC construction by drill bit or by MLC ROV system. The MLC ROV system results in the larger disturbance area. Benthic organisms within the area directly affected by MLC construction and anchor mooring would likely be buried or decimated due to the weight and force of the anchors and MLC drill bit or subsequent displacement. Approximately 10 additional acres (0.04 km^2) may be indirectly impacted by the re-deposition of cuttings from MLC construction and drilling to thickness of 0.4 in. (1.0 cm) or more resulting in the smothering of benthic organisms. It would affect the benthic communities, which are prey species for ringed seals, bearded seals, and walruses, in the immediate vicinity of the drilling units, but the area affected is small in comparison to the benthic habitat available to these species in the Chukchi Sea.

The effect of drilling waste discharges on marine mammals is discussed above in Section 4.7.7, and the effects on ringed seals, bearded seals and walruses would be similar to those described for spotted, and ribbon seals and other marine mammals as described therein. Drill cuttings and drilling mud discharges are regulated by the EPA's NPDES exploration facilities GP. The permit establishes discharge limits for drilling fluids (at the end of a discharge pipe) to a maximum of 1,000 bbl/hr (159 m^3/hr) in receiving waters with a depth of 130 ft (40 m) or more. Actual discharge rates during Shell's exploration drilling operations are expected to be between 72 to 88 bbl/hr when drilling. At the end of each well, Shell may discharge drilling fluids remaining in a reserve pit at a rate up to 1,000 bbl/hr. All discharged fluids are required to meet strict toxicity limits with a minimum 96-hr LC50 of 30,000 ppm. Both modeling and field studies have shown that discharged drilling fluids are diluted rapidly in receiving waters (Ayers et al. 1980a, 1980b; Brandsma et al. 1980; NRC 1983; O'Reilly et al. 1989; Nedwed et al. 2004; Smith et al. 2004; Neff 2005). The EPA modeled a hypothetical 1,000 bbl/hr discharge of drilling fluids in waters of the Chukchi Sea ranging between 131 to 164 ft (40 to 50 m) in depth and predicted a minimum dilution of 600:1 at 330 ft (100 m) down-current from the discharge point (EPA 2012b). Thus, the potential source of an impact, the discharged drilling fluid, is diluted to the extent that any impacts would be minimal.

Drill cuttings and mud discharges could temporarily displace ringed seals, bearded seals, and walruses a short distance from the discharge point at drill site. Any effects on walrus feeding patterns would also be indirect by way of impacts on their prey. Walruses are benthic feeders and rely upon organisms living on the seafloor for nutrition. Smothering of benthic organisms by drill cuttings discharges would reduce the prey available to the walrus; If Shell uses the MLC ROV system to construct the MLCs, a higher amount of seafloor would be disturbed as presented in Table 4.3.1-1. However, the impacted area would be small compared to the total area available to walruses for feeding regardless of which option is chosen for MLC construction. Thus, even the indirect impacts on walruses from drill cuttings and mud discharges are unlikely to have a biologically important effect on walruses in the project area.

Ringed seals, bearded seals and walruses would not be expected to be impacted by drilling fluid or cuttings. It is unlikely that seals or walruses would remain near the discharge point for an extended time period, so exposure to discharged fluid and cuttings would limit any impacts to these highly mobile species. Discharge of drilling fluid and cuttings would likely result in some loss of benthic invertebrates on and in the seafloor due to the smothering. If Shell uses the MLC ROV system to construct the MLCs, a higher amount of seafloor would be disturbed as presented in Table 4.3.1-1. This loss would have negligible effects on walruses because of the small area likely to be affected, regardless of which option is chosen for MLC construction. This area, compared with the total area of feeding habitat available to ringed or bearded seals, is very small. Any direct effects from the discharge on seal prey would have a negligible effect on the seals.

Conclusion

In conclusions, the localized and temporary effects of drilling unit mooring and MLC construction, mooring and MLC construction are not expected to affect ringed seals, bearded seals, and walruses. Additionally under EPA guidelines, concentrations of drilling fluids drop below levels that would affect ringed seals, bearded seals, or walruses within a few minutes, and are diluted within a few hundred meters. Furthermore, the areas affected by drilling discharges would be small, recover quickly, represent a small portion of benthic habitat available to walruses, and would be in the general proximity of activities causing enough noise to discourage visitation by ringed seals, bearded seals and walruses. Thus, they are not expected to be adversely affected by drilling wastes. Based on analysis above, threatened seals and walruses may be affected by drilling unit mooring, MLC construction, and drilling wastes survey activities. Therefore, given the significance thresholds and level of effects definitions determined by BOEM (2011a), the applicable level of effect is minor, and the impacts will not be significant.

Impacts of Other Permitted Discharges on Threatened Seals and Walruses

The impacts of other permitted discharges on ringed seals, bearded seals and walruses are expected to be negligible. These discharges include sanitary and domestic wastewater and minor discharges include non-contact cooling water, bilge and ballast water, desalination wastes, and deck drainage.

Cooling water forms the bulk of such discharges by volume, but is essentially uncontaminated, heated seawater. The discharged water would be reduced to very near 32.9 °F (0.5 °C) ambient seawater temperatures within 33 to 820 ft (10 to 250 m) of the outfalls. The discharge of cooling water would have no direct or indirect effects on ringed seals, bearded seals or walruses.

By implementing the sanitary and domestic wastewater treatment protocol, it is unlikely that Shell's sanitary and domestic wastewater discharges will introduce pathogens and parasites into marine mammals and fish present in Arctic waters. Shell plans to have an MSD onboard each vessel. The concentrations of fecal coliform allowed in the effluent from these discharges as allowed by the NPDES permits and MARPOL are at or below levels determined to be safe for human exposure for *E. coli* (EPA 1986). Because *E. coli* is a subset of fecal coliform, these levels are not expected to result in an increase in pathogens that may be harmful to fish or marine mammals.

The potential for introducing exotic and invasive species through minor discharges such as bilge and ballast water are also expected to be negligible. The USCG CFR 151 subpart D requires that mid-ocean exchange of ballast water occur. Further discharges authorized under the NPDES exploration facilities GP or the EPA's VGP and will result in only minor, temporary changes in water quality, such as temporary increases in TSS and BOD.

Conclusion

In conclusion, discharges will increase incrementally compared to that determined for EP Revision 1 due to two drilling units operating simultaneously at the Burger Prospect and an associated increase in supporting activities; however, all discharges will be managed according to NPDES permit requirements and MARPOL and USCG regulations. Direct effects on ringed seals, bearded seals and walruses from discharges are not expected. Areas affected by other permitted discharges would be small, recover quickly, represent a small portion of habitat available, and would be in the general proximity of activities causing enough noise to discourage visitation by seals and walruses. Any indirect effects on ringed seal, bearded seal and walrus prey or habitat would be negligible and short-term in a localized area, lasting only as long as the discharge is ongoing. Permit and regulation requirements and described mitigation measures will minimize any impacts on marine mammals. Based on analysis above, threatened seals and walruses will not be affected by other permitted discharges associated with Shell's planned exploration drilling activities. Therefore, given the significance thresholds and level of effects definitions determined by BOEM (2011a), the applicable level of effect is negligible, and the impacts will not be significant.

Impacts of Small Liquid Hydrocarbon Spills on Threatened Seals and Walruses

Section 2.10 of this EIA analyzes in detail the potential sources of a hydrocarbon spill, the probability of various types of spills occurring, Shell's plans for responding to a "small" spill (defined as 48 bbl or less), and Shell's WCD scenario. As explained in Section 2.10 Shell's categories of spill sizes are different from, but not incompatible with, those used by BOEM. The probability of a large (>48 bbl) liquid hydrocarbon spill is sufficiently small to conclude it would not occur during the proposed exploration drilling activities. Prudent planning and state and federal regulatory requirements nevertheless require that Shell have comprehensive spill prevention and response plans and capabilities in place. Shell's plans include measures to prevent any release from occurring and to respond in the event of a spill, including capabilities for responding to a WCD scenario. In the unlikely event of a spill, implementation of Shell's comprehensive spill response plan would minimize the impacts from the spill on ringed seals, bearded seals or walruses. Response equipment and trained personnel would be available on site to deploy boom and recovery equipment for the control and removal of product spilled in the environment. Additionally, the procedures of Shell's FTP for fuel transfers between vessels would be utilized in accordance with BOEM lease stipulation No. 6, USCG requirements, and Shells operating procedures.

An assessment of the potential effects of a small spill (<48 bbl diesel fuel) on marine mammals is provided above in Section 4.7.9; effects of such a release on ringed seals, bearded seals and walruses would be similar to those described in that section for spotted seals and other marine mammals. While the probability of any spill occurring is remote due to the implementation of rigorous spill control policies and procedures, a small spill (defined as 48 bbl or less), such as a spill incidental to a refueling operation, has been determined to be the most likely spill scenario during an exploration drilling activities.

An uncontrolled release of 48 bbl of diesel fuel could result in a slick that encompasses 10 to 200 ac (0.1 to 0.8 km^2) if not contained by booms and quickly recovered. However, fate and transport information indicates that up to 99 percent of the released diesel fuel would either evaporate or be widely dispersed in the water column within 48 hr. of release. Given the small area that would be affected by such a spill, the short duration of a slick, the density of ringed seals, bearded seals or walruses in the area, and tendency for marine mammals to avoid the immediate area of the drilling units, there would be limited opportunity for ringed seals, bearded seals or walruses to contact the slick. It is unlikely that any seal or walrus deaths, disability, or loss of fitness or reproductive potential would result if they were to contact the slick. The scientific literature indicates that seals are relatively resistant to the environmental effects of petroleum.

Seals that directly contact a slick at a small spill could experience irritation of the eyes and other mucosal membranes, swollen noses, ulcers, and scratches on the cornea (Geraci and Smith 1976). Given the volume of the release and the short duration of the slick, it is extremely unlikely that marine mammals could ingest sufficient quantities (St. Aubin 1988) of the petroleum to impact their health. Ingestion of small amounts would likely have no acute effects. A release of diesel would result in volatilization of hazardous air pollutants and could present an inhalation hazard to marine mammals. However, given the size of the slick, its short duration and the open, windy, high-energy conditions in the Chukchi Sea, it is doubtful that the concentration of the vapors would reach levels that would be harmful to marine mammals. Even if high concentrations were reached, these components usually evaporate within a few hours of the spill. Such a small spill would be insufficient to produce any population level effects on ringed seals or walruses in the Chukchi Sea. The weathering process should act to quickly break up or dissipate oil/fuel through the local environment to harmless residual levels that would eventually become undetectable. Ice seals are believed to have the ability to detect and avoid oil spills (Geraci 1990; St. Aubin 1990). Walruses are likely to avoid and disperse from areas with lots of human activity (such as cleanup crews or drilling operations), it is likely that those walruses not oiled immediately would avoid the area of the spill as long as cleanup activities were ongoing.

Conclusion

In conclusion, such a small spill would be insufficient to produce any population level effects on small or large groups of ringed seals, bearded seals or walruses. Mitigation measures will be fully implemented that will reduce the probability of such spills occurring and minimize the environmental effects through containment and cleanup. Shell's FTP requires pre-booming prior to transferring fuel between vessels. Additionally, Shell's oil spill response equipment would be mobilized to contain and clean up any release that was to occur. The above assessment of the effects of a small spill is therefore considered to be the maximum, most-likely spill event. Even at these levels for an uncontained release, the effects would be temporary and non-lethal. Because the possibility of even a small spill is remote and because most likely effect of a spill on ringed seals, bearded seals, and walruses is displacement from the area of the spill, impacts of such an event are likely to be insignificant . Based on analysis above, threatened seals and walruses may be affected by a small liquid hydrocarbon spill. Therefore, given the significance thresholds and level of effects definitions determined by BOEM (2011a), the applicable level of effect is minor, and the impacts will not be significant.

4.8.4 Impacts on Endangered Whales

In Section 3.7 of this EIA, Shell identified four species of endangered baleen whales that could potentially be affected by the activities proposed in EP Revision 2: bowhead, fin, humpback, and North Pacific right whales. Of these, critical habitat has been designated for the North Pacific right whale in the Gulf of Alaska and in the Bering Sea. As noted in Section 3.8 although transiting vessels in the Bering Sea could encounter the North Pacific right whales, transit to the Chukchi Sea was not included as part of the exploration drilling project activities at the Burger Prospect. Regardless, Shell does address impacts to the North Pacific right whale in this section where applicable.

The worldwide bowhead population was greatly reduced as a result of commercial whaling, but has rebounded in the last 30 years. Some reports (Shelden et al. 2001; IWC 2004; IWC 2005) suggest the Western Arctic stock of bowhead whales is now approaching the lower limit of the historical (pre-industry whaling) population size. The majority of these whales winter in the central and northwestern Bering Sea (November to March), migrate (Figure 3.8.4-1) through the Chukchi Sea in the spring (March to June) following offshore ice leads, and summer in the Canadian Beaufort Sea (mid-May through September) (Braham et al. 1980; Moore and Reeves 1993). All of the planned drill sites in Shell's Burger Prospect are located seaward of the generalized spring migration route (Figure 3.8.4-1), which likely be completed before Shell begins operations on or around 1 July. In the fall bowheads migrate westward along the U.S. Beaufort Sea coast across the Chukchi Sea to Russian waters and then south through the Bering Strait to the Bering Sea (Figure 3.8.4-1). The EP lease blocks in Shell Burger Prospect are located within the generalized fall migration route. Bowhead whales typically reach the Barrow area following their westward migration in mid-September to late-October, and thus may overlap with Shell's operations in space and time. Prior survey data indicate that bowhead whales may be observed in the vicinity of the Burger Prospect.

Humpback and fin whales occur in very low numbers in the project area, but may be regular visitors (NMFS 2013). These whales may occur in the project area during operations, but would not be expected. Humpback whales are migratory. In Alaska, their range includes the Gulf of Alaska, the Aleutians, the Bering Sea, and the southwestern Chukchi Sea (Allen and Angliss 2010), but recent observations of humpbacks have been reported in the northeastern Chukchi Sea and the Beaufort Sea. Published range maps indicate the Alaska stock of fin whales is restricted to the Gulf of Alaska and the Bering Sea in U.S. waters, and the southwestern Chukchi Sea along the Russian coast (Allen and Angliss 2014). However, they have recently been observed in the Lease Sale 193 area, and their range may be expanding.

The North Pacific right whale is not found in the Alaska Chukchi Sea, but does occur in the Bering Sea, through which the vessels will pass en route to the drilling sites. Migratory patterns of the North Pacific right whale are unknown, but observational data indicate that the vicinity of its designated critical habitat in the Bearing Sea is important foraging habitat. They are not expected in the vicinity of drilling operations, but may overlap in space and time with vessels transiting the Bering Sea en route to or from the Chukchi Sea.

Prior Analysis of Impacts to Endangered Whales

BOEM and BSEE and their predecessor agencies have engaged in consultations with NMFS on the impacts of oil and gas leasing and exploration in the Arctic. The most recent consultation concluded on 2 April 2013, with a BO analyzing the effects of authorizing oil and gas leasing and exploration in the Arctic on these four species of baleen whale and associated critical habitat for the 14-yr period beginning March 2013 and ending March 2027 (NMFS 2013b).

As relevant to Shell's EP Revision 2, NMFS assumed up to two exploration drilling units per sea per drilling season, with each unit capable of drilling up to four wells per year. Drilling operations were expected to take 30 to 90 days per well, with the drilling season extending a maximum of 120 days. NMFS assumed a typical exploration well depth of 10,000 ft (3,048 m). NMFS assumed that drilling operations would be supported with helicopter flights from base camp up to three times per day and support vessel trips up to three times per week. NMFS further assumed that each exploratory drilling unit would be supported by 1 to 2 ice-breakers/anchor handlers, up to three waste control vessels, 1 to 2 oil spill response barge and tug, 1 tank vessel for spill storage, and 2 to 3 small support vessels.

NMFS concluded that leasing and exploration operations in the Beaufort and Chukchi seas over the 14-yr period and related cumulative impacts would not jeopardize the continued existence of the four baleen whales. Specifically with regard to the impacts of exploration drilling on these species, NMFS concluded that only bowhead, fin, and humpback whales have the potential for exposure to the drilling operations, and few, if any, are expected for the fin and humpback given their low densities in the Chukchi Sea. NMFS examined all seismic activity in the aggregate and determined that it was not likely to appreciably reduce the likelihood of the bowheads, fin, or humpback whales surviving or recovering in the wild. For each species, NMFS cited the population's increase during a time of active seismic exploration as strongest evidence for its conclusion. Finally, NMFS concluded that the likelihood of a large or very large oil spill was so low as to make the risk of impacts from such an event negligible.

NMFS concluded that standard mitigation measures designed to avoid or minimize impacts associated with vessel traffic would result in a negligible level of effect to the four baleen whales and that standard mitigation measures applied to air traffic would keep aircraft at a high enough altitude to prevent harassment to marine mammals. NMFS concluded that, taking into consideration the likelihood that whales would avoid vessel activity and certain ensonified areas (and the lower densities of all whales, particularly fin, humpback, and North Pacific right whale), there would be few instances when whales were exposed to continuous noise sources. The agency did not expect those whales exposed to devote attentional resources to the stimulus. That exposure, if it occurred, would be relatively localized (the agency assumed a 25 km radius) and any short-term interruptions in vocalizations were not expected to represent significant disruptions or normal behavioral patterns because the ensonified area is a small portion of the range and because the noise levels that would not harm the species.

To reach these conclusions, NMFS began its analysis by screening species and habitat that were not expected to be adversely affected by the activity and excluded the critical habitat for the North Pacific right whale as too distant from anticipated activity to be adversely affected. NMFS then analyzed the rangewide status of each species. From there it identified three categories of anticipated project stressors:

- Sound fields produced by active acoustic devices (including devices for seismic exploration), vessels and aircraft traffic, and drilling operations;
- The risk of collisions between vessels and whales;
- The risk of pollution from unauthorized oil spills.

These project-specific stressors were analyzed in combination with other stressors affecting the species including historic commercial and subsequent illegal whaling, subsistence whaling for bowhead whales, ambient Arctic noise, including natural noise and anthropogenic noise, vessel collisions, increases in shipping activity, potential contamination, and climate change.

With this information, NMFS then analyzed whether members of a species would be exposed to a project-stressor and potential responses. Finally, NMFS concluded an integration and synthesis for each stressor and each species, each time focusing on the "critical question" of how the species is likely to respond upon being exposed to the stressor (NMFS 2013b).

The NMFS analysis, which is based on up to two drilling units operating simultaneously in the Chukchi Sea and an expanded level of activity, is a useful guideline in assessing the impacts associated with Shell's EP Revision 2. NMFS assumed that mitigation measures that have been required in past IHAs would be included in its future authorizations. For exploration drilling, NMFS identified the following mitigation measures:

- PSOs on all drill structures, ice management vessels, and other vessels exceeding NMFS acoustic thresholds;
- aircraft shall not fly within 1,000 ft (305 m) of marine mammals or below 1,500 ft (457 m) AGL or ASL;
- vessels shall reduce speed to less than 18.5 mph (10 kts) within 300 yd (274 m) of whales, steer around whales if possible, should not separate members of a group of whales, should refrain from multiple changes in direction and speed within 300 yd (274 m) of a whale, check water before engaging propeller; and when visibility is reduced, adjust speed accordingly; and
- notify BOEM or BSEE and NMFS if any equipment that could pose a risk to marine mammals is lost.

For seismic exploration, NMFS identified the following as standard mitigation measures: PSOs on all vessels that may result in incidental take through acoustic exposure, establishment and monitoring of radii association with received sound level thresholds for shutdown/power down at 180 dB for cetaceans, and use of start-up and ramp-up procedures for airgun arrays. All of these measures have been included in Shell's prior authorizations, were included within Shell's EP Revision 1, and are continued in EP Revision 2. Shell maintains a 4MP, which is described in more detail in Section 4.7.

In reviewing Shell's EP Revision 1, BOEM determined that acoustic impacts from exploration drilling in the northeastern Chukchi Sea would have a minor impact on bowhead whales and a negligible impact on fin and humpback whales due to their low presence in the area. BOEM expected negligible impacts to bowhead, fin, and humpback whales due to vessel traffic and minor impacts for all three species due to aircraft traffic. (BOEM did not analyze potential impacts on the North Pacific right whale). BOEM expected ice-breaking to result in minor impacts to bowhead whales and negligible impacts to fin and humpback whales due to their low densities in the project area. BOEM estimated that a maximum of three ZVSP surveys would be conducted, for a maximum of 42 hr a season in which the airguns would discharge. With appropriate mitigation measures applied, BOEM expected a minor impact on bowhead whales (25 whales exposed each season) and a negligible impact on fin and humpback whales (zero whales expected to be exposed due to their scarcity in the area). BOEM concluded that impacts due to permitted discharges were unlikely because the affected areas are so small and would recover quickly. It concluded that the impacts of a small fuel spill would be negligible.

EP Revision 2 exploration drilling activities are described in detail in Section 2.0. Section 4.7 discusses the changes in the program from EP Revision 1 and associated impact factors that are relevant to marine mammals. The main sources of potential disturbance to marine mammals associated with the exploration drilling activities proposed in this EP Revision 2 will be acoustic impacts from aircraft traffic, the drilling units, and support vessels. Vessels, anchor handling, drilling equipment and operations, including ZVSP survey operations and ice management, emit low-frequency sound energy into the water that may alter marine mammal behavior and could affect marine mammals' hearing abilities. Additional impacts include collision, sediment-impacts, and discharges, and air emissions. The impacts on endangered whales that are associated with each of these activities are discussed below.

In summary, consistent with conclusions drawn by NMFS and BOEM, Shell expects the effects on bowhead, fin, humpback, and North Pacific right whales to be minor and temporary and consist primarily of behavioral responses (avoidance). Below Shell analyzes the potential effects of activities under EP Revision 2. Because of the unlikely occurrence of humpback and fin whales in Shell's Burger Prospect area, and therefore the small probability of having any impact on these species, emphasis will be given to bowhead whales in this discussion of impacts from exploration drilling activities.

Impacts of Aircraft Traffic on Endangered Whales

The impacts of aircraft traffic associated with EP Revision 2 on cetaceans generally are discussed in Section 4.7.1. Aircraft traffic is expected to have minor impacts on endangered bowhead, fin, and humpback whales. The most likely response, if any, to aircraft noise, would be very brief and minor alterations in swimming or diving behavior.

The most common reaction to aircraft traffic is avoidance behavior, such as diving. Richardson et al. (1985b) monitored the responses of summering bowhead to overflights with both fixed wing (Islander) aircraft and helicopter (Sikorsky S-76) in a set of planned experiments. Overflights of fixed-wing aircraft sometimes evoked responses at altitudes of less than 1,000 ft (305 m), infrequently at altitude of 1,500 ft (457 m), and virtually never at altitudes greater than 2,000 ft (610 m). The researchers concluded that bowhead whale behavior is generally not disturbed by aircraft if an altitude of 1,500 ft (457 m) is maintained. The most common bowhead reactions to overflights were sudden or hasty dives, but changes in orientation, dispersal or movement out of the area, and change in activity were sometimes noted. Bowheads that were engaged in social activities or feeding or were less sensitive than those that were not. Whales in shallow water <33 ft (<10 m) were often very sensitive. No overt responses were observed to helicopter overflights at an altitude of 500 ft (152 m); however, others (Richardson et al. 1995a) have reported disturbances such as hasty dives in response to low-level helicopter overflights. Richardson and Malme (1993) reported that most bowhead whales in their study did not show a response to helicopters flying at altitudes above 500 ft (150 m).

Conclusion

Aircraft traffic associated with Shell's exploration drilling activities will have little impact on bowhead whales, or fin or humpback whales either. Aircraft may momentarily alter the behavior of bowheads in the form of hasty dives and changes in respiration rates. These impacts will not have any effect on the bowhead or bowhead populations. As a mitigation measure, aircraft associated with the exploration drilling activities will fly at a minimum altitude of 1,500 ft (457 m), which should prevent or minimize most such impacts. Any reactions to aircraft that must fly at altitudes below 500 ft (152 m) for safety concerns will be temporary and are not expected to harm the health or safety of bowhead whales (Richardson et al. 1995b). Impacts on fin whales and humpback whales would be similar. Based on the analysis above, endangered whales may be affected by aircraft traffic associated with Shell's exploration activities. Therefore, given the significance thresholds and level of effects definitions determined by BOEM (2011a), the applicable level of effect is minor, and the impacts will not be significant.

Impact of Vessel Traffic on Endangered Whales

Increased vessel traffic in the Chukchi Sea associated with exploration drilling operations may potentially impact marine mammals by collisions of the vessels with animals in the water or by effects of the sounds from the vessels entering the water. These potential impacts; however, will be mitigated by Shell's 4MP and would be unlikely to have an impact at the population level. Additionally, it is possible that Shell's vessels transiting through the Bering Sea may encounter North Pacific right whales. While such an encounter is highly unlikely, Shell's mitigation measures would minimize impacts, if any. NMFS concluded in its BO that the probability of vessel strikes in the Bering Sea is sufficiently small as to be discountable (NMFS 2013b).

Vessel Collisions

Few vessel strikes of marine mammals have been reported in the Chukchi Sea; however, increased numbers of vessels working in an area increase the likelihood of vessel strikes of marine mammals. Operations occurring during the fall bowhead migration also would potentially encounter more whales than during other portions of the year. All transiting vessels will have PSOs onboard to assist in spotting marine mammals and avoiding vessel strikes of animals. Shell has successfully operated a large number of vessels in the Chukchi Sea since 2006 and an exploration drilling operation in 2012 without any marine mammal strikes. These mitigation measures will decrease the likelihood of a bowhead whale strike by a vessel. Further, George et al. (1994) examined subsistence-harvested bowheads and quantified how many of them had scars that appeared to have been inflicted by vessels. Among 236 whales examined between 1976 and 1992, they found two whales that exhibited evidence of past interactions with vessels, and one with questionable scarring. One carcass was reported more recently that appeared to have been struck by a vessel (Rosa 2009). Even with the increase in traffic associated with EP Revision 2, it is unlikely that a ship strike of a listed whale species would occur during this project. If a collision did occur, it would impact the individual animal but would not affect animal populations in the project area.

Vessel Sounds

Like other cetacean species, bowhead and humpback whales have been reported to avoid vessels that are under way, but it is often unclear if the animals avoid vessels because of the sound of the vessel or if visual cues are also important. Fin whales are expected to respond similarly. One study of North Pacific right whales revealed these animals showed little response to vessel sounds . Studies related to potential avoidance behavior are reviewed in detail in Section 4.7.2 for marine mammals in general. This section describes studies specific to endangered whales. There is limited information available on responses of North Pacific right whales to vessel traffic, but they are assumed to exhibit responses similar to bowhead whales.

While no information is available on the North Pacific right whale hearing range, it is anticipated that they are low-frequency specialists similar to other baleen whales (NMFS 2013b). Thickness and width measurements of the basilar membrane have been conducted on North Atlantic right whale and suggest and estimated hearing range of 10 Hz-22 kHz based on established marine mammal models (Parks et al. 2007). In right whales, the level of sensitivity to noise disturbance and vessel activity appears related to the behavior and activity in which they are engaged at the time (Watkins 1986; NMFS 1991); Kraus and Mayo unpubl. data as cited in NMFS 1991). In particular, feeding or courting right whales may be relatively unresponsive to loud sounds and, therefore, slow to react to approaching vessels (NMFS 2013b).

Based on a review of observations of the behavioral responses of baleen whales, including 833 right whales, to various sources of human disturbance, Watkins (1986) reported that North Atlantic right whales ignored sounds that occurred at relatively low received levels, that had the most energy at frequencies below or above their hearing capacities appeared not to be noticed, or that were from distant human activities, even when those sounds had considerable energies at frequencies well within the whale's range of hearing. Most of the negative reactions that had been observed occurred within 100 m of a sound source or when sudden increases in received sound levels were judged to be in excess of 12 dB, relative to previous ambient sounds (NMFS 2013b).

Reports of observations of the reactions of bowhead whales to vessels have been variable and somewhat contradictory; however they indicate that vessel traffic will likely result in some temporary avoidance behaviors. Bowhead whales have exhibited avoidance of marine vessels. When a vessel approaches a bowhead whale, the most likely response is to swim away from the vessel (Richardson and Malme 1993). Hobbs and Goebel (1982) reported that bowheads react more strongly to boats with outboard motors than to diesel ships. Richardson and Finely (1989) noted that bowheads tend to react most strongly to vessels when the vessels were moving quickly and directly toward the whale than if the vessel was moving more slowly or in any other direction than at the whale.

Richardson et al. (1985b) studied the reactions of bowheads to small crew boats, fishing vessels, and large supply vessels and icebreakers in the Canadian Beaufort. The bowheads were found to react more strongly to vessel traffic than other industrial disturbances such as aircraft overflights and drilling. Most bowheads began to turn away when vessels approached within 0.6 to 2.5 mi (1 to 4 km) of the whale. The whales typically tried to outrun the boat; when the vessel was within a few hundred yards (meters); the whales turned away from the vessel path or dove. Groups of whales scattered, fleeing generally stopped a few minutes after the vessel passed but the scattering was evident for a longer period of time – perhaps an hour or more. Additional behavioral responses to vessel traffic included changes in respiration rates. Similar responses to vessels have been observed in fin (Ray et al. 1978 in Richardson et al. 1985b) and humpback whales (Baker et al. 1983 in Richardson et al. 1985b).

Koski and Johnson (1987) made similar observations of bowheads in the Alaskan Beaufort where strong responses by feeding bowheads to large icebreakers and supply vessels were observed. On two occasions, the support vessel passed within 0.6 to 1.9 mi (1.0 to 3.0 km) of the whales, all of which moved directly away from the vessel, some as far as 2.5 to 3.7 mi (4.0 to 6.0 km). Changes in whale behavior were temporary, with feeding often resuming while the moving vessel was still within 3.7 to 6.0 mi (6.0 to 10.0 km). At least some of the whales were observed back at the same area the next day indicating there was little if any effect on use of the area by whales.

Wartzok et al. (1989) followed radio-tagged whales in the Canadian Beaufort and observed their response to vessel traffic. They reported that bowheads generally ignored a small ship at distances greater than 1,640 ft (500 m). Over 180 whales voluntarily approached within 1,640 ft (500 m) of the vessel. Little response was noted unless there was a sudden change in sound level due to ship acceleration.

These studies indicate that some bowheads will react more strongly than others to vessel traffic associated with Shell's exploration drilling activities. Bowheads may alter their behavior and avoid the area within 0.6 to 2.5 mi (1 to 4 km) of the vessel. Any changes in behavior such as swimming speed and orientation, respiration rate, surface-dive cycles will be temporary and last only minutes or hours. Similarly, any consequent displacement of bowheads will be of a similar length of time and be restricted to a distance of a few miles (kilometers) from the vessel. The drillship and support vessels do not anticipate entering the Chukchi Sea until on or about 1 July when most of the spring bowhead migration is complete. Few bowheads are expected to be encountered during the exploration drilling operations, minimizing any effects. Fall migrating bowheads could encounter the drilling operations as they move west across the Chukchi Sea to feeding areas along the Russian coast before moving and down the Russian coast into the Bering Sea wintering grounds. The fall migratory path that bowheads use through the Chukchi Sea is variable with some whales traveling well north of project area while others move through the area south of Hanna Shoal near and through the proposed drilling area. Still other whales appear to move south along the Alaskan Chukchi Sea coast. Given the variable nature of the migration route displacement of whales by vessel traffic is unlikely to have more than a temporary effect on bowhead behavior and no lasting impacts on individuals or the population.

Nowacek et al. (2004) used controlled exposures to demonstrate behavioral reactions of northern right whales to various non-pulse sounds. Playback stimuli included ship noise, social sounds of conspecifics, and a complex, 18-min "alert" sound consisting of repetitions of three different artificial signals. Ten whales were tagged with calibrated instruments that measured received sound characteristics and concurrent animal movements in three dimensions. Five out of six exposed whales reacted strongly to alert signals at measured received levels between 130 and 150 dB re 1μPa rms (i.e., ceased foraging and swam rapidly to the surface). Two of these individuals were not exposed to ship noise and the other four were exposed to both stimuli. These whales reacted mildly to conspecific signals. Seven whales, including the four exposed to the alert stimulus, had no measurable response to either ship sounds or actual vessel noise.

Shell has agreed to reduce vessel speed in order to avoid separating members from a group of whales and will also avoid multiple course changes when within 900 ft (274 m) of whales. Vessel speed will be reduced during inclement weather conditions in order to avoid collisions with whales. With these mitigation measures in place, any effects on bowheads from vessel traffic will be minor and temporary, lasting only minutes or hours after the vessel has passed.

Conclusion

Endangered whales (bowheads, fin, humpbacks, or North Pacific right whales) may react to noise from vessels. These reactions are expected to be minor and temporary, lasting only a short time after the vessel has passed. With the application of mitigation measures to minimize the risk of collision and reduce impacts of vessel noise, it is unlikely that there would be a population level impact. Based on analysis above, endangered whales may be affected by vessel traffic associated with Shell's exploration drilling activities. Therefore, given the significance thresholds and level of effects definitions determined by BOEM (2011a), the applicable level of effect is minor, and the impacts will not be significant.

Impact of Drilling and Ice Management Sound on Endangered Whales

The impacts from drilling and ice management sounds on endangered whales would be identical to those discussed in detail in Section 4.7.3 for baleen whales. Overall these studies suggest bowhead whales in the project area are likely to respond to drilling sounds, and to a lesser extent, ice management and MLC construction, by avoiding the area of operations. Humpback whales and fin whales, to the extent they may be within the project area, are expected to respond similarly. The continuous sound sources may mask whale vocalizations and may impact migration routes of whales passing within close proximity of operations. Shell will implement mitigation measures to minimize the impact of continuous sounds on endangered whales.

Drilling Sounds

Studies suggest bowhead whales in the project area are likely to respond to drilling sounds by avoiding the area of operations. During much of the exploration drilling period few bowheads will be present in or near the project area as most bowheads summer in the Canadian Beaufort Sea well away from the project area. Quakenbush et al. (2013) reported based on a six-year tagging study that bowheads were primarily present in the Chukchi Sea Lease Sale 193 area in the fall from approximately 28 August to 26 November, but were sporadically present from 6 July to 25 December. On average, tagged whales were present within Area 193 for 10 days (range = 1 to 36 days, n = 45 whales). Because operations may continue into October, fall migrating bowheads could encounter the exploration drilling operations as they move west across the Chukchi Sea to feeding areas along the Russian coast before moving down the Russian coast into the Bering Sea wintering grounds. The fall migratory path that bowheads use through the Chukchi Sea is broad covering much of the Chukchi Sea. Some whales travel well north of the Burger Prospect while others move through the area south of Hanna Shoal near and through the prospect, and still others appear to move south along the Alaskan Chukchi Sea coast (Quakenbush et al. 2010, 2013).

Based on the above-referenced monitoring studies of historical oil and exploration drilling, it is possible that some bowhead whales migrating past the drill sites during the fall may deflect around the drill site due to the drilling sounds and activities. Bowheads may avoid the area by 12 mi (20 km) or more on either side of operations during periods of active drilling, particularly during the fall westward migration. Shell relied on the NMFS 120 dB re 1µPa rms continuous sound threshold to estimate the potential for avoidance behavior. The migration area is in excess of 220 mi (351 km) wide near the Burger Prospect, thus migration would not be impeded, as has been shown through the many monitoring studies referenced above.

Ice Management Sounds

Although bowhead whales react to icebreaking and ice-management activities, these activities are expected to have a minor level of effect on the bowhead whale population in the Chukchi Sea for the following reasons: the timing of this project during the open-water season; the low likelihood of the presence of large amounts of sea ice; a scarcity of bowhead whales during the July-August segment of this project when ice management is more likely to occur; and the short duration of this project. The reactions of fin and humpback whales to icebreaking and ice-management activities are expected to be similar to that of bowhead whales. However, very few, if any, fin and humpback whales are expected in the project area. No detectable population-level effects have been measured for either.

Available data suggest baleen whales avoid ice management vessels. Migrating bowhead whales appeared to avoid an area around a drill site by >16 mi (>25 km) where an icebreaker was working in the Beaufort Sea. There was intensive icebreaking daily in support of the drilling activities (Brewer et al. 1993). Migrating bowheads also avoided a nearby drill site at the same time of year when little icebreaking was being conducted (LGL and Greeneridge 1987). It is unclear as to whether the drilling activities, icebreaking operations, or the ice itself might have been the cause for the whales' diversion. As noted in the EP Revision 2 and supporting documents, Shell intends to manage ice in the first instance, as opposed to break ice, so effects may be less significant than those described directly above.

MLC Construction Sounds

A MLC will be constructed at each drill site using either a large diameter bit operated by hydraulic motors and suspended from the *Discoverer* or *Polar Pioneer* or with an excavator on a ROV system. The MLC ROV would excavate the MLC using implements such as a bucket, grinder, or rock hammer on the ROV sled. Use of a MLC ROV system would require an additional OSV type vessel from which the ROV would be transported, deployed and operated. This specific technology has not been put to use for construction of MLC's, but similar technology has been used for very similar work elsewhere.

Sounds from construction of an MLC during Shell's 2012 exploration drilling activities in the Chukchi Sea were recorded by hydrophones moored to the seafloor at distances of 0.6, 1.2, 2.5, and 5.0 mi (1, 2, 4, and 8 km). JASCO (Austin et al. 2013) calculated that these sounds diminished below the 120 dB rms threshold at 5.1 mi (8.2 km) from the drill site. The MLC in the 2012 program was constructed using the drilling unit. If Shell constructs MLCs using the ROV system, emitted sounds would be expected to be quieter than when using the drilling unit. Sound profile modeling, as described in Section 4.0, was conducted using the louder option of constructing a MLC using a drilling unit in the scenarios to be conservative. Regardless of which option Shell chooses for MLC construction, endangered whales are likely to exhibit no more than temporary localized disturbance resulting in avoidance or deflection of the area.

Masking

Masking of the ability of bowheads to hear other bowheads calls and their ability to make their calls heard by other whales could also occur for some animals that moved in closer proximity to operations. These effects would remain as long as operations were ongoing and the whales being affected remained within the area where sound levels were great enough to cause masking. There are no definitive studies to suggest how big the area of masking around a drilling unit might be for most animals but it would likely extend some distance beyond the 120 dB rms sound pressure level isopleth recognized by NMFS as the behavioral reaction zone around continuous sound sources. Results from sound profile modeling, as described in Section 4.0, determined that the largest area estimated to be exposed to continuous sounds ≥120 dB re 1µPa rms during a single activity scenario was 2,046.3 km^2 and resulted from concurrent MLC construction at two different sites and anchor handling at a third site.

Migration Impacts

During much of the exploration drilling period few bowheads will be present in or near the project area as most bowheads summer in the Canadian Beaufort Sea well away from the project area. Since operations may continue into October, fall migrating bowheads could encounter the exploration drilling operations as they move west across the Chukchi Sea to feeding areas along the Russian coast before moving down the Russian coast into the Bering Sea wintering grounds. The fall migratory path that bowheads use through the Chukchi Sea is variable with some whales traveling well north of project area while others move through the area south of Hanna Shoal near and through the proposed drilling area (Quakenbush et al. 2010). Still other whales appear to move south along the Alaskan Chukchi Sea coast. Given the variable nature of the migration route displacement of whales by the drilling operations is unlikely to have more than a temporary effect on bowhead behavior and no lasting impacts on individuals or the population.

In recent years, bowheads have been seen feeding in the Peard Bay area in the Chukchi Sea (Thomas et al. 2010) but any sounds from the drilling operation that would reach into the feeding area along the coast over 60 mi (97 km) away would be too low energy to affect whales that might be using the area. Additionally, feeding whales in the Canadian Beaufort Sea and in Camden Bay in the Alaskan Beaufort Sea have been shown to be more tolerant of industrial sounds (Koski et al. 2009; Christie et al. 2010). Previous studies have not found that avoidance of drilling or other industrial operations has impeded the fall migration of bowhead whales (Davis 1987; Gallagher et al. 1992; Brewer et al. 1993; Funk et al. 2010). Richardson et al. (2008) and Blackwell et al. (2008) reported a slight change in the distribution of bowhead whale calls in response to operational sounds on BP's Northstar Island. The southern edge of the call distribution ranged from 0.47 to 1.46 mi (0.76 to 2.35 km) farther offshore, apparently in response to industrial sound levels. This result however, was only achieved after intensive statistical analyses, and it is not clear that this represented a biologically effect on bowhead distribution.

The possible presence of two drilling units and associated operations proposed in Shell's EP Revision 2 may cause whales to stay farther north than they normally would until they are past the drilling operations in the Chukchi Sea before they head south into the Bering Sea. Alternatively, they may stay closer to shore and travel south along the Alaskan coast. In the activities scenario modeled to have greatest ensonified area (MLC construction at two sites and anchor-handling at a third), the sound signatures from the three operations did not overlap to any great degree as the distances between the operations are greater than the distance at which drilling and operational sounds are expected to drop to background levels. A deflection to the north would potentially increase the distance a whale would travel as they move through the Chukchi Sea, although we believe the deflection would be temporary and weak. Many bowhead whales appear to currently use a more northerly route currently, though data from tagged whales is limited to a relatively small number of individuals, and such deflection would affect an unknown portion of the population. Satellite data suggest that the greatest number of tagged whales moved across the Chukchi Sea to feeding areas along the coast of Russia. Whales stopped at these feeding areas before eventually heading south into the Bering Sea. The increased migration distance that a somewhat more northerly route would require would be unlikely to affect bowhead energetics given that most measured deflections around drilling and seismic operations are on the order of approximately 12 to 15 mi (20 to 24 km). Given the variable nature of the migration route displacement of whales by the drilling operations is unlikely to have more than a negligible, temporary effect on bowhead behavior and no lasting impacts on individuals or the population.

Mitigation

In order to limit the close contact between the whales and ice management vessels and related operations, PSOs will be stationed on all transiting support vessels. When within 900 ft (274 m) of whales, vessels will reduce speed, avoid separating members from a group and avoid multiple changes of direction. Vessel speed will also be reduced during inclement weather conditions in order to avoid collisions with all marine mammals, including whales. Regular overflight surveys and support vessel surveys for marine mammals will be conducted to further monitor exploration drilling areas.

Conclusion

A small number of bowhead whales and few humpback and fin whales would be expected to be in the Burger Prospect when Shell would conduct the exploration drilling operations based on known densities of these whales, experience with historical exploration drilling activities in the same area of the Chukchi Sea (Table 3.7-2), and surveys conducted for Shell in the Burger Prospect (Table 3.7-5). The estimated numbers of endangered whales that might be exposed to sound levels of greater than 120 dB re 1µPa rms and 160 dB re 1µPa rms are included in the overall exposure estimates provided in Table 4.7.3-1.

Reactions of endangered whales exposed to continuous sounds from drilling, icebreaking and other support activities, including MLC excavation, are expected to include temporary (short-term) disturbance consisting of avoidance of or deflection around a localized area. No mortality or population-level effects are anticipated. Effects on endangered whales from program-related continuous sounds in EP Revision 2 would incrementally increase above levels described in EP Revision 1 due to the addition of an ice management vessel and two drilling units operating simultaneously at the Burger Prospect; however, any effects are not anticipated to accumulate across multiple seasons. Effects would be minimized by fully implementing mitigation measures with PSOs stationed on drilling units, OSVs, ice management vessels, and anchor-handling vessels to apply real-time mitigation, if necessary. These mitigation measures should minimize any potential effects that whales occurring near project activities could experience.

Based on these numbers of expected exposures and the above analysis of impacts, the effects of sound energy generated by exploration drilling and ice management on endangered whales would affect few, if any, whales, and consist of temporary behavioral responses. Based on analysis above, endangered whales occurring near Shell's activities may be affected by continuous sounds associated with Shell's exploration drilling activities. Therefore, given the significance thresholds and level of effects definitions determined by BOEM (2011a), the applicable level of effect is minor, and the impacts will not be significant.

Impacts of ZVSP Survey Sound on Endangered Whales

The impacts from ZVSP survey-generated sounds on endangered whales would be identical to those discussed in detail in Section 4.7.4 for baleen whales. Baleen whales generally tend to avoid operating airguns, but the distances of avoidance radii are quite variable.

Whales are often reported to show no overt reactions to pulses from large arrays of airguns used in seismic surveys at distances beyond a few kilometers, even though the airgun pulses remain well above ambient noise levels out to much greater distances. However, baleen whales exposed to strong noise pulses often react by deviating from their normal migration route. In the case of migrating bowhead whales, observed changes in behavior appeared to be of little or no biological consequence to the animals. They simply avoided the sound source by displacing their migration route to varying degrees, but within the natural boundaries of the migration corridors. Baleen whale responses to pulsed sound however, may depend on the type of activity in which the whales are engaged. Some evidence suggests that feeding bowhead whales may be more tolerant of underwater sound than migrating bowheads (Miller et al. 2005; Lyons et al. 2009; Christie et al. 2010).

Data on short-term reactions (or lack of reactions) of cetaceans to impulsive noises do not necessarily provide information about long-term effects. Bowhead whales have continued to travel from the Bering Sea through the Chukchi Sea to the eastern Beaufort Sea each summer despite seismic exploration, drilling, and other industrial operations in their summer and autumn range for many years (Richardson et al. 1987). Populations of bowhead whales have grown substantially during this time.

Given the small size of the airgun array proposed for use in the ZVSP survey and the short time period during which the guns would be fired (approximately 10 to 14 hr per survey, 1 survey per well), relatively few bowhead whales are likely to be affected by the ZVSP survey. Most airgun noise is focused beneath the airgun array, though some noise radiates horizontally from firing airgun arrays. Horizontally radiated noise quickly attenuates in the ocean, with decibel levels dropping from source levels to much lower levels in a few tens of meters (Blackwell et al. 2013). Mitigation measures in place during the surveys would include the shut down or power down of airguns if whales entered or approached exclusion zones while the guns were firing and a ramp up of the airgun array.

With these measures it is unlikely that any animals would experience more than behavioral reactions to the planned ZVSP surveys. Behavioral reactions would be limited to short-term avoidance of the area around the survey operations. Further, the small broadband sound radii caused by the airguns would be unlikely to deflect whales to as great an extent as the exploration drilling and ice management activities described above, so it is unlikely that the ZVSP survey operations would increase the distance of potential deflection around the project area or have an impact at the population level. Based on observed whale densities in the Chukchi Sea and modeled sound energy propagation and transmission loss, a small number of bowheads, fin whales, and humpback whales would likely be exposed to sound levels of 160 dB re 1µPa rms or more (Table 4.7.3-1).

Whales begin diverting when received levels of noise reach approximately 150 to 180 dB re 1µPa rms (Richardson et al. 1995b), and so it is reasonable to expect avoidance behavior from mysticetes to begin before they approach to within 5.14 mi (8.27 km) of ZVSP survey operations (160 dB re 1µPa rms). By applying PSOs and ramp-up protocols as mitigation measures for ZVSP survey operations, TTS and PTS effects to the hearing of baleen whales should be avoided.

Conclusion

Given the small size of the sound sources planned for the planned ZVSP survey activity, the very short duration it will be conducted at each drill site, and mitigation measures to be applied, it is unlikely that there would be any cases of temporary or especially permanent hearing impairment, or non-auditory physical effects in any marine mammal species that would be found in the project area, including in endangered whales. More likely, behavioral disturbance - including temporary avoidance or deflection reactions - could occur. These non-lethal effects are not anticipated to last beyond minutes to hours after the ZVSP survey activities are completed and will not accumulate across multiple seasons. Effects would be minimized by fully implementing mitigation measures described above as part of the 4MP, including ramp-up and shut down procedures. Based on analysis above, endangered whales that occur near Shell's activities may be affected by ZVSP survey activity. Therefore, given the significance thresholds and level of effects definitions determined by BOEM (2011a), the applicable level of effect is minor, and the impacts will not be significant.

Impacts of Project Air Emissions on Endangered Whales

The impacts of project air emissions associated with Shell's planned exploration drilling activities on air quality are discussed in Section 4.1, and the effect of such emissions on marine mammals are discussed in Section 4.7.6. Emissions associated with Shell's EP Revision 2 are expected to have a minor impact on air quality overall and a minor impact on offshore air quality. Because whales are transitory, they are not likely to be exposed to air quality impacts related to the project emissions for extended periods, resulting in no measureable impact.

Conclusion

Endangered whales are likely to avoid areas of operations due to acoustic impacts, so they are not likely to be exposed to potentially elevated levels of emissions for extended periods. Because whales are transitory, they are not likely to be exposed to air quality impacts related to the project emissions for extended periods, resulting in no measureable impact. Based on analysis above, endangered whales will not be affected by air emissions associated with Shell's exploration activities. Therefore, given the significance thresholds and level of effects definitions determined by BOEM (2011a), the applicable level of effect is negligible, and the impacts will not be significant.

Impacts of Drilling Unit Mooring, MLC Construction and Drilling Wastes on Endangered Whales

The impacts of drilling unit mooring and early phases of drilling on marine mammals are discussed in Section 4.7.5. Effects of sound generated by MLC construction is discussed below under effect of exploration drilling sounds above. MLC construction or drilling unit mooring would have only a localized and temporary effect. It would affect the benthic communities, which are prey species for endangered whales in the immediate vicinity of the drilling units, but the area affected is small in comparison to the benthic habitat available to whales in the Chukchi Sea.

Drilling unit mooring and MLC construction will have little effect on endangered whales. Setting and recovering the anchors require use of the anchor handling vessel, which could result in avoidance of the area by bowhead, fin or humpback whales as described for vessel traffic. The activity would occur within the anchor radii and therefore to the area within about 3,609 ft (1,100 m) of each drilling unit. The physical manifestations of anchor disturbances associated with mooring the two drilling units (3.7 ac, 14,923 m^2) would attenuate after removal over time by the natural movement of seafloor sediments and ice scours. The physical effects of mooring and MLC construction would be restricted to a very small portion of the Chukchi Sea seafloor area (4.01 to 5.28 ac [16,158 to 21,354 m^2]), depending on MLC construction by drill bit or by MLC ROV system. The MLC ROV system results in the larger disturbance area. Benthic organisms within the area directly affected by MLC construction and anchor mooring would likely be buried or decimated due to the weight and force of the anchors and MLC drill bit or subsequent displacement. Approximately 10 additional acres (0.04 km^2) may be indirectly impacted by the re-deposition of cuttings from MLC construction and drilling to thickness of 0.4 in. (1.0 cm) or more resulting in the smothering of benthic organisms. T&E whales are not benthic feeders and thus will not be indirectly affected due to smothering of benthic organisms. Effects of sound generated by MLC construction is discussed above under effect of exploration drilling sounds. Re-suspension of sediments and subsequent sedimentation resulting from MLC construction or drilling unit mooring would have only a localized and temporary effect. Any effects on bowhead whales from these activities would be negligible due to limited effects and few bowheads in the area (as described in Section 3.8.6), and they would be temporary. Fin whales and humpbacks are not expected to be found in the Burger Prospect during the proposed activities, but if they are found in the area, the effects would be similar to those described for bowheads.

EPA determined in its Biological Evaluation for the NPDES exploration facilities GP (EPA 2012c) that impacts on whale food sources from cuttings discharge would likely be limited to a localized area and would not be substantial at a landscape level. NMFS consulted on the issuance of the GP and concurred with the EPA's determination that the planned actions, including cuttings discharges, "may affect, but are not likely to adversely affect" bowhead, fin, and humpback whales (NMFS 2012).

Given that endangered whales are not expected to occur in large numbers at the Burger Prospect, and that the relative area affected compared to the habitat available for these whales is very small, adverse effects from drilling unit mooring and MLC construction are not expected. Any effects that do occur will be temporary, will not result in mortality or physical harm, and will not affect whales on a population level. Based on the level of effects definitions determined by BOEM (2011) and provided above, direct and indirect effects on T&E whales will not be significant and will be negligible.

The impacts of drilling wastes related to Shell's EP Revision 2 on marine mammals are discussed in Section 4.7.7. Negative effects on endangered whales from drilling discharges are not expected. Baleen whales, such as bowheads, fin, or humpbacks, tend to avoid drilling units at distances up to 12 mi (20 km). Therefore, it is highly unlikely that the whales will swim or feed in close enough proximity of discharges to be affected. Any whales that might come in contact with drilling waste discharge plumes or drilling wastes deposited on the seafloor would likely be unaffected. Bowheads commonly feed in turbid waters. Metals in drilling fluids and drill cuttings are not bio-available and have not been found in bio-accumulate or bio-magnify in organisms on which the whales feed.

The levels of drill cuttings and drilling mud discharges are regulated by the EPA's NPDES exploration facilities GP. Discharges related to Shell's EP Revision 2 are expected to be well below both the discharge and toxicity limits established in that permit. The impact of drill cuttings and drilling mud discharges would be localized and temporary. Drill cuttings and mud discharges could displace endangered whales a short distance from the discharge point at the drill site. Effects on the whales present within a few meters of the discharge point would be expected, primarily due to sedimentation. However, endangered whales are not likely to have long-term exposures to drilling muds because of the episodic nature of discharges (typically only a few days in duration).

Both modeling and field studies have shown that discharged drilling fluids are diluted rapidly in receiving waters (Ayers et al. 1980a, 1980b; Brandsma et al. 1980; NRC 1983; O'Reilly et al. 1989; Nedwed et al. 2004; Smith et al. 2004; Neff 2005). The dilution rate is strongly affected by the discharge rate; the NPDES exploration facilities GP limits the discharge of cuttings and fluids to 1,000 bbl/hr (159 m^3/hr) or less in waters of the Chukchi Sea ranging between 130 to 164 ft (40 to 50 m) in depth and predicted a minimum dilution of 600:1 at 330 ft (100 m) down-current from the discharge point (EPA 2012b).

It is expected that any toxic effects on endangered whales present within a few feet of the discharge point would be negligible and ephemeral. Under EPA guidelines, concentrations of drilling fluids drop below levels that would affect T&E whales within a few minutes, and are diluted within a few hundred meters.

Excavation of the MLC will disturb seafloor sediments and result in an increase of total suspended solids in the water column. Use of the MLC ROV system rather than the drilling unit for excavation would result in a larger area of disturbance. However, it is unlikely that the increase in suspended solids would affect endangered whales that might swim through the area. Furthermore, T&E whales potentially occurring near the Burger Prospect feed on prey in the water column which will not be largely affected by the increase in seafloor sediment disturbance.

Conclusion

In conclusion, given the localized and temporary effects of drilling unit mooring and MLC construction and the low densities of endangered whales in the Chukchi Sea, mooring and MLC construction are not expected to affect bowhead, fin, or humpback whales. Further, as explained above, the areas affected by discharges of wastewater, drill cutting, and drilling fluids would be small, would recover quickly, and would be in the general proximity of activities causing enough noise to discourage visitation by endangered whales. Identifiable impacts to these whales from discharges are therefore unlikely. Based on analysis above, endangered whales will not be affected be affected by wastes associated drilling unit mooring, and MLC construction, and drilling. Therefore, given the significance thresholds and level of effects definitions determined by BOEM (2011a), the applicable level of effect is negligible, and the impacts will not be significant.

Impacts of Other Permitted Discharges on Endangered Whales

The impacts of other permitting discharges related to Shell's EP Revision 2 on marine mammals are discussed in Section 4.7.8, and no differences are expected for T&E whales. Discharges will increase incrementally compared to that determined for EP Revision 1 due to two drilling units operating simultaneously at the Burger Prospect and an associated increase in supporting activities; however, all discharges will be managed according to NPDES permit requirements and MARPOL and USCG regulations. Direct effects on marine mammals from discharges are not expected. Areas affected by other permitted discharges would be small, recover quickly, represent a small portion of habitat available to marine mammals, and would be in the general proximity of activities causing enough noise to discourage visitation by marine mammals. Any indirect effects on marine mammal prey or habitat would be negligible and short-term in a localized area, lasting only as long as the discharge is ongoing.

Conclusion

Permit and regulation requirements and described mitigation measures will minimize any impacts on marine mammals. Because impacts of other permitted discharges would be limited to very small areas where other activities would discourage visitation by marine mammals, and because of the low densities of endangered whales in the Chukchi Sea, bowhead, fin, and humpback whales are not anticipated to be affected by other permitted discharges. Based on analysis above, endangered whales will not be affected by other permitted discharges associated with Shell's exploration activities. Therefore, given the significance thresholds and level of effects definitions determined by BOEM (2011a), the applicable level of effect is negligible, and the impacts will not be significant.

Impacts of Small Liquid Hydrocarbon Spill on Endangered Whales

Section 2.10 of this EIA analyzes in detail the potential sources of a hydrocarbon spill, the probability of various types of spills occurring, Shell's plans for responding to a "small" spill (defined as 48 bbl or less), and Shell's WCD scenario. As explained in Section 2.10, Shell's categories of spill sizes are different from, but not incompatible with, those used by BOEM. The probability of a large (> 48 bbl) liquid hydrocarbon spill is sufficiently small to conclude it would not occur during the proposed exploration drilling activities. Prudent planning and state and federal regulatory requirements nevertheless require that Shell have comprehensive spill prevention and response plans and capabilities in place.

Shell's plans include measures to prevent any spill release from occurring and to respond in the event of a spill, including capabilities for responding to a WCD scenario. In the unlikely event of a spill, implementation of Shell's comprehensive spill response plan would minimize the impacts from the spill and any effects on whales. Response equipment and trained personnel would be available and on site to deploy boom and recovery equipment for the control and removal of hydrocarbons spilled into the environment. Additionally, the procedures of Shell's FTP for fuel transfer between vessels would be utilized in accordance with BOEM lease stipulation No. 6, USCG requirements, and Shell's operating procedures.

The number of whales that come into contact with oil would depend on the size of the spill, when the spill occurred, the number of whales in the area of the spill, and the whales' ability to effectively avoid the oil. Even for the whales that are exposed to oil, it is unlikely to have impact on them (Geraci and St. Aubin 1982; St. Aubin et al. 1984). There are no documented reports of baleen whale mortalities due to oil (Richardson et al. 1989). In a study by Harvey and Dahlheim (1994) on cetaceans during the Exxon Valdez spill, it was reported that they behaved normally in the presence of oil. It is likely that bowhead whales would behave similarly to the cetaceans in that study (USACE 1998).

Section 4.7.9 discusses the thermoregulatory and toxicological effects of oil and marine mammals. As with cetaceans discussed previously, bowhead, fin, and humpback whales have skin that is nearly impenetrable by oil (Geraci and St. Aubin 1985). However, oil can cause irritation to eyes and mucous membranes (Geraci 1988). In a study by Geraci and St. Aubin (1990), oil applied to cetacean skin with a sponge for 45 min showed no adverse effects. Even when applied to an open wound, the crude oil did not affect healing. When gasoline was applied in the same manner to healthy skin for 75 min there was no severe reaction. However, when the gasoline was applied to a cut, strong inflammation was observed. This inflammation was undetectable after 24 hr of recovery.

Neurological disorders and liver damage in whales can result from inhalation of oil vapors (Hansen 1985). These vapors are unlikely to reach high concentrations due to the windy climate of the Chukchi Sea and that the volatile fraction of crude oil evaporates within a few hours after a spill occurs. If whales are limited in their mobility when traveling in a lead and exposed to high concentrations of hydrocarbon vapors, the subsequent inhalations could be toxic and cause organ failure. Two to four hr after the spill, harmful vapor concentrations would decrease considerably through evaporation and no longer be a threat.

Endangered whales could ingest oil or oil-contaminated prey while feeding (Geraci and St. Aubin 1982). Whales are known to skim the water surface and take in large volumes water over long periods of time. This could lead to the ingestion of large patches or concentrations of oil when feeding (Albert 1981). It is also suggested that ingested baleen hairs could mix with the oil and create masses that could block portions of the stomach (Tarpley et al. 1987). However, other studies suggest that cetaceans can metabolize ingested oil, and hence, detoxify it (Hansen 1985; Hansen 1992). Hansen (1985) also reported that the digestion process would break down the oil and hair masses. Further evidence of the ability of baleen whales to metabolize oil has been reported by Geraci and St. Aubin (1990).

There has been concern that oil could coat baleen plates and hinder the ability to feed. The coating of baleen by oil would allow increased amounts of plankton to slip through the plates (Bratton et al. 1993). A heavy oil spill could reduce feeding efficiency for several days or more (Geraci and St. Aubin 1985). However, bowheads would not likely occupy oiled waters for long and oil would be fairly quickly flushed from baleen in clean water. Studies done by Geraci and St. Aubin (1982) showed that water flow was restored up to 15 min after baleen was coated by oil.

There have been no scientific reports on whether bowhead whales are displaced due to oil spills. However, Traditional Knowledge of Alaska Natives suggests that oil spills reduce the abundance of bowheads in the area. For example, Thomas Brower Sr. reported it took four years for oil to disappear after a 25,000-gal spill in 1994 (probably a diesel fuel spill). During that time, he observed that the whales were deflected from the area. They migrated further than usual around Elson Lagoon where the spill occurred. However, Von Ziegesar et al. (1994) reported no evidence of change in calving rate, whale abundance, seasonal use of the area by mothers and calves, or mortality due to an observed spill. However, they did notice temporary avoidance of some areas.

The types of oil spills that could occur and the probabilities of such spills occurring, response actions, and impacts are discussed in Section 2.10. The probability of a large crude oil spill occurring is so low that it is not regarded as reasonably foreseeable for this exploration drilling activities (see Section 2.10). A small spill, such as a release of 48 bbl of diesel fuel, is the most probable type and volume of spill, if any, to occur as a result of EP Revision 2. Such a spill would have only minor and temporary effects on T&E whale. These potential impacts of a small spill are analyzed below.

While still a remote possibility due to the implementation of rigorous spill control policies and procedures, small spills (48 bbl or less), such as a spill incidental to a refueling operation, have been determined to be the most likely spill scenario during an exploration drilling activities.

An uncontrolled release of 48 bbl of diesel fuel could result in a slick that encompasses 10 to 200 ac (0.1 to 0.8 km^2) if not contained. Fate and transport information indicates over 99 percent of the diesel would evaporate or be widely dispersed in the water column within 48 hr. Given the small area that would be affected by such a spill, the short duration of a slick, the density of bowhead, fin, and humpback whales in the area, and avoidance of the immediate area around vessels by marine mammals, there would be limited opportunity for any whales to contact the slick. If contact occurred, it is highly unlikely that any whale deaths, disability, or loss of fitness or reproductive potential would result. The scientific literature indicates that both whales are relatively resistant to the environmental effects of petroleum.

Bowhead, fin, and humpback whales that directly contact a slick at a small spill could experience irritation of the eyes and other mucosal membranes, swollen noses, ulcers, and scratches on the cornea

(Geraci and Smith 1976). Given the volume of the release and the short duration of the slick, it is extremely unlikely that marine mammals could ingest sufficient quantities (St. Aubin 1988) of the petroleum to impact their health. Ingestion of small amounts would likely have no acute effects. A release of diesel would result in volatilization of hazardous air pollutants and could present an inhalation hazard to marine mammals. However, given the size of the slick, its short duration and the open, windy, high-energy conditions in the Chukchi Sea, it is doubtful that the concentration of the vapors would reach levels that would be harmful to marine mammals. Even if high concentrations were reached, these components usually evaporate within a few hours of the spill.

Thus, an uncontrolled release of 48 bbl of diesel fuel would have little if any impact on the whales. Mitigation measures will be in place that will reduce the probability of such spills occurring, and minimize the environmental effects through containment and cleanup. Shell’s FTP requires pre-booming prior to transferring fuel in any quantity between vessels. Additionally, Shell’s OSR equipment would be mobilized to contain and clean up any release that was to occur. The above assessment of the effects of a small spill is therefore considered to be the maximum, most-likely spill event. Even at these levels for an uncontained release, the effects would be minor and temporary, having no noticeable impact on total whale populations.

The most likely effect of a spill on endangered whales would be displacement from the area caused by the increased vessel and aircraft traffic that would be involved in spill response and cleanup efforts. Such displacement would be temporary and occur over a relatively short period of time and therefore be unlikely to have more than a negligible effect on whales in the area. Spill response operations occurring during bowhead whale migration could affect larger numbers of animals. A few whales could encounter fuel in the water and suffer some discomfort associated with exposure to the fuel.

Such a small spill would be insufficient to produce any population level effects on T&E whales in the Chukchi Sea. Oil generally poorly adheres to the skin of mysticete whales, and cetaceans are believed to have the ability to detect and avoid oil spills (Geraci 1990; St. Aubin 1990). Furthermore, the weathering process should act to quickly break up or dissipate oil/fuel through the local environment to harmless residual levels that would eventually become undetectable.

<u>Conclusion</u>

In conclusion, such a small spill would be insufficient to produce any population level effects on small or large groups of endangered whales. Mitigation measures will be fully implemented that will reduce the probability of such spills occurring, and minimize the environmental effects through containment and cleanup. Shell’s FTP requires pre-booming prior to transferring fuel between vessels. Additionally, Shell’s oil spill response equipment would be mobilized to contain and clean up any release that was to occur. The above assessment of the effects of a small spill is therefore considered to be the maximum, most-likely spill event. Even at these levels for an uncontained release, the effects would be temporary.

The possibility of even a small spill is remote and the most likely effect of a spill on endangered whales is displacement from the area of the spill and impacts of such an event are likely to be insignificant. Based on analysis above, endangered whales may be affected by a small liquid hydrocarbon spill. Therefore, given the significance thresholds and level of effects definitions determined by BOEM (2011a), the applicable level of effect is minor, and the impacts will not be significant.

4.9 Impacts on Sensitive Biological Resources

Sensitive biological resources in offshore waters of the Lease Sale 193 Area and coastal waters between the lease sale area and the coastline, and on shore along the Chukchi Sea coast include LBCHU, Kasegaluk Lagoon, Peard Bay, the Alaska Maritime NWR, HSWUA, and the polynya zone as described in Section 3.9. Distances to these sensitive resources from Shell's Burger Prospect are presented in Table 4.9-1. The HSWUA and the polynya zone are traversed by Shell's planned flight and vessel corridors. Other than HSWUA, all identified sensitive resources are located more than 31 mi (50 km) from the boundary of the Burger Prospect. Spectacled eider critical habitat in the LBCHU is also described in Section 4.8.1. Potential direct and indirect impacts on other identified sensitive biological resources or habitats from Shell's planned exploration drilling activities are discussed below.

Table 4.9-1 Distances from Burger Prospect to Sensitive Biological Resources

Sensitive Area	Distance from Nearest Boundary of the Burger Prospect
Polynya Zone	31 mi (50 km)
Ledyard Bay	54 mi (87 km)
Kasegaluk Lagoon	70 mi (113 km)
Alaska Maritime NWR	68 mi (109 km)
Peard Bay	100 mi (161 km)
HSWUA	1.5 mi (2.5 km)

As presented in the analyses below, the exploration drilling activities as described in the Chukchi Sea EP Revision 2 will have only negligible to minor effects on these sensitive biological resources (Table 4.9-2).

BOEM did not establish a NEPA significant threshold or level of effect for sensitive biological resources in its analysis of Shell's EP Revision 1 (BOEM 2011a). Shell has developed the following standards to evaluate potential impacts resulting from its exploration activities under EP Revision 2 on sensitive biological resources:

Significance Threshold:

An impact may temporarily occur in the sensitive biological resource area, leaving a minor impact that dissipates within one year.

Level of Effects:

Negligible

- An impact may temporarily occur in the sensitive biological resource area, but the impact dissipates immediately upon the termination of the impact-causing activity, leaving no measurable lasting impact.

Minor

- An impact may temporarily occur in the sensitive biological resource area, but the impact dissipates shortly after the termination of the impact-causing activity, leaving no measurable lasting impact.

Moderate

- An impact may temporarily occur in the sensitive biological resource area, leaving a measurable impact that dissipates within one year but causing no measurable impact on the life cycle of species dependent on the sensitive biological resource area.

Major

- An impact may temporarily occur in the sensitive biological resource area, leaving an impact that persists more than one year and may cause a measurable impact on the life cycle of species dependent on the sensitive biological area.

Table 4.9-2 Effects of Shell's Exploration Drilling Program on Sensitive Resources

Resource / Analyzed Activity	EP Revision 2
Sensitive biological resources (overall)	Minor
From aircraft traffic	None
From vessel traffic	Negligible
From drilling and ice management sound	Minor
From ZVSP survey sound	Negligible
From drilling wastes	None
From other permitted discharges	None
From small liquid hydrocarbon spills	Negligible
Cultural Resources	None

4.9.1 Impacts of Aircraft Traffic on Sensitive Areas

Aircraft traffic will have no effect on the identified sensitive biological resources. Regular aircraft traffic will consist of helicopter traffic between the drilling unit and shorebase facilities flown along the corridors identified in Figure 2.2-2 and PSO or ice reconnaissance overflights with a fixed wing aircraft This corridor traverses the polynya zone and a very small portion of the HSWUA, but is located no closer than 18 mi (29 km) to LBCHU, Kasegaluk Lagoon, Peard Bay, and the Alaska Maritime NWR (Table 4.9.1-1).

Table 4.9.1-1 Distances from Flight Corridor to Sensitive Resources and Habitats

Vessel Corridor Section	Polynya Zone	Ledyard Bay LBCHU	Kasegaluk Lagoon Sensitive Area (SA)	Alaska Maritime NWR	Peard Bay SA	HSWUA
Wainwright-Burger	traverses	41 mi (65 km)	18 mi (29 km)	40 mi (65 km)	17 mi (28km)	7 mi (12 km)
Barrow-Burger Alt1	traverses	62 mi (99 km)	60 mi (96 km)	66 mi (106 km)	27 mi (44 km)	Traverses
Barrow-Burger Alt2	traverses	64 mi (103 km)	52 mi (84 km)	64 mi (103 km)	13 mi (21 km)	Traverses

[1] Based on minimum distances from flight corridors on Figure 2.2-2

Shell's exploration drilling activities will occur during the Arctic open water season. Polynyas, which are areas of open water sounded by sea ice, will not be present during Shell's exploration drilling activities; therefore, Shell's activities will have no impact on that sensitive biological resource. A small portion of the HSWUA would be traversed by helicopter flights between Barrow and the Burger Prospect at a rate of up to 40/week; however these flights will be at a minimum altitude of 1,500 ft (457 m) and will have no effect on the habitat or walruses.

Aerial surveys for marine mammals will be conducted along a standardized route, two times per week, for the duration of the exploration drilling activities (EP Revision 2 Appendix B – 4MP). A portion of these surveys will be conducted over the LBCHU, where a minimum flight altitude of 1,500 ft (457 m) will be maintained. Given their low frequency and minimum altitudes the flights are expected to have no effect on molting or staging spectacled eiders in the LBCHU. USFWS (2009c) came to a similar conclusion in its BO for oil and gas exploration in the Beaufort and Chukchi Sea, in which USFWS stated that marine mammal survey flights in the LBCHU with a fixed-wing plane at an altitude of 1,500 ft (457 m) are unlikely to disturb or adversely affect spectacled or Steller's eiders.

Aircraft traffic associated with the exploration drilling activities, as described in EP Revision 2, will have no effect on the identified sensitive biological resources.

4.9.2 Impacts of Vessel Traffic on Sensitive Areas

Regular vessel traffic will be along corridors identified in Figure 2.2-1. Some portions of the vessel route corridor traverses the polynya zone; however, as Shell's exploration drilling activities will occur during the open water season when there are no polynyas, such crossing will have no impact on that sensitive biological resource. The vessel route between the Burger Prospect and Barrow traverses a small portion of the HSWUA, but the Burger/Barrow route is a contingency route that will not be used frequently, if at all. Vessel traffic for ice scouting or management may occur in the HSWUA, but will be conducted under a variance for entry issued by the USFWS with appropriate mitigation measures (i.e., Adaptive Management Approach to areas where walruses are present.). Other identified sensitive areas are located no closer than 17 mi (28 km) from the vessel corridor (Table 4.9.2-1). Vessel traffic associated with the exploration drilling activities, as described in EP Revision 2, and due to integrated mitigation measures will have no, or only negligible, discernible effect on the identified sensitive biological resources.

Table 4.9.2-1 Distances from Vessel Corridor to Sensitive Resources

Vessel Corridor Section	Polynya Zone	Ledyard Bay LBCHU	Kasegaluk Lagoon SA	Alaska Maritime NWR	Peard Bay SA	HSWUA[3]
Wainwright-Burger	traverses	41 mi (66 km)	17 mi (28 km)	40 mi (65 km)	18 mi (29 km)	7 mi (12 km)
Barrow-Burger	traverses	64 mi (104 km)	60 mi (97 km)	66 mi (107 km)	27 mi (44 km)	Traverses
Dutch Harbor-Burger [2]	traverses	19 mi (30 km)	61 mi (99 km)	32 mi (51 km)	90 mi (145 km)	10 mi (17 km)

[1] Based on minimum distances from vessel corridors on Figure 2.1-1
[2] Corridor sections between Dutch Harbor and prospect only address portion within Chukchi Sea
[3] Portions of HSWUA will likely be traversed not by the vessel transit corridor, but for the purpose of ice management, and under a variance for entry issued
by the USFWS.

4.9.3 Impacts of Drilling and Ice Management Sound on Sensitive Areas

Exploration drilling and ice management activities will take place at Shell's Burger Prospect, which is located more than 54 mi (87 km) from LBCHU, Kasegaluk Lagoon, Peard Bay, and the Alaska Maritime NWR, and is 31 mi (50 km) seaward of the polynya zone. Modeling of the propagation and transmission loss of sound energy generated by exploration drilling and ice management is described in Section 2.9. The modeling indicates that received sound levels should be reduced to 120 dB or less within about 0.93 mi (1.5 km) of the drilling unit and within about 5.96 mi (9.6 km) of the ice management vessel. These sound levels, which last only as long as the activity is on-going, will be at or near ambient at the identified sensitive biological resources. Therefore, exploration drilling operations at the Burger Prospect well locations will have no effect on these resources.

Ice management vessels will traverse and conduct ice management in the HSWUA depending on conditions. Ice reconnaissance with the vessels is expected to occur out to distances of at least 30 nmi (55.5 km) from the drill site, and ice management activities may occur to a distance of 20 nmi (37 km). Given these distances, vessel traffic and ice management are expected to occur within the HSWUA.

Walrus reactions to vessels and ice management activities are analyzed in Section 4.8.3. As discussed in Section 4.8.3, walrus reactions to vessels consist of behavioral responses ranging from head raising and/or escape behavior (leaving the ice). Most reactions occurred when the walruses were within 550 yd (599 m) of the vessel. Walruses in the water (as opposed to on ice) generally demonstrate less reaction. Any responses would be negligible and very brief in duration. Ice management generates greater under water sound than vessel activity levels, and would be expected to result in some redistribution of the walruses and avoidance of the area by as much as 12.4 to 15.5 mi (20 to 25 km).

Monitoring data and observations by icebreaker operators also suggest that most walruses will leave ice floes long before they reach drilling rigs or ice management vessels intercept a floe that has to be deflected or broken up (USFWS 2013a) offering no opportunity for physical collisions.

The above analyses indicate that incursions by ice management vessels and transiting vessels into the HSWUA required to support exploration drilling activities in the Chukchi Sea could result in the disturbance of walruses by ensonification of the water column or the visual presence of the vessels. The impact to walruses will be temporary and minor, consisting of brief behavioral disturbance such as the temporary abandonment of ice floes. There is the low probability that such disturbances could result in the abandonment of young walruses. The probability and severity of such consequences will be ensured by implementation of the standard mitigation measures required by MMPA authorizations, which include:

- Operational and support vessels must be staffed with dedicated protected species observers to alert crew of the presence of walruses and initiate adaptive mitigation responses.
- At all times, vessels must maintain the maximum distance possible from concentrations of walruses.
- Except in an emergency, vessels will not approach within 0.5 mi (0.8 km) of walruses or polar bears when observed on ice.
- Except in an emergency, vessels will not approach within 1.0 mi (1.6 km) of groups of walruses or 0.5 mi (0.8 km) of polar bears when observed on land. Vessels should take all reasonable precautions (i.e., reduce speed, change course heading) to maintain a minimum operational exclusion zone of 0.5 mi (805 m) around groups of 12 or more walruses in the water.
- Vessel operators must take every precaution to avoid harassment of concentrations of feeding walruses when a vessel is operating near these animals.
- Vessels should reduce speed and maintain a minimum 0.5 mi (805 m) operational exclusion zone around groups of 12 or more walruses encountered in the water.
- Vessels may not be operated in such a way as to separate members of a group of walruses from other members of the group. When weather conditions require, such as when visibility drops, vessels should adjust speed accordingly to avoid the likelihood of injury to walruses.

In addition, prior to entry into the HSWUA, all vessels must follow the risk assessment approach outlined in the *Adaptive Approach to Ice Management in Areas Occupied by Pacific Walruses* (Appendix J to EP Revision 2). Necessity for entry is dependent on the presence of ice within HSWUA that necessitates management for the safety of drilling operations. Shell's mitigation toward entry into HSWUA and a request for variance will include the *Adaptive Approach to Ice Management in Areas Occupied by Pacific Walrus.* Shell developed the first version of this adaptive approach in consultation with the USFWS. Shell will synthesize the best available real time data from multiple sources to assess indications of walrus distribution in combination with ice maps and forecasts. Shell will be able to generate assessments of the potential for such activities to interact with walruses prior to a vessel or aircraft's planned entry into the HSWUA. The adaptive approach process will be used to rank risks and initiate consultation both within Shell and between Shell and USFWS is as follows:

- Ice and weather forecasting will evaluate the potential risk to walruses on the basis of proximity of ice to survey vessel and factors influencing ice movement. Sighting data from available sources will be evaluated to assess walrus presence/absence.
- If the area of operation is ice free or there is a low probability that walruses are present and monitoring continues.
- If ice is present and the possibility exists that walruses may be present based on recent observations in the area, the risk level will be assessed. The USFWS would be notified by email and updates will be provided by telephone, or in person, during regular business hours.
- At red risk levels (ice and walruses are present in areas) the on duty compliance representative for Shell will notify a designated USFWS representative by calling a duty phone to engage in real-time consultation.

The risk level will be communicated to USFWS prior to entering the HSWUA. If risk level is ”1”, monitoring continues and USFWS will be notified by. At a risk level of “2”, email notifications will be made and telephone, or in person, consultations will occur during business hours. If the risk level becomes ”3”; however, Shell will notify the designated duty individual within the Service and initiate direct consultation. With these mitigation measures in place, vessel traffic and ice management in or near the HSWUA would have minor behavioral and avoidance effects on walruses in the area, and no effect on the sensitive biological resource.

4.9.4 Impacts of ZVSP Survey Sound on Sensitive Areas

ZVSP surveys will be conducted at the planned drill sites located more than 54 mi (87 km) offshore of LBCHU, Kasegaluk Lagoon, Peard Bay, and the Alaska Maritime NWR, 31 mi (50 km) seaward of the polynya zone, though as noted above the timing of ZVSP surveys will not be coincident with Spring when leads develop in the polyna zone, and 7.26 mi (11.68 km) southwest of HSWUA. Modeling of the propagation and transmission loss of sound energy generated by the planned ZVSP surveys indicates that sound energy will be reduced to 160 dB or less within about 5 mi (8 km) of the drilling unit. Therefore, the sound level will be lower than the 160 dB threshold for Level B harassment of marine mammals within HSWUA. With the conservative factor of 1.5 applied to the 160 dB radius, the closest border of HSWUA would be just inside (7.43 mi [11.96 km]). However, Shell believes it is very unlikely that sensitive biological resources (e.g., marine mammals) located in these areas will be exposed to received levels of sound that could cause disturbance. Thus, exploration drilling operations at the Burger Prospect well locations will likely result in no impacts to, at most, negligible impacts..

4.9.5 Impact of Drilling Wastes on Sensitive Areas

Discharges of drill cuttings and drilling fluids will take place at the drill sites, which are located more than 54 mi (87 km) offshore of LBCHU, Kasegaluk Lagoon, Peard Bay, and the Alaska Maritime NWR and 31 mi (50 km) seaward of the polynya zone, and more than 1.5 mi (2.4 km) from HSWUA to the nearest boundary to the Burger Prospect (Table 4.9-1), and even farther from the nearest proposed drill site at the Burger Prospect (7.26 mi [11.68 km]). The discharges will have negligible effects on water quality near the drilling unit, consisting primarily of increases in TSS concentrations, which will be limited primarily to the area within about 984 to 3,380 ft (300 to 1,000 m) of the drill site. Most seafloor effects due to deposition of drill cuttings and drilling fluids will be restricted to the area within about 394 ft (120 m) of the drill site, although some negligible amounts of deposition will occur at greater distances. These discharges will have no effect on the identified sensitive biological resources due to the distance between the resources and the drill sites.

4.9.6 Impacts of Other Permitted Discharges on Sensitive Areas

Permitted discharges will have very minor effects on the water column as described in Section 4.2.2, but these effects would be ephemeral and restricted to the area immediately down current of the discharges. The EPA (2012b) has determined that these types of discharges, which would be conducted according to the NPDES exploration facilities GP, will not result in unreasonable degradation. Any minor effects on water quality (see discussion in Section 4.2.2) would be limited to the immediate vicinity of the discharge. Such discharges will have no effect on the identified sensitive biological resources due to the distance between the resources and the drill sites.

4.9.7 Impacts of a Small Liquid Hydrocarbon Spill on Sensitive Areas

The types of oil spills that could occur and the probabilities of such spills occurring, response actions, and impacts are discussed in Section 2.10. The probability of a large crude oil spill occurring is so low that it is not regarded as reasonably foreseeable for this exploration drilling activities (see Section 2.10). As described in Section 2.10, a small spill, such as a release of 48 bbl of diesel fuel, is the most probable type and volume of spill, if any, to occur as a result of this EP Revision 2.

The fate and transport of a 48 bbl diesel fuel spill is described in Section 2.10. An uncontrolled spill of 48 bbl of diesel would likely result in a slick size of 20 to 200 ac (0.08 to 0.81 km^2) if not contained by booms and quickly recovered. The slick would quickly dissipate, with over 99 percent being evaporated or be widely dispersed in the water column within 48 hr of release (Section 2.10). Given average current speeds in the Chukchi Sea, the slick from a release of 48 bbl of diesel would not be expected to reach any of the sensitive biological resource areas before evaporating or dispersing into the water column. Thus, a small fuel spill is expected to have a negligible effect on the identified sensitive biological resources, depending on the location of the release. Nearshore spills could have some effect on the identified biological resources, but for the reasons discussed above and in Section 2.10, any effect would be negligible and short-term. Further, any adverse impacts from a small spill will be mitigated by pre-booming all refueling to or from vessels in accordance with Shell's FTP.

4.10 Impacts on Cultural Resources

Cultural resources could potentially be altered or destroyed by mooring of the drilling units, wet storage of anchors, construction of MLCs, and shorebase expansion and presence. Drilling units, construction of MLCs, and wet storage of anchors will occur in areas where shallow hazards surveys and archaeological assessments have conducted, and found to be clear of cultural resources. All planned shorebase expansion would take place on existing gravel pads, and will therefore have no impact on cultural resources.

BOEM established the following significance threshold and definitions for levels of effect for archeology, also referred to as cultural resources (BOEM 2011a; MMS 2007b):

<u>Significance Threshold</u>

- The action is likely to result in an interaction between an archeological site and an effect-producing factor which will result in the loss of unique, archeological information.

<u>Level of Effects</u>

Negligible

- This category equates to No Historic Properties Affected as defined by 36 CFR 800.4(d)(1), the Code of Federal Regulations that promulgates Section 106 of the National Historic Preservation Act of 1966 as amended

Minor

- This category equates to a finding of No Historic Properties affected when the Agency identifies a potential conflict within an Area of Potential Effect due to the presence of a geomorphological feature and revises the plan to avoid it prior to consultation with the SHPO.

Moderate

- This category equates to a finding of No Adverse Effect as defined by 36 CFR 800.5(c)(1) when the SHPO identifies a conflict that requires a change in plan to avoid effect on an Historic Property as defined by 36 CFR 800.16(l)(1&2).

Major

- This category equates to a finding of Adverse Effect as defined by 36 CFR 800.5(a)(1) requiring mitigation and a Memorandum of Agreement 36 CFR 800.6.

As discussed below, Shell's exploration drilling activities, as described in EP Revision 2, will have no effect on cultural resources (Table 4.10-1).

Table 4.10-1 Potential Effects of Shell's Exploration Drilling Program on Cultural Resources

Resource / Analyzed Activity	EP Revision 2
Cultural resources (overall)	None
From drilling unit mooring, MLCs and drilling waste	None
From shorebase expansion	None

4.10.1 Impacts of Drilling Unit Mooring, MLCs, and Drilling Wastes on Cultural Resources

Mooring of the drilling units, and MLC construction will directly disturb about 4.01 to 5.28 ac (1.62 to 2.14 ha) of seafloor over the course of the exploration drilling activities. Seafloor disturbance could potentially damage or destroy prehistoric and historic archaeological resources if they were present at the identified drill sites. Shallow hazards surveys and archaeological assessments have been conducted at all the drill sites where drilling unit mooring and MLC construction are planned. The archaeological assessments concluded that the potential for both historic and prehistoric cultural resources at these sites is very low. Buried Pleistocene channels are located near some of the drill sites (Burger A, F, S), but the possible levees that might have been constructed on the sides of these subsurface channel features have likely been eroded during the last sea level rise, and are covered in turn by Holocene age materials. Thus the possibility of occurrence of preserved archaeological resources on these subsurface channel features has been decreased and the possibility of disturbing such resources is very low. No cultural resources were detected or identified in the drill site area using side-scan sonar and magnetometers in the shallow hazards survey areas. None of the unidentified side-scan sonar contacts or magnetic anomalies is believed to be of archaeological significance. Mooring analysis was conducted for each drill site and anchor locations were selected that avoid all magnetic anomalies and side-scan sonar contacts. No magnetic anomalies or side-scan sonar contacts were recorded at the locations where MLCs would be constructed. Mooring of the drilling units and construction of the MLCs are therefore expected to have no effect on cultural resources.

Anchors for the containment system barge may be wet stored, at one of the drill sites. The wet storage of the anchors; however, will have no effect on cultural resources because the anchors will be placed at a drill site where an archaeological assessment has been conducted and indicates no cultural resources are present.

Discharges of drill cuttings and drilling fluids will take place only at the locations of drill sites. Most seafloor effects due to deposition of drill cuttings and drilling fluids will occur in an area within about 394 ft (120 m) of any drill site, although some negligible amounts of deposition will occur at greater distances. Regardless, the locations of each drill site have been subject to shallow hazard and site clearance surveys which concluded the very low probability for disturbance of potential archaeological features at these drill sites. In 2011, BOEM (2011b) concluded that no cultural resources are present in the area of potential effect of the exploration activities, and given that the same drill sites are included in EP Revision 2, the same conclusion can be reached. Because cultural resources are not present at the drillsites and impacts from discharges related to unit mooring, MLCs, and drilling wastes do not extend beyond the immediate vicinity of the drilling unit, these discharges are expected to have no effect on cultural resources.

4.10.2 Impacts of Shorebase Expansion on Cultural Resources

Shell's existing 75-person man camp and KDR unit are located on a pad constructed by UIC in 2012. Shell will lease an existing 40-person construction camp nearby. A review of the AHRS database indicates there are historic properties in the area, including the NARL facilities themselves, and the NARL Historic District (BAR-00075), which has been determined eligible for National Register of Historic Places listing by the Alaska State Historic Preservation Officer. Shell's existing accommodations and the planned KDR unit are modular, portable, facilities that will only be there as long as Shell's exploration drilling activities requires them. The facilities are located on mats and skids and are self-contained. Any effects on this resource from the installation of Shell's 75-person man camp with a KDR unit will be negligible, temporary, and reversible, and will not affect the historic integrity of the NARL Historic District. Therefore, the shorebase expansion is expected to have no effect on cultural resources.

4.11 Impacts on Socioeconomics and Subsistence

Shell's planned Chukchi Sea exploration drilling activities as described in EP Revision 2 will have positive effects on the NSB economy and provide employment and community development opportunities for residents from the region. Shell developed a POC and has contacted and met with community leaders and residents of the borough to solicit comments, questions, and concerns about this program, and will continue that process in the future through an ongoing stakeholder engagement program. Communication with the residents most directly affected by this program is an important part of Shell's participation in the exploration and evaluation of these potential new energy resources.

The socioeconomic composition of the NSB is a blend of traditional subsistence activities; federal, state and local government services and jurisdictions; Alaska Native ANCSA corporations; and the unique benefits and pressures that are part of life in the Arctic. A comprehensive review of these resources is provided in Sections 3.11 – 3.12 of this EIA.

BOEM has established separate significance thresholds and definitions for levels of effect for sociocultural systems, subsistence, and economic impacts (BOEM 2011a).

BOEM has developed the following significance threshold and levels of effects for subsistence:

<u>Significance Threshold</u>:

- Adverse impacts which disrupt subsistence activities, or make subsistence resources unavailable, undesirable for use, or only available in greatly reduced numbers, for a substantial portion of a subsistence season for any community.

<u>Level of Effects</u>:

Negligible

- Subsistence resources could be periodically affected with no apparent effect on subsistence harvests.

Minor

- Adverse impacts to subsistence activities are of an accidental and/or incidental nature and limited to a short-term.

Moderate

- Adverse impacts, which disrupt subsistence activities, or make subsistence resources unavailable, undesirable for use, or only available in greatly reduced numbers, of a substantial portion of a subsistence season for any community.

Major

- Adverse impacts resulting in one or more important subsistence resources becoming unavailable, undesirable for use, or available only in greatly reduced numbers for any community.

BOEM defines the economic impacts of a proposed action as those associated with socioenomic systems, including employment, personal income, and revenues accruing to local, state, and federal government.

<u>Significance Threshold</u>:

- No measurable effects beyond short term, periodic impacts.

<u>Levels of Effect</u>

Negligible

- No measureable effects beyond short term, periodic impacts.

Minor

- Adverse impacts to the affected activity or community are unavoidable without proper mitigation.
- Impacts would not disrupt normal routine or functions of the affected activity or community. Economic system would be impacted for a period of up to 1 year.
- Once the impacting agent is eliminated, the affected activity or community will return to a condition with no measurable effects from the proposed action without any mitigation.

Moderate

- Impacts to the affected activity or community are unavoidable. Proper mitigation would reduce impacts substantially during the life of the project.
- Effects on economic systems would be unavoidable for a period of longer than 1 year.
- The affected activity or community would have to adjust somewhat to account for disruptions due to impacts of the project.
- Once the impacting agent is eliminated, the affected activity or community will return to a condition with no measurable effects from the proposed action if proper remedial action is taken.

Major

- Impacts to affected community are unavoidable.
- Proper mitigation would reduce impacts somewhat during the life of the project.
- The affected activity or community would experience unavoidable disruptions to a degree beyond what is normal.
- Once the effect producing agency is eliminated, the affected activity or community may retain measurable effects of the proposed action even if proper remedial action is taken.

BOEM defines sociocultural systems to include social organization, cultural values, and/or institutional arrangements and has developed the following standards:

Significance Threshold:

- A disruption of social organizations, cultural values, and/or institutional arrangements with a tendency towards displacement of existing social patterns.

Level of Effects:

Negligible

- Periodic disruptions of social_organizations, cultural values, and/or institutional arrangements occurs without displacement of existing social patterns.

Minor

- Disruptions of social organizations, cultural values, and/or institutional arrangements occurs for a period of less than one year, without a tendency toward displacement of existing social patterns.

Moderate

- Chronic disruption of social organizations, cultural values, and/or institutional arrangements occurs for a period of more than one year, without a tendency toward displacement of existing social patterns.

Major

- A disruption of social organizations, cultural values, and/or institutional arrangements with a tendency towards displacement of existing social patterns.

This section of the EIA addresses specific components of these socioeconomic resources that are most relevant to the NSB and specifically the communities of Barrow, Wainwright, Point Lay and Point Hope, including employment, community health, and subsistence. The discussion incorporates by reference the analysis of potential effects of exploration drilling in the Chukchi Sea developed by the BOEM (2015) in the Final Second SEIS for Lease Sale 193. This discussion also builds on BOEM's analysis of economic impacts related to Shell's proposed activities in previous versions of this EP. MMS 2009, BOEM 2011a. The impacts described herein do not constitute a significant change in the impacts previously analyzed, evaluated, and approved with conditions.

The discussion of subsistence is of particular importance in the ongoing cooperation between Shell and the communities of Barrow, Wainwright, Point Lay and Point Hope. Shell has developed comprehensive subsistence mitigation plans to minimize impacts on subsistence resources and avoid unreasonable conflicts with subsistence activities. These include Shell's POC Addendum (EP Revision 2, Appendix D) and 4MP (EP Revision 2, Appendix B).

This review and analysis of the socioeconomic conditions and resources on the North Slope indicates there will be negligible impacts on the subsistence resources and economy of the area.

Plan of Cooperation

BOEM Lease Sale Stipulation No. 5 and MMPA authorizations require Shell to implement a POC. In accordance with the POC requirements, Shell has conducted POC meetings with the following potentially affected villages regarding Shell's planned exploration drilling activities in the Chukchi Sea: Barrow, Wainwright, Point Lay and Point Hope. Additionally, Shell met with residents of other Chukchi Sea and Bering Sea coastal villages, including Dutch Harbor, Gambell, Kiana, Kivalina, Kotzebue, Savoonga, Shishmaref, and with members of subsistence groups including the Alaska Eskimo Whaling Commission (AEWC), Alaska Beluga Whale Committee, Alaska Eskimo Walrus Commission, the Ice Seal Commission, and the Alaska Nanuuq Commission. Shell also presented information regarding Shell's planned activities to the NSB and NWAB Assemblies, and NSB and NWAB Planning Commissions. Shell's POC Addendum is attached to Shell's revised Chukchi Sea EP as Appendix D. Shell intends to implement its POC fully and to continue its consultation efforts with local communities.

Impacts of Program Activities on Population, Goods and Services

Some indirect and direct community and economic development benefits will result from Shell's exploration activity. Minor and temporary influxes of people may occur in Wainwright or Barrow through the operation of the shorebase facilities. Positive economic benefits include jobs that are generated and the opportunities for for-profit village corporations to provide goods and services.

Most activities associated with Shell's planned exploration drilling activities will take place at or near the drill sites that are more than 64 mi (103 km) offshore. Support vessel crews are expected to remain offshore for the duration of the drilling season. Drilling unit crews will rotate off the vessel approximately every 21 days and will normally leave the shorebase immediately for destinations off the North Slope. The offshore vessels will have their own medical facilities. Most supplies will be shipped in; relatively few purchases will be made in local communities due to the short duration of the program and limited local availability of necessary supplies. Shorebase facilities in Wainwright will be located approximately 0.5 mi (0.8 km) from the town. Staff at the shorebase is expected to include 25 to 75 persons, but the camp will be largely self-contained. Therefore impacts are expected to be negligible as concluded by BOEM (2011a). The influx of people into local neighboring communities will be minimal and temporary and is expected to have negligible effects on the local population or the availability of goods and services in the community.

Impacts of Program Activities on Employment and Local, State, and Federal Revenue

Direct Impact on Employment from the Proposed Exploration Drilling Activities

Activities related to Shell's exploration drilling activities may generate positions for local hire and revenues through the leasing of facilities and contracting of services at a shorebase, resulting in direct economic benefits to the affected community. Current employment opportunities are:

- PSO
- SA
- Com Centers
- OSR technicians

The PSO program employs local Inupiat residents to monitor and document marine mammals in the program area. The PSOs participate in intensive training for marine mammal identification and documentation, and in computer use and health and safety regulations.

The SA program recruits a local resident from each village to communicate local concerns and subsistence issues from residents to Shell. The SA speaks with other village members and documents subsistence information. Shell may then develop appropriate mitigation measures to address issues of concern related to subsistence activities and potential conflicts with exploration drilling activities. Shell plans to continue its SA program during the planned exploration drilling season.

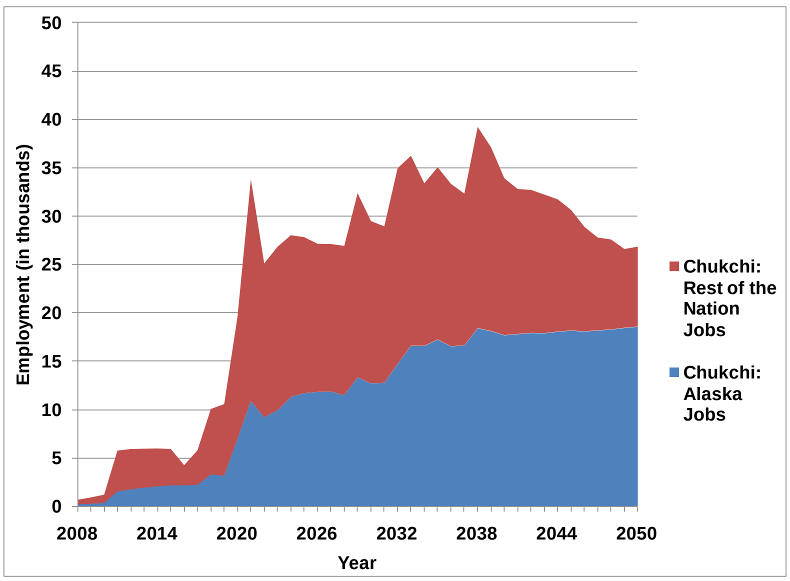
The Com Center program involves hiring one or two individuals from each of the Beaufort and Chukchi Sea villages. These individuals will monitor and relay radio transmissions between subsistence vessels and industry vessels. This sharing of information is intended to reduce or eliminate the potential conflict between subsistence users and industry vessels. Shell will implement a Communications Plan during the exploration drilling seasons in order to further avoid conflicts with subsistence users.

During Shell's planned exploration drilling operations, Shell will make best efforts to hire and train qualified local residents for the exploration drilling activities. Providing these employment opportunities to local residents creates the potential for positive economic benefits to the communities most affected by Shell's activities. These efforts will also provide a conduit for communication between Shell and residents.

Indirect Impact on Employment from the Proposed Exploration Drilling Activities

The primary purpose of exploration drilling is to make new discoveries that result in oil and gas development and production. The proposed exploration drilling activities could lead to a significant discovery and result in an oil and gas development with substantial and positive socio-economic impacts. An estimated annual average of 24,600 new jobs could be created and sustained for 50 years from development of the oil and gas resources of the Chukchi Sea, with total payroll of $65 billion (NEI 2011). Approximately 12,500 of these new jobs would be in Alaska and approximately 2,800 would be located in the NSB (NEI 2011).

Figure 4.11-1 Predicted Employment from Potential Oil & Gas Development, Chukchi Sea



Source: NEI 2011

Indirect Impact on Local Government Revenue from the Proposed Exploration Drilling Activities

New revenue for the NSB from development of the oil and gas resources of the Chukchi Sea would total nearly $2.8 billion over a 50-year period under current policies (NEI 2011).

Indirect Impact on State Government Revenue from the Proposed Exploration Drilling Activities

New revenue for the SOA from development of the oil and gas resources of the Chukchi Sea would total approximately $7.7 billion over a 50-year period, with another $2.8 billion of new government revenue generated in other states (NEI 2011).

Indirect Impact on Federal Government Revenue from the Proposed Exploration Drilling Activities

New revenue for the federal government from development of the oil and gas resources of the Chukchi Sea would total approximately $82.6 billion over a 50-year period (NEI 2011).

Impacts of Program Activities on Existing Offshore and Coastal Infrastructure

There is currently no existing offshore infrastructure in the area of Shell's Burger Prospect or the Lease Sale 193 Area, and the exploration drilling activities will not involve the construction of any new offshore infrastructure. All wells will be plugged and abandoned in compliance with applicable BOEM regulations after exploration drilling. No pipelines or other permanent structures will be built. There will be no effect on offshore infrastructure.

Shell's shorebase activities are expected to have no effect on existing coastal infrastructure. Shorebases will be located in Barrow and Wainwright, and will use existing facilities.

Impacts of Program Activities on Existing Offshore and Coastal Infrastructure

Shell expects no impacts on land uses from its exploration drilling activities. Most activities associated with the program will take place at or near the drill sites that are more than 64 mi (103 km) offshore. Support vessel crews are expected to remain offshore for the duration of the drilling season.

- Temporary shorebase facilities will be located in Wainwright and Barrow for the planned exploration drilling activities. Temporary facilities are provided by local village corporations and will be located in previously developed areas that are not currently in use. There will be an expansion of the air support shorebase in Barrow to lease an additional 40-person accommodation. eas that have been previously developed. Shorebase facilities would therefore have minor effects on land use.

Impacts of Program Activities on Subsistence Activities

The following section addresses the potential effects of Shell's planned Chukchi Sea exploration drilling activities as described in EP Revision 2 on the subsistence activities and resources near the program areas in the Chukchi Sea, as well as the potential impacts on the subsistence activities of local residents.

Subsistence hunting and fishing were historically, and continue to be, an essential aspect of Iñupiat Native life, especially in rural coastal villages. The Iñupiat participate in subsistence hunting and fishing activities in and around the Chukchi Sea. The animals taken for subsistence provide a major portion of the food that will last the community through the year. Marine mammals represent on the order of 60 to 80 percent of the total subsistence harvest (Table 3.11.6-2). Other resources harvested in the marine environment include a number of species of fish and birds. The importance of the species (in terms of the number of animals or pounds harvested) varies from year to year and among the villages, but they are all essential species as hunting focus shifts with availability of the different resources (Figures 3.11.6-1 and 3.11.6-2). Along with the nourishment necessary for survival, the subsistence activities strengthen bonds within the culture, provide a means for educating the young, provide supplies for artistic expression, and allow for important celebratory events.

General Summary

Impacts to subsistence may be direct or indirect and include those which affect the subsistence user's activities or affect the subsistence resources. Reductions in subsistence resources and changes in subsistence resource distribution may impact subsistence users and their activities (MMS 2008a).

Sound energy and physical disturbance can impact subsistence resources and harvests without the implementation of appropriate mitigation measures. However, BOEM has determined that, with Shell's adherence to proposed mitigation, monitoring, communication, and response plans, short-term effects from drilling and air and vessel traffic on subsistence resources range from no effect to minor (BOEM 2011a).Shell's proposed drill sites are located 64 mi (103 km) to 126 mi (187 km) offshore of the coastline in the OCS. Review of available information on subsistence use areas (Figures 3.11.6-3 through 3.11.6-11) indicates that all of Shell's proposed drill sites are far offshore (seaward) of all identified subsistence use areas for the villages of Barrow, Wainwright, Point Lay, and Point Hope by at least 30 mi (48 km). It is therefore unlikely that offshore operations (exploration drilling and ice management) will have any direct or indirect impacts on subsistence activities. Potential indirect impacts from offshore operations on subsistence resources may occur, for example, from support aircraft Any such indirect impacts, however, are expected to be negligible, temporary and localized (Table 4.11-1).

Table 4.11-1 Effects of Shell's Exploration Drilling Program on Subsistence

Resource / Analyzed Activity	EP Revision 2
Subsistence (overall)	Negligible
From aircraft traffic	Negligible
From vessel traffic	Negligible
From drilling sound generation	Negligible
From ZVSP sound	Negligible
From air emissions	None
From drilling waste discharges	Negligible
From other permitted discharges	Negligible
Socioeconomics (overall)	Negligible
From shorebase expansion	Negligible
Minority/Lower Income Groups & Community Health	Negligible

4.11.1 Impacts of Aircraft Traffic on Subsistence

Aircraft traffic associated with the exploration drilling activities as described in EP Revision 2, which includes an increase in crew change helicopter flights between the prospect and Barrow could potentially affect subsistence by interrupting hunts or by displacing, deflecting, or otherwise affecting the behavior of subsistence resources. The effects of aircraft traffic on subsistence resources such as fish, marine birds, and marine mammals, as described above, are temporary and restricted to areas very near the aircraft, consisting of temporary displacement or deflection of their path of movement. Most potential effects on subsistence resources and therefore subsistence activities will be avoided or greatly reduced by implementation of a number of mitigation measures that have previously been successfully implemented by Shell, including:

- Vessels will not enter the Chukchi Sea until on or about July 1[11];
- All aircraft traffic will be communicated to and coordinated with subsistence users through a system of Com Centers, SAs, and Community Liaisons;
- Aircraft will not operate below and altitude of 1,500 ft (457 m) unless the aircraft is engaged in marine mammal monitoring, approaching, landing or taking off, in poor weather, or in an emergency situation; and
- Other procedures in Shell's Communication Plan.

The most important of these mitigation measures is the coordination of aircraft traffic through the system of Com Centers and SAs. Operational calls are held each morning and afternoon that are attended by the SAs, Com Center staff, and Shell operational and logistical staff. Current and expected subsistence activity types and locations are described by the SAs during these calls, and planned operational activities

[11] *See supra* note 2.

such as helicopter traffic are described by Shell staff. Adjustments to the timing and route of any pending aircraft traffic are made at this time to avoid any conflict with subsistence users to the extent practicable. With these measures, any potential effects of aircraft traffic on subsistence from activities associated with the exploratory drilling program as described in EP Revision 2 will be avoided; any effects that are not avoided will be short-term and negligible. Effects on specific subsistence hunts are discussed below.

Impacts of Aircraft Traffic on Bowhead Whale Hunting

According to BOEM, sound energy from aircraft could potentially cause some disruption to the bowhead whale harvest, but would not make the bowhead as a subsistence resource unavailable to subsistence users (MMS 2008a). Scientific evidence shows that bowhead whales may respond to low-flying aircraft, but generally exhibit no response to aircraft flying above 500 ft (150 m) (MMS 1987a, 1987b, 2008a). Bowhead whales may temporarily deflect from the sound source. These impacts are discussed above in Section 4.0.

Information from TK and statements from traditional subsistence users indicated the belief that whales can hear sounds at much greater distances and will modify their behavior for longer periods of time (MMS 2008a), resulting in potentially greater effects to the subsistence hunters.

Many Iñupiat hunters maintain that the bowhead whale is more sensitive than scientific equipment and thus can pick up sounds much farther away, and that they can hear sounds in the air as well as in the water. They state that bowhead whales flee loud sounds. For example, Barrow residents ask pilots not to fly over open leads and disturb the whales (MMS 2008a). Iñupiat hunters are concerned that increased oil and gas industry activity will disrupt current whale migration routes. They fear the bowhead may change their route to one much farther from shore (MMS 2008a).

Spring whaling by the Chukchi Sea villages is concluded prior to the dates when Shell's exploration drilling activities would commence (Tables 3.11.6-5 and 3.11.6-6). Barrow residents hunt bowheads in the fall (August to October) as well as the spring. Since 1994, Barrow fall bowhead harvests have taken place between 4 September and 23 October (Table 3.11.6-6). Most fall whaling by Barrow crews is conducted east of Barrow; however, whaling is conducted in the Chukchi Sea west of Barrow in some years (Suydam et al. 2008). Helicopters servicing offshore operations could therefore traverse areas utilized by Barrow whalers for fall whaling if the whaling were to be conducted in the Chukchi Sea (to the west of Barrow) rather than the Beaufort Sea (to the east of Barrow).

Crews from the village of Wainwright conducted fall whaling in 2010 and harvested the first fall whale in over 90 years. Wainwright whalers continued the fall hunt in 2011 to 2013 and have indicated they plan to continue fall whaling in the future. If fall whaling were to be conducted by Wainwright it would likely be during the time period of Shell's exploration drilling activities (Table 3.11.6-5). Helicopter flights could therefore potentially traverse areas where whaling might be conducted. However, the primary aircraft corridor (Barrow to Burger) does not traverse these areas, and the secondary corridors (Wainwright to Burger, Barrow to Burger) would only be used occasionally, as required due to weather (Figure 2.2-2).

As discussed in Section 4.8, helicopter traffic often evokes no response from bowheads, but the whales sometimes engage in hasty dives or abrupt turns (Richardson et al. 1985b, 1995a). Bowhead whales tend to be more sensitive in shallow water (Richardson et al 1985b). Any such behavioral responses would be momentary and have only a negligible effect on the subsistence resource and no effect on the subsistence activity. Flight path and altitude restrictions of 1,500 ft (457 m) would avoid or greatly minimize such potential impacts. Implementation of Shell's 4MP and POC (see Section 8.1), which includes the use of SAs and operation of Com Centers, is expected to further minimize or avoid impacts of aircraft traffic on marine mammals, particularly bowhead whale and their subsistence harvest. Given the remote location of Shell's proposed exploration drilling activities as in relation to subsistence hunting activities, and with the implementation of appropriate mitigation measures, Shell expects the impact to subsistence activities will be no more than negligible..

Impacts of Aircraft Traffic on Beluga Hunting

Helicopter traffic between the shorebase and offshore drill sites have the potential to cause some disruption of communal hunts for belugas by disturbing and altering the course of the whales, possibly rendering them more difficult to herd or harvest. Most of the beluga harvest by these villages occurs during spring whaling and in the first two weeks of July in Kasegaluk Lagoon, but some hunting continues through the summer in coastal lagoons. The spring hunt occurs before Shell's planned exploration drilling activities would commence, but Shell's operations would be on-going in July.

Helicopter traffic will be primarily between Barrow and the Burger Prospect along a prescribed direct route. This prescribed route does not traverse areas where belugas are commonly hunted, so little or no effect on this subsistence activity would be expected. Shell has established an alternative route to be used only in the event of adverse weather conditions along the primary route between Barrow and the drill sites. That alternative route could follow an onshore corridor to Wainwright and then offshore to the drill sites, a route that would traverse some areas where belugas are hunted by residents of Wainwright, Point Lay and Point Hope. Use of this alternative route could create some potential for disturbance of summer beluga hunts from associated helicopter traffic. However, flights between Wainwright and the drill sites would be only occasional.

Observed reactions of spring-migrating belugas have been variable. Belugas have been observed to react to helicopter overflights, but all of these effects would be temporary behavioral changes, occurring during the actual flight, and would not have any effect on the beluga population as a subsistence resource. Richardson et al. (1991, 1995b) reported that most spring-migrating belugas exhibited no overt response to helicopter overflights at altitudes of more than 500 ft (150 m), but some belugas exhibited responses such as turning or diving to helicopter flights as high as 1,500 ft (457 m) and within a distance of 700 ft (250 m) laterally. These studies indicate that any effects would be temporary and limited to a very small area along the helicopter flight path (Figure 2.2-2), and would be negligible, as the most important beluga hunts would be conducted prior to the drilling season. Such potential impacts are expected to be minimized or avoided due to flight path and altitude restrictions on aircraft and through implementation of Shell's POC (see, e.g., Section 8.1) and 4MP and other subsistence mitigation measures.

Aircraft will follow defined flight paths and maintain a regulated altitude, and all operations will be carried out consistent with Shell's POC and 4MP. These measures are expected to minimize or avoid impacts to beluga whales and the subsistence harvest. Shell will take all reasonable steps to minimize conflicts with subsistence hunting activities of the local residents. Part of this effort is addressed through the POC and the outreach and consultation actions Shell implements. This is a major component of Shell's effort to identify and address any impacts to subsistence activities. Given the remote location of Shell's proposed exploration drilling activities as in relation to subsistence hunting activities, and with the implementation of appropriate mitigation measures, Shell expects the impact to subsistence activities will be no more than negligible.

Impacts of Aircraft Traffic on Polar Bear Hunting

Polar bears are harvested throughout much of the year, but peak harvests are reported in May and December (USFWS 2013a). Polar bear are often harvested coincidentally with beluga and bowhead whale harvests. Most polar bear hunting typically occurs within 10 mi of the community and some bears are harvested within the village itself. Most polar bear harvests by Barrow residents occur in February and March (USFWS 2013a) and are often associated with other subsistence hunting activities (e.g., bowhead or beluga whales and seals) or where bears are considered to be a danger to the community or hunters.

As discussed in Section 4.8, polar bears exposed to aircraft may move away, show curiosity, or show no effect. Polar bears may exhibit avoidance behavior resulting in short-term and localized effects. This may disrupt some polar bear harvest activities, but will not likely affect annual harvest levels (MMS 2008a), especially given the conditions identified above when and where most polar bear hunting occurs. Implementation of Shell's POC will minimize or avoid the potential for aircraft traffic to impact polar bear or interfere with their subsistence harvest.

While sound energy from aircraft may impact this subsistence resource in a limited manner, it may impact the related subsistence activities to a greater extent. Subsistence hunters may view increased air traffic from Shell's activities and associated sound as disruptive and as imposing on their traditional subsistence areas. Shell will take all reasonable steps to minimize conflicts with subsistence hunting activities of the local residents. Part of this effort is addressed through the POC and the outreach and consultation actions Shell implements. This is a major component of Shell's effort to identify and address the perceived impacts to subsistence activities.

Aircraft will follow a defined flight path and maintain a regulated altitude. Shell will implement its POC. Shell will also implement a polar bear avoidance and interaction plan to prevent problems with human-bear interactions. These measures will minimize or avoid impacts on polar bears from Shell's air traffic. Aircraft already occupy the airspace throughout the North Slope for personal and commercial uses. The small scope of Shell's program and related air traffic will be a minimal addition to the existing conditions. Given the remote location of Shell's proposed exploration drilling activities as in relation to subsistence hunting activities, and with the implementation of appropriate mitigation measures, Shell expects the impact to subsistence activities will be no more than negligible.

Impacts of Aircraft Traffic on Seal Hunting

Impacts to seals and seal hunting activities from aircraft traffic will be negligible, temporary and localized. Sound energy from aircraft can disturb bearded, ringed, and spotted seals haul out on the ice and along the coast on beaches. Low-flying helicopters and fixed wing aircraft have often been observed to cause ringed and bearded seals to dive into the water, but this is not always the case (Burns and Harbo 1972; Burns and Frost 1979; Alliston 1981). Spotted seals hauled out on beaches have been observed to leave the beach and enter the water when survey aircraft flew at altitudes of 1,000 to 2,500 ft (305 to 760 m) or more came within 0.6 mi (1 km) (Frost and Lowry 1990; Frost et al. 1993; Rugh et al. 1993; Richardson et al. 1995a).

Subsistence hunters may view increased air traffic from Shell's activities and associated sound as disruptive and as imposing on their traditional subsistence areas. TK explain that intense sound startles, annoys, and can cause flight of seals.

Shell will take all reasonable steps to minimize conflicts with subsistence hunting activities of the local residents. Part of this effort is addressed through the POC and the outreach and consultation actions Shell implements. This is a major component of Shell's effort to identify and address the perceived impacts to subsistence activities.

Aircraft will follow defined flight paths and maintain a regulated altitude, and all operations will be carried out consistent with Shell's POC. These restrictions will minimize or avoid impacts to seals and the subsistence harvest of seals from Shell's aircraft traffic. Aircraft already occupy the airspace throughout the North Slope for personal and commercial uses. Helicopter traffic between the shorebase and the offshore drill sites would be minor due to the number of flights and the altitude at which flights occur. Further, most seal hunting is done during the winter and spring, not during the exploration drilling season when Shell will be active. Any effects on seals and subsistence hunts for seals will be negligible and temporary, lasting only minutes after the flight has passed. Given the remote location of Shell's proposed exploration drilling activities as in relation to subsistence hunting activities, and with the implementation of appropriate mitigation measures, Shell expects the impact to subsistence activities will be no more than negligible

Impacts of Aircraft Traffic on Walrus Hunting

As discussed in Section 4.8, helicopter and vessel traffic between the Burger Prospect and the shorebase could potentially disturb walruses or the walrus hunt. Fay et al. (1984) reported that walruses hauled out on the pack ice left the ice when helicopters approached within 1,300 to 2,000 ft (400 to 600 m) upwind or 3,300 to 5,900 ft (1,000 to 1,800 m) downwind of the animals. Brueggeman et al. (1990) reported on the reactions of walruses to overflights of a fixed-wing survey aircraft at an altitude of 1,000 ft (305 m) in the Chukchi Sea. Twelve percent of 34 walrus groups in the open ocean and 38 percent of the walrus groups observed on the pack ice reacted to the aircraft by diving or escaping into the water.

The primary aircraft corridor for helicopters servicing Shell's exploration drilling operations traverses some areas where Barrow residents hunt walruses. The secondary aircraft travel corridor traverses areas utilized by Wainwright residents to hunt walruses, but the frequency of travel along this route would be very low. Although a portion of the walrus harvest occurs in the spring prior to Shell's planned exploration drilling operations, some walrus hunting is conducted throughout the summer and could potentially be impacted by vessel and helicopter traffic servicing the offshore operations. All helicopter flights would be required to maintain an altitude of 1,500 ft (457 m) or more on these flights, which will minimize potential disturbance of walruses and any effects on walrus hunting. All operations will be conducted consistent with Shell's POC and 4MP. These measures will minimize or avoid impacts on walruses and subsistence walrus hunting. Any such effects would be temporary and negligible due to the small number of vessel and helicopter trips that would be undertaken. Given the remote location of Shell's proposed exploration drilling activities as in relation to subsistence hunting activities, and with the implementation of appropriate mitigation measures, Shell expects the impact to subsistence activities will be no more than negligible.

Impacts of Aircraft Traffic on Bird Hunting

Helicopter traffic between the shorebase and offshore drill sites, and fixed wing aircraft traffic between the shorebase and regional hub airports, could potentially disturb birds and therefore subsistence hunts for birds during the summer and fall, but these effects are anticipated to be minor due to the small number of flights and the altitude at which flights typically occur.

As discussed in Section 4.6.1, aircraft traffic may cause some disturbance to both onshore and offshore birds, resulting in displacement of small numbers of birds from preferred habitat and induced stress to birds, potentially resulting in impacts to subsistence bird hunting and egg collection. Any such impacts would be negligible and temporary. Shell does not anticipate long-term impacts to subsistence bird hunting and egg collection due to aircraft associated with this program. Aircraft traffic may cause short-term impacts to subsistence hunting and egg collecting.

Stress from aircraft overflights on molting birds can make it difficult for birds to maintain or acquire sufficient nutrients for subsequent migration to staging areas (Taylor 1993). Aircraft, especially helicopters, may cause the most intense responses (Bélanger and Bédard 1989 cited in Miller 1994), and birds do not habituate well to small low-flying aircraft (Owens 1977). Aircraft may disturb birds, but are not anticipated to directly lead to mortality. However, loss of eggs and young from predators may occur when parent birds are displaced (MMS 2008a). Therefore, aircraft may impact bird resources during exploration drilling activities, but impacts should not extend to following years.

Because birds are important food sources, Iñupiat interpret harm to birds as a threat to subsistence and their livelihood (MMS 2008a). While aircraft sound may impact this subsistence resource in a limited manner, it may impact the related subsistence activities to a greater extent. Subsistence hunters may view increased air traffic from Shell's activities and associated sounds as disruptive and as imposing on their traditional subsistence areas.

Shell will take all reasonable steps to minimize conflicts with subsistence hunting activities of the local residents. Part of this effort is addressed through the POC and the outreach and consultation actions Shell implements. This is a major component of Shell's effort to identify and address the perceived impacts to subsistence activities.

Given the remote location of Shell's proposed exploration drilling activities as in relation to subsistence hunting and gathering activities, and with the implementation of appropriate mitigation measures, Shell expects the impact to subsistence activities will be no more than negligible.

Impacts of Aircraft Traffic on Land Mammal Hunting

Aircraft traffic associated with Shell's exploration drilling activities would be expected to have little to no impact on land mammals or the subsistence hunting of land mammals. Caribou is the most important land mammal subsistence resource in the coastal Chukchi Sea villages. Caribou are found in coastal habitats in the summer, and are known to utilize beach habitats to minimize harassment by insects, and caribou hunting is conducted in coastal areas. Helicopter traffic could therefore potentially disturb caribou in these areas and therefore subsistence hunts for caribou. Observed caribou responses to helicopter overflights have varied from no response to running away.

The BOEM states that although no effects are expected, subsistence resources could be rarely but periodically affected, but there would be no apparent effect on subsistence harvests (BOEM 2011a). Subsistence hunters may view increased aircraft traffic as disruptive and the aircraft as imposing on their traditional subsistence areas. They may avoid areas in which they can see and hear aircraft traffic. Planned helicopter flights will be conducted along a direct route from the Barrow Airport to the drill sites and would therefore not traverse any areas utilized for caribou hunting. However, helicopter flights along the secondary flight corridor from Barrow to the prospect (Barrow-Prospect, Figure 2.2-2) overland does traverse areas used by caribou and caribou hunters. Alternate routes located offshore have been designated and will be used to avoid such impacts. Routes will be considered and selected on up to a twice-daily basis after conference with SAs. Shell's mitigation measures require a minimum altitude of 1,500 ft (457 m), which should minimize any potential effects. Any effect on caribou and caribou hunting would be temporary, lasting only minutes after the helicopter flight.

Shell will take all reasonable steps to minimize conflicts with subsistence hunting activities of the local residents. Part of this effort is addressed through the POC and the outreach and consultation actions Shell implements. This is a major component of Shell's effort to identify and address the perceived impacts to subsistence activities. Given the remote location of Shell's proposed exploration drilling activities as in relation to subsistence hunting activities, and with the implementation of appropriate mitigation measures, there will only be a negligible effect on subsistence resources and no effect on subsistence activities.

Impacts of Aircraft Traffic on Fishing

Aircraft traffic will have no impact on the availability of subsistence fish resources or subsistence fishing.

Conclusion

With the implementation of Shell's mitigation measures, potential effects of aircraft traffic on subsistence from activities associated with the exploratory drilling program as described in EP Revision 2 are expected to be avoided; any effects that are not avoided will be short-term. It is possible that the resources may be periodically affected, but such impacts are expected to have no impact on subsistence harvests. Therefore, aircraft traffic is expected to have a negligible impact on subsistence.

4.11.2 Impacts of Vessel Traffic on Subsistence

Shell's Burger Prospect drill sites as described in EP Revision 2 are located over 78 mi (126 km) from the nearest village, 64 mi (103 km) offshore of the coastline (Table 3.0-1) and more than 30 mi (48 km) from areas known to be used for subsistence (Figure 3.11.6-11). Vessel locations, travel routes, and the frequencies and durations of vessel trips are provided in Table 2.2-4. Primary vessel transit corridors are indicated in Figure 2.2-1. Most, but not all, of the vessel traffic associated with the exploration drilling activities will take place in Federal waters near the EP blocks in and around the Burger Prospect, between the prospect and Dutch Harbor, and between the prospect and the OSR vessels. These areas are well offshore of areas where subsistence activities are known to be conducted. Under normal circumstances, the vessels that would be expected to operate within areas used for subsistence include the nearshore OSR tug and barge, OSR workboats, the shallow water vessels, and other vessels that are lightering crews or supplies to the shallow water vessels. Trips in these areas are expected to be infrequent.

Vessel traffic could potentially affect subsistence by interrupting hunts or by displacing, deflecting, or otherwise affecting the behavior of subsistence resources. The effects of vessel traffic on subsistence resources such as fish, marine birds, and marine mammals, are temporary and restricted to areas very near the vessel, consisting of temporary displacement or deflection of their path of movement. Shell will implement a number of mitigation measures to minimize any such effects from vessels that travel within areas where subsistence occurs, including:

- Vessels will not enter the Chukchi Sea until on or about July 1[12];
- All vessel traffic will be communicated to and coordinated with subsistence users through a system of Com Centers, SAs, and Community Liaison Officers (CLOs); and
- Other procedures in Shell's Communication Plan.

With these measures, Shell expects the impact of vessel traffic on subsistence activities will be no more than negligible. Effects on specific subsistence hunts are discussed below.

<u>Impacts of Vessel Traffic on Bowhead Whale Hunting</u>

Residents of Barrow, Wainwright, and Point Hope hunt bowheads during the spring migration. Point Lay began hunting bowheads in the spring of 2008. Spring hunts are conducted in open leads in the ice typically from late March or early April until the first week of June. Shell's operations will commence in July when these spring hunts are over so the exploration program would have no impact on whaling subsistence activities.

In the recent past, residents of Wainwright have been prevented from conducting successful fall whaling by weather (wind / waves) or the location of the migrating bowheads being too far offshore. However, Wainwright crews conducted fall whaling in 2010, and harvested the first fall bowhead by the northeastern Chukchi Sea villages in over 90 years (Table 3.11.6-4 and Table 3.11.6-5). The whale was harvested offshore of Point Franklin north of Wainwright. Wainwright residents subsequently conducted fall hunts in 2011 and 2012, and have expressed interest in continuing fall whaling efforts in the future. Barrow residents also hunt bowheads in the fall; since 1994 Barrow fall bowhead harvests have taken place between 4 September and 23 October (Table 3.11.6-6). Almost all of this fall hunting is conducted east of Barrow; however, some whaling is occasionally conducted in the Chukchi Sea west of Barrow (Suydam et al. 2008).

Vessel traffic associated with the exploration drilling activities as described in EP Revision 2 includes an increase in re-supply trips, contingency vessel crew changes between the prospect and Barrow, and a

[12] *See supra* note 2.

general increase in vessel traffic associated with the increase in number of support vessels. The additional re-supply trips will occur between the prospect and Dutch Harbor and will therefore be located more than 60 mi (97 km) west and more than 30 mi (48 km) offshore of areas known to be used for the fall bowhead hunts. Because bowheads are migrating generally in an east to west direction during the fall, and the vessel corridors are located west of areas commonly used by Barrow fall whaling crews, any effects on bowhead behavior or movements would have no impact on Barrow’s fall whaling. Primary vessel corridors are well offshore of areas used by Wainwright whaling crews in the fall. The contingency vessel crew change will occur in or near areas where whaling occurs. Shell's mitigation measures include a system of SA, CLOs, and Com Centers that will be established and utilized on a daily basis to coordinate and modify vessel traffic based on current or anticipated subsistence activities to avoid any effects from vessel traffic on fall whaling. Given the remote location of Shell’s proposed exploration drilling activities as in relation to subsistence hunting activities, and with the implementation of appropriate mitigation measures, Shell expects the impact to subsistence activities will be no more than negligible.

Impacts of Vessel Traffic on Beluga Whale Hunting

Beluga are occasionally hunted by Barrow residents in coastal waters during July and August, primarily after the spring bowhead hunt, but beluga represented only about 0.5 percent of the total Barrow subsistence harvest from 1962 to 1982. Local hunters reported that belugas have not been commonly hunted by Barrow residents in recent years (Sound Enterprises and Associates 2008). Wainwright residents are similarly reluctant to hunt beluga during the spring as it might disrupt the bowhead hunt, but they do hunt for beluga in spring leads when bowheads are not present and also during July and August in coastal waters.

The beluga is a more important subsistence resource to Point Lay residents based on the weight of meat harvested. The Point Lay beluga hunt is concentrated in the first two weeks of July (but sometimes continues into August), when belugas are herded by hunters with boats into Kasegaluk Lagoon and harvested in shallow waters. Point Hope hunters primarily harvest beluga in conjunction with spring bowhead hunts in late March and early June, but continue to hunt them in open water along the coast from late July through early September. Beluga harvests by Chukchi Sea villages are presented in Table 4.11.2-1.

Table 4.11.2-1 Beluga Harvests - Barrow, Wainwright, Point Lay and Point Hope

Year [1]	Number of Belugas Harvested by Village by Year			
	Barrow	Wainwright	Point Lay	Point Hope
1990	0	0	62	16
1991	1	5	35	39
1992	0	20	24	15
1993	2	0	77	79
1994	5	0	56	53
1995	0	0	31	40
1996	2	0	41	15
1997	8	4	3	32
1998	1	38	48	52
1999	1	3	47	33
2000	1	0	0	16
2001	1	23	34	24
2002	1	37	47	23
2003	2	38	36	34
2004	1	0	53	29
2005	7	1	41	11
2006	1	0	29	0
2007	ND 2	ND	ND	ND
2008	10	25	48	34

Table 4.11.2-1 Beluga Harvests - Barrow, Wainwright, Point Lay and Point Hope

Year [1]	Number of Belugas Harvested by Village by Year			
	Barrow	Wainwright	Point Lay	Point Hope
2009	2	22	28	11
2010	2	9	23	62
2011	7	10	22	32
2012	7	34	14	84
average	3	12	35	32

[1] Source: 1990-2004 data from MMS 2007b citing Alaska Beluga Whale Committee 2002, 2006; Fuller and George 1997; Lowry et al. 1989; Burns and Frost 1979; Impact Assessment, Inc. 1989; Burns and Seaman 1986; and Braund and Burnham 1984; 2005-2006 data from Frost and Suydam 2010; 2008-2012 data from provided by Alaska Beluga Whale Committee

[2] ND is no data

According to the MMS (2008a), sound energy from vessel traffic could cause brief disruption to beluga whale harvest but does not make the resource unavailable to subsistence users. Beluga whales respond differentially to vessel sound energy, but temporary and localized sound energy from vessels should cause only brief disturbances to the whales. These disturbance effects have durations of one day or less (MMS 2008a). While vessel traffic may impact beluga whale as a subsistence resource in a limited manner, it could potentially impact the related subsistence activities to a greater extent. Subsistence hunters may view increased vessel traffic from Shell’s activities and associated sound as disruptive and the vessels as imposing on their traditional subsistence areas. They may avoid areas in which they can see and hear vessel traffic.

Vessel traffic associated with Shell’s exploration program includes re-supply trips, contingency vessel crew changes between the prospect and Barrow, and general vessel traffic associated with the support vessels. The re-supply trips will occur between the prospect and Dutch Harbor and will therefore be located more than 60 mi (97 km) west and more than 30 mi (48 km) offshore of areas known to be used for the beluga hunts. Additionally, the drilling units and support vessels will not enter the Chukchi Sea until on or about 1 July, which is after much of the beluga harvests in Point Hope and Wainwright takes place. The contingency vessel crew change will occur in or near areas where some hunting for belugas by Barrow residents may occur. Shell's mitigation measures include a system of SAs, CLOs, and Com Centers that will be established and utilized on a daily basis to coordinate and modify vessel traffic based on current or anticipated subsistence activities to avoid any effects on beluga hunting. Implementation of Shell’s 4MP is expected to further minimize or avoid impacts of vessel traffic on marine mammals, including belugas; thus vessel traffic associated with the exploration drilling activities as described in EP Revision 2 will have little effect on the availability of beluga to subsistence hunters (MMS 2008a) or on the hunt. Given the remote location of Shell’s proposed exploration drilling activities as in relation to subsistence hunting activities, and with the implementation of appropriate mitigation measures, Shell expects the impact to subsistence activities will be no more than negligible.

Impacts of Vessel Traffic on Polar Bear Hunting

Polar bear are hunted for their meat and pelts. Polar bear subsistence hunts occur in the fall and winter anywhere between September and April depending on the region. In general, polar bear are hunted along the coast, rarely more than two miles offshore. Shell anticipates minimal to no impact to subsistence polar bear hunting. Polar bears react little to vessels because they do not stay long in the open water (MMS 2008a). When they do react, polar bears show a range of behavior responses to vessel traffic from curiosity to avoidance. MMS (2008a) has concluded that vessel traffic associated with oil and gas exploration would not change the availability of polar bears as a subsistence resource.

Polar bears are harvested throughout much of the year, but peak harvests reported in May and December (USFWS 2013a). They are often harvested coincidentally with beluga and bowhead whale harvests. Most polar bear hunting typically occurs within 10 mi (16.1 km) of the community and some bears are harvested within the village itself. Most polar bear harvests by Barrow residents occur in February and March (USFWS 2013a) and are often associated with other subsistence hunting activities (e.g., bowhead or beluga whales and seals) or where bears are considered to be a danger to the community or hunters. They are generally on ice or on land. These conditions greatly limit any opportunity for vessel traffic associated with Shell's exploration drilling activities to impact polar bear hunting.

Shell will take all reasonable steps to minimize conflicts with subsistence hunting activities of the local residents. Part of this effort is addressed through the POC and the outreach and consultation actions Shell implements. This is a major component of Shell's effort to identify and address the perceived impacts to subsistence activities. With these mitigation measures in place, and given the location and timing of most polar bear hunts, no impact on polar bear hunting would be expected from vessel traffic associated with the exploration drilling activities as described in EP Revision 2.

Impacts of Vessel Traffic on Seal Hunting

Seals are an important subsistence resource as evidenced by 1962 to 1982 harvest data summarized in Tables 3.11.6-3, 4.11.2-2, and 4.11.2-3. Ringed seals make up the bulk of the seal harvest. Most ringed and bearded seals are harvested in the winter or in the spring before Shell's exploration drilling activities would commence, but some harvest continues into the open water period and could possibly be affected by Shell's planned activities. Spotted seals are also harvested during the summer.

Table 4.11.2-2 Chukchi Sea Subsistence Harvest of Hair Seals 1962-1982

Village	Average Annual Harvest[1]	Percent Total Harvest[1]	Timing of the Harvest
Barrow	955 seals	4.3 %	October through June, peak in February-March (ringed seals) Open water period (spotted seals)
Wainwright	375 seals	4.4 %	Most intensively May to July (ringed seals) Open water period (spotted seals)
Point Lay	--	--	Most intensively April to June (ringed seals) Open water period (spotted seals)
Point Hope	1,400 seals	14.8 %	Available October to June, most in November to March peak in February (ringed seals)

[1] Source ACI and SRBA 1984

Table 4.11.2-3 Chukchi Sea Subsistence Harvest of Bearded Seals 1962-1982

Village	Average Annual Harvest	Percent Total Harvest	Timing of the Harvest
Barrow	150 seals	2.9 %	During spring whaling, and in open water
Wainwright	250 seals	12.3 %	Most intensively May to July
Point Lay	2 to 10 seals	--	Peak in June to August, peak in June
Point Hope	200 seals	8.9 %	Peak in May and June

[1] Source ACI and SRBA 1984

Potential effects of Shell's planned exploration drilling activities as described in EP Revision 2 on bearded, ringed, and spotted seals are discussed above. Ringed seals in particular appear to be relatively tolerant of vessels and ice-breaking. For example, Brewer et al. (1993) and Hall et al. (1994) reported that ringed seals were often observed apparently feeding in the wake of icebreakers associated with exploration drilling in the Beaufort. Kanik et al. 1980 as cited in Richardson et al. 1995a reported that ringed seals remained on the ice unless icebreakers approached within 0.6 mi (1.0 km) of the seals. Brueggeman et al. 1992a as cited in Richardson et al. 1995a similarly noted that ringed and bearded seals tended to remain on the ice until the vessel came within 0.58 mi (0.93 km) when they would dive into the water. Any such effects from the planned activities would be minor behavioral effects and temporary lasting only minutes or hours after the activity ceased. Alliston (1980, 1981 as cited in Richardson et al. 1995a) found the distribution and density of ringed seals was the same in the year following icebreaking activities in study sites in the Beaufort and off the coast of Labrador. According to BOEM, vessel traffic should not cause long-term effects to seal distribution or availability for subsistence use (MMS 2008a).

The lease blocks where Shell's exploration drilling activities will occur are located more than 64 mi (103 km) offshore and more than 30 mi (48 km) offshore from any subsistence use areas, so activities within the Burger Prospect would have no impact on subsistence hunting for seals. Vessel traffic may cause temporary displacement of bearded, ringed, and spotted seals hauled out on the ice or on beaches, as wells as those feeding and swimming in the water (MMS 2008a). However, most vessel traffic associated with the exploration program will take place offshore of areas where seal hunting takes place. The increase in re-supply trips will take place along corridors that are more than 30 mi (48 km) offshore of areas known to be used when hunting seals. The contingency vessel crew change through Barrow will occur in or near areas where some hunting for seals by Barrow residents occurs. As part of its mitigation plan, Shell will establish and utilize a system of SA, CLOs, and Com Centers on a daily basis to coordinate and modify vessel traffic based on current or anticipated subsistence activities to avoid any effects on subsistence including seal hunting. The implementation of Shell's 4MP and POC is expected to further minimize or avoid impacts on seal species; thus, vessel traffic associated with the exploration drilling activities as described in EP Revision 2 will have little effect on the availability of seals to subsistence hunters or the hunt. Given the remote location of Shell's proposed exploration drilling activities as in relation to subsistence hunting activities, and with the implementation of appropriate mitigation measures, Shell expects the impact to subsistence activities will be no more than negligible .

Impacts of Vessel Traffic on Walrus Hunting

The walrus is an important subsistence resource as evidenced by harvest data summarized below in Tables 3.11.6-3, 4.11.2-4 and 4.11.2-5, and is especially significant to residents of Wainwright. Walruses are harvested by Barrow residents in conjunction with the spring bowhead hunt in the Chukchi Sea from Point Barrow to Peard Bay, but the primary effort occurs from late June to mid-September with a peak in August. Wainwright residents hunt walruses in July to August along the retreating ice pack but occasionally harvest walruses that are hauled out on the beaches in late August and September. Point Lay residents harvest most of their walruses from the end of June through July, but continue to harvest them into August north of the village. Point Hope residents harvest walruses primarily along the ice in June but also hunt walruses that are hauled out along the shore from boats throughout the summer.

Table 4.11.2-4 Chukchi Sea Walrus Subsistence Harvest 1962-1982

Village	Average Annual Harvest [1]	Percent Total Harvest	Timing of the Harvest
Barrow	55 walruses	4.6 %	June to mid-September, peak in August
Wainwright	86 walruses	18.5 %	July to September, peak in July to August
Point Lay	10 to 15 walruses	--	Late June to August, peak in late June and July
Point Hope	15 walruses	2.9 %	Peak in June to early July, by boat throughout summer

[1] Source ACI and SRBA 1984

Table 4.11.2-5 Walruses Harvested by Barrow, Wainwright, Point Lay, Point Hope 1991-2005

Year	Barrow [1]	Wainwright [1]	Point Lay [1]	Point Hope [1]
1991	23	32	0	0
1992	23	48	0	5
1993	27	44	1	5
1994	16	68	1	6
1995	12	83	4	0
1996	13	24	4	0
1997	48	50	0	3
1998	24	69	7	5
1999	17	48	8	5
2000	19	36	6	6
2001	37	94	3	2
2002	39	119	11	16
2003	51	29	9	12
2004	52	47	5	20
2005	5	21	5	0
average	27	54	4	6

[1] Source: USFWS Tagging Database cited in MMS 2008a

Although a portion of the walrus harvest occurs in the spring prior to Shell’s planned exploration drilling operations, some walrus hunting is conducted throughout the summer and could potentially be impacted by vessel traffic associated with the exploration drilling activities as described in EP Revision 2. The increase in re-supply trips will take place along corridors that are more than 30 mi (48 km) offshore of areas known to be used when hunting walruses. The contingency vessel crew change will occur in or near areas where some hunting for walruses by Barrow residents likely occurs. However, Shell will establish and utilize a system of SAs, CLOs, and Com Centers on a daily basis to coordinate and modify vessel traffic based on current or anticipated subsistence activities to avoid any effects on subsistence including walrus hunting. Given the remote location of Shell’s proposed exploration drilling activities as in relation to subsistence hunting activities, and with the implementation of appropriate mitigation measures, Shell expects the impact to subsistence activities will be no more than negligible.

Impacts of Vessel Traffic on Bird Hunting and Egg Collection

Coastal and marine birds are harvested by residents of all four villages. They compose a small (2 to 5 percent) but important part of the total subsistence harvest (ACI et al. 1984). Harvests occur throughout the spring, summer, and fall, both inland and in or adjacent to coastal waters, and often in conjunction with hunts for marine mammals.

Vessel traffic associated with Shell’s exploration drilling activities as described in EP Revision 2 will have no or only a negligible effect on birds, and therefore only negligible impacts of bird hunting. Vessel traffic has the potential to disturb (flush) birds, but the effects on the birds would be minor and temporary. The increase in re-supply trips will take place along corridors that are more than 30 mi (48 km) offshore of areas known to be used when hunting waterfowl and seabirds. The contingency vessel crew change will occur in or near areas where some hunting for birds by Barrow residents occurs, but much of the spring waterfowl hunting by Barrow is conducted in conjunction with spring marine mammal hunts would take place before exploration drilling activities commence, and therefore could not be affected. As part of its mitigation plan, Shell will establish and utilize a system of Subsistence Advisors, CLOs, and Com Centers on a daily basis to coordinate and modify vessel traffic based on current or anticipated subsistence activities to avoid any effects on subsistence including bird hunting. Given the remote location of Shell’s proposed exploration drilling activities as in relation to subsistence hunting activities, and with the implementation of appropriate mitigation measures, Shell expects the impact to subsistence activities will be no more than negligible.

Impacts of Vessel Traffic on Fishing

Fish play an important dietary role in the North Slope subsistence system. Fish generally represent the second or third most important subsistence resource depending on the community (MMS 1991 citing ACI and SRBA 1984). Marine and diadromous fish commonly harvested for subsistence in the villages include pink and coho salmon, char, Bering cisco, humpback whitefish, broad whitefish, rainbow smelt, capelin, Pacific cod, saffron cod, Arctic cod, Bering flounder and Arctic flounder.

Subsistence fishing is not known to be carried out in the offshore waters where most vessel traffic associated with Shell's exploration drilling activities will occur. Most fishing by Barrow residents is conducted at inland fish camps and would be unaffected by the exploration drilling program, but coastal fishing can be important and takes place in three areas near Barrow, along the Chukchi Sea coast from Barrow south to Walikpa Bay, inside Elson Lagoon on the Beaufort coast, and along the barrier islands of Elson Lagoon (Craig 1989b). Marine fishing occurs along the Chukchi Sea shoreline just west of Barrow. Marine fishing is conducted with gill nets and by jigging, with the primary species harvested including whitefishes and least cisco. Other species include capelin, char, salmon, and cod. Fishing along the Chukchi Sea coast takes place mostly in the spring and summer in conjunction with hunts for waterfowl and marine mammals.

The re-supply trips as described in EP Revision 2 will take place along corridors that are more than 30 mi (48 km) offshore of areas known to be used for fishing. The contingency vessel crew change will occur in or near coastal areas where some fishing by Barrow residents occurs. Potential effects will be negligible, as these vessel trips are for contingencies only, and would therefore be limited in frequency; little if any vessel traffic would be expected to occur in these fishing areas. Effects on fish and subsistence fishing associated with the Shell's exploration drilling activities as described in EP Revision 2 will be negligible.

Conclusion

With the implementation of Shell's mitigation measures, potential effects of vessel traffic on subsistence from activities associated with the exploratory drilling program as described in EP Revision 2 are expected to be minimal. Therefore, vessel traffic is expected to have no more than a negligible impact on subsistence activities.

4.11.3 Impacts of Drilling Sound Generation and Ice Management on Subsistence

Sound energy generated by exploration drilling and ice management could potentially impact subsistence users and their activities by impacting the subsistence resources upon which they depend. However, Shell does not expect sound energy generated by exploration drilling or ice management sound associated with this program to result in impacts on subsistence activities. Shell's planned drill sites where exploration drilling and most ice management would occur are located over 64 mi (103 km) offshore and more than 30 mi (48 km) from areas known to be used for subsistence. The duration of the impacts would last only as long as the planned exploration drilling and ice management activities occur.

The presence or absence of pack ice in the area cannot be predicted at this time. During historic exploration drilling in the Chukchi Sea, ice was present in some years and not in others, with many more marine mammals being found in the Burger Prospect when ice was near. If pack ice is located within 10 to 20 mi (16 to 32 km) of the drilling unit, more marine mammals would likely be affected. Ice management would occur in the area of the Burger Prospect, located more than 30 mi (48 km) from subsistence areas.

Residents from Barrow regularly note that whales and other marine mammals are sensitive to sound. They assert past seismic and drilling activities affected marine mammals' behaviors; often resulting in subsistence hunters traveling farther offshore to hunt (MMS 2008a; AES-RTS 2009). Additionally, whaling captains have noted that some whales become skittish, harder to approach, and thus harder to hunt (MMS 2008a). While species-specific sound thresholds of signal characteristics and distance have not been established, BOEM has concluded that past industry mitigation measures effectively limit the effects to marine mammals.

The degree of potential impacts to subsistence users and activities vary depending on the subsistence resource, when it is harvested, and where it is harvested. Sound energy has the potential to impact whaling, seal hunting, bird hunting and egg collection, and fishing in the open water season. Additionally, if exploration drilling and ice management sound energy impacts the behavior, population, or distribution of any subsistence resources, the associated subsistence activity(ies) or user(s) would be impacted (MMS 2008a). Such impacts are largely avoided with respect to the exploration drilling and ice management activities associated with Shell's program due the timing and location of the program.

Bowhead Whale Hunting

Exploration drilling and ice management sound energy is not expected to extensively impact bowhead whales and will not impact bowhead whale hunting. Spring bowhead whale hunts will be complete before the exploration drilling season commences, and Barrow's fall hunt will occur before fall-migrating bowhead whales approach the area of exploration drilling activities. Bowhead whale hunting by residents of the Chukchi Sea villages (Wainwright, Point Lay, and Point Hope) has historically occurred in the spring before exploration drilling operations would commence. However, fall hunting has occurred recently. All exploration drilling and most ice management activities will occur over 64 mi (103 km) from shore, and more than 30 mi (48 km) from areas where bowheads are hunted, and this distance is greater than reported distances for disturbance reactions or deflection by bowheads. Exploration drilling sound energy has not been shown to block or impede bowhead whale migration even in narrow ice leads (Davis 1987; Richardson et al. 1991). The potential effects of Shell's planned exploration activities on bowhead whales are discussed in detail in Section 4.8.4.

Beluga Whale Hunting

Sound energy from exploration drilling may result in beluga whale avoidance of the vicinity of the drilling unit; ice management, if required, would likely result in avoidance of a larger area. However, exploration drilling, ice management, and associated activities in the offshore waters of Shell's Burger Prospect should have no effect on the beluga hunt as the activities would be conducted over 64 mi (103 km) offshore. Most beluga hunting is conducted in the spring in conjunction with the spring bowhead whale hunts and would occur before exploration drilling would commence. The important beluga hunts in Kasegaluk Lagoon occur through the first two weeks in July when exploration drilling could take place but exploration drilling and ice management would be undertaken at locations more than 60 mi (97 km) from areas typically hunted. Therefore Shell does not expect any impacts to beluga whale hunting from sound energy generated by the planned exploration drilling and ice management activities in the Chukchi Sea. The potential effects of Shell's planned exploration drilling activities on beluga whales are discussed in detail in Section 4.7.

Iñupiat hunters and TK assert that sound affects beluga whales and may cause the whales to leave an area for the long-term. Hunters conduct themselves quietly when hunting beluga, even going as far as using hand signals to communicate. Beluga are said to have an excellent hearing ability and can identify and remember individual outboard motor boats. Some Iñupiat worry that beluga will remember sounds in an area from one year and avoid that area in following years (MMS 2008a).

Shell will take all reasonable steps to minimize conflicts with subsistence hunting activities of the local residents. Part of this effort is addressed through the POC and the outreach and consultation actions Shell implements. This is a major component of Shell's effort to identify and address the perceived impacts to subsistence activities.

Given the remote location of Shell's proposed exploration drilling activities as in relation to subsistence hunting activities, and with the implementation of appropriate mitigation measures, Shell expects the impact to subsistence activities will be no more than negligible.

Polar Bear Hunting

Shell anticipates minimal to no impact on polar bears and subsistence polar bear hunting from the sound energy of exploration drilling and ice management. Polar bears likely react little to exploration drilling and ice management because they do not stay long in the open water (MMS 2008a). When they do react, polar bears show a range of behavior responses to vessel traffic – from curiosity to avoidance (see Section 4.8.2). Any impact to the hunt is expected to be short-term and localized. BOEM does not expect change in polar bear availability due to vessel traffic (MMS 2008a). Implementation of Shell's 4MP will further minimize or avoid impacts to polar bear or the subsistence harvest of polar bear.

While ice management and exploration drilling are unlikely to impact the polar bear as a subsistence resource, they may impact the related subsistence activities. Subsistence hunters may view Shell's activities and associated sound as disruptive and as imposing on their traditional subsistence areas.

Shell will take all reasonable steps to minimize conflicts with subsistence hunting activities of the local residents. Part of this effort is addressed through the POC and the outreach and consultation actions Shell implements. This is a major component of Shell's effort to identify and address the perceived impacts to subsistence activities.

Impacts to polar bear and their habitat will be minimal and have little effect on their habits and behavior. The short duration of the program and its location offshore will have little impact on this resource or polar bear hunting.

Seal Hunting

Shell expects limited impact to seals and no impact to seal hunting from exploration drilling and ice management. Temporary and localized impacts to seals, limited to avoidance and flushing, may occur near the activity, but these impacts will be minimized or avoided by implementation of Shell's 4MP. All exploration drilling and most ice management would take place over 64 mi (103 km) offshore and more than 30 mi (48 km) from any areas known to be used for subsistence hunting. Modeling indicates that sound levels generated by exploration drilling or ice management that could result in disturbances to seals would be limited to the area within about 264 ft (80 m) of the drilling unit.

Shell will take all reasonable steps to minimize conflicts with subsistence hunting activities of the local residents. Part of this effort is addressed through the POC and the outreach and consultation actions Shell implements. This is a major component of Shell's effort to identify and address the perceived impacts to subsistence activities. Given the remote location of Shell's proposed exploration drilling activities as in relation to subsistence hunting activities, and with the implementation of appropriate mitigation measures, Shell expects the impact to subsistence activities will be no more than negligible.

Walrus Hunting

Walruses exhibited little or no response to drilling and drilling units during past exploration drilling programs. The animals were, however, observed to respond to the approach of icebreakers and other large support vessels, often reacting by avoiding the vessels when they are at a distance of about 0.25 mi (0.46 km) (Brueggeman et al. 1990, 1991a). Icebreaking created a larger disturbance area, with walruses moving back into the ice floes sometimes as far as 10.8 to 13.5 mi (20 to 25 km) and redistributing themselves in a more clumped pattern. These effects on walruses would be minor, having no real effect on the walrus population as a subsistence resource, and would be temporary, with walrus distribution and behavior normalizing shortly after ice-breaking is completed or the vessel has moved on.

Shell's exploration drilling and ice management activities, and most associated vessel traffic, would be conducted at or near the drill sites more than 64 mi (103 km) offshore and over 30 mi (48 km) from any mapped subsistence use areas. Implementation of Shell's 4MP is expected to further mitigate any impacts on walruses and walrus hunting. Activities within the Burger Prospect would therefore have no more than a negligible impact on subsistence hunting for walruses.

Caribou Hunting and Other Land Mammals

All exploration drilling and most ice management activities will occur far offshore, over 64 mi (103 km) from the nearest coastline. Sound energy from these distant activities will have no impact on land mammals or the hunting of land mammals, including caribou present on the coast.

Fishing

Sound energy from exploration drilling and ice management is expected to have no effect on subsistence fishing activities and fish resources. Sound energy from these activities may impact fish temporarily and in a localized manner, limited to avoidance. Some fish may exhibit avoidance behavior in the area near the drilling unit and around ice management vessels in transit and during ice management. Any avoidance reactions will last only minutes. See Section 4.5.2 for a more detailed discussion. Such impacts will occur far offshore, over 78 mi (126 km) from coastal villages and traditional fishing grounds (MMS 1987a). Thus, Shell expects little to no impacts to subsistence fishing activities.

Some local residents worry that sounds from exploration drilling and other sources will impact fish and subsistence fishing. Some local residents have expressed concern that vessel traffic (whether oil industry, barges, or others) may have negative impacts to fish resources and thus to the subsistence way of life (MMS 2008a). Shell will take all reasonable steps to minimize conflicts with subsistence hunting activities of the local residents. Part of this effort is addressed through the POC and the outreach and consultation actions Shell implements. This is a major component of Shell's effort to identify and address the perceived impacts to subsistence activities. Given the remote location of Shell's proposed exploration drilling activities as in relation to subsistence fishing activities, and with the implementation of appropriate mitigation measures, Shell expects the impact to subsistence activities will be no more than negligible.

Bird Hunting and Egg Collection

Based on studies on seismic survey effects, Shell anticipates only negligible to minor impacts to birds resulting from sound energy from exploration drilling and ice management. No impacts to the subsistence harvest of birds and egg collection likewise are expected due to sound energy generated by exploration drilling or ice management.

Studies on the effects of seismic surveys on birds, which might present an indication of how exploration drilling and ice management sounds could affect birds, found no observable difference in bird behavior (See Section 4.6.3). Birds did not display differences in behavior when close to or far from the survey vessels and the birds were not repelled by or attracted to the vessels.

The location of Shell's planned exploration drilling activities avoids any critical habitat and other areas of high bird concentrations. Shell's activities may disturb some foraging and loafing birds (see discussion in Section 4.6.3). The impacts of these activities are negligible and will not influence bird mortality. Therefore, these activities will not impact the availability or distribution of birds and bird eggs in the long-term.

Conclusion

Given the distance between Shell's proposed drilling sites and subsistence hunting areas, impacts from drilling sound and ice management are expected to have minimal impact on subsistence activities. Therefore, drilling sounds and ice management are expected to have no more than a negligible impact on subsistence activities.

4.11.4 Impacts of ZVSP Survey Sound Generation on Subsistence

The drill sites are located more than 64 m (103 mi) from shore and more than 30 mi (48 km) from any subsistence areas. Sound generation by the ZVSP surveys will not have any effect on most subsistence resources, but could potentially result in some avoidance of the areas ensonified to ≥ 160 dB. Modeling indicates that received levels of the underwater will attenuate to ≤ 160 dB within approximately 3.4 mi (5.2 km). Given the remote location of Shell's proposed exploration drilling activities as in relation to subsistence hunting activities, and with the implementation of appropriate mitigation measures, Shell expects the impact to subsistence activities will be no more than negligible.

4.11.5 Impacts of Air Emissions on Subsistence

Potential impacts to air quality from air emissions associated with the exploration drilling program are described above in Section 4.1.1 (onshore) and Section 4.1.2 (offshore air quality). As described, the model-predicted concentrations of air pollutants are ≤ 50 percent of all NAAQS primary standards (Table 4.1.1-1) at the shoreline and within onshore areas. All peak model-predicted concentrations of air pollutants in offshore areas used for subsistence are below impact criteria based on OSHA standards. Given that impacts to air quality will be minor, project emissions will have no impact on subsistence activities.

4.11.6 Impacts of Drilling Waste Discharges on Subsistence

Shell's planned drill sites where exploration drilling and drilling waste discharges will occur are located over 78 mi (126 km) from the nearest village, 64 mi (103 km) offshore of the coastline (Table 3.0-1) and more than 30 mi (48 km) from areas known to be used for subsistence (Figure 3.11.6-11). The discharge of drilling waste from these drill sites will have minor temporary effects on water quality near the drilling unit or MLC ROV System, consisting primarily of increases in TSS concentrations, which will be limited primarily to the area within about 0.62 mi (1.0 km) of the drill site. These water quality effects will have no effect on the act of subsistence because of the distance (> 30 mi [48.3 km]) to subsistence use areas, or to subsistence resources such as fish, birds, or marine mammals.

Most seafloor effects due to deposition of drill cuttings and drilling fluids will be restricted to the area within about 460 ft (140 m) of the drill site, although some negligible amounts of deposition will occur at greater distances. Deposition of these materials will have no direct effect on subsistence due to the distances from the drill sites to the nearest subsistence use areas. Deposition will smother some benthic organisms and result in long-term changes to the benthic community. Some subsistence species, such as eiders and other sea ducks, bearded seals, walruses, and gray and to a lesser degree bowhead whales are benthic feeders. Loss of feeding habitat for these subsistence resources could be considered an indirect effect on subsistence; however, use of the area by sea ducks is very low due to water depths, and the area of effect is small so that any such effects on sea ducks or other benthic feeding species are negligible. A total of about 15.7 to 33.2 ac (6.3 to 13.4 ha) of seafloor within the Chukchi Sea would be expected to experience accumulations of ≥ 0.4 in (≥ 1.0 cm) when all six wells in the EP are drilled. This represents less than 0.000011% to 0.000024 percent of the seafloor of the Chukchi Sea of the Chukchi Sea.

The deposition will result in nominal increases in the concentrations of some metals. Past modeling of similar discharges in the Chukchi Sea (Shell Global Solutions 2009) indicates that increases in mercury, cadmium, and chromium, if any, would be minimal, below concentrations found to have ecological effects (Long et al. 1995). Laboratory studies of bioaccumulation of drilling fluids have found only a small degree of barium and chromium uptake, and little or no uptake of other metals (Neff et al 1989a, 1989b). When bioaccumulation has been observed it has not been high enough to be harmful to the accumulating animals (Melton et al. 2000). Studies of bioaccumulation of mercury, cadmium, copper, lead, and arsenic have found that these metals are virtually non-available for bio-accumulation due to their chemical form (Neff et al. 1989b). Studies have also shown that these heavy metals do not bio-magnify in marine food webs (Neff et al. 1989a, 1989b). Therefore the discharges will not impact subsistence.

Toxicity of the drilling fluid components (Table 4.4.1-1) and the whole fluid are low. Drilling waste discharges will have no direct effect on subsistence due to the distance between the drill sites and areas used for subsistence, and only periodic, if any, effect on subsistence resources or their habitats and food resources that will not affect subsistence harvest. Therefore, drilling waste discharges are expected to have a negligible impact on subsistence.

4.11.7 Impacts of Other Permitted Discharges on Subsistence

Vessel discharges will have no or only a negligible effect on subsistence. These discharges within the OCS will be conducted under MARPOL and USCG regulations, there will be no discharge of free oil, floating solids, or trash that could potentially oil, entangle, or otherwise affect fish, marine birds, and marine mammals. Only sanitary wastes treated in a MSD will be discharged. Food wastes, which could potentially attract fish, marine birds, and marine mammals, will not be discharged; food wastes on the drilling units and many vessels will be incinerated. Discharges will result in slight changes in pH, temperature, TSS, and BOD within the immediate vicinity of the vessel, but these water quality effects would have no effect on subsistence or subsistence resources. These water quality effects will be limited to the area within about 328 ft (100 m) of the vessel, and will cease almost immediately after the discharged is stopped. Most vessel traffic will be in offshore waters seaward of areas used for subsistence. Vessel traffic will be coordinated through Shell’s system of Com Centers and SAs in such a manner as to avoid areas where subsistence is occurring, thus vessel discharges will not occur in such areas. EP Revision 2 includes an increase in the number of support vessels, increases in resupply trips, and contingency vessel-based crew changes between the prospect and Barrow. These changes may result in a slight increase in total vessel discharge volumes, and may result in vessel traffic near Barrow. However, the effect of vessel discharges on subsistence will have at most a periodic impact on subsistence resources and will not affect subsistence harvests. Therefore, other permitting discharges are expected to have a negligible impact on subsistence.

4.11.8 Impacts of Shorebase Expansion on Socioeconomic/Socio-cultural Resources

EP Revision 2 includes infrastructure improvements. Activities would include expansion of a 75 person camp facility and KDR unit to include a 40-person construction camp in Barrow, and use of a larger facilities in Wainwright. Direct and indirect effects of the increased shorebase presence are described below.

Impacts of Shorebase Expansion at Barrow on Socioeconomics

As part of this EP Revision 2, Shell’s Barrow facilities will be expanded by leasing an additional nearby 40-person construction camp, and potentially reserving a block of rooms at an existing local hotel. The planned shorebase expansion is largely to accommodate the increase in offshore crews associated with the vessels added as a part of EP Revision 2, but also to reduce the number of hotel rooms and rental properties used by Shell in Barrow during the 2012 exploration drilling season.

With their subsistence lifestyle and culture, the Inupiat residents of the North Slope are considered a minority/Native American community under the Presidential Order on Environmental Justice. The Inupiat are a minority population in the SOA and are indigenous inhabitants of Alaska. The SOA estimate of Barrow's population is 4,380 (ADCA 2013), the U.S. Census Bureau 2010 estimate is 4,212 (U.S. Census Bureau 2010), and the NSB census for 2010 placed the Barrow population at 4,719 (NSB 2010). Approximately 65 percent of the Barrow population is Inupiat (Figure 3.11.2-5). Two man camps of a totaling 115 represents a potential influx of non-NSB residents equaling about 3.0 percent of the total Barrow population, and therefore holds potential for some socio-cultural effects.

The two pads where the 75-person and 40-person camps are/will be located are in the NARL area approximately 4.0 mi from the center of Barrow. Shell's management of the camp will minimize the potential for socio-cultural effects. Most crew members will be transported directly between the airport and the camp via vans, which will minimize vehicular traffic in Barrow associated with the operation of the camp. Crews are generally restricted to the camp, but with permission are permitted to visit the cultural center or the AC store. With these restrictions, socio-cultural impacts are expected to be negligible.

Negative socioeconomic effects of work camps in relatively small communities are generally associated with effects on goods and services. Shell's Barrow man camp is largely self-contained with little potential for effects on goods and services. Power and heat (electricity) are provided by the camp's generators, and will therefore not place a load on municipal utilities. Diesel fuel would be purchased locally. Blackwater and graywater from the camps will be held in holding tanks at each site, then picked up by the NSB and treated in their waste water plant. Shell expects to generate about 1,000 gal of combined blackwater and graywater wastes per day. These volumes will not tax Barrow's municipal wastewater treatment system, which accommodates a population of over 4,000 people, and consists of a series of large water treatment lagoons. Household trash from the camps will be disposed of at the NSB Landfill. The volume of household trash (200 yd^3 / 153 m^3) expected to be generated each season and disposed of at the landfill represents less than 0.75 percent of the average annual volumes currently disposed of at the landfill by all users, and should therefore have negligible impact on the landfill operations or services.

Expansion of the accommodations will minimize the need for hotel rooms and rental properties. This will reduce revenues of local business but avoid any substantial reductions in the availability of such services for local residents and other visitors. The camp will be managed by one of the village native corporations, resulting in revenues for the business and shareholders.

<u>Conclusion</u>

With these policies and management strategies in place, the expansion of the Barrow man camp associated with the exploration program and activities associated with Shell's EP Revision 2 overall are expected to cause, at most, periodic disruptions of social organization, cultural values and institutional arrangements. The influx of people into the community will be temporary and have negligible effects on the local population or the availability of goods and services and no measurable economic effects beyond short term, periodic impacts. Therefore, the shorebase expansion and the activities associated with Shell's EP Revision 2 overall are expected to negligible impact on socio-cultural or socioeconomic resources.

4.11.9 Impacts on Minority/Lower Income Groups & Community Health

Most of the residents of Barrow, Wainwright, Point Lay, and Point Hope are Iñupiat and constitute a minority under Environmental Justice guidelines. Potential effects on this minority population are addressed above as potential impacts to subsistence and socioeconomics.

Shell does not anticipate the program to result in disproportionate adverse effect on the Inupiat of the Chukchi Sea villages given that the program involves routine and seasonal exploration drilling activities in localized areas (MMS 2007b). In the unlikely event of an accidental oil spill, there could be disproportionately high adverse effects on Inupiat subsistence-harvest activities and socio-cultural systems (MMS 2007b). Specific mitigation measures have been developed to address impacts of exploration drilling activities on subsistence activities and resources, particularly the subsistence whaling activities and bowhead whales.

Impacts of Permitted Discharges on Community Health

Existing water quality of the OCS is good due to the remoteness, active ecological system, and the limited presence of human (anthropogenic) inputs. Existing contaminants occur at very low levels in Arctic waters and sediments and do not pose an ecological risk to marine organisms in the OCS (MMS 2008a). Water quality and water quality impacts are discussed in more detail in Section 3.2.7 and Section 4.2.

Changes in marine water quality can impede or alter existing natural properties and processes, increase sedimentation, increase water temperature, lower dissolved oxygen, degrade aquatic habitat structure, and cause loss of fish and other aquatic populations.

The impact of NPDES exploration facilities GP permitted discharges will be negligible and temporary. Main discharges include sanitary and domestic wastewaters. Minor discharges include non-contact cooling water, ballast water, desalination wastes, and deck drainage. Increases in turbidity and biological and chemical oxygen demand are expected near the discharge site, but the effects will be minor and have no effect on marine mammals. These effects will be limited to a radius of 328 ft (100 m) about the discharge location and would not likely affect marine mammals in the area. Non-contact cooling water is expected to be only a few degrees above the ambient water temperature at the point of discharge, and this difference in temperatures would be reduced to within 32.9 °F (0.5 °C) of ambient within 33 to 820 ft (10 to 250 m) of the outfall.

Analysis of Impact of a Small Liquid Hydrocarbon Spill (less than 48 bbl) on Community Health

While a remote possibility due to the implementation of rigorous spill control policies and procedures, small spills (48 bbl or less), such as a spill incidental to a refueling operation, have been determined to be the most likely spill scenario during an exploration drilling program. Impacts of a small spill are analyzed below.

Given the open ocean location of Shell's Burger Prospect, the duration of a small spill and opportunity for effect would be brief. Nearly 100 percent of a small spill (diesel fuel) evaporates (48 percent) or disperses (51 percent), but recovery controls would ensure that any spill effects are localized and would result only in short-term environmental consequences.

Response equipment and trained personnel would be available on site to deploy boom and recovery equipment for the control and removal of product spilled into the environment. Additionally, pre-booming prior to transfer operations would be used in accordance with BOEM lease stipulation No. 6, USCG requirements, and Shell's operating procedures. Impacts to community health from oil spills or unintentional releases of hydrocarbons would be negligible.

Impacts of Project Air Emissions on Community Health

As described in Section 3.1.3, air quality in the Lease Sale 193 Area and onshore on the North Slope is classified by the EPA as good. The exploration drilling activities will emit air pollutants, largely through the use of combustion engines, which are discussed in Section 7 of the EP Revision 2. The emissions of primary interest from Shell's exploration drilling activities include NO_2, CO, SO_2, small-diameter PM, and VOC. Shell does not intend to produce or flow test any of the exploration wells during the exploration drilling activities, so flaring will not be required and burn products associated with flaring will not be released.

The planned exploration drilling will be conducted a minimum of 64 mi (103 km) offshore, and 78 mi (126 km) from the nearest village. Air dispersion modeling of the emissions from the offshore activities indicates that predicted design (background + project) concentrations of air pollutants will be less than 50 percent of the primary and secondary NAAQS at the shoreline. The NAAQS are designed by EPA to protect human health (primary NAAQS) and flora and fauna (Secondary NAAQS) from excessive long- and short-term exposure to ambient levels of six pollutants: CO, NO_2, PM, SOx, ozone, and Pb. Primary standards set limits to protect public health. Secondary standards set limits to protect public welfare, including, inter alia, animals and vegetation.

During a community engagement meeting in Point Hope, the concern about respiratory illnesses associated with oil production was raised as an issue based on reports from Nuiqsut that some residents there had breathing problems in winter months. These breathing difficulties were attributed to oilfield operations at Prudhoe Bay particularly gas flaring and atmospheric inversions which combined to transport flared products into the village. The concern is that offshore developments in the Chukchi Sea could have a similar effect on villagers along the Chukchi Sea coast, and those suffering from COPD or other breathing difficulties would be adversely affected.

Shell's planned exploration drilling plan involves wells that are far removed from population centers on the Chukchi Sea coastline providing ample space and time for any potential air pollutants to dilute, diffuse and disperse into the air column. Ambient air quality standards are achieved far offshore, which will ensure there are no project impacts to community health.

<u>Conclusion</u>

Shell's planned exploration drilling will take place at a significant distance from population centers, and discharges to air and water are expected to dilute and diffuse prior to reaching the population center. Planned discharges (i.e., permitted discharges to water and air emissions) will have no impact on community health. A small liquid hydrocarbon spill would also be likely to have no impact on community health. If the population did feel impacts from such a spill, those impacts would be temporary and cause, at most, periodic disruptions of social organization, cultural values , institutional arrangements, .and the availability of goods and services. Accordingly, Shell's activities associated with EP Revision 2 are likely to have at most a negligible impact on socio-cultural or socioeconomic resources in minority and lower-income communities and on community health.

4.12 Impacts on Coastal and Marine Uses

All use of offshore waters is sparse given the size of the Chukchi Sea and the limited amount of human activity. The primary use of offshore waters in the northeastern Chukchi Sea is subsistence hunting and fishing. Impacts on subsistence are discussed in Section 4.11. Other uses of offshore waters include the military, shipping, fishing, and mineral exploration. Shell expects the exploration drilling activities, air traffic, vessel traffic, air emissions, and a small liquid hydrocarbon spill to have no impacts on these uses. The establishment and use of camps, hangars, and other facilities onshore will have minor, temporary effects on the use of these land areas.

BOEM did not establish a NEPA significant threshold or level of effect for impacts on coastal and marine uses in its analysis of Shell's EP Revision 1 (BOEM 2011a). Shell has developed the following standards to evaluate potential impacts resulting from its exploration activities under EP Revision 2 on coastal and marine use:

Significance Threshold:

An impact may affect a marine or coastal use, requiring the marine or coastal use to make adjustments, leaving measurable impacts that resolve within one year.

Level of Effects:

Negligible

- An impact may temporarily affect a marine or coastal use, requiring the marine or coastal use to make small adjustments, but the impact is eliminated immediately upon the termination of the impact-causing activity, leaving no measurable lasting impact.

Minor

- An impact may temporarily affect a marine or coastal use, requiring the marine or coastal use to make small adjustments, but the impact is eliminated shortly after the termination of the impact-causing activity, leaving no measurable lasting impact.

Moderate

- An impact may affect a marine or coastal use, requiring the marine or coastal use to make adjustments, leaving measurable impacts that resolve within one year.

Major

- An impact may affect a marine or coastal use, requiring the marine or coastal use to make adjustments or precluding the use for a period of time, leaving measurable impact that persists for more than one year.

Table 4.12-1 Effects of Shell's Exploration Drilling Program on Coastal and Marine Uses

Resource	EP Revision 2
Overall	negligible
On land use	negligible
On military use	none
On shipping	none
On recreational fishing	none
On commercial fishing and mariculture	none
On mineral exploration and development	none

Impacts on Land Use

Shell expects no impacts on marine or land uses from its exploration drilling activities. Most activities associated with the program will take place at or near the drill sites that are more than 64 mi (103 km) offshore. Support vessel crews are expected to remain offshore for the duration of the drilling season.

Temporary shorebase facilities will be located in Wainwright and Barrow for the planned exploration drilling activities. These facilities are located on existing gravel pads and other developed sites. Temporary facilities are provided by local village corporations and will be located in previously developed areas that are not currently in use.

Construction impacts from Shell's shorebase activities may temporarily affect other land uses, which may require small adjustments, but the impacts, if any, will be resolved immediately upon the termination of the construction, leaving no measurable lasting impact. Shorebase facilities would therefore have negligible temporary effects on land use.

Impacts on Military Use

The USCG has conducted relatively limited activities in the Chukchi Sea in the recent past. While it plans to increase its operations in the seas of Northern Alaska, the USCG is in the process of conducting studies to determine the extent and types of activities it will conduct in the northern seas. Shell's activities will have no effect on current military use of the Lease Sale 193 Area or adjacent coastal areas.

Impacts on Shipping

Shipping and air freighting currently occur at very low levels in the Lease Sale 193 Area. This is not expected to change greatly over the term of this exploration drilling activities. Most commercial traffic, primarily consisting of barges, occurs in more protected waters, much closer to shore than Shell's planned drill sites. The presence of the drilling units and support vessels in the area of Shell's Burger Prospect, and the projected associated vessel and aircraft traffic between the prospect and shorebase, and between shorebase and regional hub airports, will have no effect on current or expected future levels of shipping over the time period of the planned exploration drilling activities.

Impact on Recreational Fishing

Recreational fishing is not known to take place in the vicinity of the Burger Prospect or in nearshore waters of the northeastern Chukchi Sea. As the drill sites and most activities associated with the EP Revision 2 would be located more than 64 mi (103 km) in federal waters of the Chukchi Sea Shell's exploration drilling activities will have no effect on recreational fishing.

Impacts on Commercial Fishing and Mariculture

Under the current Fisheries Management Plan for Fish Resources of the Arctic Management Area, commercial fishing is prohibited in the Chukchi Sea. The planned exploration drilling activities will have no effect on commercial fishing or mariculture.

Impacts on Mineral Exploration and Development

There are currently no mineral development activities in the Lease Sale 193 Area. Therefore, Shell's planned exploration drilling activities would not impact mineral development in this area. No concurrent exploration plans have been submitted for public review by other companies, although there currently are five other leaseholders. Shell's activities would not be expected to have any effect on other exploration drilling activities, if they were to be undertaken by these operators.

THIS PAGE
INTENTIONALLY LEFT BLANK

5.0 CUMULATIVE IMPACTS

This section presents the potential cumulative environmental impacts associated with Shell's drilling program in the Chukchi Sea. Shell's program, for the purposes of this cumulative impacts analysis includes simultaneous drilling using two drilling units, a drillship and a semi-submersible drilling unit, during each drilling season over a span of three years.

The Council on Environmental Quality's (CEQ) regulations (40 CFR 1500 - 1508) implementing the procedural provisions of the National Environmental Policy Act (NEPA) of 1969, as amended (42 U.S.C. 4321 et seq.), define cumulative effects at 40 CFR 1508.7 as: "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor, but collectively significant, actions taking place simultaneously or over time." Cumulative impacts may arise from single or multiple actions and may result in additive or interactive effects. Interactive effects may be countervailing, where the net adverse cumulative effect is less than the sum of the individual effects, or synergistic, where the net adverse cumulative effect is greater than the sum of the individual effects.

The time frame for a cumulative impacts analysis must be defined on a case-by-case basis, and depends on the characteristics of the resources affected and the magnitude and scale of a project's impacts (EPA 1999a). In regard to Shell's EP Revision 2, no significant impacts are anticipated to remain after the exploration drilling program has been concluded. Instead, any lingering impacts range from negligible to minor, as described in Section 4. The only impacts associated with the exploration drilling program that are anticipated to last beyond that three-year time period are related to seafloor sediments and disturbance. These impacts may be demonstrable for 10 or more years after drilling, but any such effects would be localized and not widespread, and therefore would be minor. Shell's exploration drilling program, as outlined in the EP Revision 2, is expected to be conducted over a period of approximately three years, with all exploration drilling likely concluded in approximately three drilling seasons. Therefore, the cumulative effects analysis is not extended into the future beyond the conclusion of the drilling program. Present and future activities considered in the cumulative effects analysis are limited to activities that are reasonably foreseeable in the next three years.

The cumulative impacts analysis also considers past activities that have resulted in impacts that are expected to still be evident in the next drilling season; therefore, the time frame of the analysis extends into the past to the time when those earliest past activities were conducted. For this analysis, the historic exploration drilling programs of 1989-1991 represent the earliest activities and the start of the cumulative impacts analysis time frame. The effects of some past activities that occurred at an earlier time are considered in the analysis of effects on certain resources, specifically the effects of commercial whaling on marine mammals, but little effects of these activities remain.

The cumulative impacts associated with Shell's exploration drilling program under EP Revision 2, when added to the aggregate effects of past actions, and other current and reasonably foreseeable future actions, are expected to range from negligible to minor (Table 5.5-1).

5.1 Previous Cumulative Impact Analyses

This analysis builds on prior information in a number of cumulative impact analyses of proposed oil and gas activities that have been prepared in recent years, including NEPA EISs and EAs, and ESA BOs, as well as draft and final cumulative impact analyses that have been completed since 2011, including the following:

- Supplemental Draft EIS on Effects of Oil and Gas in the Arctic Ocean (NOAA 2013b)

- EA for Incidental Take Regulations for Walruses and Polar Bears in the Chukchi Sea (USFWS 2013a)
- BO for Polar Bears and Conference Opinion for Pacific Walrus on the Chukchi Sea Incidental Take Regulations. (USFWS 2013b)
- EA for Shell's EP Revision 1 (2012 Exploration Drilling Program in the Chukchi Sea) (BOEM 2012)
- Final EIS for Outer Continental Shelf Oil & Gas Leasing Program: 2012-2017 (BOEM 2012)
- EA for ancillary activities (Statoil shallow hazards surveys) in the Chukchi Sea (BOEM 2011a)
- Cumulative impact section of the EIA for Shell's EP Revision 1 (Shell 2011)
- Final Supplemental EIS for Lease Sale 193 in the Chukchi Sea (BOEMRE 2011b)
- Final EIS for Lease Sale 193 and seismic surveys in the Chukchi Sea (MMS 2007b)
- Final EIS for Outer Continental Shelf Oil & Gas Leasing Program: 2007-2012 (MMS 2007d)
- Programmatic EA for seismic surveys in Chukchi and Beaufort Seas (MMS 2006b)
- BO and Conference Opinion for Oil and Gas Activities in the Beaufort and Chukchi Sea Planning Areas on Polar Bears, Polar Bear Critical Habitat, Spectacled Eiders, Spectacled Eider Critical Habitat, Steller's Eiders, Kittlitz's Murrelets and Yellow-billed Loons (USFWS 2012)
- BO, Oil and Gas Leasing and Exploration Activities in the U.S. Beaufort and Chukchi Seas, Alaska (NMFS 2013b)
- BO for IHA for Shell's exploration drilling in the Alaskan Chukchi Sea in 2012. (NMFS 2012)
- BO for the USFWS Region 7 Polar Bear and Pacific Walrus Deterrence Program (USFWS 2014b)

The reader is referred to the above-referenced larger documents for detailed analyses of past, present, and reasonably foreseeable activities in the Chukchi Sea and their potential effects on the environment. These documents cover periods of time ranging from one to 20 years. The level and types of activities planned in Shell's EP Revision 2, including the contemplation of two drilling units operating simultaneously within the same Sea, are within the range of past, present, and reasonably foreseeable activities identified in the cumulative impacts scenarios and evaluated in these documents.

5.2 Past, Present, and Reasonably Foreseeable Activities

The following sections identify past, present, and reasonably foreseeable future activities considered in the cumulative impacts analysis.

5.2.1 Past, Present, and Future Oil and Gas Exploration

Past Exploration Drilling Programs

Operators have drilled five exploration wells in the U.S. waters of the Chukchi Sea in 1989-1991 (Table 1.2-1). In 2012, Shell constructed the MLC and drilled the upper sections of the Burger A well. These wells represent all the exploration drilling conducted in the Chukchi Sea to date. Investigations of well sites, where drilling was conducted in the 1980s and 1990s in the Chukchi and Beaufort Seas, indicate that little impact remains to date. For example, Neff et al. (2010) evaluated concentrations of metals and various hydrocarbons in sediments at the historic Burger and Klondike wells drilled in the Chukchi Sea in 1989-1990. Surface and subsurface sediments collected in 2008 at the historic drill sites contained higher concentrations of all types of analyzed hydrocarbon in comparison to the surrounding area. The same pattern was found for the metal barium, with concentrations 2 to 3 times greater at the historic drill sites (mean = 1,410 μ/g and 1,300 μ/g) than in the surrounding areas (639 μ/g and 595 μ/g). Concentrations of copper, mercury, and lead, were elevated in a few samples from the historic drill sites where barium was also elevated. All observed concentrations of hydrocarbons or metals in the sediment samples from the historic drill sites were below levels (below ERL or Effects Range Low of Long et al. 1995) believed to have adverse ecological effects (Neff et al. 2010). Trefry et al. (2012) confirmed findings by Neff et al. 2010 that concentrations of all measured hydrocarbon types were well within the range of non-toxic background concentrations reported by other Alaskan and Arctic coastal and shelf sediment studies.

Similar results were reported by Trefry and Trocine (2009) for the historic Hammerhead drill sites in the Beaufort Sea, where elevated levels of barium, silver, chromium, lead, selenium were found within 328 ft (100 m) of the Hammerhead drill site. Some changes in relief are still evident such as MLC excavations.

All of the effects associated with past drilling are negligible but some effects are long term and will overlap in time with any similar effects associated with Shell's EP Revision 2.

Present and Future Offshore Oil and Gas Exploration Drilling

Both Shell's approved EP Revision 1 and EP Revision 2 include the same six drill sites (Table 2.1-1). There are other lease holders within federal waters of the OCS (none in State waters) in the Chukchi Sea, but any additional exploration drilling by other lease holders is considered speculative at this time for the reasons described below. In addition to the proposed six wells under this EP Revision 2, Shell may conduct an exploration drilling program in the Camden Bay area of the Beaufort Sea under a revision to its approved EP during the same time frame as the proposed Chukchi Sea program. The Camden Bay exploration drilling program includes drilling up to four exploration wells within two prospects (Torpedo and Sivulliq) located in the Beaufort Sea approximately 410 mi (660 km) east of Shell's Burger Prospect in the Chukchi Sea.

<u>Speculative Offshore Oil and Gas Exploration Drilling</u>

A cumulative impacts analysis must consider "reasonably foreseeable future actions" per 40 CFR § 1508.7. While some "reasonable forecasting" is required under NEPA and a project sometimes must be considered in a cumulative impacts analysis even if a specific proposal is not available, a cumulative impacts analysis need not include projects that are "speculative" (EPA 1999a). Although "speculative" is not defined in NEPA or the 'CEQ's regulations, case law interpreting the term "speculative" holds that whether a future project is to be considered speculative depends upon: (1) the likelihood the future project will occur and (2) whether there is sufficient information available for a meaningful analysis. *Environmental Protection Information Center v. U.S. Forest Serv.*, 451 F.3d 1005, 1014 (9th Cir. 2006) ("*EPIC*"); *Habitat Education Ctr. v. U.S. Forest Serv.*, 609 F.3d 897 (7th Cir. 2010) (reasonably foreseeable future projects that do not have enough information for a meaningful analysis do not need to be included in a cumulative analysis); EPA 1999(a) *Consideration of Cumulative Impacts in EPA Review of NEPA Documents* (identifying actions the cumulative impacts analysis should consider, including the likelihood the project will occur and the imminence of the project).

When courts have found that future projects were inappropriately excluded from an agency's cumulative impacts analysis, the cases involved future projects which, at the time of the NEPA analysis, were likely, imminent, and had sufficient project detail available to allow for a meaningful analysis of both the activity anticipated and the associated environment impacts. *Muckleshoot Indian Tribe v. U.S. Forest Serv.*, 177 F.3d 800, 812 (9th Cir. 1990) (court held that a future land exchange should have been included in the cumulative impacts analysis when there was a summary document describing the future land exchange one year before the final NEPA document was issued, and a press release five months before, finding the "virtual certainty of the transaction and its scope" required agency to evaluate the future land exchange under NEPA); *Blue Mountain Biodiversity Project v. Blackwood*, 161 F.3d 1208 (9th Cir. 1998) (the court found that five future timber sales should have been included in the cumulative impacts analysis because they were disclosed by name, and estimated sale quantities and timelines were known before the NEPA document was completed). While it is not appropriate to defer the cumulative impacts analysis to a future date when a meaningful analysis can occur now, when not enough information is available to allow for meaningful consideration it is impractical to include a vague proposal in the analysis. *EPIC*, 451 F.3d at 1014 (citing *Kern v. BLM*, 284 F.3d 1062, 1075 (9th Cir. 2002) and *Blue Mountains Biodiversity*, 161 F.3d at 1215).

Two other operators have indicated their interest in drilling exploration wells in the Chukchi Sea. Statoil holds an interest in, and is designated the operator at, 16 leases at prospects named Amundsen and Augustine in the Chukchi Sea, located to the northwest of Shell's Burger Prospect; 14 of these leases are in collaboration with Eni. Statoil is also a partner in the Devils Paw prospect where ConocoPhillips is the operator. Statoil originally indicated its intent to drill at Amundsen and Augustine as early as 2014, but in July 2013 it publically announced that it would not make a decision on future drilling in the Chukchi Sea until 2015, at the earliest.

ConocoPhillips acquired 98 Chukchi Sea leases in 2008 at Lease Sale 193. The company submitted draft EPs to BOEM in 2011 and again in 2013, proposing to drill up to two exploration wells at the Devils Paw Prospect in 2014, which is located southwest of Shell's Burger Prospect. ConocoPhillips' 2013 draft EP was never "deemed submitted" by the BOEM. ConocoPhillips subsequently announced in April 2013 that it put plans for exploration drilling in the Chukchi Sea in 2014 on hold, citing uncertainty created by evolving federal regulatory requirements and operational permitting standards. See ConocoPhillips News Release, *Regulatory Uncertainty Leads ConocoPhillips to Put 2014 Chukchi Sea Exploration Drilling Plans on Hold* (Apr. 10, 2013), at http://alaska.conocophillips.com/EN/news/newsreleases/Documents/NR-AK-Chukchi%20Sea-FINAL%204-9-2013.pdf.

Importantly, despite multiple, active oil and gas leases in the Chukchi and Beaufort Seas, and the government's projections of more significant exploration and development in the area, the Arctic Ocean, generally, and the Chukchi Sea, specifically, remain a frontier. In light of the demanding and changing regulatory and permitting hurdles required to proceed with exploratory drilling in the Arctic, other companies' plans are uncertain and predicting such activity over the next three years is difficult.

At this time, exploration drilling by Statoil or ConocoPhillips is not imminent, and it is unclear whether or when either project might move forward. Numerous state and federal permits and approvals are required before Statoil or ConocoPhillips could conduct exploratory drilling. Shell is not aware of proposals, permits, or applications pending that provide current information or timing regarding either company's future plans. Specifically, it does not appear likely that an exploratory drilling program in the Chukchi Sea from Statoil, ConocoPhillips, or another company, is likely within the next three years.

Even if such a project were likely in the next three years, which Shell concludes it is not, Shell cannot make reasonable forecasts as to how these companies would conduct any future operations. There is no public information about: (1) when any future drilling would occur, (2) what drilling unit, support vessels and infrastructure would be used, (3) the air emissions and NPDES and other water discharges associated with any future operations, (4) which and how many specific prospects and locations would be drilled, (5) the site-specific biological, physical, and socioeconomic characteristics of the prospect(s), (6) what distinct oil spill concerns would be posed by the locations and the OSR vessels to be employed, and, most importantly (7) the anticipated environmental impacts of such a project. Without any of this basic operational information and site characterization, Shell cannot forecast what environmental impacts would be associated with any future, hypothetical drilling program and what mitigation measures would be adopted. Shell cannot conduct a meaningful analysis of the cumulative impacts associated with such activity.

Shell used the legal standard for determining when future projects should be considered reasonably foreseeable when determining the status of other potential exploration activities in the Chukchi Sea. For purposes of this cumulative impacts analysis, Shell considers any EP (or Development Plan) that has been approved or "deemed submitted" by BOEM and is publicly available, to be "reasonably foreseeable" and appropriate for inclusion in a cumulative impacts analysis. By the same token, Shell considers any discussions of possible activity without the submission of an EP (or Development Plan) and completeness determination by BOEM to indicate a project is not likely in the short-run. Without sufficient information and detail regarding the parameters of another project and its potential effects, a meaningful analysis is impractical, and Shell considers any such activity "speculative" and inappropriate for inclusion in a cumulative impacts analysis. Based on this definition of speculative, Shell has not considered any potential exploration activity in the Chukchi Sea by Statoil, ConocoPhillips, or other companies in this cumulative impacts analysis. BOEM (2011a) used this same criterion for determining when offshore exploration drilling programs are reasonably foreseeable in the NEPA EA for Shell's EP Revision 1.

Shell notes that if an EP is submitted by another company in the future, any subsequent EP consideration and NEPA review by BOEM would be in a better position to consider the cumulative impacts of those programs in conjunction with previously-approved EPs in the Arctic. *See Kleppe v. Sierra Club,* 427 U.S. 390, 410 n.20 (1976) (noting that once contemplated actions become more formal proposals, later impact statements on those projects will take into account the effect of the earlier proposed actions); *EPIC* 451 F.3d at 1014 & n.5.

Past Seismic Surveys and Shallow Hazards Surveys

Offshore oil and gas exploration programs have operated in the Alaskan Chukchi Sea since the 1950s, although the extent of these activities has varied significantly over the years. Since 2006, seismic and shallow hazards surveys have been conducted by industry in the Alaskan Chukchi Sea. The levels of survey activity, as represented by survey trackline distances per year in the Chukchi Sea are presented in below in Table 5.2.1-1. Survey activity levels were greatest in 2006 and lowest in 2012. Similar survey activity levels occurred in the Chukchi Sea in 2007-2010, and 2013.

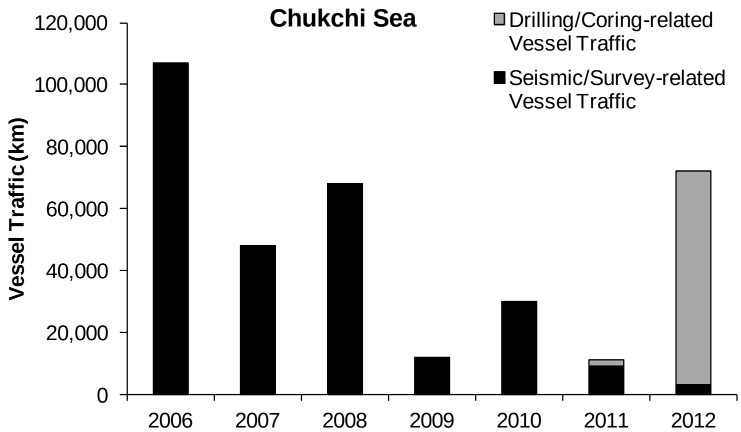
Table 5.2.1-1 Recent Seismic and Shallow Hazards Survey Effort in the Chukchi Sea 2006-2013

Survey Type	Source Vessel Trackline by Year [1]							
	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Shallow Hazards	0 mi	0 mi	1,365 mi	1,107 mi	0 mi	2,785 mi	0 mi	1,521 mi
	0 km	0 km	2,196 km	1,781 km	0 km	4,482 km	0 km	2,448 km
Deep Seismic	11,359 mi	1,812 mi	905 mi	0 mi	2,785 mi	329 mi	115 mi	4,046 mi
	18,280 km	2,916 km	1,457 km	0 km	4,482 km	530 km	185 km	6,511 km
Total Survey	11,359 mi	1,812 mi	2,270 mi	1,107 mi	2,785 mi	3,114 mi	115 mi	5,567 mi
	18,280 km	2,916 km	3,653 km	1,781 km	4,482 km	5,012 km	185 km	8,959 km
All Industry Survey-Related Vessel Traffic	66,386 mi	25,743 mi	27,642 mi	7,618 mi	30,035 mi	ND	ND	25,902 mi
	106,838 km	41,430 km	44,485 km	12,260 km	48,336 km	ND	ND	41,686 km

[1] Source: Funk et al. 2011b for 2006-2010, Hartin et al. 2011 and RPS 2013 for 2011, Beland et al. 2013 for 2012, Reider et al. 2013 and Cate et al. 2014 for 2013

Seismic surveys, shallow hazards surveys, and exploration drilling require support vessels in addition to the survey source vessel or drilling unit. Vessel traffic experienced in the Chukchi Sea in 2006-2012 is presented in Figure 5.2.1-1.

Figure 5.2.1-1 Oil and Gas Exploration Vessel Traffic, Alaskan Chukchi Sea 2006-2012



Source: LGL Alaska Research Associates, Inc., JASCO Applied Sciences, Inc., and Greeneridge Sciences, Inc. 2013.

Present and Future Offshore Seismic Surveys and Shallow Hazards Surveys

Shell has no current plans to conduct large-scale 3D or 2D seismic surveys in the Chukchi Sea during the same time frame covered by EP Revision 2. Shell may conduct shallow hazards surveys during the time period covered by EP Revision 2. A typical shallow hazards site survey is conducted by a single survey vessel. If Shell conducts shallow hazards surveys, they would occur only on Shell leases. Shallow hazards survey vessels may require one or two crew changes in a season; these crew changes may be in Nome, Kotzebue, Wainwright, or Barrow. The anticipated equipment to be used for any shallow hazards surveys would include: dual-frequency, side-scan sonar; single-beam, bathymetric sonar; multi-beam, bathymetric sonar; shallow sub-bottom profiler; deep penetration profiler 40 in^3 airgun array; medium penetration profiler 40 in^3 airgun array; ultra short baseline acoustic positioning; navigation instrumentation; and magnetometer. These types of surveys using the identified equipment have been conducted in the recent past, and the environmental effects associated with the reasonably foreseeable future surveys would be expected to mirror those identified for past surveys. Some of the proposed equipment (multi-beam sonars, side-scan sonars, and most single beam sonars) are operated at frequencies that are above what is thought to be the hearing range of most marine mammal species and are expected to have no effect on marine mammals. Other proposed equipment could have transient effects (i.e., lasting only as long as the activity), restricted to ensonification by the vessels and operating equipment, vessel presence, and vessel discharges, and do not result in additive or synergistic effects with Shell's exploration drilling program.

Shell's shallow hazards survey activities are considered reasonably foreseeable and included in this cumulative impact analysis. Shell is not aware of any proposed seismic surveys or shallow hazards surveys in 2015 or beyond by other oil and gas operators. No applications for permits with BOEM or NMFS for such surveys were posted on agency websites at the time this analysis was conducted. Vessel traffic expected in the Chukchi Sea in the near future is expected to be similar to levels observed in 2006-2012.

Present and Future Geophysical, Geotechnical, and Environmental Surveys

The Office of Coast Survey, NOAA has filed an application with NMFS for development and implementation of regulations governing the incidental taking of marine mammals that cover hydrographic surveys in coastal waters of the U.S., including the Chukchi Sea over the course of five years from the date of issuance. The application was submitted in late 2012 and is still in process. The application is not specific as to which years the Alaskan surveys would be conducted or the specific locations of the surveys. Geophysical equipment operated during these hydrographic surveys includes single-beam and multi-beam echosounders and side-scan sonars. Potential environmental effects of hydrographic surveys include vessel discharges and operation of geophysical equipment. Multi-beam sonars, side-scan sonars, and most single beam sonars used in the Chukchi Sea are operated at frequencies that are above what is thought to be the hearing range of most marine mammal species. Sound energy from these types of equipment would therefore be expected to have no effect on marine mammals.

Shell may conduct ice gouge and strudel scour surveys, geotechnical surveys, or environmental surveys of various types in the Chukchi Sea during the time period covered in EP Revision 2. While Shell has not determined if and when any of these surveys will take place, Shell has determined that they are "reasonably foreseeable" in one or more of the years covered and has conservatively included them in its cumulative impacts analysis. The types of geophysical equipment typically utilized in these surveys are indicated in Table 5.2.1-2 provided below.

Table 5.2.1-2 Equipment Use for Possible Offshore Surveys by Shell in the Chukchi Sea 2006-2013

Equipment Type [1]	Ice Gouge	Strudel Scour	Geotechnical	Environmental
Dual-frequency, side-scan sonar	●	●	--	--
Single-beam, bathymetric sonar	●	●	●	--
Multi-beam, bathymetric sonar	●	●	--	--
Shallow sub-bottom profiler	●	--	--	--
Deep Penetration Profiler 40 in^3 airgun	--	--	--	--
Medium Penetration Profiler 40 in^3 airgun	--	--	--	--
Ultra Short Baseline Acoustic Positioning	●	--	●	--
Navigation Instrumentation	●	●	●	●
Magnetometer	●	--	●	--
Rotary drilling	--	--	●	--
Cone penetrometer	--	--	●	--

[1] Equipment types may vary slightly from that proposed, thus all equipment types are qualified with, "or similar"
[2] Key: ● = Possible use for this survey type during the cumulative impacts analysis time frame; -- = Not intended for this survey type

Shell may use a total of about six vessels to conduct all these different types of surveys across broad areas of the Chukchi Sea in a given open water season. Ice gouge, geotechnical, and environmental surveys would be conducted in and around Shell OCS leases as well as coastal waters between the OCS leases and the shoreline. Periodic crew changes would be conducted for these vessels. The crew changes would likely to be staggered on a weekly basis, but would vary depending on weather and other considerations. Approximately 8 to 24 crew personnel would be rotated off the vessel to shore by a shallow water vessel each week, and exit the shore location on the same day via commercial airlines. At this time, Kotzebue is a likely shore location, but Nome may also be used for part or all of these crew changes. A block of hotel rooms may be booked in Kotzebue as a contingency when timing or weather prevents same-day departure.

Geotechnical surveys, if conducted by Shell during the time period covered in this cumulative effects analysis, would consist of the collection of soil borings to assess the index and engineering properties of the soils encountered. The borings would range in depth and generally fall into three categories: shallow pipeline borings generally no deeper than 50 ft (15 m); deep assessment borings drilled no deeper than 450 ft (137 m) and typically range between 200 to 300 ft (61 to 91 m); and deep platform borings no deeper than 500 ft (152 m). All boreholes would likely be conducted using a rotary drilling type system, with either conventional (on the vessel) equipment or the newer seabed-based technology. These activities would be conducted from the deck of a single vessel in either DP mode or utilizing an anchoring system. The type of vessel is expected to be a DP vessel with a length of approximately 261 ft (79.6 m), or of similar size. The number of borings to be drilled would depend on the speed with which the drilling effort proceeds; Shell estimates that approximately 22 shallow pipeline borings, two deeper assessment borings, and four deep platform borings could potentially be drilled in an open water season. Drilling fluids consisting primarily of a viscosifier such as bentonite or attapulgite clay and a weighting agent such as barite would be used when drilling the deeper boreholes; in general, the shallow pipeline boreholes would not require drilling fluid. Other discharges from the survey vessel would likely include those that are normal parts of vessel activity, including: non-contact cooling water, bilge, ballast, gray water, and black water. The geotechnical work is expected to take about 40 days (excluding any downtime) per year and would be conducted during an open water season, most likely in August-September. The borehole locations would be located within Shell leases and along prospective pipeline routes between Shell OCS leases and the Chukchi Sea shoreline.

Ice gouge and strudel scour surveys may be conducted during the time period covered by the cumulative effects analysis. These surveys would likely be carried out by two survey vessels; one (a larger vessel with a length of approximately 230 ft/70 m) would conduct the offshore ice gouge surveys in water depths of 66 to 166 ft (20 to50 m), and the other would conduct the nearshore ice gouge surveys and strudel scour surveys in water depths of less than 98 ft (30 m). The survey work would take about 48 days per year and would be conducted during an open water season, most likely in July-September. Ice gouge surveys would likely be conducted along about 650 mi (1,050 km) of tracklines per year between Shell OCS leases and the Chukchi Sea shoreline. The strudel scour survey may entail the use of a helicopter for an aerial reconnaissance during break-up (mid-May to early June) to locate strudel holes in the ice. The vessel-based geophysical surveys associated with the strudel scour survey would take place subsequently in the open water season at locations identified in the aerial reconnaissance.

Shell may also conduct vessel-based fish and bird surveys in coastal waters of the Chukchi Sea during the time period covered by the cumulative effects analysis. A single vessel with a minimum length of about 50 ft (15m) would be used to conduct the fish and bird surveys. The fish surveys would consist of towing beam and pelagic trawls behind the vessel in nearshore waters in June-August, as well as setting fyke nets and using beach seines near the shoreline. Bird surveys would be conducted along transects within 6 mi (9 km) off the coast in a series of cruises in June-September.

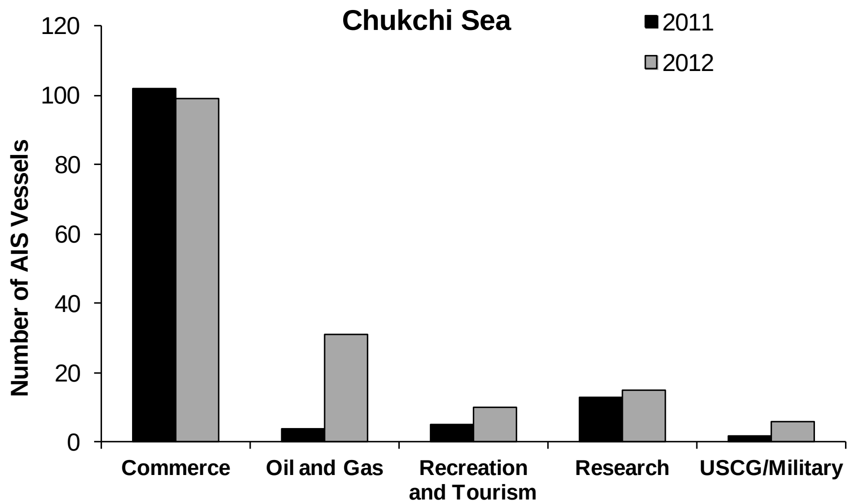
Shell may also conduct various environmental surveys onshore on the North Slope during the time period covered by the cumulative effects analysis. These surveys could include cultural resource surveys, shore-based radar studies of bird movements, meteorological monitoring, permafrost characterization (geotechnical), wildlife habitat assessments, and hydrology studies (e.g. spring break-up, surface hydrology). Staff utilized in some of these surveys may potentially utilize shorebases established for the exploration drilling program. The onshore program would also use two or more helicopters to transport crews between field sites and shorebase facilities at Wainwright, Atqasuk, Umiat, Inigok and potentially another remote camp.

5.2.2 Past, Present, and Future Vessel Traffic

Various types of barge traffic unrelated to Shell's exploration drilling or seismic surveying occur in the Chukchi Sea. Chukchi Sea barge traffic is generally coastal, with the traffic occurring landward of Shell's Burger Prospect. Information on the total number of vessels that operated in the Chukchi Sea with an operating Automatic Identifications System (AIS) in 2011 and 2012 (most recent year Shell had available) is provided in Figure 5.2.2-1. The AIS data does not capture all vessels present; for example, USCG requires only passenger vessels, tankers, and commercial vessels of > 300 gross tons have AISs onboard. Therefore these data should be considered minimums. Barge traffic levels in 2013 are thought to have been similar to barge traffic levels from 2006 – 2010 as presented in the EP Revision 1 EIA.

Environmental effects of vessel traffic are largely restricted to ensonification of waters by the operation of the vessels, vessel presence, and vessel discharges. All of these effects are transient lasting only as long as the specific activity is ongoing. Therefore, past barge traffic provides no opportunity for additive or synergistic effects with Shell's exploration drilling program as described in EP Revision 2. Future vessel traffic during the time period of the cumulative effects analysis is expected to occur at similar levels to those presented below in Figure 5.2.2-1 below.

Figure 5.2.2-1 AIS-equipped Vessels in the Chukchi Sea 2011-2012



Source: LGL Alaska Research Associates, Inc., JASCO Applied Sciences, Inc., and Greeneridge Sciences, Inc. 2013.

5.2.3 Past Present, and Future Subsistence

Subsistence activities in the Chukchi Sea are expected to continue at approximately the same level and in the same areas as identified in Section 3.11.6.

5.2.4 Past, Present and Future Commercial Fishing

No significant commercial fisheries have occurred or currently exist in the Chukchi or Beaufort Seas. The North Pacific Fishery Management Council's (NPFMC's) Fishery Management Plan (FMP) for the Arctic, which includes the Chukchi Sea (NPFMC 2009), was recently approved by the U.S. Secretary of Commerce. The FMP governs all finfish and shellfish except Pacific salmon and Pacific halibut. The FMP prohibits commercial harvest of all fish species under its jurisdiction until sufficient information is available to support management of a sustainable commercial fishery. There has been concern that potential changes in fish habitat in the Chukchi and Beaufort Seas related to climate change could result in changes in the distribution and abundance of some marine fish species that could lead to future commercial fishing activities in both seas. Commercial fishing activity is not expected to occur during the 3 years covered by this cumulative impacts analysis. Shell's anticipated activities as described in EP Revision 2 are not expected to have any influence on future commercial fishing activities in the Chukchi or Beaufort Seas.

5.2.5 Past, Present, and Future Scientific Research

The Chukchi Sea has been host to a significant amount of scientific research. Research has been conducted primarily from vessel and aerial platforms. Research activities are expected to continue at levels consistent with recent and current investigations. The amount of research could increase in future years, and Shell plans to continue its own scientific studies in addition to collaborating with other private and public partners.

5.3 Cumulative Impacts on the Physical Environment

The environment within the area of analysis is considered to be relatively free of accumulated human impacts from previous development. The work planned in EP Revision 2 is limited in geographic scope and duration, and is expected to be conducted during summer and early fall. Shell expects the six planned wells may be drilled over three drilling seasons. Impacts from the proposed exploration drilling program will be correspondingly limited.

Shell's exploration drilling program in the Chukchi Sea will result in negligible or minor and temporary effects on ambient sound levels, air quality, water quality, and sediment quality. Each of these is discussed in further detail below.

5.3.1 Climate Change

There has been concern for several decades that the earth may be undergoing global climate changes that impact environmental patterns such as ocean temperatures, extent and persistence of the polar pack ice, and weather patterns. Climate models consistently indicate that the Arctic is the most sensitive region of the Northern Hemisphere in terms of potential changes in climate, particularly near sea ice margins. Temperatures in Alaska and throughout the Arctic are thought to have fluctuated considerably over the past few centuries (Mann et al. 1999). Despite this fluctuation, the last 100 years appear to have been the warmest in the last 400 years (Overpeck et al. 1997). While it is unclear to what extent anthropogenic contributions of greenhouse gases (GHGs) have contributed to climate warming, the Arctic marine environment has shown changes over the past several decades that are suggestive of a broader global warming that exceeds the range of natural variability over the past 1,000 years (Walsh 2008). Most scientists attribute these changes, at least partly, to emissions of GHGs. The CEQ has issued guidance under NEPA indicating that climate change is a reasonably foreseeable impact of GHG emissions. (CEQ 1997; IPCC 2001a,b). USFWS has determined that climate change poses a threat to the survival of the polar bear and other marine mammal species throughout their ranges because of the resulting loss of sea ice, upon which they depend. Rode et al. (2013); however, recently reported that climate change is having little or no effect on polar bears in the Chukchi Sea.

A synthesis of climate model projections for arctic environments indicates additional warming of several degrees Celsius in much of the Arctic marine environment by 2050 (Walsh 2008). The greatest warming is projected to occur in fall and winter resulting in further retreat of sea ice, which reached record minima in recent years (Stroeve et al. 2008), and longer periods of open water. These changes coupled with hydrographic changes in temperature, salinity and stratification in ocean waters due to freshening, and changes in circulation (Bryden et al. 2005) have the potential to affect biological resources in the Beaufort and Chukchi Seas. Increased permafrost thaw onshore could result in increased river runoff and coastal erosion with increased sediment loads and freshening of coastal waters. Changes in the marine environment due to climate change may interact with other impacts associated with offshore development and result in cumulative impacts to various taxa.

The exploration drilling and support activities proposed in Shell's EP Revision 2 are sources of GHG emissions and will contribute additively to cumulative impacts of such emissions on climate change. However, the exploration drilling and support activities proposed in EP Revision 2, which will take place over no more than 120 days per season, are expected to contribute an extremely small amount to overall GHG emissions into the planet's atmosphere (Section 4.1.5). BOEM estimated the contribution of OCS oil and gas activities to GHG emissions in the EIS for the 2012-2017 five-year OCS leasing plan (BOEM 2012), and determined that these operations will not contribute substantively to GHG emissions in the vicinity of the planned operations. In prior studies, BOEM has analyzed the potential cumulative impacts of climate change (Arctic warming) in conjunction with oil and gas exploration and development activities in the Arctic, which would include the activities described in the Chukchi Sea Lease Sale 193 EIS (MMS 2007b). The Lease Sale 193 EIS reviewed the existing information and data concerning the potential effects of climate change on marine mammals and concluded that ringed seals, Pacific walruses, and polar bears are vulnerable to climate change and that close attention and effective mitigation measures with respect to polar bears are warranted (MMS 2006a, 2007b). BOEM also concluded that there is no current evidence of negative effects from climate change on whales (MMS 2007b). These prior analyses are incorporated herein by reference.

Emissions from other reasonably foreseeable activities, including Shell's Camden Bay exploration drilling program should it be conducted simultaneously with drilling operations proposed in EP Revision 2, would also be minimal in comparison to the Alaska total statewide and Alaska oil and gas industry GHG emissions. Therefore, Shell's proposed activities would contribute a negligible amount to overall GHG emissions into the planet's atmosphere.

Effects of Climate Change on Marine Lower Trophic Organisms

Reductions in the persistence and extent of sea ice could impact ice associated marine plankton (Clarke 1988). The lower surface of the ice and interstices in the ice are highly productive habitats for plankton which provide an important food source for herbivores both while the sea ice is in place and when it breaks up in the spring (Melillo et al. 1990). Gulliksen and Lonne (1989) indicated that sea ice habitat was quantitatively important to the marine food web of high latitude systems for fishes, sea birds and marine mammals. Hydrographic changes in currents, water temperatures, salinity and stratification of ocean waters may affect the productivity and distribution of plankton blooms with subsequent effects on species that utilize these organisms for food. Similarly, hydrographic changes may also alter the distributions and structures of benthic and epibenthic communities and organisms.

Effects of Climate Change on Marine Fish

Polar marine habitats are characterized by well-oxygenated waters with narrow cold temperature ranges (Rose et al. 2000). Because of their narrow temperature limits, even slight changes in polar temperatures may cause fish populations to shift their migratory patterns and geographical ranges. Cold-water adapted fishes may need to seek deeper water for cooler temperatures. Depending on how the ocean currents change, if some areas become isolated and remain very cold, the potential for horizontal migration would also exist. Further, changes in prey availability due to climate factors could also result in changes in the distributions of fish populations and communities. The effects, however, of such migrations on fish foraging patterns and life history strategies are unknown (Roessig et al. 2004).

Hydrographic changes that result is changes in salinity may also affect fish distributions. At present, there is little information available on the salinity tolerances or preferences of polar fishes. If polar fishes are intolerant of wide salinity ranges (stenohaline), they will be limited to the area below the halocline or will have to migrate to more haline areas. It is possible that these polar waters may eventually resemble the physical conditions in our present-day temperate waters. This may allow temperate fishes to colonize these areas, but such colonization may be at the expense of the polar species (Roessig et al. 2004).

Perry et al. (2005) found that the distributions of both exploited and nonexploited North Sea fishes responded markedly to recent increases in sea temperature, with nearly two-thirds of species shifting in mean latitude or depth or both over a 25-year period. For species with northerly or southerly range margins in the North Sea, half showed boundary shifts with warming, and all but one shifted northward. Species with shifting distributions had faster life cycles and smaller body sizes than nonshifting species. Similar changes have been reported in the Bering Sea (ACIA 2004, 2005) and would be expected in the Chukchi and Beaufort seas as well.

Effects of Climate Change on Marine and Coastal Birds

Most predictions of the effects of climate change on marine and coastal birds assume that temperature increases will lead to contraction of species ranges at low latitudes, accompanied by expansion at higher latitudes. In general, climate regimes influence species distributions through species-specific physiological thresholds for tolerance of temperature and other environmental variables. As climate warms these favorable conditions are shifted towards the poles. To the extent that dispersal and resource availability allow, species are expected to track the shifting climate and shift their distributions poleward in latitude as well. Since not all species will respond to climate change at the same rate, some species may be exposed to new competitors for resources in their environment while others may have new areas open to them for colonization and expansion. These interactions may alter distributions and community structure of bird communities.

In general, there are few studies that have documented shifts in bird populations associated with climate. Most birds inhabiting the project area are migratory species that often show large fluctuations from year to year in breeding sites and phenological patterns making it difficult to document long-term shifts.

Effects of Climate Change on Marine Mammals

The potential effects of climate change on marine mammals in the Chukchi and Beaufort seas vary among species. The current warming trend has increased sea–water temperature, and reduced the size of the polar ice cap (Stroeve et al. 2008). Climate change may potentially affect marine mammals in the Chukchi and Beaufort seas in numerous ways and at locations outside of the Chukchi and Beaufort seas. The potential impacts of global climate change on marine mammals in the Arctic may be much greater than those that are likely to result from industrial activities or subsistence hunting.

MMS (2007b) described numerous activities or situations related to global climate change that have the potential to impact marine mammals in the Chukchi and Beaufort seas. These include factors such as:

- potential changes in the distribution, concentration and availability of marine mammal prey species such as fish, benthic invertebrates, and plankton;
- changes in distributions of marine mammals in response to changes in distribution of prey species;
- impacts to subsistence hunting of marine mammals resulting from changes in marine mammal distribution;
- potential expansion of the ranges of some predators such as killer whales that prey on marine mammal species;
- increased shipping and research vessel traffic through the Northwest passage and other areas of the Arctic which could result in increased disturbance to marine mammals, and the potential for collisions of marine mammals with vessels;
- potential for commercial fishing activities to occur in the Chukchi and Beaufort Seas accompanied by increased disturbance from vessel traffic, and potential for marine mammal collision with vessels, entanglement with fishing gear, and possible competition with marine mammals for prey species;
- increased risk of contaminants such as oil or fuel spills from vessel traffic being released into marine environments; and
- increased potential for conflicts between humans and polar bears.

Perhaps the most obvious impact to the environment resulting from climate change in the Arctic has been the retreat of the polar pack ice. Stroeve et al. (2008) reported a declining trend in the extent of Arctic sea ice since 1953. The extent of Arctic sea ice declined to an unprecedented low in 2007 which was a 23% reduction from the previous low in 2005.

Polar bears and ringed seals are year–round residents of the Arctic that rely on the polar pack ice. Ringed seals excavate breathing holes and lairs in the ice which are used for resting, giving birth, and during pup weaning. Ringed seals also use the pack ice for resting during their annual molt. Polar bears feed primarily on ringed seals and female polar bears build winter dens on ice and land to give birth (Bentzen et al. 2007; Bergen et al. 2007; Fischbach et al. 2007). Earlier melting of sea ice in spring may result in exposure of ringed seal lairs making seals more susceptible to polar bear predation, reduce the availability of molting habitat, and result in reduced growth rate and survival of pups. A reduction in the ringed seal population could reduce availability of food for polar bears and affect polar bear survival. Early melting may also have the potential to cause polar bear dens to collapse reducing survival of cubs and adult females.

It is likely that some effects of global warming on polar bears have already been observed. Regehr et al. (2006) reported reduced survival of polar bear cubs in the southern Beaufort Sea region of the U.S. and Canada that appeared to be related to warming conditions in the Arctic. Regehr et al. (2006) also reported a reduction in the body weight and skull size of adult male polar bears captured from 1990 to 2006 compared to bears captured prior to 1990. The smaller stature of adult males was notable since it corresponded with higher mean age of the captured male bears. Relatively high numbers of polar bears were seen along the Beaufort Sea coast in 2007 and 2008 and the Chukchi Sea coast in 2008. Most of these bears were seen during periods when vessels were not actively working or during aerial surveys. Movement of polar bears to coastal areas has been suggested as an early result of climate warming and has been predicted to increase as the climate warms and the pack ice retreats. USFWS has determined that climate change poses a threat to the survival of the polar bear and other marine mammal species throughout their ranges because of the resulting loss of sea ice, upon which they depend. The USFWS listed the polar bear as threatened under the Endangered Species Act (USFWS 2008d). USGS information from nine recent studies presenting the relationships of polar bears to present and future sea–ice environments is available online at http://www.usgs.gov/newsroom/special/polar_bears/.

Changes in the extent of the pack ice will likely result in changes in the distribution and abundance of ringed seals, polar bears, and other marine mammals. Pacific walruses and bearded seals move with the ice edge from the Bering Sea during the winter to the Chukchi Sea (and Beaufort Sea for bearded seal) in the spring and summer. Walruses and bearded seals feed primarily on benthic invertebrates and the ice edge provides them with a platform for resting adjacent to feeding habitat. Pacific walruses and bearded seals probably feed in relatively shallow water to ~80 m (87 yd) in depth although deeper dives have been recorded (Fay and Burns 1988).

Pacific walruses (and possibly bearded seals) are probably more common in the Chukchi than the Beaufort Sea due to the greater concentrations of benthic biomass in the Chukchi Sea (Dunton et al. 2005). Most of the Chukchi Sea is relatively shallow with depths generally <50 m (164 ft) providing extensive feeding habitat for benthic–feeding marine mammals. Pacific walruses normally haul out on ice to rest during the summer in the Chukchi Sea and generally do not haul out on land in large numbers along the Chukchi Sea coast. However, as described earlier, in summer 2007, 2009 and 2010 the pack ice retreated north of the Chukchi Sea into the Arctic Ocean where water depths were much greater and large numbers of Pacific walruses were observed hauled out along coastal locations from Barrow to Cape Lisburne. In those years, the pack ice likely retreated to water too deep for walrus feeding and that their use of land–based haulouts along the Chukchi Sea coast was an effect of increasing temperatures due to climate change. How the use of land–based haulouts along the Chukchi Sea coast rather than haulout locations on the pack ice will impact walruses is unknown. However, there may be potential for mortality of young walruses to result during stampedes of large walrus groups at land–based haulouts as occurred in 2009. The USFWS was petitioned to list Pacific walruses as a T&E species under the ESA (CBD 2008). Much of the rationale in the petition was based on the potential effects of global climate change. The Pacific walrus was subsequently given candidate species status as described in Section 3.8.9.

The retreating pack ice may also increase the likelihood of walrus calf mortality due to cow/calf separation. Cooper et al. (2006) reported the occurrence of walrus calves that had been separated from adult female walruses on ice floes in the Canadian Arctic. Pack ice in the area had retreated and the ice floes were located in water depth of >9,843 ft (>3,000 m) (well over depths within which walruses are known to feed).

How changes in environmental variables resulting from global climate change are likely to affect cetaceans in the Arctic is unknown; however, some preliminary analyses have found positive correlations between the extent of open water in bowhead whale summer feeding areas and bowhead calf production. Thus, some types of environmental changes may be beneficial to some species while other changes may have negative impacts.

Increasing temperatures could also result in changes in the distribution and abundance of cetacean prey such as fish, benthic invertebrates, and plankton, which could be beneficial if food availability increased. If prey availability increased further offshore as a result of the current warming trend, bowhead whales may move further offshore during migration and become less available to subsistence hunters. This could produce an overall benefit to the whales but could seriously impact the cultural and social traditions and activities of Native communities.

Alternatively, invasions of new species either through range expansion or as introduced species may impact the availability of various prey species via increased competition among organisms. Very few introduced species are currently known at high latitudes, probably due to environmental resistance due to cold water temperatures, seasonal fluctuations in resources, and the relative lack of human disturbance (Ruiz and Hewitt 2009). As temperatures change, environmental resistance would be lowered for some species allowing range expansion. Increased ship traffic and development of coastline and offshore structures will increase the numbers of introduced species reaching northern waters and the lower environmental resistance may increase the potential for introduced species to become established.

Other cetaceans not normally found in the Arctic could also extend their ranges northward and compete with Arctic cetaceans for food. Sightings of humpback whales, fin whales and increased numbers of harbor porpoises and Minke whales in the Chukchi and Beaufort Seas in 2007 and 2008 (Funk et al. 2007; Ireland et al. 2008; Reiser et al. 2009; Green et al. 2007) may be an early example of such a range extension. Killer whales are known predators on beluga whales as well as on large baleen whales, and increased numbers of killer whales in the Arctic could result in higher predation pressure on beluga, bowhead, and gray whales. MMS (2007b) concluded that the potential effects of climate change on bowhead whale populations are uncertain, and there is no current evidence of negative effects from climate change on the whales.

Various types of anthropogenic activities, which are generally thought to negatively impact cetaceans and other marine mammals, are likely to increase in the Arctic if the pack ice continues to retreat. Increased vessel traffic may result from various sources such as oil and gas exploration and development, scientific research, commercial fishing, and increased shipping activity. Increased vessel traffic could increase disturbance to marine mammals resulting in displacement from preferred habitats as discussed above. However, it is not clear that temporary displacement or changes in behavior produce impacts that are biologically significant. Increased vessel traffic would increase the potential for marine mammal collisions with vessels which could result in mortality. Commercial fishing could also impact marine mammals through potential entanglement in gear, and trawling activities have the potential to disturb benthic communities that serve as food sources for some marine mammals (McConnaughey et al. 2000).

Interaction of the Effects of Climate Change with those of EP Revision 2

Almost all identified effects associated with the proposed exploration drilling program would no longer be evident within one year of cessation of the exploration drilling. Some negligible effects on the seafloor sediments, such as alterations of relief, changes in sediment consistency, and changes in the benthic invertebrate community, may be evident for a longer period of time – a few years or more – but would be restricted to an extremely small portion of the Chukchi Sea. Climate change is a slow and continuous process, with noticeable change unlikely to occur over the next one to a few years when effects from Shell’s exploration drilling program would be evident. The effects of the exploration drilling program have been assessed in Section 4.1 through 4.12 under the current climate regime and considering the current levels of stressors on the various resources from past and present climate change. These project effects are not significant to the state of the climate over the next several years.

5.3.2 Potential Cumulative Impacts on Ocean and Airborne Ambient Sound Levels

For the purpose of the cumulative impact analysis, Shell's proposed activities under EP Revision 2 have been assumed to begin in 2015 and take three drilling seasons to drill six wells. The planned exploration drilling program will introduce industrial sounds into the marine environment from exploration drilling, anchor handling, ice management, short-term (approximately 10-14 hours per well) ZVSP airgun operations, and vessel and aircraft traffic. Vessels are the greatest anthropogenic contributors to overall sound energy in the sea. Sound levels and frequency characteristics of vessel sound energy underwater generally are related to vessel size and speed. Larger vessels generally emit more sound than smaller vessels, and those underway with a full load, or those pushing or towing a load, are noisier than unladen vessels. The primary sources of sounds from all vessel classes are propeller cavitation, propeller singing, and propulsion or other machinery. Propeller cavitation is usually the dominant noise source for vessels (Ross 1976).

Ice management vessels contribute greater sound levels during ice-breaking activities than ships of similar size during normal operation in open water (Richardson et al. 1995a). This higher sound production results from the greater amount of power and propeller cavitation required when operating in thick ice.

Marine geophysical surveys including seismic and shallow hazards surveys use high-energy sources of sound or vibration to create seismic waves in the earth's crust beneath the sea. Airguns function by venting high-pressure air into the water. High-energy, low-frequency sounds usually in the form of short-duration pulses are created along survey grids. Airgun arrays are designed to transmit strong sounds downward through the seafloor, and the amount of sound transmitted in near-horizontal directions is considerably reduced. Nonetheless, they also emit sounds that travel horizontally toward non-target areas. Sound pulses from marine seismic surveys are often detectable in the water at tens or hundreds of kilometers (Richardson et al. 1995a).

Underwater sound propagation from the drilling unit results from the use of generators, drilling machinery, and the drilling unit itself. Sound levels during vessel-based operations may fluctuate depending on the specific type of activity at a given time and aspect from the vessel. Underwater sound levels may also depend on the specific equipment in operation. Lower sound levels have been reported during well logging than during drilling operations (Greene 1987b), and underwater sound appeared to be lower at the bow and stern aspects than at the beam (Greene 1987a).

The levels and duration of sounds entering the water from a passing helicopter or fixed-wing aircraft are a function of the type of aircraft, orientation of the aircraft, and water depth (Table 2.9-6). Aircraft sounds are detectable underwater at greater distances when the receiver is in shallow rather than deep water. Generally, sound levels received underwater decrease as the altitude of the aircraft increases (Richardson et al. 1995a). Aircraft sounds are audible for much greater distances in air than in water.

All of the above sounds that will be generated during Shell's planned exploration drilling program will contribute additively to other industrial sounds that enter the Chukchi Sea marine environment from aircraft, vessel, and barge traffic, and any other oil and gas exploration activities that might occur. Shell is not aware of any seismic survey activities planned in the vicinity of the Burger Prospect area or elsewhere in the Chukchi Sea in 2015, nor does Shell expect that the other two operators with aspirations to drill exploration wells in the Chukchi Sea would be in a position to commence exploratory drilling operations during the 3 year period covered by this cumulative impacts analysis. Furthermore, should Shell conduct exploration drilling activities in Camden Bay simultaneously with the proposed Chukchi Sea exploration program, the acoustic footprints of the Chukchi and Beaufort Sea drilling operations would be separated in space such that they would not overlap or act cumulatively. Thus, no other exploration programs are anticipated to overlap with Shell's proposed exploration drilling program or contribute additively to industrial sound in the Chukchi Sea.

Small boats with inboard and outboard motors used for subsistence activities also contribute to in-water sound. In general, sound in the world's oceans has increased (Weilgart 2007). As described in Section 4.7, underwater sound has the potential to cause disturbance to marine organisms, particularly marine mammals.

Given the type and number of identified activities that may take place during Shell's exploration drilling program, and the area encompassed by the Chukchi Sea, cumulative effects on ambient sounds levels will be minor. MMS (2007) reviewed the cumulative effects of noise associated with oil and gas exploration and production, and seismic surveys, and concluded similarly that these activities would not add significantly to the cumulative impacts on such species as bowhead whale.

5.3.3 Potential Cumulative Impacts on Air Quality

Air quality in the Chukchi Sea and onshore areas adjacent to the Chukchi Sea is considered to be good as indicated by EPA designation and air quality monitoring data from monitoring stations in Wainwright and Point Lay, Alaska (Table 3.1.3-1). Emissions in the region come primarily from vessels and from electrical power generation in the villages of Barrow, Wainwright, Point Lay, and Point Hope, with smaller amounts from the operation of heavy equipment, vessels, and vehicles such as cars, trucks, and all-terrain vehicles. These would be expected to continue at the present levels during the time period of the cumulative effects analysis. Other reasonably foreseeable activities that would also potentially affect air quality include the general vessel traffic, shallow hazards, hydrographic, geophysical, geotechnical, and environmental surveys described above. Various engines on the vessels used for these purposes will emit pollutants of the same type and similar quantities as vessels used for Shell's exploration drilling program.

Shell's exploration drilling program will emit air pollutants, largely through the use of combustion engines. EP Revision 2 effects on air pollutants include two drilling units, an increase in the number of support vessels, increased vessel and aircraft traffic, and use of an expanded shorebase in Barrow. Emissions of primary interest include NO_2, CO, SO_2, $PM_{2.5}$, and VOC. As described in Sections 4.0 and 4.1 and indicated in Table 4.1.1-1, modeled cumulative pollutant concentrations resulting from the drilling units and their support vessels plus existing background concentrations at the shoreline are less than 50 percent of the NAAQS primary and secondary standards, which are designed to protect human health and all aspects of the public welfare, including flora and fauna. Modeling also indicates that any effects on air quality in offshore areas will be minor. Predicted cumulative concentrations of air pollutants in offshore areas used for subsistence are far below the impact criteria thresholds developed, as indicated in Table 4.1.2-1.

The air quality modeling utilized background concentrations from baseline air quality data collected at Wainwright in 2009 to 2013 and Point Lay in 2010 to 2013. These baseline data were collected during years and times when the other offshore activities described above, such as aforementioned surveys, barge traffic, and onshore power generation, were ongoing. Because these other activities are expected to occur in the future at the range of activity levels experienced during collection of the baseline data, the modeling results represent an assessment of the cumulative impacts on air quality given the above-identified reasonably foreseeable activities.

If Shell conducted exploration drilling activities in Camden Bay simultaneously with Chukchi Sea exploration drilling activities, emissions from both drilling operations would also meet NAAQS standards. Given the significant distance between the proposed drill sites in the Chukchi Sea and Beaufort Sea, Shell's two exploration drilling programs would not cumulatively affect the same resources. The anticipated emissions at both locations are expected to be well below NAAQS and AAAQS at the shoreline as a result of distance from shore, permit restrictions, and dispersion. The incremental contribution to cumulative impacts on air quality from the revised Chukchi Sea exploration drilling activities is therefore expected to be minor. Given that other present and reasonably foreseeable activities will occur during the exploration drilling program at approximately the current level, no additional impacts would be expected, and the cumulative effects on air quality are considered minor and will last only as long as the drilling.

5.3.4 Potential Cumulative Impacts on Water Quality

Water quality is considered to be good in the Chukchi Sea, with few if any effects of past human activities. Potential water quality impacts of the EP Revision 2 include the discharge of drilling wastes at each drill site and the discharge of wastewaters associated with vessel and drilling units such as graywater, treated blackwater, deck drainage, cooling water, ballast water, and bilge water from the additional vessels. These discharges will result in negligible effects on water quality (e.g. increases in turbidity, BOD, temperature) that are restricted to the area within near the discharge outfall and ephemeral lasting only minutes longer than the discharge.

As noted above, the drilling units will discharge drilling wastes with resulting negligible water quality effects. EP Revision 2 includes the addition of a number of new drilling fluid components and increases in estimated drill waste discharge volumes. The drilling fluids have been shown to have low toxicity. The primary water quality effect of the discharges will be temporary increases in TSS, which would largely be limited to the area within 328 to 984 ft (100 to 300 m) of the discharge.

Other reasonably foreseeable activities that would also potentially affect water quality include vessel discharges associated with the general vessel (barge) traffic, and shallow hazards, hydrographic, geophysical, geotechnical, and environmental surveys described above. Vessels used for these purposes will necessarily discharge the same types of effluents due to normal vessel activity. Quantities of the discharges will also be similar to those from vessels associated with Shell’s exploration drilling program, depending on vessel size and crew numbers. Geotechnical surveys will also discharge drill cuttings and potentially drilling fluids, at each borehole. Volumes of these discharges will be much less than those associated with the drilling of exploration wells at the Burger Prospect, due to the smaller diameter and shallower depth of the boreholes.

Water quality effects of vessel discharges of deck drainage, cooling water, ballast water, and bilge water, associated with the Shell’s EP Revision 2 and the other identified reasonably foreseeable activities, will be negligible, lasting only minutes longer than the actual discharge, and not causing unreasonable degradation of water quality. The effects from these discharges will be limited to the immediate vicinity of the vessels and the drilling units, as indicated by modeling and published findings. Although these activities would occur in the same sea and are therefore technically additive, there would be little or no opportunity for overlapping or synergistic effects. The vessels will be at various scattered locations across the Chukchi Sea when in transit or on standby, while the ephemeral impacts associated vessel discharges will be generally limited to the area within 330 ft (100 m) of the vessel. The Chukchi Sea is a very large open water body of more than 230,000 mi^2 (595,697 km^2) and the Lease Sale 193 Area is 53,125 mi^2 (137,593 km^2). Additive effects on water quality would be negligible given the immense size of the Chukchi Sea.

The EPA has evaluated the cumulative environmental impact of these types and quantities of vessel discharges in territorial seas as part of their NPDES program prior to issuing their GPs for vessels (VGP) (EPA 2006a, 2008, 2012a), and drilling discharges under the NPDES exploration facilities GP for oil and gas exploration facilities (AKG-28-8100). EPA has concluded repeatedly that these discharges would not result in “unreasonable degradation” (as defined in 40 CFR 125.122) of ocean waters of the Chukchi Sea, which means they will not result in:

- Major adverse changes in the ecosystem diversity, productivity, and stability of the biological community within the area of discharge and surrounding biological communities
- Threat to human health through direct exposure to pollutants or through consumption of exposed aquatic organisms
- Loss of aesthetic, recreational, scientific, or economic values

Cumulative impacts on water quality of the Chukchi Sea from Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities, are considered negligible. Modeling (as described in Sections 4.0 and 4.2) has confirmed that the effects from these discharges on water quality are temporary and limited to the vicinity of the drilling units. Therefore, there would be no opportunity for cumulative effects when considering impacts from Shell's Camden Bay exploration activities should drilling occur simultaneously with the proposed exploration drilling activities in the Chukchi Sea. This finding is generally consistent with the BOEM's conclusion in its Lease Sale 193 FEIS, where the BOEM concluded that sustained effects on water quality resulting from any post lease activities would be low, represent only a small percentage of the foreseeable cumulative effects, and would not contribute significantly to cumulative effects on water quality (MMS 2007b). BOEM further stated that degradation of local and regional water quality from discharges and offshore construction activities was unlikely (MMS 2007b).

5.3.5 Potential Cumulative Impacts on Sediment Quality

Sediment quality is considered to be good in the Chukchi Sea. Metal concentrations are low and thought to be due to terrigenous rather than anthropogenic input. Contaminated sediments are not known to occur in the area. Anthropogenic disturbances to the seafloor in the area of analysis have been few. Although sedimentation rates are low, sediments are reworked by such natural forces as ice gouging, storms, and currents that ameliorate any lasting effects of such disturbances. Anchoring (Table 2.3-2) and MLC construction (Table 2.3-4) over the course of the exploration drilling program are expected to directly disturb less than 5.28 ac (21,354 m^2) of seafloor and indirectly affect an additional area of seafloor encompassing between 16.2 (0.07 km^2) and 32.6 ac (0.13 km^2) (Table 4.3.2-1) by the re-deposition of drill cuttings to a depth of about 0.4 in (1.0 cm). There will be some changes in relief and sediment consistency over these areas as well as minor elevations in concentrations of some metals (Section 4.3). However, these elevations have not been found to exceed risk-based exposure thresholds at historical wells (Trefry and Trocine 2009) or to produce discernible differences in the benthic biological communities (Dunton et al. 2009). Some of these effects will last beyond the time frame of the exploration drilling program, but will be ameliorated by natural forces in 10 to 20 years (DTI 2003). Given the enormity of the seafloor in the area of analysis, these effects are considered negligible. Impacts on sediment quality at each of the proposed drill sites are so localized that they are not expected to affect any other drill site in Shell's Burger Prospect in the Chukchi Sea, even if Shell is operating its two drilling units simultaneously at the closest two drill sites. Further, impacts on sediment quality will not have any synergistic or additive impacts were Shell to conduct simultaneous operations in the Beaufort Sea (or even if other operations were to drill in the Chukchi Sea in the next few years).

5.4 Cumulative Impacts on the Biological Resources

Shell's exploration drilling program in the Chukchi Sea will result in negligible or minor and temporary cumulative effects on lower trophic organisms, fish and essential fish habitat, marine mammals (including T&E marine mammals), birds (including T&E birds), subsistence, and socioeconomics. Each of these is discussed in further detail below.

5.4.1 Potential Cumulative Impacts on Lower Trophic Organisms

Potential effects from Shell's exploration drilling program on lower trophic organisms could occur from changes to water quality associated with disturbance caused by sediment plumes from MLC construction and vessel mooring, and various permitted discharges that may change the temperature or chemical properties of the water column. Additionally, benthic organisms could be impacted by destruction of habitat associated with vessel mooring, MLC construction, and drilling waste discharges. Changes for EP Revision 2 include two drilling units, additional support vessels, changes in drilling fluids, and increased estimates of the volume of drilling wastes to be discharged at each drill site.

Other reasonably foreseeable activities potentially affecting lower trophic organism include discharges from barges and other vessels in the Chukchi Sea, including the described geophysical and geotechnical surveys to be conducted by Shell and NOAA, and seafloor impacts from past exploration drilling and present and future geotechnical surveys.

Water quality effects from discharges associated with vessels and drilling are ephemeral and unlikely to have any more than a negligible impact on plankton and other lower trophic organisms and would be unnoticeable at the population level. The effects are limited to the immediate vicinity of the discharge so no overlapping or synergistic effects will occur between discharges from the various identified present or reasonably foreseeable activities. Most of these effects due to water quality would end as soon as the discharge is discontinued.

A small amount of seafloor habitat will be altered from construction of MLCs, mooring and anchoring of drilling units and vessels, and accumulation of drill cuttings and drilling fluids on the seafloor. This will result in localized effects to lower trophic organisms through direct destruction of benthic organisms and the loss of available habitat. The seafloor would be re-colonized by benthic organisms over the course of a year or more. Habitat effects due to mooring, MLC construction, and drilling waste discharges may remain longer, but would be minor given the small area affected and the enormity of available habitat in the Chukchi Sea.

The habitat loss associated with EP Revision 2 will be additive to the seafloor impacts remaining from the five historical wells in the Chukchi Sea and future seafloor disturbances from geotechnical surveys. Monitoring studies indicate that little environmental effect remains at the historical well sites. Geotechnical surveys will disturb very little seafloor due to the small number, small diameter, and shallow depth of the boreholes. Together, the area of impact represents an extremely small portion of the available similar habitat in the Chukchi Sea. Cumulative impacts on lower trophic organisms from Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities, are considered minor.

5.4.2 Potential Cumulative Impacts on Fish and EFH

Potential effects from Shell's exploration drilling program on fish and EFH are described in Section 4.5 and could potentially occur from changes to water quality associated with disturbance caused by sediment plumes from MLC construction, drilling unit and vessel mooring and anchoring, various permitted discharges that may change the temperature or chemical properties of the water column, and small releases of liquid hydrocarbons. Sound energy generated by vessels, ice management, drilling, and the operation of ZVSPs could also affect fish. Aspects of EP Revision 2 that could potentially impact fish or EFH include two drilling units, additional support vessels, changes in drilling fluids, and increases in drilling waste discharges.

Overall, the cumulative impacts on fish and EFH from Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities, are considered negligible to minor. Details of the cumulative effects for each impact factor are discussed below.

Cumulative Effects of Marine Sounds on Fish

Shell's proposed activities will introduce industrial sounds into the environment from drilling operations, anchor handling, ice management, ZVSP operations, and vessel and aircraft traffic. New measurements of the sound energy generated by vessel traffic, drilling, and ice management, are provided in Section 2.9 of this document. Reasonably foreseeable activities that would result in sound generation include the identified hydrographic, geophysical, geotechnical and environmental surveys. Sound would be generated by vessel engines and movement as well as geophysical equipment. Shallow hazards surveys would involve the use of airguns. Past requests for MMPA authorization for airgun arrays used in shallow hazards surveys indicate the maximum 160 dB distance (e.g., ensonification distance for an impulse underwater sound source to which exposure to sound may constitute incidental harassment) would be 0.6 to 1.8 km (0.38 to 1.13 km) from the airgun source. These surveys are typically limited to prospective well site locations and would be distant from on-going exploration drilling activities. Geotechnical surveys would result in some sound generation in conjunction with conducting the borings. Preliminary modeling analyses of geotechnical surveys in prior requests for MMPA authorization indicate the maximum 120 dB distance (e.g., ensonification distance for a continuous underwater sound source to which exposure to sound may constitute incidental harassment) would be approximately 4 km (2.5 mi) from the geotechnical survey vessel, equal to the sound of the vessel positioned by DP. These types of surveys are very short term in duration, hours to just a few days. Current levels of marine sound are not great enough to cause abandonment of habitat at a level that has affected fish populations of any species present in the project area. While it is theoretically possible that impacts could accumulate to that level in the future it would require much greater impacts than those expected from Shell's exploration drilling program and the other identified reasonably foreseeable activities.

Potential cumulative effects from the proposed project on marine fish could occur from increased in-water sound from numerous industrial sources including aircraft The cumulative impacts on fish from sound generation associated with Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities, will be negligible.

Cumulative Effects of Water Quality Impacts on Fish

Potential effects on water quality from Shell's drilling program as described in EP Revision 2 include increased TSS, BOD, and water temperature associated with vessel and drilling waste discharges and potentially the introduction of petroleum through small spills. These types of impacts will be short term and limited to very small areas near the point of discharge.

Other reasonably foreseeable activities that would have similar water quality impacts due to vessel discharges include general vessel and barge traffic, NOAA's proposed hydrographic surveys, and Shell's potential geophysical and geotechnical surveys. Geotechnical surveys would also discharge drill cuttings and possibly drilling fluids. Although these activities would occur in the same sea, they would be separated in time and space and would be unlikely to have any additive or synergistic effects, particularly given the size of the Chukchi Sea. Similarly, no additive or synergistic effects would be expected as a result of Shell's drilling operations in Camden Bay occurring simultaneously with the proposed exploration drilling program in the Chukchi Sea. The cumulative impacts of water quality on fish associated with Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities, will be nonexistent or negligible.

Cumulative Effects of Seafloor Habitat Impacts on Fish

Shell's exploration drilling program as described in EP Revision 2 will have localized impacts on seafloor sediments associated with mooring of the drilling units and vessels, MLC construction, and the discharge of drilling wastes. These types of impacts will be long term but limited to a very small portion of the available habitat in the Chukchi Sea.

Other reasonably foreseeable activities that would have similar seafloor habitat impacts include past exploration drilling and present or future geotechnical surveys. Monitoring studies indicate that little effect due to past exploration drilling programs remains. Were Shell to conduct geotechnical surveys, they would result in very little seafloor disturbance due to the number, diameter, and depth of the boreholes. The cumulative impacts on fish from seafloor habitat impacts associated with Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities, will be negligible given the size of the Chukchi Sea.

5.4.3 Potential Cumulative Impacts on Birds

Potential effects from Shell's exploration drilling program as described in EP Revision 2 on birds, including those listed under the ESA, are described in detail in Section 4.6 and 4.8 include: disturbance and/or collisions by vessel and aircraft traffic; effects from sound energy generated by vessels, drilling, and ZVSPs; water quality effects from vessel discharges, drilling waste discharges, and small petroleum spills; and air quality effects due to emissions from vessels and the drilling units.

Other reasonably foreseeable activities potentially affecting birds include: disturbance associated with barges and other vessel traffic in the Chukchi Sea, including the described geophysical, shallow hazards, geotechnical, and environmental surveys to be conducted by Shell and NOAA; discharges associated with vessel traffic and survey vessels for these activities; seafloor impacts from past exploration drilling and geotechnical surveys; and air quality impacts from other emission sources in the region including vessels and village power generation.

Overall, the cumulative impacts on birds from Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities, are considered minor. Details of the cumulative effects for each impact factor are discussed below.

Cumulative Effects of Vessel Traffic on Birds

Shell's exploration drilling program as described in EP Revision 2 will contribute to an increase in vessel traffic in the northeastern Chukchi Sea where the project is located and throughout the Chukchi Sea in general. Vessels associated with Shell's exploration drilling program in 2012 resulted in temporary avian disturbances and a small number of bird mortalities due to vessel collisions. The identified reasonably foreseeable barge and general vessel traffic and surveys vessels would be expected to have similar effects. Disturbance effects are likely not additive as they would not occur in the same time and space often enough to result in any cumulative effects such as area abandonment. Mortalities due to vessel-avian collisions would be additive if they occurred in the same season, but the sum total would be an extremely small portion of the bird populations and would therefore have minor and temporary effects.

Oil and gas exploration is expected to increase the number and extent of scientific studies in the Chukchi Sea, but such studies generally have little impact except for temporary behavioral disturbance of fish, birds, and marine mammals.

Current levels of vessel traffic as identified in Table 5.2.1-1 and Figure 5.2.1-1 above are not great enough to cause abandonment of coastal or marine bird habitat of the Chukchi Sea or North Slope, or to result in more than small number of avian collisions. Levels of vessel traffic expected to occur during the time period of the cumulative effects analysis, including Shell's EP Revision 2 and other identified present and reasonably foreseeable activities, are not expected to vary greatly from the range of these previous annual vessel traffic levels.

Most bird species using offshore habitats in the project area are migratory and are exposed to greater levels of vessel traffic in other portions of their range than they are exposed to on the North Slope. The cumulative impacts on marine and coastal birds due to vessel traffic associated with Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities, including a case where simultaneous drilling operations were conducted in Camden Bay and the Chukchi Sea, will be minor and temporary.

Cumulative Effects of Air Quality on Birds

Ambient air quality modeling conducted for Shell's exploration drilling program under EP Revision 2 was based on emission estimates that are considered to be maximums. Primary and secondary NAAQS standards will be met seaward of the shoreline, with the projected impact values at the shoreline being less than 50 percent of NAAQS (Table 4.1.1-1). Actual emissions are expected to be less than these calculated emissions. The NAAQS primary and secondary standards are designed to protect human health and all aspects of the public welfare, including flora and fauna. The modeling also indicated little effect on air quality in offshore waters (Table 4.1.2-1). The modeling effort included background concentrations collected during years when emissions are similar to that expected in the future. The cumulative impacts on marine and coastal birds from air quality impacts associated with Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities, will be negligible.

Cumulative Effects of Sound on Birds

Shell's exploration drilling program will introduce industrial sounds into the environment from drilling operations, anchor handling, ice management, ZVSP operations, and vessel and aircraft traffic. Sound energy would be emitted into the air and water. These sounds contribute additively to other industrial and non-industrial sounds when they are contemporaneous. Birds react to in-air sounds associated with various activities by flushing and moving away from the sound source. If sound in an area increased enough it is possible that birds might abandon use of the area. If that area was preferred feeding, molting, or brood-rearing habitat population level consequences for those species might occur. Current levels of underwater and in-air sound are not great enough to cause abandonment of coastal or marine bird habitat on the North Slope (Section 4.6).

Reasonably foreseeable activities that would also contribute sound in the Chukchi Sea include barge and vessel traffic, NOAA's proposed hydrographic surveys, and Shell's potential geophysical and geotechnical surveys. Marine and coastal bird species with the potential to be impacted by the EP Revision 2 activities are migratory. Table 5.4.3-1 details the types of impacts the migratory bird species most likely to be encountered in the Chukchi Sea would experience outside of the Chukchi Sea during migration, and identified potential cumulative impacts that might be experienced over the course of a year as a function of seasonal timing and location. The cumulative impacts on marine and coastal birds due to underwater and in-air sound associated with Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities, will be negligible.

Current levels of in-air sound are not great enough to cause abandonment of coastal or marine bird habitat on the North Slope. While it is theoretically possible that impacts could accumulate to that level in the future it would require much greater impacts than those proposed for Shell's exploration drilling program in conjunction with present and reasonably foreseeable activities. Most bird species using North Slope habitats are migratory and are often exposed to greater levels of sound in other portions of their habitat than they are exposed to on the North Slope.

Cumulative Effects on Migration of Marine and Coastal Birds

As discussed in Sections 3.6 and 3.8, marine and coastal bird species with the potential to be impacted by EP Revision 2 activities are migratory. These species spend the summer months in northern latitudes and overwinter to the south, often in offshore or coastal areas. Migratory bird species could be impacted by activities or events outside the Burger Prospect area and these impacts would be additive to or interactive with impacts from within the project area. Table 5.4.3-1 presents the migratory bird species most likely to be encountered during the project, summarizes their annual migratory patterns, and addresses potential cumulative impacts over the course of a year as a function of seasonal timing and location. Federally-listed bird species are also presented in Table 5.4.3-1 (Steller's and spectacled eiders, and yellow-billed loon); however, these species are uncommon in the project area. The list of species presented in Table 5.4.3-1 is not exhaustive; however, other migratory bird species are less common in the project area and few, if any, individuals from other species are likely to be encountered. Additionally, cumulative impacts on any other migratory marine or coastal bird species would be similar to those for species addressed in detail Table 5.4.3-1.

Potential impacts from activities and events outside the Burger Prospect that were considered for this analysis included those discussed above in Section 5.2 as well as inland development, competition with invasive species, and military operations. These additional considerations represent sources of potential impacts that migratory bird species may encounter during periods when they are away from the project area. .

Table 5.4.3-1 Summary of Potential Cumulative Impacts from Migration on Marine and Coastal Bird Species Most Likely to be Encountered During EP Revision 2 Activities (federally-listed species found in the region are also shown; however, these species are uncommon in the project area)

Species	Potential Presence during EP Activities[1]		Migration Summary[2]		Winter Habitats[2]	
	Most Likely Timing	Potential Impacts	Route / Location	Potential Impacts	Location	Potential Impacts
Pacific Loon *(Gavia pacifica)*	Fall	A, C, D, E, F, G	Spring and Fall: most follow coastal route, some individuals follow inland corridors	A, B, C, D, E, F, G, H	Pacific Coast from southeastern Alaska and northwest British Columbia to Mexico, casual on Great Lakes and Atlantic coast	A, B, C, D, E, F, G, H
Yellow-billed Loon† *(Gavia adamsii)*	Fall	A, C, D, E, F, G	Spring and Fall: coastal around western Alaska, some individuals follow inland corridors	A, B, C, D, E, F, G, H	Along Pacific Coast from southeastern Alaska to Vancouver Island	A, B, C, D, E, F, G, H
Northern Fulmar (*Fulmarus glacialis*)	Summer - Fall	A, C, D, E, F, G	Spring and Fall: pelagic across Chukchi and Bering Seas and Pacific Ocean	A, B, C, D, E, F, G, H	(Pacific race) offshore waters of SW Bering Sea, north and NE Pacific Ocean	A, B, C, D, E, F, G, H
Short-tailed Shearwater (*Puffinus tenuirostris*)	Summer - Fall	A, C, D, E, F, G	Spring and Fall: pelagic across Chukchi and Bering Seas and Pacific Ocean	A, B, C, D, E, F, G, H	Breeds off Australia during Alaska's winter	A, B, C, D, E, F, G, H
King Eider *(Somateria spectabilis)*	Fall	A, C, D, E, F, G	Spring and Fall: coastal Alaska; Spring: along open leads in ice	A, B, C, D, E, F, G, H	As far north as open water in Bering and Chukchi Seas; east coast of Kamchatka Peninsula to the Kurile Islands; Aleutian and Shumagin Islands and Kodiak Island	A, B, C, D, E, F, G, H

† indicates species classified as "Warranted but Precluded" by higher-priority species for listing under Endangered Species Act; uncommon in project area

"*Potential Impacts*" categories: A) Vessel/Aircraft Traffic; B) Commercial Fisheries; C) Oil and Gas Offshore Development; D) Non-oil and Gas Offshore Development; E) Inland Development; F) Hunting; G) Competition with Invasive Species; H) Military Operations

Table 5.4.3-1 continued Summary of potential cumulative impacts from migration on marine and coastal bird species most likely to be encountered during EP Revision 2 activities (federally-listed species found in the region are also shown; however, these species are uncommon in the project area)

Species	Potential Presence during EP Activities[1]		Migration Summary[2]		Winter Habitats[2]	
	Most Likely Timing	**Potential Impacts**	**Route / Location**	**Potential Impacts**	**Location**	**Potential Impacts**
Spectacled Eider* (Somateria fischeri)	Fall	A, C, D, E, F, G	Spring: possibly along ice leads, close to mountains and along river drainages; Fall: some over coastal plains adjacent to Brooks Range	A, B, C, D, E, F, G, H	ice leads in Bering Sea	A, B, C, D, E, F, G, H
Steller's Eider* *(Polysticta stelleri)*	Fall	A, C, D, E, F, G	Spring: offshore along major ice leads; Fall: along northwest coast of Alaska to Bering Strait and then along coast to winter habitats	A, B, C, D, E, F, G, H	Pribilof and Aleutian Islands, east along the southern coast of Alaska to Cook Inlet and along Pacific Coast to southern British Columbia, Eurasia from Scandinavia and Northern Russia south to Baltic Sea, Kamchatka and Commander and Kurile Islands and Japan	A, B, C, D, E, F, G, H

* indicates species listed as "Threatened" under Endangered Species Act; uncommon in project area

"*Potential Impacts*" categories: A) Vessel/Aircraft Traffic; B) Commercial Fisheries; C) Oil and Gas Offshore Development; D) Non-oil and Gas Offshore Development; E) Inland Development; F) Hunting; G) Competition with Invasive Species; H) Military Operations

Table 5.4.3-1 continued Summary of potential cumulative impacts from migration on marine and coastal bird species most likely to be encountered during EP Revision 2 activities (federally-listed species found in the region are also shown; however, these species are uncommon in the project area)

Species	Potential Presence during EP Activities[1]		Migration Summary[2]		Winter Habitats[2]	
	Most Likely Timing	**Potential Impacts**	**Route / Location**	**Potential Impacts**	**Location**	**Potential Impacts**
Long-tailed Duck *(Clangula hyemalis)*	Summer - Fall	A, C, D, E, F, G	Spring: along Pacific coast and interior along major river drainages, also along interior routes from Great Lakes; Fall: same as spring with possibly larger offshore component	A, B, C, D, E, F, G, H	Pacific Coast from Bering Sea to Washington State and in Eastern Asia	A, B, C, D, E, F, G, H
Pomarine Jaeger *(Stercorarius pomarinus)*	Summer - Fall	A, C, D, E, F, G	Spring: migrate north over open ocean and along coastal Alaska in Arctic, some inland migration along Colville River valley and across Arctic Coastal Plain; Fall: generally offshore	A, B, C, D, E, F, G, H	Those that breed in the Beaufort winter at sea primarily in the Pacific as far south as Peru	A, B, C, D, E, F, G, H
Parasitic Jaeger *(Stercorarius parasiticus)*	Summer - Fall	A, C, D, E, F, G	Spring: northward at sea on route that parallels coast, some inland migration as well; Fall: generally offshore	A, B, C, D, E, F, G, H	Winter well offshore in Pacific Ocean from southern California and Japan to Chile and New Zealand and Indian Ocean	A, B, C, D, E, F, G, H

"*Potential Impacts*" categories: A) Vessel/Aircraft Traffic; B) Commercial Fisheries; C) Oil and Gas Offshore Development; D) Non-oil and Gas Offshore Development; E) Inland Development; F) Hunting; G) Competition with Invasive Species; H) Military Operations

Table 5.4.3-1 continued Summary of potential cumulative impacts from migration on marine and coastal bird species most likely to be encountered during EP Revision 2 activities (federally-listed species found in the region are also shown; however, these species are uncommon in the project area)

Species	Potential Presence during EP Activities[1]		Migration Summary[2]		Winter Habitats[2]	
	Most Likely Timing	Potential Impacts	Route / Location	Potential Impacts	Location	Potential Impacts
Long-tailed Jaeger *(Stercorarius longicaudus)*	Summer - Fall	A, C, D, E, F, G	Spring: migrate northward at sea on route that parallels the coast, some inland migration as well; Fall: generally offshore	A, B, C, D, E, F, G, H	Offshore in Pacific Ocean from 0 to 50 degrees south latitude, most common in waters offshore Argentina and Chile	A, B, C, D, E, F, G, H
Black-legged Kittiwake *(Rissa tridactyla)*	Summer - Fall	A, C, D, E, F, G	Spring and Fall: offshore, typically along ice leads	A, B, C, D, E, F, G, H	Nearshore and pelagic waters from northeast Asiatic coast south to Japan and to North American coast from pack ice in Bering Sea to Baja California	A, B, C, D, E, F, G, H
Glaucous Gull *(Larus hyperboreus)*	Summer - Fall	A, C, D, E, F, G	Spring: migration near the coast following open leads in ice; Fall: follows spring migration route	A, B, C, D, E, F, G, H	Pacific Coast from Aleutian Islands to California	A, B, C, D, E, F, G, H
Ross's Gull (*Rhodostethis rosea*)	Fall	A, C, D, E, F, G	Spring: overland from northern Sea of Okhotsk and Anadyr Bay; Fall: eastward from Siberia into Chukchi Sea, then back westward into southern Chukchi and Bering Seas	A, B, C, D, E, F, G, H	Chukchi and Bering seas, Sea of Okhotsk, Kurile Islands	A, B, C, D, E, F, G, H

"*Potential Impacts*" categories: A) Vessel/Aircraft Traffic; B) Commercial Fisheries; C) Oil and Gas Offshore Development; D) Non-oil and Gas Offshore Development; E) Inland Development; F) Hunting; G) Competition with Invasive Species; H) Military Operations

Table 5.4.3-1 continued Summary of potential cumulative impacts from migration on marine and coastal bird species most likely to be encountered during EP Revision 2 activities (federally-listed species found in the region are also shown; however, these species are uncommon in the project area)

Species	Potential Presence during EP Activities[1]		Migration Summary[2]		Winter Habitats[2]	
	Most Likely Timing	Potential Impacts	Route / Location	Potential Impacts	Location	Potential Impacts
Sabine's Gull (*Xema sabini*)	Summer - Fall	A, C, D, E, F, G	Spring and Fall: pelagic across Chukchi and Bering Seas and Pacific Ocean	A, B, C, D, E, F, G, H	Winters at sea primarily in southern Pacific and Atlantic Oceans	A, B, C, D, E, F, G, H
Arctic Tern *(Sterna paradisaea)*	Summer - Fall	A, C, D, E, F, G	Spring and Fall: offshore, possibly completing final leg during Spring at high altitudes	A, B, C, D, E, F, G, H	Antarctic and subantarctic waters of Pacific, Atlantic and Antarctic Oceans	A, B, C, D, E, F, G, H
Common Murre (*Uria aalge*)	Summer - Fall	A, C, D, E, F, G	Spring and Fall: pelagic across Chukchi and Bering Seas and Pacific Ocean	A, B, C, D, E, F, G, H	Offshore and coastal waters of southern Bering Sea, Aleutian Islands, north and northeastern Pacific Ocean	A, B, C, D, E, F, G, H
Thick-billed Murre (*Uria lomvia*)	Summer - Fall	A, C, D, E, F, G	Spring and Fall: pelagic across Chukchi and Bering Seas and Pacific Ocean	A, B, C, D, E, F, G, H	Offshore of southern Bering Sea, Aleutian Islands, and north Pacific Ocean	A, B, C, D, E, F, G, H
Kittlitz's Murrelet† (*Brachyramphus brevirostris*)	Summer - Fall	A, C, D, E, F, G	not clearly defined for Chukchi individuals, offshore areas between Aleutian Islands and Chukchi Sea	A, B, C, D, E, F, G, H	Offshore areas of Aleutian Islands to northwest British Columbia	A, B, C, D, E, F, G, H

† indicates species classified as "Warranted but Precluded" by higher-priority species for listing under Endangered Species Act; uncommon in project area

"*Potential Impacts*" categories: A) Vessel/Aircraft Traffic; B) Commercial Fisheries; C) Oil and Gas Offshore Development; D) Non-oil and Gas Offshore Development; E) Inland Development; F) Hunting; G) Competition with Invasive Species; H) Military Operations

Table 5.4.3-1 continued Summary of potential cumulative impacts from migration on marine and coastal bird species most likely to be encountered during EP Revision 2 activities (federally-listed species found in the region are also shown; however, these species are uncommon in the project area)

Species	Potential Presence during EP Activities[1]		Migration Summary[2]		Winter Habitats[2]	
	Most Likely Timing	Potential Impacts	Route / Location	Potential Impacts	Location	Potential Impacts
Least Auklet (*Aethia pusilla*)	Summer - Fall	A, C, D, E, F, G	Spring and Fall: offshore areas between Aleutian Islands and Chukchi Sea	A, B, C, D, E, F, G, H	Offshore areas of southern Bering Sea and north Pacific Ocean east to Kodiak Island	A, B, C, D, E, F, G, H
Crested Auklet (*Aethia cristatella*)	Summer - Fall	A, C, D, E, F, G	Spring and Fall: offshore areas between Aleutian Islands and Chukchi Sea	A, B, C, D, E, F, G, H	Offshore areas of southern Bering Sea and north Pacific Ocean east to Kodiak Island	A, B, C, D, E, F, G, H
Red-necked Phalarope *(Phalaropus lobatus)*	Summer - Fall	A, C, D, E, F, G	Spring: across ocean and along Atlantic and Pacific coasts, also along inland prairie provinces of Canada; Fall: mostly offshore along spring routes, some travel inland along western North America	A, B, C, D, E, F, G, H	Offshore in South China Sea, in Indian ocean and off the coast of Peru	A, B, C, D, E, F, G, H
Red Phalarope *(Phalaropus fulicaria)*	Summer - Fall	A, C, D, E, F, G	Spring: well offshore; Fall: well offshore, flocks concentrate at ice edges and ocean fronts to feed	A, B, C, D, E, F, G, H	Offshore of Peru and Chile, West Africa south to Cape Good Hope, possibly South China Sea	A, B, C, D, E, F, G, H

[1] Gall and Day 2010

[2] Johnson and Herter 1989

† indicates species classified as "Warranted but Precluded" by higher-priority species for listing under Endangered Species Act; uncommon in project area

* indicates species listed as "Threatened" under Endangered Species Act; uncommon in project area

"*Potential Impacts*" categories: A) Vessel/Aircraft Traffic; B) Commercial Fisheries; C) Oil and Gas Offshore Development; D) Non-oil and Gas Offshore Development; E) Inland Development; F) Hunting; G) Competition with Invasive Species; H) Military Operations

5.4.4 Potential Cumulative Impacts on Marine Mammals

Potential effects from Shell's exploration drilling program on mammals and T&E mammals are described in detail in Sections 4.7 and 4.8 and include: disturbance by vessel and aircraft traffic; effects from sound energy generated by vessels, two drilling units and ZVSPs; water quality effects from vessel discharges, drilling waste discharges, and small petroleum spills; and air quality effects due to vessel and drilling unit emissions.

Past, present, and potential future actions that have impacted, or have the potential to impact marine mammals in the Chukchi Sea include: historic commercial whaling; past, current, and future subsistence hunting; previous and expected oil and gas exploration; the aforementioned reasonably foreseeable geophysical, shallow hazards, hydrographic, geotechnical, and environmental surveys that may be conducted by Shell and NOAA; present and future research activities; and climate change. The cumulative effects of climate change on marine mammals are discussed above in Section5.3.1.

Most of the marine mammal species within the Lease Sale 193 Area are migratory; therefore, activities and events outside the area considered for most of this cumulative effects analysis affect marine mammals that use the Chukchi Sea. These activities include marine traffic, commercial fisheries, offshore and near shore development (related to oil and gas operations, tidal power generation, and marine construction projects), mining, subsistence hunting, invasive species, and military exercises. Table 5.4.4-1 below provides detailed information on the marine mammals most likely to be encountered during the exploration drilling program, their feeding/summering grounds, migration routes, and their breeding/wintering grounds.

Overall, the cumulative impacts on marine mammals and T&E marine mammals from Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities, would be negligible to minor. Details of the cumulative effects for each impact factor are discussed below.

Cumulative Effects of Industrial Whaling on Marine Mammals

Industrial whaling was responsible for the depletion of stocks of a number of baleen whales including the two common whales in the Lease Sale 193 Area, the gray whale and the bowhead whale. Stocks have rebounded with the elimination of commercial whaling for these species.

The population size of the Eastern North Pacific gray whale stock has been increasing since cessation of whaling and was removed from the T&E species list in 1994. The population has continued to increase over the past several decades with an estimated annual rate of increase of about 3.7% and a 2011 population of about 16,892 animals (Givens et al. 2013). The stock may be reaching carrying capacity; therefore, remaining effects of industrial whaling are therefore negligible.

All stocks of bowhead whales were severely depleted during intensive commercial whaling. The pre-commercial-whaling population of the Western Arctic stock of bowhead whales has been estimated to be 10,400-23,000 whales (Woodby and Botkin 1993) dropping to less than 3,000 at the end of commercial whaling. The stock has rebounded substantially. The most recent population estimate for the stock is 16,892 for 2011 (Givens et al. 2013). Estimates of the annual increase rate were 3.4 percent in 2001 (Zeh and Punt 2005) and 3.7 percent in 2011 (Givens et al. 2013), as current population levels are in the range of pre-commercial whaling estimates and the population continues to grow. The 2015 Bering-Chukchi-Beaufort (BCB) bowhead whale population may number around 19,534 animals. The cumulative impacts of industrial whaling on marine mammals associated with Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities, will be negligible.

Effects of Subsistence Harvests on Marine Mammals

The activities associated with Shell's exploration drilling program as described in EP Revision 2 could result, at most, in negligible impacts, if at all. There are no known conflicts between Shell previous offshore operations and subsistence activities, and Shell's mitigation measures (including the coordinated communications of Shell, other operators, and SAs in the nearest effected communities during twice-daily subsistence advisor calls, cessation of operations for whaling in important hunting areas, consistent communication between operators and Com Centers, and the 4MP) safeguard against future conflicts.

The cumulative impacts on marine mammals from subsistence whaling does not appear to affect the species on a population level in light of the estimates that the BCB bowhead whale population and the beluga whale population in the Chukchi Sea continues to grow. Similarly, the cumulative impacts from subsistence hunting on other marine mammals (including ringed, bearded, and spotted seals, the Pacific walrus, and polar bear) are not expected to affect these species at a population level.

<u>Cumulative Effects of Subsistence Hunting on Whales</u>

The growth of the BCB bowhead whale population has continued despite annual Native subsistence hunts from coastal villages in Alaska and Russia. Subsistence hunts have been conducted for several thousand years, and far fewer whales are taken annually during subsistence hunts than during commercial hunting activities, when they took place. There is no evidence that past and current subsistence hunts have affected bowhead whales at the population level, and in fact, data indicate that the population has grown at 3.4 - 3.7 percent per year. Subsistence hunts for bowhead whales are managed cooperatively by the NMFS, the International Whaling Commission (IWC), and the AEWC under the Whaling Convention Act. Under the preferred alternative of an EIS prepared by NMFS (2013), the AEWC would be granted an annual strike quota of 82 bowhead whales, not to exceed a total of 306 landed whales over the five year period 2013 through 2018, with no more than 15 unused strikes from the previous year added to the annual strike quota. This alternative would continue management of the bowhead subsistence hunt as in the recent past. The annual average subsistence take (by Natives of Alaska, Russia, and Canada) between 2002 and 2011 was 38.8 bowhead whales (NMFS 2013d). Because current technology has increased the efficiency of subsistence hunts and fewer whales have been struck and lost during recent years than during the early years of the hunt (Suydam and George 2004), the BCB bowhead population is expected to increase under the current quota system. Subsistence hunting does not appear to have affected bowhead whales at the population level, and NMFS (2013) rated the overall impact of the bowhead subsistence hunt under the preferred alternative as negligible.

Subsistence hunts for beluga whales occur annually at Point Lay on the Chukchi Sea coast and opportunistically at other locations in Alaska. The removal of beluga whales from the Eastern Chukchi Sea stock by Alaska Natives during subsistence activities averaged 94.2 whales annually from 2005–2009 not including animals struck and lost (Allen and Angliss 2011). Nearly all of these whales were harvested by villagers from Point Lay, Pt. Hope, and Wainwright (Table 4.11.2-1). In 2007 approximately 70 beluga whales were harvested south of Point Hope by villagers at Kivalina in late July. Beluga whales had not been seen in large numbers in this area since the mid–1990s. There was speculation that seismic activities had helped drive the whales close to shore but the harvest in July occurred well before the beginning of seismic activities in the Chukchi Sea in late August.

Allen and Angliss (2011) reported that on average Alaska Natives landed 25.8 beluga whales annually from 2005 through 2009 in the Beaufort Sea. No information was given on the locations of the beluga whale subsistence hunts in the Alaskan Beaufort Sea or which villages participate in the hunts. Allen and Angliss (2011) also reported that the annual subsistence harvest of belugas in the Canadian Beaufort Sea averaged 100 whales during the five–year period 2005 through 2009. These harvest numbers for the Alaskan and Canadian Beaufort Sea include only landed animals and do not account for animals struck and lost. The minimum population estimate for the Beaufort Sea beluga population is 32,453 based on an aerial survey conducted in 1992 with a correction factor of two to account for availability bias (Allen and

Angliss 2011). Because the 1992 survey covered only a small part of the summer range of Beaufort Sea belugas (Richard et al. 1997, 2001), it is likely that the population is much larger than the minimum population estimate.

The most recent estimate of the size of the Chukchi Sea beluga population is 3,710 whales (Allen and Angliss 2014) although some evidence (Suydam et al. 2001) suggests overlap in the range of this population with the larger Beaufort Sea population estimated at nearly 40,000 whales. Subsistence harvest of beluga whales in the Chukchi Sea does not appear to have affected this species on a population level.

<u>Cumulative Effects of Subsistence Hunting on Other Marine Mammals</u>

Native communities also conduct subsistence hunts for other marine mammal species including ringed, bearded, and spotted seals, and Pacific walruses. Seals are much less high–profile species than bowhead whales, and subsistence hunts for seals are less regulated. No current annual estimates of the numbers of ice seals (ringed, bearded, and spotted seals) taken during subsistence hunts are available. The ADF&G collected subsistence data on annual seal harvests that were based on information collected prior to 2000 (Allen and Angliss 2010). From 1962 to 1982 Barrow harvested an average of 955 ringed seals and spotted seals and 150 bearded seals per year, Wainwright harvested 375 ringed and spotted seals and 250 bearded seals annually, Point Lay harvested 2-10 bearded seals, and Point Hope harvested 1,400 spotted and ringed seals and 200 bearded seals (Table 4.11.2-2 and 4.11.2-3). The current population estimates for each of these seal species is in the hundreds of thousands, and current level of subsistence harvests are not expected to affect these species at population levels.

The size of the Pacific walrus population is not known with certainty, but the species is uncommon in the Beaufort Sea. Pacific walruses have been hunted commercially in the past, and it is likely that the population has fluctuated markedly (USFWS 2010a). The actual numbers of walruses currently harvested during subsistence hunts are unknown, but it may be similar to recent decades; from 1962-1982 Barrow harvested an average of 27 walruses annually, Wainwright harvested an average of 54, Point Lay harvested an average of 4, and Point Hope harvested an average of six walruses per year (Table 4.11.2-4). The USFWS bases its current estimate of the annual Pacific walrus harvest on the average number of walruses harvested during the 5-year period 1996–2000 resulting in an annual estimated harvest of 5,789 animals. Although there are no current estimates of the size of the Pacific walrus population, estimates of the population from 1975–1990 ranged from approximately 200,000-246,000 animals (USFWS 2010a). Recent declines in sea–ice concentration in the Arctic have raised concerns by some for walruses due to their reliance on the use of pack ice for haulouts near feeding areas in summer. It is thought that declines in the pack ice might result in poorer nutritional health of walruses and declines in the population.

Subsistence and sport hunting of the Chukchi/Bering Sea stock and southern Beaufort Sea population of polar bears has occurred in Alaska and Canada. The greatest harvest numbers were reported in the mid- to late 1960s when aerial hunting was permitted (USFWS 2010b). Aerial hunting was prohibited in 1972, and current harvest levels are much lower. A management agreement between the Canadian Inuit and the Alaskan Iñupiat regulating polar bear hunts has been in place since 1988. The harvest in Canada is regulated by a quota system and in Alaska by voluntary actions of local subsistence hunters. The combined annual harvest of southern Beaufort Sea polar bears in Alaska and Canada was 53.6 animals for the period 2003–2007 (USFWS 2010c). The annual harvest from the Chukchi/Bering Sea stock was 92/year in the 1980s, 49/year in the 1990s, and 43/year in the 2000s; more recently, the 2003−2007 average Alaska harvest for the Chukchi/Bering Sea stock in Alaska was 37 (USFWS 2010b).

Cumulative Effects of Vessel and Aircraft Traffic on Marine Mammals

Potential cumulative effects on marine mammals could occur due to vessel and aircraft traffic. Shell's exploration drilling program as described in EP Revision 2 will contribute to vessel and aircraft traffic in the northeastern Chukchi Sea. Impacts will consist only of brief behavioral disturbances. No vessel strikes of marine mammals are likely to occur.

Aircraft and vessel traffic associated with identified reasonably foreseeable activities such as barge and general vessel traffic, geophysical, geotechnical, shallow hazards, and environmental surveys would be expected to have similar effects. Oil and gas exploration may increase the number and extent of scientific studies in the Chukchi Sea, but such studies generally have little impact except for temporary behavioral disturbance of fish, birds, and marine mammals.

The total annual vessel traffic in the Lease Sale 193 Area during the time frame of the cumulative effects analysis is not expected to vary greatly from the recent past levels indicated in Figures 5.2.1-1 and 5.2.2-1 above. Mortalities or injuries due to vessel-marine mammal collisions are not expected to occur given past experience. Brief behavioral disturbances will likely result from vessel traffic at these levels are likely not additive as they would not occur in the same time and space often enough to result in any cumulative effects such as area abandonment. Current levels of vessel traffic as identified in Figures 5.2.1-1 and 5.2.2-1 are not great enough to cause abandonment or alter migration routes. The cumulative impacts on marine mammals due to vessel traffic associated with Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities, including an increase in vessel traffic through the Chukchi Sea associated concurrent drilling in Camden Bay, would be negligible to minor.

Cumulative Effects of Industrial Sound on Marine Mammals

Shell's proposed activities will introduce industrial sounds into the marine environment from drilling operations by two drilling units, anchor handling, ice management, ZVSP operations, and vessel and aircraft traffic. These sounds contribute additively to other industrial sounds that enter the Chukchi Sea marine environment from oil and gas exploration activities. Additionally, small boats used for recreational and subsistence activities as well as non-oil and gas barge traffic contribute to in-water sound. In general, sound in the world's oceans has increased (Weilgart 2007). Underwater sound has the potential to cause disturbance to marine organisms, particularly marine mammals (Section 4.7.3).

As described in Section 4.7 high levels of sound in water may cause temporary or permanent hearing impairment to some species or individual marine mammals. However, the levels at which hearing impairment might occur are well above levels that are produced by all but the strongest sound sources (Southall et al. 2007). Disturbance reactions, including avoidance, displacement, and masking, are the most likely impacts of increased sound in the environment on marine mammals. Some behavioral changes such as temporary changes in breathing or diving rates, or avoidance behavior are unlikely to result in biologically discernible impacts to individual marine mammals or to marine mammal populations. However, disturbance that causes avoidance of preferred feeding or resting areas could affect energy budgets and result in reduced rates of adult or calf survival.

At current levels, disturbance by marine sounds associated with offshore oil and gas exploration and production are unlikely to affect bowhead whales or other marine mammal species at the population level. Deflections of migrating whales that have been measured in response to oil production at Northstar Island (Richardson 2008), in Camden Bay in response to seismic surveys (Funk et al. 2010), and during previous exploration drilling (Richardson et al. 1995a; Brewer et al. 1993) appear to be too small to affect whales energetically by increasing their migration distance and do not appear to have prevented whales from accessing their usual feeding areas. Additionally, deflections that have been measured do not appear to have caused whales to vary their migration path beyond the boundaries of statistically established typical or traditional routes given ice conditions in the Beaufort Sea (Blackwell et al. 2010). Further, deflections that have been measured have not affected the ability of Alaska Native hunters to successfully harvest bowhead whales since the adoption of conflict avoidance measures; whale quotas in most years have been reached despite various industry operations. Lastly, the populations of marine mammals in the Chukchi Sea appear to be stable (beluga whale, harbor porpoise, gray whale, ringed, spotted and bearded seal and walrus) or increasing (bowhead whale).

Exploration drilling activities in the Chukchi Sea will occur farther from shore than in the Beaufort Sea. Shell's planned exploration drill sites are located at least 64 miles (103 km) from shore. Fall migrating bowheads could encounter the exploration drilling operations as they move west across the Chukchi Sea to feeding areas along the Russian coast before moving down the Russian coast into the Bering Sea wintering grounds. The fall migratory path that bowheads use through the Chukchi Sea is variable with some whales traveling well north of the Burger Prospect while others travel south of Hanna Shoal, near and through the prospect. Still other whales appear to move south along the Alaskan Chukchi Sea coast (Quakenbush et al. 2010). Given the variable nature of the migration route displacement of whales by drilling sounds is unlikely to have more than a temporary effect on bowhead behavior and no lasting impacts on individuals or the population, though the route of an individual's migration through the Chukchi Sea or Beaufort Sea may be changed somewhat.

The cumulative impacts on marine mammals, due to industrial sound associated with Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities, including an increase in vessel traffic through the Chukchi Sea associated concurrent drilling in Camden Bay, would be negligible to minor.

Cumulative Effects of Habitat Loss from MLCs and Mooring of Vessels on Marine Mammals

A small amount of seafloor habitat will be lost from construction of MLCs and mooring and anchoring of vessels. Shell's proposed future geotechnical surveys will add to the total impacts on the seafloor; however, given the distance of these proposed surveys from Shell's exploration activities, the additional impacts will not be additive or synergistic. Although benthic feeders (gray whales, bearded seals, and walruses) in the project and survey areas could also be affected by habitat loss, the loss will be small, localized and non-significant when compared to the amount of available similar habitat in the Chukchi Sea. No cumulative impacts are expected to marine mammals as a result of seafloor habitat loss associated with Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities, including potential simultaneous exploration drilling activities in Camden Bay.

Cumulative Effects Along the Migration Route of Marine Mammals

Several marine mammal species that occur in the proposed project area are migratory species, therefore consideration has been given to the effects of potential disturbances that these species could encounter anywhere along their migration routes. Sources of cumulative impacts considered include marine traffic, commercial fisheries, offshore and nearshore development (related to oil and gas operations, as well as other industries, including tidal power generation and marine construction projects), mining, hunting, invasive species, and military exercises. Detailed information for each species may be found below in Table 5.4.4-1.

Table 5.4.4-1 Summary of Potential Cumulative Impacts from Migration on Marine Mammals

Species	Potential presence during EP activities	Feeding/Summering Grounds			Migration Route			Breeding/Wintering Grounds		
	Timing	Location	Timing	Potential Impact	Location	Timing	Potential Impact	Location	Timing	Potential Impact
Beluga Whale *Delphinapterus leucas* [1,2]	Jul - Oct	Coastal estuaries throughout Eastern Beaufort Sea, Amundsen Gulf, Mackenzie Delta; Northeastern Chukchi Sea, Kasegaluk Lagoon, Kotzebue Sound, Norton Sound, Yukon Delta, Bristol Bay, Kvichak & Nushagak Bays	Apr - Sep	A(1-3), C (1-6), D (1-6), F1, G (1-2)	Throughout coastal and offshore Bering, Chukchi and Beaufort Seas	Mar - Jul; Aug - Oct	A (1-3), B (1-3), C (1-6), D (1-6), E (1-3), F1, G (1-2)	Offshore Bering Sea, associated with pack ice	Oct - Apr	A (1-3), B (1-3), E (1-3), F1, G (1-2)
Bowhead Whale* *Balaena mysticetus* [3]	Jul - Oct	U.S. and Canadian Beaufort Sea, Mackenzie Delta, Amundsen Gulf, few individuals may summer in eastern Chukchi Sea	May - Oct	A (1-3), C (1-6), D (1-6), E (1-3), F1, G (1-2)	Spring - coastal waters in eastern Chukchi and Beaufort Sea; Fall - waters over continental shelf in Beaufort Sea, entire eastern and western Chukchi Sea, including waters of northerneastern Russia	Mar - Jul; Aug - Oct	A (1-3), B (1-4), C (1-6), D (1-6), E (1-3), F1, G (1-2)	Bering Sea	Sep - Mar	A (1-3), B (1-4), E (1-3), G (1-2)
Gray Whale *Eschrichtius robustus* [1, 4, 7]	Jul - Oct	Shallower waters of western Beaufort Sea, throughout Bering and Chukchi Seas, Northern Gulf of Alaska, occasionally eastern Beaufort Sea	May - Nov	A (1-3), B (1-4), C (1-6), D (1-6), E(1-3), G (1-2), H (1-3)	Coastal waters along west coast of North America	Feb - May; Nov - Jan	A (1-3), B (1-4), C (1-7), D (1-7), E (1-3), F (1-2), G (1-2), H (1-3)	Baja California, Mexico in coastal waters and lagoons	Nov - Mar	A (1-3), B (1-4), D (4-6), E (1-3), G (1-2), H (1-3)

A Marine Traffic
A1 noise
A2 collision risk
A3 pollution

B Commercial Fisheries
B1 Entanglement
B2 Competition for prey
B3 Pollution
B4 Habitat degradation (trawling)

C Offshore Development
C1 Oil & gas rig - noise
C2 Oil & gas rig - effluent discharge
C3 Oil & gas rig - toxin release
C4 Exclusion from habitat
C5 Marine seismic survey - noise
C6 Marine seismic survey - entanglement
C7 Tidal power generators

D Nearshore Development
D1 Oil & gas rig - noise
D2 Oil & gas rig - effluent discharge
D3 Oil & gas rig - toxin release
D4 Exclusion from habitat
D5 Land reclamation
D6 Dredging
D7 Tidal power generators

E Mining
E1 Pollution - direct
E2 Pollution - effects on prey
E3 Pollution - habitat degradation

F Hunting
F1 Subsistence harvest
F2 Illegal poaching

G Invasive Species/Range Expansion
G1 Competition for resources
G2 Disease

H Military
H1 Unexploded ordnance
H2 Naval mid-frequency sonar exercises
H3 Explosive training exercises

Table 5.4.4-1 continued Summary of Potential Cumulative Impacts from Migration on Marine Mammals

Species	Potential presence during EP activities	Feeding/Summering Grounds			Migration Route			Breeding/Wintering Grounds		
	Timing	Location	Timing	Potential Impact	Location	Timing	Potential Impact	Location	Timing	Potential Impact
Minke whale *Balaenoptera acutorostrata* [1]	Jul - Oct	Throughout Chukchi and Bering Seas, Gulf of Alaska, and North Pacific Ocean	Apr - Nov, timing likely sea ice dependent	A (1-3), B (1-4), C (1-7), D (1-7), E (1-3), F (1-2), G (1-2), H (1-3)	Throughout Bering and Chukchi seas, route and timing likely sea ice dependent	Apr - Jul; Oct - Nov	A (1-3), B (1-4), C (1-6), D (1-6), E (1-3), G (1-2)	Throughout North Pacific Ocean	year-round	A (1-3), B (1-4), C (4-7), D (4-7), E (1-3), F2, G (1-2), H (1-3)
Humpback Whale* *Megaptera novaeangliae* [1, 4]	Jul - Oct	Throughout Chukchi and Bering Seas, Gulf of Alaska, and North Pacific Ocean, rare sightings near Point Barrow in Beaufort Sea	Apr - Nov, timing likely sea ice dependent	A (1-3), B (1-4), C (1-7), D (1-7), E (1-3), F2, G (1-2), H (1-3)	Throughout the North Pacific, generally along west coast of North America, east coast of Asia, and in the central North Pacific Ocean between Hawaii and Alaska	Apr - Jul; Sep - Feb	A (1-3), B (1-4), C (1-7), D (1-7), E (1-3), F2, G (1-2), H (1-3)	Throughout North Pacific Ocean (prefer shallower waters during winter), typically along the west coast of North America, near the Hawaiian islands, and the coast of Japan, small population near the northern Phillipines	Nov - Apr	A (1-3), B (1-4), C (4-7), D (4-7), E (1-3), F2, G (1-2), H (1-3)
Fin Whale* *Balaenoptera physalus* [4]	Jul - Oct	Throughout North Pacific Ocean, Gulf of Alaska, Bering Sea, southern Chukchi Sea, occasionally northern Chukchi Sea	Apr - Nov, timing likely sea ice dependent	A (1-3), B (1-4), C (1-7), D (1-7), E (1-3), G (1-2), H (1-3)	not well defined, may range throughout North Pacific Ocean and Bering Sea	Aug - Jan;	A (1-3), B (1-4), C (1-7), D (1-7), E (1-3), G (1-2), H (1-3)	Throughout North Pacific Ocean, known concentrations along west coast of U.S. and Aleutian Islands, occasionally near Hawaii	Aug - Feb	A (1-3), B (1-4), C (1-7), D (1-7), E (1-3), G (1-2), H (1-3)
Killer Whale *Orcinus orca* [5, 6]	Jul - Oct	Near Point Barrow in Beaufort Sea, throughout Chukchi and Bering Seas and North Pacific Ocean	Apr - Nov, timing likely sea ice dependent	A (1-3), B (1-4), C (1-7), D (1-7), E (1-3), G (1-2), H (1-3)	Throughout Bering and Chukchi seas, route and timing likely sea ice dependent	not well defined	A (1-3), B (1-4), C (1-6), D (4-6), E (1-3), G (1-2)	Bering Sea, North Pacific	Oct - Jul	A (1-3), B (1-4), C (4-7), D (4-7), E (1-3), G (1-2), H (1-3)

A Marine Traffic
A1 noise
A2 collision risk
A3 pollution

B Commercial Fisheries
B1 Entanglement
B2 Competition for prey
B3 Pollution
B4 Habitat degradation (trawling)

C Offshore Development
C1 Oil & gas rig - noise
C2 Oil & gas rig - effluent discharge
C3 Oil & gas rig - toxin release
C4 Exclusion from habitat
C5 Marine seismic survey - noise
C6 Marine seismic survey - entanglement
C7 Tidal power generators

D Nearshore Development
D1 Oil & gas rig - noise
D2 Oil & gas rig - effluent discharge
D3 Oil & gas rig - toxin release
D4 Exclusion from habitat
D5 Land reclamation
D6 Dredging
D7 Tidal power generators

E Mining
E1 Pollution - direct
E2 Pollution - effects on prey
E3 Pollution - habitat degradation

F Hunting
F1 Subsistence harvest
F2 Illegal poaching

G Invasive Species/Range Expansion
G1 Competition for resources
G2 Disease

H Military
H1 Unexploded ordnance
H2 Naval mid-frequency sonar exercises
H3 Explosive training exercises

Table 5.4.4-1 continued Summary of Potential Cumulative Impacts from Migration on Marine Mammals

Species	Potential presence during EP activities	Feeding/Summering Grounds			Migration Route			Breeding/Wintering Grounds		
	Timing	Location	Timing	Potential Impact	Location	Timing	Potential Impact	Location	Timing	Potential Impact
Harbor Porpoise *Phocoena phocoena* [1, 4]	Jul - Oct	Coastal Bering and Chukchi Seas and occasionally Beaufort Sea	Apr - Nov, timing likely sea ice dependent	A (1-3), B(1-4), C (1-6), D (1-6), E (1-3), G (1-2)	unknown, Bering and Chukchi Seas, likely near coast, route and timing likely sea ice dependent	not well defined	A (1-3), B (1-4), C (1-6), D (1-6), E (1-3), G (1-2), H (1-3)	Coastal Bering Sea, Aleutian Islands	Oct - Jun	A (1-3), B (1-4), E (1-3), D (4-6), E (1-3), G(1-2), H (1-3)
Ringed Seal* *Pusa hispida* [4]	Jul - Oct	Throughout Chukchi and Beaufort seas, associated with sea ice	Jul - Oct	A (1-3), C (1-6), D (1-6), E (1-3), F1, G (1-2)	Throughout Chukchi and Bering Seas	Apr - Jun	A (1-3), B (1-4), C (1-6), D (1-6), E (1-3), F1, G (1-2)	Throughout Beaufort, Chukchi and Bering seas, Bristol Bay, Sea of Okhotsk, Sea of Japan, ice associated	Oct - Apr	A (1-3), B (1-4), C (1-6), D (1-6), E (1-3), F1, G (1-2), H (1-3)
Spotted Seal *Phoca largha* [4]	Jul - Oct	Throughout Chukchi and Beaufort seas, use coastal haulouts, Colville River delta	Jul - Oct	A (1-3), C (1-6), D (1-6), E (1-3), F1, G (1-2)	Throughout Chukchi and Bering Seas, route and timing likely ice dependent	Apr - Jun	A (1-3), B (1-4), C (1-6), D (1-6), E (1-3), F1, G (1-2), H1	Throughout Bering Sea, Pribilof Islands, eastern Aleutian Islands, Bristol Bay, Sea of Okhotsk, Sea of Japan, associated with southern margins of sea ice	Oct - Apr	A (1-3), B (1-4), E (1-3), F1, G (1-2), H (1-3)
Bearded Seal *Erignathus barbatus* [4]	Jul - Oct	Throughout Chukchi and Beaufort seas, associated with sea ice, some remain offshore in Bering Sea	Jun - Nov	A (1-3), B (1-4), C (1-6), D (1-6), E (1-4), F1, G (1-2)	Throughout Chukchi and Bering Seas, route and timing likely ice dependent	Apr - Jun	A (1-3), B (1-4), C (1-6), D (1-6), E (1-3), F1, G (1-2)	Northern part of Bering Sea shelf, associate with sea ice, 20 - 100 nmi from shore, nearshore to the south of Kivalina	Jan - Apr	A (1-3), B (1-4), E (1-3), F1, G (1-2)
Ribbon seal *Phoca fasciata* [4]	Jul - Oct	Bering, Chukchi Seas, Arctic basin	Jul - Oct	A (1-3), B (1-4), C (1-6), D (1-6), E (1-3), F1, G (1-2)	unknown, associate with sea ice edge	May - Jul	A (1-3), B (1-4), C (1-6), D (1-6), E (1-3), F1, G (1-2)	Sea ice edge in Bering Sea	Mar - May	A (1-3), B (1-4), E (1-3), F1, G (1-2)

A Marine Traffic
A1 noise
A2 collision risk
A3 pollution

B Commercial Fisheries
B1 Entanglement
B2 Competition for prey
B3 Pollution
B4 Habitat degradation (trawling)

C Offshore Development
C1 Oil & gas drilling unit - noise
C2 Oil & gas drilling unit - effluent discharge
C3 Oil & gas drilling unit - toxin release
C4 Exclusion from habitat
C5 Marine seismic survey - noise
C6 Marine seismic survey - entanglement
C7 Tidal power generators

D Nearshore Development
D1 Oil & gas rig - noise
D2 Oil & gas rig - effluent discharge
D3 Oil & gas rig - toxin release
D4 Exclusion from habitat
D5 Land reclamation
D6 Dredging
D7 Tidal power generators

E Mining
E1 Pollution - direct
E2 Pollution - effects on prey
E3 Pollution - habitat degradation

F Hunting
F1 Subsistence harvest
F2 Illegal poaching

G Invasive Species/Range Expansion
G1 Competition for resources
G2 Disease

H Military
H1 Unexploded ordnance
H2 Naval mid-frequency sonar exercises
H3 Explosive training exercises

Table 5.4.4-1 continued Summary of Potential Cumulative Impacts from Migration on Marine Mammals

Species	Potential presence during EP activities	Feeding/Summering Grounds			Migration Route			Breeding/Wintering Grounds		
	Timing	Location	Timing	Potential Impact	Location	Timing	Potential Impact	Location	Timing	Potential Impact
Pacific Walrus** *Odobenus rosmarus* [1, 4]	Jul - Oct	Continental shelf waters of Chukchi Sea, occasionally Beaufort Sea and East Siberian Sea, occasionally use terrestrial haulouts when ice unavailable	Jun - Nov	A (1-3), C (1-6), D (1-6), E (1-3), F1, G (1-2)	Throughout Bering and Chukchi Seas, migrate with sea ice edge	May - Jul; Nov - Dec	A (1-3), B (1-4), C (1-6), D (1-6), E (1-3), F1, G (1-2)	Continental shelf waters of Bering and Chukchi Seas, coastal areas of Gulf of Anadyr, Bering Straight, and Bristol Bay	Nov - May	A (1-3), B (1-4), E (1-3), F1, G (1-2)
Polar bear* *Ursus maritimus* [1, 8]	Jul - Oct	Associate with pack ice in the Beaufort and Chukchi seas; congregate around bowhead whale carcasses on shore and barrier islands following subsistence harvests	Jul - Nov	A (1-3), C (1-6), D (1-6), E (1-3), F (1-2), G (1-2)	Throughout Beaufort Sea and northern Chukchi Sea; travel with ice edge when possible	May - Aug	A (1-3), C (1-6), D (1-6), E (1-3), F (1-2), G (1-2)	Den in drifting pack ice, fast ice, or on land along the coast of the Chukchi and Beaufort seas, east as far as the Baillie Islands in northwest Canada	Nov - Apr	A (1-3), C (1-6), D (1-6), E (1-3), F (1-2), G (1-2)

A Marine Traffic
A1 noise
A2 collision risk
A3 pollution

B Commercial Fisheries
B1 Entanglement
B2 Competition for prey
B3 Pollution
B4 Habitat degradation (trawling)

C Offshore Development
C1 Oil & gas rig - noise
C2 Oil & gas rig - effluent discharge
C3 Oil & gas rig - toxin release
C4 Exclusion from habitat
C5 Marine seismic survey - noise
C6 Marine seismic survey - entanglement
C7 Tidal power generators

D Nearshore Development
D1 Oil & gas rig - noise
D2 Oil & gas rig - effluent discharge
D3 Oil & gas rig - toxin release
D4 Exclusion from habitat
D5 Land reclamation
D6 Dredging
D7 Tidal power generators

E Mining
E1 Pollution - direct
E2 Pollution - effects on prey
E3 Pollution - habitat degradation

F Hunting
F1 Subsistence harvest
F2 Illegal poaching

G Invasive Species/Range Expansion
G1 Competition for resources
G2 Disease

H Military
H1 Unexploded ordnance
H2 Naval mid-frequency sonar exercises
H3 Explosive training exercises

* Threatened or Endangered under the Endangered Species Act
** Candidate species for listing under the Endangered Species Act

[1] Reeves 2002.
[2] Frost and Lowry 1990.
[3] Moore and Reeves 1993.
[4] Allen and Angliss 2010.
[5] Leatherwood et al. 1986.
[6] Lowry et al. 1987.
[7] Rugh and Fraker 1981.
[8] Stirling 2002.

5.4.5 Potential Cumulative Impacts on Subsistence

Potential effects from Shell's exploration drilling program on subsistence activities are described in detail in Section 4.11 and include: disturbance by vessel and aircraft traffic; effects from sound energy generated by vessels, drilling; and water quality effects from vessel discharges and drilling waste discharges.

Effects on subsistence activities from the Shell's exploration drilling program as described in EP Revision 2 are minimized by Shell's extensive mitigation measures (including its successful SA program, Com Centers and 4MP). Subsistence impacts from Shell's planned exploration drilling program within the area of analysis will be no more than negligible, but the local perceptions of subsistence impacts vary (MMS 2007b, 2007c). Any activity that affects subsistence resources, subsistence use areas, or harvest activity patterns has the potential to affect subsistence users. Because of the short-term and locally constrained disturbance of exploration drilling, BOEM's analysis in the Sale 193 FEIS concluded that no long-term permanent effects on subsistence use would result and no harvest areas would become unavailable to subsistence users (MMS 2007b).

In general, bowhead whale and other subsistence resources may avoid areas of exploration drilling during times of active drilling, but this avoidance is temporary. As discussed above, marine mammals can be affected by sound generated by the drilling units and support vessels; however, any effects are minimal and temporary because marine mammals tend to naturally avoid vessels. The Burger Prospect drill sites, where most of these activities would be conducted, are located more than 64 mi (103 km) offshore and more than 30 mi (48 km) from areas used for subsistence. Anticipated impacts associated with these activities and any associated vessel and aircraft traffic that will occur within areas used for subsistence will be mitigated by a number of mitigation measures, including the North Slope Inupiat SA program, implementation of a system of Com Centers, and implementation of Shell's 4MP. Aircraft traffic associated with the exploration drilling program will be restricted, short-term and localized, and will not substantially increase normal commercial or chartered aircraft traffic in the vicinity. Shell's activities under EP Revision 2, including an increased activity associated with concurrent drilling in Camden Bay, are not expected to impact actual subsistence activities. NSB residents have expressed concerns that oil and gas industry activities have cumulative effects on culturally important subsistence activities. However, in BOEM's EA for Shell's 2012 activities, the agency determined that the project's contribution to cumulative effects would be negligible and would result in no change in the moderate to major level of effect for subsistence resources from past, present, and reasonably foreseeable future actions (BOEM 2011a).

Other reasonably foreseeable activities that could potentially affect subsistence activities in the marine environment of the Chukchi and Beaufort Seas include: disturbance associated with barges and other vessel traffic in the Chukchi Sea, including the described geophysical, shallow hazards, geotechnical, and environmental surveys to be conducted by Shell and NOAA; and aircraft traffic associated with these types of activities. Geophysical, hydrographic, geotechnical, and shallow hazards surveys generally require incidental take authorizations under the MMPA from NMFS and USFWS. These authorizations require consultation with the potentially affected villages, and mitigation measures that will minimize subsistence impacts, similar to Shell's exploration drilling program. These activities are subject to temporal and spatial conditions, such as limits for activities within 20 to 30 miles (32 to 48 km) of the coast during subsistence hunting, which are as a result of consultations and therefore further limit the prospect of impacts. Additionally, much of the activity associated with these surveys occurs seaward of areas known to be used for subsistence.

Effects on subsistence from EP Revision 2 would be additive to the effects of the identified reasonably foreseeable activities, including potential simultaneous exploration drilling activities in Camden Bay. However, Shell's mitigation measures would apply to most of these activities, and any impacts would be dispersed given the size of the Chukchi and Beaufort Seas. Cumulative impacts on subsistence from

Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities, are considered to be minor.

5.4.6 Potential Cumulative Impacts on Socioeconomic and Sociocultural Resources

Potential effects from Shell's exploration drilling program on socioeconomics include: effects on wages and employment, and on goods and services. Sociocultural impacts could potentially occur with the influx of workers in the villages. Activities under EP Revision 2 that could potentially impacts these resources include: aircraft and vessel traffic, mooring of vessels, shorebase expansion and operation. As discussed above in Section 4.11, some increases in employment and wages will occur through hiring by Shell and Shell contractors for various positions. Additional employment and revenues will be generated by providers of the shorebase facilities. These effects may increase slightly with the expansion of the Barrow man camp, and the utilization of a larger camp in Wainwright.

Other identified reasonably foreseeable activities potentially affecting socioeconomic and sociocultural resources include: barge and vessel traffic that may access the villages or occur in coastal waters; and Shell's geophysical, geotechnical and environmental surveys, which include vessel traffic and possible crew changes through the Port of Kotzebue, Barrow, Wainwright, or Nome. Geophysical, shallow hazards, geotechnical, and environmental surveys and other reasonably foreseeable activities will likely add to the number of non-residents staying in or passing through these villages. These types of activities involve fewer vessels and typically smaller crew sizes, and would therefore result in less socioeconomic effect. Any increased shorebase presence may also exert some pressure on goods and services (including vehicular traffic). Cumulative impacts on socioeconomics from Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities, including potential simultaneous exploration drilling in Camden Bay, are considered negligible and short term.

Sociocultural and population effects may also be experienced in Barrow, Nome, Wainwright, and Kotzebue where crews and other personnel from outside the region will reside or pass through. There will be no effects in Point Lay or Point Hope. Cumulative impacts on sociocultural resources from Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities, including potential simultaneous exploration drilling in Camden Bay, are considered to be negligible.

5.5 Summary of Cumulative Impacts Analyses

A summary of the cumulative impacts analyses is below in Table 5.5-1. All assessed cumulative impacts were found to be negligible or minor. The conclusions are in general alignment with the findings of BOEM in its EA analyzing Shell's EP Revision 1 (BOEM 2011a).

Table 5.5-1 Summary of the Results of the Cumulative Impacts Analysis

Resource	Shell EIA for EP Revision 2
Climate Change	negligible
Ocean and Airborne Ambient Sound Levels	minor
Air quality	minor
Water quality	negligible
Seafloor Sediments	negligible
Lower trophic organisms	minor
Fish and ESH	negligible - minor
Birds	minor
Marine mammals	negligible-minor
Subsistence	negligible
Socioeconomics/Sociocultural	negligible

6.0 VERY LARGE OIL SPILL

In the context of several prior NEPA analyses, BOEM has concluded that the risk of a VLOS resulting from a well control incident at an Arctic OCS exploration well is highly unlikely (MMS 2003a; MMS 2007b; BOEMRE 2011b; BOEM 2011a; BOEM 2015). This conclusion is based on technical evaluations of the geologic formations reasonably anticipated for wells drilled in Arctic OCS, which evaluations were informed by the well logs and formation data obtained during the successful completion of 98 exploration wells across the Arctic OCS (MMS 2007a; MMS 2007b; BOEMRE 2011b; BOEM 2015). In its review of Shell's EP Revision 1, BOEM determined that the risk of a VLOS associated with Shell's proposed Burger exploration wells also is highly unlikely (BOEM 2011a). That conclusion is supported by specific technical data and reservoir evaluations of the Burger prospect.

For purposes of completing a comprehensive review of the possible impacts of Shell's proposed Burger exploration program, Shell has developed the following analysis of the potential impacts associated with a hypothetical VLOS. This analysis is tiered to and based on Shell's review of BOEM's three recent NEPA analyses. First, Shell tiers to BOEM's Chukchi Sea OCS Lease Sale 193 FSEIS (BOEMRE 2011b) and BOEM's update of that analysis in the agency's recent Final Second SEIS. When BOEM revised its NEPA analysis for Chukchi Sea Lease Sale 193, the agency addressed an issue that was not specifically remanded by the District Court: "potential effects of a low-probability high impacts event-a VLOS" (BOEMRE 2011b), and this analysis was included in the agency's recent Final Second SEIS BOEM added that new VLOS analyses based on public comments received after the *Deepwater Horizon* event. This EIA is the first opportunity for Shell to evaluate its proposed Burger exploration program against the Chukchi Sea Lease Sale 193 FSEIS and Final Second SEIS and incorporate BOEM's VLOS analyses. The VLOS analyses supporting the Chukchi Sea Lease Sale 193 FSEIS and Final Second SEIS provide detailed descriptions of the impacts of a VLOS on various resources. However, the model a much higher volume and duration of oil spilled, resulting in a higher total volume and larger modeled impacts than would be associated with any oil spill event related to the exploration drilling program described in Shell's EP Revision 2. Second, Shell tiers to BOEM's Environmental Assessment (EA) for Shell's EP Revision 1 (BOEM 2011a). That analysis tiered to the Chukchi Sea Lease Sale 193 FSEIS and repeatedly found that the detailed analyses provided in the FSEIS remained valid and were sufficient to analyze the impacts associated with Shell's EP.

Because this EIA tiers to BOEM's prior comprehensive VLOS impacts analyses, Shell's analysis of the impacts associated with a VLOS here is different from the EIA that supported EP Revision 1. As a result of this new methodology, Shell's amended analysis will necessarily result in higher stated impacts than in prior Shell analyses. This is not due to a change in Shell's estimated WCD volume associated with EP Revision 2. Shell's WCD has not changed since EP Revision 1 was submitted, nor have Shell's extensive response efforts changed. Instead, Shell simply revised its VLOS impacts analysis methodology to ensure that its analysis is consistent with BOEM's previous findings in recent VLOS analyses for the Chukchi Sea.

Worst Case Discharge

Shell's Worst Case Discharge for EP Revision 2

Following the guidance of BOEM's NTL-06 and 30 CFR 550.213 (g), to prepare for an unlikely, unplanned well control event, Shell's OSRP for EP Revision 2 considers a WCD response planning scenario. The response planning scenario is based upon a site-specific calculated WCD with a 30-day duration for the blowout. The WCD volume for EP Revision 2 has not changed from the WCD calculated for EP Revision 1. The site-specific WCD is built upon the characteristics of prospective hydrocarbon-bearing reservoirs through the proposed total depth of the wells to be drilled at the Burger prospect identified in EP Revision 2. The legacy Burger #1 well supplied most of the reservoir characteristics and conditions required as input to calculate a WCD; thus there is less uncertainty in the results of this calculation than for an undrilled prospect with speculative reservoir and subsurface conditions. The calculated daily WCD is established for Burger J at 23,100 bbl/day but diminishes over the 30 days.

Both the *Discoverer* and *Polar Pioneer* will serve as their own primary relief well drilling unit. If either the *Discoverer* or the *Polar Pioneer* cannot be used to drill its own relief well, the other drilling unit would be used for that purpose. If both units are operating in the Chukchi Sea, the time required to drill the relief well would be 34 days. Should one of the drilling units be as distant as Dutch Harbor when the other drilling unit is drilling hydrocarbon bearing zones, then the time needed to mobilize to the Burger Prospect, moor, and then drill a relief well and kill the flow is 38 days (Table 6.0-1). The remainder of this VLOS analysis will assume that 38 days are needed to drill a relief well and kill the flow.

Table 6.0-1 Comparison of the WCD Planning Scenario Developed for the Chukchi Sea Regional OSRP with the WCD Calculated for EP Revision 2 for Two Relief Well Scenarios

	OSRP WCD Scenario	**EP Revision 2 WCD – *Two Drilling Units in the Chukchi Sea***	**EP Revision 2 WCD – *One Drilling Unit as far away as Dutch Harbor***
Maximum Flow Rate	25,000 bbl	23,100 bbl[a]	23,100 bbl[a]
Total Duration	30 days	34 days	38 days
Total Oil Volume	750,000 bbl	603,564 bbl	669,479 bbl

[a] Calculated WCD for Burger J; flow rate diminishes over time

This WCD has not changed since EP Revision 1 and is used in the EP Revision 2 EIA Section 6 VLOS impacts analysis. Although Shell's WCD for EP Revision 2 is less than BOEM's hypothetical VLOS scenarios, this EIA for EP Revision 2 tiers to BOEM's Lease Sale 193 FSEIS and EA for EP Revision 1 when it characterizes the level of potential impacts from a VLOS.

Shell's VLOS scenario for EP Revision 2 assumes the unlikely WCD event has occurred and the robust response assets of Shell's Chukchi Sea Regional Exploration OSRP are onsite in the Chukchi Sea, in response mode within one hr, and beginning recovery of released oil from the WCD event. Shell's WCD and VLOS scenarios also include consideration of the deployment of Shell's OSR assets in Alaska, including the availability of both primary and secondary relief well drilling units, both in Alaska, and Shell's capping stack and containment system.

For the purposes of the response planning scenario, Shell elected to utilize a conservative WCD of 25,000 bpod. (Table 6.0-2). The WCD response planning scenario provided below in Table 6.0-2 exceeds the actual WCD calculation of 23,100 for Burger J in EP Revision 2 as indicated in Table 6.0-1. The comparison indicates that spill response capabilities exceed the calculated WCD for EP Revision 2.

Table 6.0-2 Oil Volume of the Worst Case Discharge Planning Scenario for the Chukchi Sea Oil Spill Response Plan

Element	Capacity (bbl)	Reference
Possible Daily Volume of Highest Capacity Well	25,000	30 CFR 254.47(b)
Total WCD (Daily Volume x 30-day Duration of Blowout)	750,000	30 CFR 254.47(b)
Total Storage Capacity Requirements	750,000	30 CFR 254.47(b)

VLOS as Defined by BOEM

A VLOS is defined by BOEM as a release of 150,000 bbl or more. A VLOS is not a reasonably foreseeable effect of Shell's planned exploration under EP Revision 2; however, BOEM has analyzed the impacts of a VLOS in the Arctic Ocean in several overarching NEPA documents (MMS 2003a; MMS 2007b). In the FSEIS for Chukchi Lease Sale 193, BOEM (BOEMRE 2011b) analyzed the potential impacts associated with a 2,160,000 bbl release from a blowout in the Chukchi Sea. BOEM repeated this analysis in its Final Second SEIS (BOEM 2015). In the Final Second SEIS, the large spill is defined by BOEM as greater than or equal to 1,000 bbl and is modeled as a single trajectory and the VLOS is modeled as multiple trajectories (BOEM 2015).

BOEM's VLOS Analysis for Lease Sale 193

BOEM's VLOS analysis prepared for the Chukchi Sea OCS Lease Sale 193 FSEIS (BOEMRE 2011b) and Final Second SEIS (BOEM 2015) uses BOEM's own hypothetical blowout and release from a hypothetical candidate prospect with maximized geological characteristics for the highest flow rate for the entire Chukchi Sea OCS Lease Sale Planning Area, rather than being site-specific. Characteristics of BOEM's VLOS scenario bear little resemblance to Shell's Burger Prospect and proposed EP Revision 2 drilling activities. While subsurface characteristics at the Burger Prospect have been previously determined by exploration drilling, subsurface characteristics of BOEM's VLOS scenario are speculative. Subsurface characteristics of BOEM's VLOS scenario were not observed in the Burger #1 well and cannot reasonably be expected to be encountered by further drilling to the same objective horizon at a similar depth as the prior exploration well.

BOEM's VLOS scenario assumes an initial flow rate of >61,000 bopd, a rate over 2.6 times higher than Shell's Burger Prospect's actual WCD of 23,100 bopd. BOEM's VLOS analysis includes no assumptions for effective oil recovery, collection, containment, or potential capping of the blowout well during the entirety of a VLOS event. BOEM's analysis assumes that, in the best case, the hypothetical blowout well is controlled by Day 39 with a relief well drill and kill; in the worst case, BOEM assumes 74 days for the well to be controlled if the operator did not have a relief well drilling unit in the Alaska theatre at the time of the blowout and that it would take 30 days before the relief well drilling unit arrives.

There are differences between the VLOS assumed in the agency's programmatic lease sale documents and the WCD accompanying an EP, which has a different set of governing regulatory requirements and guidance. In particular, an EP-specific WCD represents "the largest potential discharge from one actual (known) drilling location." As a result, an EP-specific WCD typically results in "lower aggregate discharges than a VLOS" as it does here (BOEMRE 2011b; BOEM 2015). BOEM's hypothetical VLOS scenario in the Chukchi Sea Lease Sale 193 FSEIS assumed a= high initial flow rate. Even in their best case for timing to kill the blowout (39 days), BOEM assumed more than double the cumulative oil (1,384,000 bbl) would be released into the environment compared to the amount calculated in Shell's site-specific analysis (38 days; 669,479 bbl). All of these factors lead to a cumulative oil discharge associated with BOEM's VLOS Chukchi Sea Lease Sale 193 FSEIS (BOEMRE 2011b) and the Final Second SEIS (BOEM 2015) that greatly exceeds Shell's WCD analysis.

BOEM's VLOS Impacts Analyses

The detailed impact analyses of the Chukchi Sea Lease Sale 193 EIS, FSEIS, and Final Second SEIS, 2003 Multi-Sale EIS, and Lease Sale 126 EIS, provide decision-makers with useful information on the anticipated impacts of a VLOS from a given project.

The CEQ and Department of Interior encourage tiering to prior NEPA documents in an effort to avoid duplication, and courts have specifically approved tiering of existing NEPA analyses on spill impacts when the analysis covers the same area. 40 CFR 1502.20, 1508.28; 43 CFR 46.180; *Defenders of Wildlife v. Bureau of Ocean Energy*, 684 F.3d 1242, 1251 (11th Cir. 2012). The existing analyses of

VLOS impacts in prior NEPA documents illustrate the reasonably foreseeable impacts from a hypothetical VLOS resulting from the exploration drilling program described in EP Revision 2 and are incorporated by reference in the impact analysis provided below.

The following Section 6 subsections:

- provide a discussion and analysis of the probability of a hypothetical VLOS occurring;
- describe the location, volume, and timing of a hypothetical VLOS;
- describe the fate and effect of the hypothetical VLOS;
- provide an analysis of the probabilities of the hypothetical VLOS reaching offshore and coastal resources; and
- provide an analysis of the potential effects the hypothetical VLOS might have on physical, biological, and socioeconomic resources.

6.1 Probability of a VLOS Occurring

Oil and gas exploration activities, such as those proposed in Shell's EP Revision 2, carry the risk of an oil spill. Various events could cause a spill, ranging from a hose rupture to the extreme example of a loss of well control (blowout). However, as discussed in Section 2.10, the most likely (i.e., reasonably foreseeable) spill to occur during the activities in EP Revision 2 would be a spill of approximately 48 bbl resulting from a refueling operation. This conclusion is consistent with BOEM's prior findings when analyzing the likelihood of various kinds of spill impacts. Accordingly, the impacts of a 48 bbl spill on existing environmental resources were evaluated in Section 4. As analyzed for potentially affected resources throughout Section 4 above, the impacts of a 48 bbl spill resulting from a refueling operation are expected to be localized and fleeting, and would not be significant.

Nonetheless, a well blowout (loss of well control) is of greatest concern with regard to oil spill risk analysis due to the potential for a large release of liquid hydrocarbons. BOEM (MMS 2003a; MMS 2007b; BOEMRE 2011b; BOEM 2011a; BOEM 2015) has concluded that the risk of a VLOS resulting from a well control incident that impacts the environment is very low. No blowouts have occurred within the Alaskan OCS as a result of the 98 exploration wells drilled to date (MMS 2007a; MMS 2007b; BOEMRE 2011b; BOEM 2015). Thirty-five of these exploration wells were drilled in the Chukchi and Beaufort Seas from 1982 to 2003. The best available information on blowouts associated with oil and gas operations on Alaska's North Slope identifies 11 blowouts at onshore wells between 1977 and 2001. These blowouts released either dry gas or gas condensate only, resulting in minimum environmental impact (NRC 2003a).

The FSEIS and Final Second SEIS that BOEM prepared for the Chukchi Sea Lease Sale 193 (BOEMRE 2011b; BOEM 2015) both reported that from 1971 through 2010 approximately 15,491 exploration wells were drilled nation-wide in the OCS (including 223 in the Pacific OCS, 46 in the Atlantic OCS, and 84 in the Alaska OCS, and 15,158 in the Gulf of Mexico). A total of 77 well control incidents were identified during this time period, 14 of which resulted in oil spills ranging from 0-200 bbl for a total of 334 bbl, excluding the Deepwater Horizon event. Only one incident resulted in a spill volume in excess of 1,000 bbl, and that was Deepwater Horizon. Another BOEM study confirmed that no crude oil spills greater than 100 bbl (16 m^3) resulting from blowouts occurred from 1985 to 1999 (Hart Crowser, Inc. 2000). A 2007 report by BOEM (Izon et al. 2007) reviewed blowout statistics for the U.S. from 1992 through 2006. This paper did not distinguish between exploration and development wells but reported that the overall frequency of blowouts has diminished since their previous review for the period of 1971 through 1972.

Holand (1997) reported the U.S. Gulf of Mexico OCS exploration blowout frequency as 0.0059 per well drilled, based on worldwide historical data available from the SINTEF Offshore Blowout Database. As Holand's exploration blowout frequencies included blowouts of all types, the frequencies for a blowout resulting in oil reaching the environment are significantly less. Of the total blowouts reported by Holand (1997), gas releases accounted for 77 percent of the total blowouts, gas/liquid mixtures 14 percent, and uncontrolled liquid flows involved only three percent.

BOEM analyzed how the *Deepwater Horizon* event affected prior analysis about the likelihood of an oil spill (BOEM 2015). BOEM explained that, when preparing such predictive analyses, it used data from past OCS spills. However, from 1985-1999 (the time period used when preparing the Gulf of Mexico analysis), there were no platform or blowout spills greater than 1,000 bbl. Thus, “to allow for conservative future predictions of spill occurrence, a spill number of one was ‘assigned’ to provide a non-zero spill rate for blowouts. Therefore, this spill rate already included the occurrence of the ”Deepwater Horizon Event” (BOEMRE 2011a; BOEM 2015).

Looking at data specific to Alaska and the Arctic OCS, Scandpower (2001) used statistical blowout frequencies modified to reflect specific field conditions and operative systems at the Northstar Development in the Beaufort. The report concluded that the predicted frequency of blowouts when drilling into the oil-bearing zone is 0.000015 per well drilled. This same report estimates that the frequency for Northstar of a spill greater than 130,000 bbl (20,668 m^3) is 0.00000094 per well. This compares to a statistical blowout frequency of 0.000074 per well for an average development well.

Bercha International Inc. developed a fault tree model to estimate oil spill occurrence rates associated with Arctic OCS locations (Bercha Group 2006, 2008). In 2014, Bercha developed another fault tree analysis associated with exploration and production facilities operations specific to Sale 193 Lease Area in the Chukchi Sea (Bercha Group 2014). Because limited historical spill data for the Arctic exists, Bercha modified the existing base data using fault trees to arrive at oil spill frequencies for future development and production scenarios. For offshore exploration drilling, Bercha Group (2014) used statistics derived from Holand (1997) for non-Arctic drilling operations and Scandpower’s (2001) blowout frequency assessment for Northstar to estimate the anticipated size and frequency of spills. Based on this historical data, Bercha reported the spill frequency for non-Arctic exploration well drilling as 0.0000217 per well for a blowout equal to or in excess of 150,000 bbl (23,848 m^3).

In order to model the data variability for Arctic exploration, Bercha applied a numerical simulation approach to develop the probability distribution of 150,000 bbl (23,848 m^3) or greater, and arrived at a frequency ranging from a low of 0.00095 per well to a high of 0.0000442 per well. The expected value for historical a blowout of this size was computed to be 0.000025 per well (Bercha Group 2014). To address causal factors associated with blowouts, Bercha applied adjustments for improvements to logistics support and drilling contractor qualifications that resulted in lower predicted frequencies for Arctic drilling operations. No fault tree analyses or unique Arctic effects were applied as a modification to existing spill causes for exploration, development, or production drilling frequency distributions. For exploration wells drilled in analogous water depths to the planned Chukchi Sea exploration wells, at 143-150 ft (43.7-45.8 m), Bercha Group (2014) predicted an adjusted frequency of 0.0000362 per well for a blowout sized between 10,000 bbl (1,590 m^3) to 149,000 bbl (23,689 m^3) and 0.0000225 per well for a blowout greater than 150,000 bbl (23,848 m^3). Based on these data, the risk of a blowout resulting in the release of a VLOS associated with Shell’s exploration drilling program is extremely low.

6.2 Characteristics of a Possible VLOS

The VLOS considered in this impact analysis is based on a subsea release of crude oil resulting from a blowout of an exploration well, with the following additional assumptions.

Location and Timing of the VLOS

Shell’s EP Revision 2 encompasses six drill sites within the Burger Prospect. A well at one of these drill sites, the Burger J drill site, has been identified as having the highest calculated WCD flow rate and total volume. For this analysis, Shell assumes a crude oil blowout at the Burger J drill site. The location of the

Burger J drill site is indicated in Figures 1.1-1 and 2.1-1. The drill site is located more than 64 mi (103 km) from shore in a water depth of approximately 150 ft (45.8 m).

The exploration drilling program outlined in EP Revision 2 commences in early July and ceases on or around 31 October. For this impact analysis Shell assumes a date of 1 August for the blowout scenario and a conservative duration of 38 days (time required to position a more distance secondary relief well drilling unit and kill the flow as detailed in Section 2 of EP Revision 2). Oil spreads less in cooler water, and even less in broken ice, with oil spreading rates decreasing as concentrations of ice increase. For that reason, Shell's selection of an August date for a hypothetical spill is appropriate as it produced the maximum distances that spilled oil is likely to travel. This August date is informed by the trajectory analyses of oil spill scenarios conducted by BOEM in the Chukchi Sea FSEIS, and relied upon by Shell in its spill analyses. These trajectory analyses included thousands of individual spill scenarios, some in the arctic summer (open water in July-September) and some in the arctic winter (ice cover in October-June). Those analyses used current wind speed and direction, and ice motion speed and direction, to calculate oil spill trajectories. The trajectories also considered overwintering of oil and severe and extreme weather conditions such as storms with strong winds and rough seas. Those trajectory analyses confirm that oil moves farther in August than in colder conditions (e.g., October). Therefore an August spill assumption reflects the maximum distance oil is expected to travel, and presents a scenario with the greatest risks and impacts to resources with special economic or environmental importance. This timing is consistent with BOEM's EA for EP Revision 1 (BOEM 2011a) and BOEM's FSEIS and Final Second SEIS for Lease Sale 193 (BOEMRE 2011b; BOEM 2015), as they all assumed the spill would occur during exploration activities between July and October).

Volume of the VLOS

Regardless of the discharge source, or the low probability of a VLOS occurring, Shell's Chukchi Sea OSRP response scenario must address the potential immediate release of crude oil to the environment by a loss of well control during the drilling season. The rate and volume for the VLOS were based on the planning scenario WCD provided in the Section 2.10 of Chukchi Sea EP Revision 2, which considers a release of crude oil at 25,000 bopd (3,975 m^3/day). This volume is a conservative assumption as it exceeds the calculated WCD for the Burger J drill site. At this rate, the total over 38 days would be 950,000 bbl (151,038 m^3) of crude oil. Shell's OSRP demonstrates access to sufficient equipment and personnel needed to respond to a well blowout with this flow rate and total volume.

Crude Oil Characteristics of the VLOS

For this analysis, we assumed the release (VLOS) would be crude oil with an API gravity of 30. This is a medium weight crude and typical of Alaska North Slope crude oil.

Spreading of the VLOS

As soon as the oil is released into the environment it would begin to spread and its properties would start to change though processes collectively known as weathering. Some of the oil would disperse into the water column while still rising to the surface. Once on the surface the oil would spread across the surface forming a slick, and the oil in the slick would be subject to additional dispersion and to evaporation as well as other weathering processes. NOAA's ADIOS 2 oil weathering model was used to predict behavior of Alaska North Slope oil with an API gravity of 30 under the environmental conditions specified in the OSRP, which include an average 10 knots wind, and August air temperatures of 34 to 46 ºF (1 to 8 ºC). ADIOS 2 incorporates a database with the characteristics of more than a thousand crude oils and refined products, and provides quick estimates of the expected characteristics and behaviors of oil spilled into the marine environment. The modeling results indicate that the VLOS would lose up to 25 percent of its volume due to evaporation. An additional 5 percent would likely be removed by dispersion of oil into the water column, but a much higher dispersion rate would occur in higher wind and wave conditions than were assumed, or in the case of a turbulent blowout with high gas concentrations.

This volume would not spread uniformly; thickness would vary greatly throughout the slick. A portion of this oil may emulsify. The oil slick would also likely not be continuous, breaking into patches and windrows under the influence of waves or zones of convergence and divergence. In this case separate smaller oil slicks with variable thickness would be separated by areas of open water. An average thickness of an Alaska North Slope oil slick released under open water in arctic conditions was assumed to range from 0.01-0.1 in. (0.025-0.25 cm). Using an average thickness of 0.01 in. (0.025 cm) and therefore an average coverage of 6.5 bbl/ac of oil, we conservatively estimated the VLOS oil slick would encompass about 9,000 ac (36.4 km^2).

Potentially Affected Areas

The Chukchi Lease Sale 193 Final Second SEIS (BOEM 2015), Chukchi Sea Lease Sale 193 FSEIS (BOEMRE 2011b) and the Chukchi Sea Lease Sale 193 EIS (MMS 2007b), included an analysis of how and where offshore oil spills would move within the Chukchi Sea using a computer trajectory simulation model. Simulations were performed using a computer model called the Oil Spill Risk Analysis (OSRA). The simulation model uses wind, ice, and ocean-current information for winter and summer seasons and annual conditions derived from a variety of sources including field and satellite observations and calculated conditions. Ocean current data used for trajectory modeling is based upon BOEM's annual means analysis of Haidvogel et al. (2001) coupled with the ice-ocean model. Thousands of trajectory simulations were run for hypothetical spill launch locations distributed throughout the Lease Sale 193 Area. The trajectory runs simulate the movement of oil without consideration of oil spill containment, control, or recovery actions. The trajectory model provides conditional probabilities that oil spilled from a hypothetical launch area (LA) will contact a specific land segment (LS), ERA, or subsistence use area (SUA) within a given time frame. Conditional probabilities derived from the OSRA model are expressed as the chance of a large spill or VLOS originating from LA 1 − 13 contact a LS, ERA, or SUA with given time frames (3, 10, 30, 60, 180, and 360 Days). To apply this analysis to Shell's EP Revision 2, the assumed sites of the large spill and VLOS releases are located in LA 11. Summer conditional probabilities as estimated by BOEM (BOEM 2015) for the spill reaching specific LS, ERA, and SUA units within 3 days, 10 days, and 30 days (considered a large spill), and 60 days and 360 days (considered a VLOS) are presented in Tables 6.2-1 and 6.2-2. The spill is assumed to commence between 15 July and 31 October and reside on the surface from a few weeks to 50 days. The first 50 days would be a critical period in which response resources would be mobilized and containment and recovery operations implemented to counteract the oil spill. The additional time frame of 360 days is presented to cover the possibility of a VLOS occurring later in the drilling season, freezing into sea ice and remobilizing in the spring.

The results of BOEM's OSRA indicate a relatively low probability of the large spill from Shell's Burger Prospect a reaching the land as an oil slick, with the probability of reaching land within three days being about 1 percent, within 10 days about 1 to 4 percent and within 30 days about 1 to 6 percent. Similarly, low probabilities are predicted for the VLOS to contact land, ranging from 1 to 6 percent within 60 days and 1 to 7 percent over 360 days.

Table 6.2-1 Probabilities of a large spill (3, 10, and 30 days) and VLOS (60 and 360 days) from LA 11 Contacting Certain Land Segments

ID [2]	Land Segment [3]	Summer Conditional Probability (%) from LA 11 [1]				
		3 days	10 days	30 days	60 days	360 days
LS 65	Buckland, Cape Lisburne					
LS 66	Ayugatak Lagoon	-	-	-	-	-
LS 71	Kukpowruk R. - Sitkok Point	-	-	-	-	-
LS 72	Point Lay – Sisrikpak Point	-	-	-	-	-
LS 73	Tungaich Point - Tungak Creek	-	-	1	1	1
LS 74	Kasegaluk Lagoon - Solivik Is	-	-	1	1	1

Table 6.2-1 Probabilities of a large spill (3, 10, and 30 days) and VLOS (60 and 360 days) from LA 11 Contacting Certain Land Segments

ID [2]	Land Segment [3]	Summer Conditional Probability (%) from LA 11 [1]				
		3 days	10 days	30 days	60 days	360 days
LS 75	Akeonik - Icy Cape	-	1	1	1	1
LS 76	Avak Inlet - Tunalik River	-	-	1	1	1
LS 77	Nivat Point – Nokotlek Point	-	-	1	1	1
LS 78	Point Collie, Sigeakruk Point	-	1	2	2	2
LS 79	Pt Belcher - Wainwright	1	2	3	4	4
LS 80	Eluksinglak Point - Kugrua Bay	-	2	3	3	3
LS 81	Peard Bay - Point Franklin	-	-	1	1	1
LS 82	Skull Cliff	-	-	1	1	1
LS 83	Nulavik, Loran Radio Station	-	1	1	1	1
LS 84	Will Rogers & Wiley Post Mem	-	2	3	3	4
LS 85	Barrow, Browerville, Elson Lag..	-	4	6	6	7

[1] Source : BOEM 2015
[2] LS = Land Segment LSs with <1% probabilities for any duration are not listed
[3] Probability of <0.5 % denoted by (-)

Table 6.2-2 Probabilities of a large spill (3, 10, and 30 days) and VLOS (60 and 360 days) from LA 11 Contacting Certain ERAs and SUAs

ID [3]	Resource [3]	Summer Conditional Probability (%) from LA 11 [1]				
		3 days	10 days	30 days	60 days	360 days
ERA 0	Land	2	15	37	40	43
ERA 1	Kasegaluk Lagoon Area	1	3	4	4	4
ERA 2	Point Barrow, Plover Islands	-	-	1	1	1
ERA 3	SUA: Uelen/Russia	-	-	1	2	2
ERA 6	Hanna Shoal	2	6	11	12	13
ERA 7	Krill Trap	-	3	6	7	7
ERA 10	Ledyard Bay SPEI Critical Habitat Area	8	11	13	14	14
ERA 11	Wrangel Island 12 nm & Offshore	-	-	3	5	6
ERA 15	Cape Lisburne Seabird Colony Area	-	2	4	4	4
ERA 16	Barrow Canyon	1	11	18	19	19
ERA 18	Murre Rearing and Moulting Area	-	3	9	9	10
ERA 19	Chukchi Spring Lead System	4	6	8	8	8
ERA 20	East Chukchi Offshore	-	-	1	1	2
ERA 23	Polar Bear Offshore	4	5	7	7	7
ERA 38	SUA: PT. Hope Cape Lisburne	-	-	1	1	1
ERA 39	SUA: Pt. Lay -Kasegaluk	1	3	5	5	5
ERA 40	SUA: Icy Cape - Wainwright	14	27	34	34	35
ERA 42	SUA: Barrow – East Arch	-	4	7	8	8
ERA 46	Herald Shoal polynya	-	-		1	2
ERA 47	Hanna Shoal Walrus Use Area	27	37	46	47	48
ERA 48	Ice/Sea Segment 11	1	-	-	-	1
ERA 50	Pt. Lay Walrus Offshore	12	18	21	21	21
ERA 51	Pt. Lay Walrus Nearshore	1	3	5	5	5
ERA 52	Ice/Sea Segment 14	-	2	10	10	11
ERA 53	Chukchi Spring Lead 2	5	5	5	5	5
ERA 54	Chukchi Spring Lead 3	4	7	9	9	9
ERA 55	Point Barrow, Plover Islands	-	-	1	1	1
ERA 56	Hanna Shoal Area	6	13	17	19	20
ERA 57	Skull Cliffs	1	6	10	10	10
ERA 58	Russian Coast Walrus Nearshore	-	-	3	3	4
ERA 59	Ostrov Kolyuchin	-	-	1	1	1
ERA 61	Pt. Lay-Barrow BH GW SFF	31	44	53	54	55

Table 6.2-2 Probabilities of a large spill (3, 10, and 30 days) and VLOS (60 and 360 days) from LA 11 Contacting Certain ERAs and SUAs

ID [3]	Resource [3]	Summer Conditional Probability (%) from LA 11 [1]				
		3 days	10 days	30 days	60 days	360 days
ERA 63	North Chukchi	-	-	-	1	1
ERA 64	Peard Bay Area	2	13	21	21	21
ERA 66	Herald Island	-	-	1	2	2
ERA 70	North Central Chukchi	-	-	1	1	2
ERA 74	Offshore Herald Island	-	-	2	2	3
ERA 82	N Chukotka Nearshore 2	-	-	4	4	4
ERA 83	N Chukotka Nearshore 3	-	-	4	5	5
ERA 91	Hope Sea Valley	-	-	3	4	4
ERA 102	Opilio Crab EFH	-	1	3	3	3
ERA 103	Saffron Cod EFH	13	33	47	48	49
ERA 107	Pt. Hope Offshore	-	-	2	2	2
ERA 108	Barrow Feeding Aggregation	-	3	5	5	6
ERA 120	Russia CH GW Fall 1&2	-	1	4	4	5
ERA 121	Cape Lisburne – Pt. Hope	-	1	2	2	2
ERA 122	North Chukotka Offshore	-	-	1	1	2
ERA 123	AK Chukchi Offshore	-	2	4	5	5
ERA 124	Central Chukchi Offshore	-	1	5	5	5

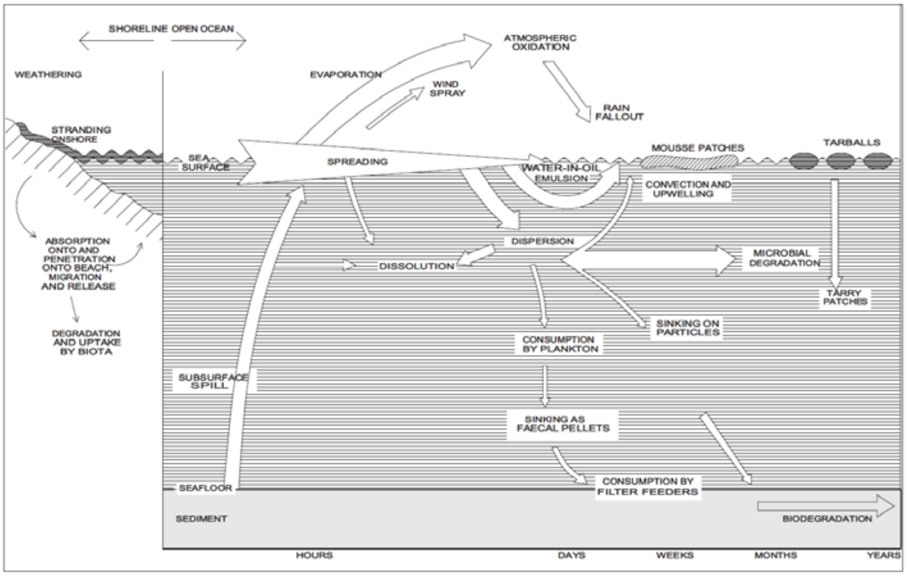
[1] Sources : BOEM 2015
[3] ERA = Environmental Resource Area; ERAs with <1% probabilities for any duration are not listed
[2] Probability of <0.5 % denoted by (-)

Behavior and Fate

Discussions of the behavior and fate of crude oils in the Arctic Ocean are provided by BOEM in the Chukchi Sea Lease Sale 193 Final Second SEIS (BOEM 2015), Chukchi Sea Lease Sale 193 FSEIS (BOEMRE 2011b, the Chukchi Sea Lease Sale 193 EIS (MMS 2007b), the Multi-Sale EIS (MMS 2003a), and the Lease Sale 126 EIS (MMS 1991), and are summarized and applied to the VLOS as follows. The generalized fate of summer oil spills in the Arctic is portrayed in Figure 6.2-1. Once the petroleum is released at the wellhead, natural processes would begin to physically, chemically, and biologically aid the degradation of the oil (NRC 2003a). The physical processes involved would include evaporation, emulsification, and dissolution, while the primary chemical and biological degradation processes include photo-oxidation and biodegradation (i.e., microbial oxidation).

After the VLOS, spreading would begin. The oil would spread horizontally in elongated patterns oriented in the direction of the wind. The resulting slick would likely spread non-uniformly with thin sheens and thick patches (Elliott et al.1986; Galt et al. 1991). The VLOS slick would remain relatively thick in the cold waters of the Chukchi Sea due to the increased viscosity (MMS 2008a).

Figure 6.2-1 Fate of Oil Spills in the Arctic Ocean in Summer



Source: MMS 2003a

Evaporation would commence immediately with the lighter, more volatile components evaporating first. Evaporation of these lighter components could reduce the spill volume by 30-40 percent, with a 25 percent reduction occurring in the first 24 hr (NAS 1985). Wind and higher temperatures, if they were to occur, would speed the evaporation process. The presence of any ice would slow evaporation (S.L. Ross Environmental Research Ltd. and Dickens Assoc. Ltd. 1987).

The VLOS would also be subject to dispersion from wind, waves, current, and potentially ice. Dispersion is an important component of the weathering of the released crude oil as it breaks the oil slick up into small oil particles (0.5 µm to several mm), which are then transported into the water column. Local sea state largely determines the dispersion rate, with high sea states facilitating rapid dispersion (Mackay 1985). Emulsions may form, by the incorporation of water droplets in the oil; Alaska North Slope crude has been shown to readily form emulsions (MMS 2008a).

The process whereby hydrocarbon molecules become dissolved in the water column is called dissolution. The process is largely restricted to low-molecular compounds such as benzene, toluene, and xylene, which are among the most toxic components of crude oil. However, the evaporation process is much more rapid than dissolution; the majority of these toxic components are evaporated rather than dissolved into the water (MMS 2008a).

Most of the oil droplets dispersed into the water column would eventually be degraded by bacteria, or deposited on the seafloor, depending on sedimentation loads and rates in the water column, water depth, sea state, oil properties, and planktonic communities.

The Chukchi Sea in the Burger Prospect region is subject to relatively high mean wind speeds and frequent high wind events (Section 3.1.1), but low air and water temperatures. Ice would not be expected at or shoreward of the drill site in August but could occur in some offshore areas. These typical weather conditions at the Burger Prospect would, in general, speed the evaporation and dispersion of released petroleum.

In the Final Second SEIS for Chukchi Sea Lease Sale 193, BOEM (BOEM 2015) assumed oil from the VLOS would remain on the surface for up to a few weeks. For EP Revision 2's hypothetical VLOS, Shell used the persistence formula used by BOEM in the Chukchi Sea Lease Sale 193 EIS (MMS 2007b), which indicates that most of the oil on the surface of the sea would persist as a slick for about 50 days. The formula was developed based on analysis of two data sets of actual spills (13 tankers and 7 blowouts) and one data set of experimental spills. The experimental spills were much smaller than the VLOS, but the other spills were large or very large spills, therefore the formula should be applicable to the VLOS.

Emulsions and tar balls would persist much longer. The tarballs would eventually sink or contact land, but as much as 16 percent of the VLOS volume could persist as tarballs through 1,000 days (MMS 1990 citing Butler et al. 1976; Jordan and Payne 1980). Oil that reaches the coast could persist much longer. Persistence in coastal areas, if contact occurs, will depend on the type of shoreline contacted. The sensitivity of shoreline habitats and the estimation of behavior and persistence of oil on intertidal habitats are based on the dynamics of the coastal environment as well as the substrate type and grain size.

6.3 Potential Impacts Associated with a Crude Oil Spill

Historical data demonstrate that the probability of a VLOS occurring during exploration drilling is extremely remote. Therefore, the potential impacts of such an event were not analyzed in Section 4.0 as potential direct or indirect impacts of the planned exploration drilling program, but are analyzed in the following sections.

BOEM has provided multiple analyses of the potential effects of large and VLOS in the Alaska OCS. In its 2003 Multi-Sale EIS, BOEM analyzed the likelihood of a spill, the fate of spilled oil without cleanup, and the most likely trajectories of spills of various sizes that could result from oil exploration and development on the proposed leased areas (MMS 2003a). For the purpose of analysis, the agency evaluated the impacts of a hypothetical 180,000 bbl spill in a nearshore area on areas identified by the agency as sensitive resources. BOEM analyzed the behavior of spilled crude oil in open water, solid ice, and broken ice. For each scenario, BOEM evaluated the impacts of the spill on environmental resources. The agency concluded that impacts to some resources were likely to be significant in the unlikely event of a VLOS. However, the agency also noted the mitigating role that OSR activities could have on these potential impacts. BOEM's EA for Shell's 2012 Chukchi Sea EP Revision 1 tiered to the Chukchi Sea Lease Sale 193 EIS and FSEIS (BOEM 2011a). BOEM's analysis in the EA assumed a potential oil discharge volume of 750,000 bbl (25,000 bopd x 30 days), and assumed 121,779 bbl would reach water based upon mitigation and response activity. In the FSEIS for Chukchi Lease Sale 193 (BOEMRE 2011b) BOEM developed a hypothetical VLOS scenario that included the release of 2,160,000 bbl of crude oil from a hypothetical blowout commencing between 15 July and 31 October. In this analysis, BOEM assumed that 10-40 percent of the release would be recovered or reduced (skimmed, dispersed, evaporated, dissolved, biodegraded) before reaching the shore. Both summer and winter spills were considered. BOEM recently reassessed the VLOS analyses in the Second Final SEIS (BOEM 2015), in which the model considered large spills as a single trajectory and VLOS as multiple trajectories. The recovery/reduction remains at 10-40 percent and the period of the hypothetical blowout remain between 15 July and 31 October. The model also considers both summer and winter spill scenarios.

Table 6.3-1 provides a summary of potential impacts from a VLOS as presented in BOEM's Chukchi Sea Lease Sale 193 Final Second SEIS (BOEM 2015) and BOEM's EA for Shell's EP Revision 1 (BOEM 2011a).

Table 6.3-1 Potential Effects from a VLOS as Presented in the Lease Sale 193 FSEIS and the EA for Shell's EP Revision 1

VLOS Impacts Analysis in Prior NEPA Documents		
Environmental Resource	**Final Second SEIS for Lease Sale 193**	**Final EA for Shell Chukchi Sea EP Revision 1**
	Level of Impact from VLOS	**Level of Impact from VLOS (Alternative 2; 750,000 bbl)**
Air Quality	Major levels of effect to air quality during some phases of the event. Emissions would be temporary and distributed over time. Air quality in the Arctic would eventually return to pre-oil-spill conditions.	Offshore: moderate to major impacts Shoreline: minor impacts
Water Quality	Significant impacts: sustained degradation of water quality, violations of state and federal criteria, and significant effects	Significant impacts: Sustained degradation of water quality, violations of state and federal criteria, and significant effects
Lower Trophic Levels	Acute, and for some species, significant impacts	Phytoplankton: negligible Zooplankton: negligible to minor benthic: minor to moderate
Fish and EFH	Fish: Significant impacts on certain fish species; population effects depend on variety of factors EFH: Saffron cod EFH, Opilio crab EFH, Arctic cod EFH, and Pacific salmon EFH could be contacted and affected by oil	Fish: at times significant, depending on timing and trajectory of spill EFH: Significant impacts for Arctic cod, saffron cod, and all five species of Pacific salmon
Marine and coastal birds	Species that congregate in potentially affected areas are most susceptible to significant impacts	Potential for significant impacts were spilled oil to reach important habitat areas
Marine Mammals	Ice seals: adverse impacts; most effects would correct within a generation; however, due to differences in generation times between species, such recoveries could easily take over five years. Pacific walruses: significant impacts if large scale contamination of prey and habitat Cetaceans: significant effects to some species (including bowhead) under some circumstances Polar bear: could result in the loss of large numbers of polar bears. Significant impact on the SBS and/or BCS stocks.	Ice seals: short-term population impacts Pacific walruses: moderate to major impacts depending on whether spill was located near large walrus concentration or carried to area with pack ice edge where walruses gather Mysticetes (bowhead, gray, fin, humpback, and minke whales): potential for significant impacts in some circumstances Odentocetes (beluga, harbor porpoise, and killer whales): moderate impacts Polar bear: moderate to major impacts depending on relationship of spill to polar bear and their prey; adverse impacts to critical habitat
Terrestrial Mammals	Adverse impact but would not rise to the level of significance; full recovery of population within one to two years	Negligible effects
Vegetation and Wetlands	Localized but potentially long-term impacts	Not considered
Subsistence Activities	Significant adverse impacts possible by diminishing or contaminating subsistence resources; concerns about contamination could persist	"Similar effects to those described in detail in other lease sale EIS's for subsistence resources"
Sociocultural Systems	Potential disruption may last years and level of impacts depends upon the effect on subsistence harvests	Major impacts, "potential to cause long-term significant effects that would disrupt or nearly eliminate subsistence harvests"
Economy	Generates jobs and income but could also have negative impacts on potential future economic activities.	Impacts in form of increased jobs and earnings, and "analyses [in prior lease sale 193 EISs] remain sufficient to analyze similar effects of . . . very large oil spills in the Chukchi Sea, including . . . the 750,000 bbl oil spill estimated for this EA."
Public Health	Impacts include contact with contaminants, which could occur mainly through inhalation, skin contact, or intake of contaminated subsistence foods; reduced availability or acceptability of subsistence resources; periodic interference with subsistence-harvest patterns	Discussed impacts (e.g., effects to air quality, water quality, subsistence resources); " analyses [in prior lease sale 193 EISs] remain sufficient to analyze similar effects of . . . very large oil spills in the Chukchi Sea, including . . . the 750,000 bbl

Table 6.3-1 Potential Effects from a VLOS as Presented in the Lease Sale 193 FSEIS and the EA for Shell's EP Revision 1

VLOS Impacts Analysis in Prior NEPA Documents		
Environmental Resource	**Final Second SEIS for Lease Sale 193**	**Final EA for Shell Chukchi Sea EP Revision 1**
	Level of Impact from VLOS	**Level of Impact from VLOS (Alternative 2; 750,000 bbl)**
	from oil spills and oil spill cleanup; and stress due to fears of the long-term implications of a spill and the disruptions it would cause.	oil spill estimated for this EA."
Archaeological Resources	Onshore spill response and cleanup had most potential for impacts	"[P]otential to adversely affect archaeological resources" with additional information available in Sale 193 NEPA analyses.
Environmental Justice	Significant, high adverse environmental and health impacts to Alaska Inupiat Natives	Level of impact not identified but notes additional information available in Sale 193 NEPA analyses.

[1] Sources: BOEM 2015, BOEM 2011a

In the resource sections that follow, Shell's analysis discusses the types of impacts anticipated to each resource based on available scientific information, as well as site-specific information for the hypothetical VLOS detailed above, which includes the specifics of Shell's EP Revision 2 (timing, drill site locations, Shell's specific exploration drilling program). Next, to define the anticipated levels of environmental impacts associated with the VLOS, Shell's revised analysis tiers to and incorporates the results of prior BOEM analyses. As noted above, this change in approach (i.e., tiering to BOEM's recent VLOS analyses which are based on higher volumes and durations of oil spilled) will necessarily result in higher impacts than presented in EP Revision 1, despite the fact that neither Shell's WCD volume nor its comprehensive response strategies have changed. Note that if the VLOS is not anticipated to have much impact on a particular resource (e.g., terrestrial mammals), as noted in the table above, it is not discussed in the sections that follow. The reader is encouraged to refer to the more detailed discussions provided in BOEM's Chukchi Sea Lease Sale 193 FSEIS and Final Second SEIS, and BOEM's EA for EP Revision 1.

6.3.1 Potential Impacts of the VLOS on Air Quality

Air quality in the Chukchi Sea is described in EP Revision 2 EIA Section 3.1. A VLOS would potentially release pollutant emissions into the atmosphere, including pollutants regulated under the CAA. After an initial explosion, emissions would occur for each phase of the event due to fires (including in-situ burning), evaporative emissions from oil, and emissions from sources operating during the oil spill recovery and cleanup process. The behavior of these emissions would be influenced by the Arctic climate, the severity of the spill, and the characteristics of the pollutant sources. Meteorological conditions (e.g., prevailing winds, precipitation, temperature inversions) define atmospheric stability and would determine the amount of turbulence, mixing, and dispersion that could occur. These parameters also affect the build up of emissions and concentration levels of pollutants that could affect human health and wildlife. BOEM's EA for EP Revision 1 (BOEM 2011a) discusses the air quality impacts associated with a VLOS in further detail.

In the VLOS assessment in BOEM's Chukchi Sea Lease Sale 193 FSEIS, the agency determined that a 2,160,000-bbl spill would cause major air quality impacts during some phases of the event, the greatest impacts during the initial event and spill response and cleanup (Phases 1 and 4), particularly if the spill occurred during winter (BOEM 2015). BOEM added that while the impacts are estimated to be major during these two phases, the emissions from the VLOS would be temporary, and, over time, air quality would return to pre-oil-spill conditions (BOEM 2015).

In the EA for EP Revision 1, BOEM determined that effects on air quality in the unlikely event of a VLOS from Shell's Burger prospect in the Chukchi Sea would be moderate to major during the initial event and during the response and cleanup process. BOEM added that effects would diminish with time because most of the surface oil would evaporate before reaching the shoreline (where effects on air quality would be minor) (BOEM 2011a).

The assumed VLOS for this analysis would occur more than 64 mi (103 km) offshore. Based on the site-specific information and BOEM's prior NEPA analyses, Shell anticipates that the VLOS would result in moderate to major short-term air quality impacts offshore near the drill site, and minor air quality impacts at the shoreline.

6.3.2 Potential Impacts of the VLOS on Water Quality

Water quality and other oceanographic characteristics of the Chukchi Sea are described in Section 3.2. Rivers that flow into the Chukchi Sea remain relatively unpolluted by human activities, but can carry suspended sediment particles with trace metals and hydrocarbons. The loading of these constituents to the marine environment is relatively low, and as a result the water quality in the nearshore is also expected to only be slightly affected locally by both anthropogenic and natural sources (MMS 2008a).

Water quality could be impacted not only by the oil, gas, and their respective components in the VLOS, but also to some degree from cleanup and mitigation efforts (such as from increased vessel traffic).

During the initial phase of the assumed blowout, immediate water quality impacts would occur mainly from the disturbance of sediments, and release and suspension of sediment, oil, and natural gas (methane) in the water column. Once the oil surfaces, evaporation of lower molecular weight aromatics (C5 – C9) would occur within the first few days significantly lowering the potential for dispersion and dissolution of these more toxic constituents into the water column. Natural physical processes (e.g., wind, waves, current) would disperse a small percent of the oil (assumed 5 percent) into smaller particles that would mix in the euphotic zone of the water column by dispersion and dissolution resulting in the contamination of the water column with increased concentrations of petroleum hydrocarbons. The initial concentrations would be diluted over time and with distance from the drill site.

The concentrations of hydrocarbons in surface waters under several very large oil spills have been measured. Hydrocarbon concentrations in surface waters under the slick resulting from the *Argo Merchant* varied greatly with measured concentrations ranging up to 0.25 ppm (Gross and Mattson 1977 in Teal and Howarth 1984). Concentrations of 0.003-0.02 ppm were measured under the slick produced by the *Amoco Cadiz* spill (Marchand et.al. 1979 in Teal and Howarth 1984). Measured volatile liquid hydrocarbon concentrations at the Ixtoc spill ranged from 0.4 ppm near the blowout to 0.06 ppm at a distance of 10.0 km (Boehm and Fiest 1980 in Teal and Howarth 1984). Hydrocarbon concentrations under the slick produced by the *Exxon Valdez* in Prince William Sound ranged from 0.001-0.006 ppm 21-41 days after the incident (MMS 2003a).

In its assessment of a hypothetical 180,000 bbl VLOS from a blowout in the Beaufort Sea, BOEMRE predicted that hydrocarbon concentrations in the water beneath the resulting slick (0.11 ppm after 30 days) would exceed the 1.5 ppm acute toxicity criterion for the first several days, and exceed the 0.015 chronic toxicity criterion for one to several months; however, they noted that the predicted concentrations (0.11 ppm at 30 days) were greater than those observed in Prince William Sound 21-41 days after the *Exxon Valdez* spill. Hydrocarbon concentrations that might occur in the upper 33 ft (10 m) of the water column beneath the slick resulting from a 160,000 bbl VLOS from a hypothetical pipeline in the Chukchi Sea were predicted by BOEM to be 0.15 ppm, declining to 0.13 ppm after 10 days and 0.09 ppm after 30 days.

Measured hydrocarbon concentrations under the above-referenced actual very large oil spills, as well as modeled hypothetical very large oil spills in the Chukchi and Beaufort Seas, indicate that the VLOS would likely result in concentrations of hydrocarbons in the upper 33 ft (10 m) of the water column under the slick, that exceed acute toxicity criteria for the first few days and could exceed chronic toxicity criteria for a month or more. In time, biodegradation processes would act on the smaller fractions of oil to further reduce their surface water concentration directly (in the water column) or indirectly through increased affinity with suspended particulate matter and eventual settlement. Higher molecular weight hydrocarbons (i.e., C11-C15+) would persist for a longer period of time (in days) and water-in-oil emulsions of these constituents would slow the biodegradation process. Diminished surface water quality would be expected in the upper water column within the boundaries of the oil slick as it moves away from the wellhead on a trajectory influenced by wind and currents.

In the VLOS assessment in BOEM's Chukchi Sea Lease Sale 193 Final Second SEIS, the agency determined that a VLOS would have a significant impact that would consist of sustained degradation of water quality from hydrocarbon contamination in exceedance of State and Federal water and sediment quality criteria (BOEM 2015) BOEM added that additional effects on water quality would occur from response efforts, including response and cleanup vessels, possible in-situ burning and/or use of dispersants, discharges and seafloor disturbance from relief well drilling, and activities on shorelines associated with cleanup, booming, beach cleaning, and monitoring (BOEM 2015).

In the EA for EP Revision 1, BOEM determined that the analysis in the Lease Sale 193 FSEIS remained sufficient to analyze the effects of very large spills in the Chukchi Sea (BOEM 2011a). The agency determined that potential effects to water quality from a VLOS would lead to sustained degradation of water quality, violations of state and federal criteria, and significant effects (BOEM 2011a).

Based on the site-specific information and BOEM's prior NEPA analyses, Shell anticipates that there would also be sustained degradation of water quality, violations of state and federal criteria, and significant effects on the water quality of the Chukchi Sea.

Potential Impacts of the VLOS on Sediment Quality

An assessment of sediment quality in the region is provided in Section 3.3. Sediment quality in the Chukchi Sea is considered good. Concentrations of hydrocarbons in the Burger Prospect area have been shown to be well within the range of non-toxic background concentrations reported in other studies of Alaskan and Arctic coastal and shelf sediments.

<u>Offshore Sediment Quality</u>

Seafloor sediments in the Burger Prospect consist largely of sandy mud with lesser amounts of gravel. In this type of offshore sediment, the assumed subsea blowout would re-suspend and disperse large quantities of sediments within a relatively large radius of the blowout site. Initial settlement of re-suspended sediment could result in burial of both infaunal (living in the sediment) and epifaunal (living on sediment) organisms, and interfere with sessile invertebrates that rely on filter-feeding organs.

Some of the oil released into the water column would attach to suspended sediment and settle out quickly in the vicinity of the wellhead. Sediment quality surrounding the wellhead is likely to be diminished temporarily until natural degradation reduces the concentration of petroleum hydrocarbons in the sediment. However, in the short term sediment quality and toxicity, as these relate to organism exposure, are likely to be of less concern than the risk of sediment burial by settling oil/sediment mixtures. Over the long term, concentrations of petroleum hydrocarbons are expected to readily degrade by sediment microbial activity.

Oil from the VLOS would reach the seafloor under the slick by several mechanisms. Oil droplets dispersed into the water column would adsorb to suspended particulate water that occurs naturally, and subsequently be deposited on the seafloor as the particulate matter sinks. This would likely represent a very small fraction of the oil in the VLOS given the water depths at the drill site and surrounding areas, and the low sediment loads and sedimentation rates reported for the Chukchi Sea. Oil may also be uptaken by zooplankton with subsequent incorporation with their fecal pellets, which then fall to the seafloor. Oil has fairly consistently been found in the gut and fecal pellets of zooplankton in the areas impacted by very large oil spills (Conover 1971; Johansson 1980; Teal and Howarth 1984). Oil can also reach the seafloor if the slick reaches shallow coastal waters where it is mixed with sediments by wave action, and subsequently transported offshore via density currents (Teal and Howarth 1984). Resulting contamination would be expected to be very low; often the hydrocarbons are detectable only in the benthic organisms, not in the sediments (Teal and Howarth 1984). However, perhaps as much as 5.0 percent of the oil could reach the benthic environment over a very large area (Teal and Howarth 1984).

Nearshore and Onshore Sediment Quality

The trajectory analysis indicates there is a 37 percent chance that the slick from the VLOS would reach the coastline and adjacent nearshore waters (ERA 0 – Land) within 30 days (Table 6.2-2). Although exposed rocky shores are present, sand gravel beaches are the most common onshore habitats along the Arctic Alaskan coast bordering the Chukchi Sea (Taylor 1981). In these "high-energy" environments, the substrates are typically unstable, porous, and subject to intense wave action from extreme tides and storms. If the slick were to reach gravel beach habitats oil could easily become buried or sequestered, making treatment or removal difficult. Early response and cleanup of oil that makes landfall on these types of beaches would be critical to the long term sediment quality of habitats along the shoreline. However, there is relatively little risk of exposure to organisms in this type of environment when compared to others (EPA 1999b).

If not adequately addressed at landfall, oil could remobilize and transport elsewhere as beaches undergo normal processes of seasonal gain and loss of unconsolidated sediment. Sheltered rocky shorelines and scarps are examples of other shoreline types in Alaska where oil could collect upon landfall or if remobilized. BOEM (BOEMRE 2010) concluded that the fate of oil in this type of environment that is not readily contained could persist through the processes of sequestration, remobilization, and transport for tens of years.

In Alaska, major rivers that flow into the Chukchi Sea are the Kivalina, the Kobuk, the Kokolik, the Kukpowruk, the Kukpuk, the Noatak, the Utukok, the Pitmegea, and the Wulik. In the event of a catastrophic spill, tidal exchange between these and other river systems flowing into the Chukchi Sea could transport oil into lower-energy environments, such as sheltered tidal flats and salt- and brackish-water marsh systems. Both systems provide heavily vegetated habitats with plentiful food and cover for many species of birds, mammals, fish, and invertebrates, in addition to serving as nursery areas for sensitive life history stages. Typically these inland systems have slower water movement, longer water exchange rates, and sediments dominated by mixtures of silt and sand. Thus, oil settling in sediments of these sensitive habitats could result in much higher impacts to aquatic life than in other higher energy onshore and offshore habitats. If impacted by oil, sediments within marshes could take years to recover (EPA 1999b).

In the VLOS assessment in BOEM's Chukchi Sea Lease Sale 193 FSEIS, the agency evaluated the impacts on sediments in conjunction with those on water quality (BOEMRE 2011b). A very large oil spill and gas blowout would present sustained degradation of water quality from hydrocarbon contamination in exceedance of State and Federal water and sediment quality criteria.

Similarly, in the EA for EP Revision 1, BOEM did not separately address sediments (BOEM 2011a).

Based on the site-specific information and BOEM's prior NEPA analyses, Shell anticipates that the VLOS would result in minor impacts on offshore sediment quality and minor to moderate impacts on nearshore and onshore sediment quality, depending on where the oil contacts the shoreline.

6.3.3 Potential Impacts of the VLOS on Lower Trophic Organisms

Planktonic and benthic communities of the northeastern Chukchi Sea and the Burger Prospect specifically are described in detail in Section 3.4. Phytoplankton, zooplankton, and benthic organisms found in the area of the Burger Prospect are similar to the communities found over large portions of the northeastern Chukchi Sea. Few especially important or sensitive benthic resources are found in the region. Some kelp beds have been identified in the Peard Bay area, the Skull Cliffs area northeast of Peard Bay, and in an area about 16 mi (25 km) southwest of Wainwright. These resources are located more than 70 mi (113 km) from the drill site where the assumed blowout would occur.

In the EA for the EP Revision 1, BOEM determined that the effects of a 750,000 bbl VLOS on lower trophic resources would be highly dependent upon the following factors: season of year and resultant potential exposure of larval or other development stages of macroinverteraters to crude oil byproducts, weather patterns, presence and classification of ice, residence time of oil within the water column or on the benthic surface, location of spill and spatial relationship to currents that could potentially advect the oil to other regions, volume of oil reaching shore, and volume of oil in contact with benthic surfaces (BOEM 2011a).

Effects of the VLOS on Lower Trophic Organisms in the Offshore Environment

<u>Phytoplankton</u>

The generation time of phytoplankton (9-12) hr is so fast that rapid replacement of the cells from adjacent waters will prevent a major effect on the surrounding phytoplankton community even if many cells are contacted by oil in the open ocean (MMS 2003a). Additionally, the potential for contact of the phytoplankton with oil is reduced because hydrocarbons tend to float on or near the surface of the sea, whereas most phytoplankton are found lower in the water column.

In the Chukchi Sea Lease Sale 193 FSEIS, BOEMRE determined that a 2,160,000-bbl VLOS would likely have less than a one-year effect on phytoplankton populations in the Chukchi Sea due to the influx of phytoplankton carried into the Chukchi Sea by water of the Gulf of Anadyr, the Bering Sea, and the Alaska Coastal currents that would supplement remaining endemic populations (BOEMRE 2011b). The agency added that short-term, local-level effects would have greater potential to affect local food webs (BOEMRE 2011b). Severity of effects would be determined by duration of the spill, weather patterns, and the resultant distribution and geographic coverage of surface oil slicks; however, BOEM concluded that impacts to lower trophic levels were acute and significant for some species (BOEMRE 2011b).

In BOEM's EA for Shell's EP Revision 1, the agency determined that the level of effects of a 750,000 bbl VLOS on phytoplankton would likely be negligible due to rapid recovery rate effected by advection of phytoplankton populations by way of regional currents and rapid (9-12 hr) generation time of phytoplankton resources (BOEM 2011a). Similar conclusions in prior NEPA analyses were based on the lack of reported adverse effects of oil spills on phytoplankton (NRC 1985), lack of reported differences in phytoplankton biomass and productivity between areas contaminated with large oil spills (e.g., *Tsesis* spill, Johansson et al. (1980; as cited in NRC 1985), and other studies that have also demonstrated an absence of substantial effects on phytoplankton following oil spills (MMS 2003a).

Based on the site-specific information and BOEM's prior NEPA analyses, Shell anticipates that the VLOS would result in negligible impacts on phytoplankton.

<u>Zooplankton</u>

Zooplankton includes copepods, euphausiids, mysids, and amphipods as well as the planktonic egg and larval stages of fish and marine invertebrates such as those of polychaetes, mollusks, crustaceans, and echinoderms (meroplankton). The effects of petroleum-based hydrocarbons on zooplankton have been observed in the field at spill sites and have been tested in the laboratory. The ability of planktonic animals to metabolize and detoxify hydrocarbons varies widely among species as does their vulnerability to dispersed and dissolved hydrocarbons in the water column. For zooplankton, lethal hydrocarbon concentrations range from about 0.05-10 ppm; sublethal crude oil concentrations range from about 1 ppm to < 0.05 ppm (NRC 1985). Examples of sublethal effects include: lowered feeding and reproductive activity, altered metabolic rates, and community changes (MMS 2003a). Whether effects are lethal or sublethal depends on exposure time, hydrocarbon toxicity, the species, and the developmental stage involved with larvae and juveniles typically more sensitive than adults.

Field observations of zooplankton communities at oil spills have shown that the communities were adversely affected but the effects are short lived (Johansson et al. 1980, as cited in NRC 1985). Adverse effects on zooplankton organisms include direct mortality, external contamination by oil, tissue contamination by aromatic constituents, inhibition of feeding, and altered metabolic rates (MMS 2003a). However, because of their wide distribution, large numbers, short generation time, and high fecundity, zooplankton communities exposed to oil spills appear to recover (NRC 1985). Where flushing rates and water circulation are reduced, the effects of an oil spill would probably be greater and the recovery of zooplankton biomass and standing stocks will take somewhat longer (MMS 2003a).

Marine invertebrates have been shown to be more affected by polycyclic aromatic hydrocarbons while under ultraviolet radiation (Pelletier et al. 1997). This phototoxicity was more obvious with heavy oils, such as Liberty crude, than with light diesel oil. Copepods, a major component of zooplankton, show increased vulnerability to oil toxicity in the presence of ultraviolet radiation (Shirley and Duesterloh 2001). However, Gibson et al. (2000, as cited in MMS 2003a) concluded that ultraviolet radiation influences on food-web process in the Arctic Ocean are likely to be small relative to the effects caused by variation in the concentrations of natural ultraviolet radiation-absorbing compounds that enter the Arctic basin from river runoff. Pelletier et al. (1997) had also noted that ultraviolet light would not penetrate turbid coastal water.

In general, oil spill effects on zooplankton depend on the amount of sunlight, wind speed and duration, air and water temperature, and oil composition (MMS 2003a). However, using data gleaned from the weathering of Prudhoe Bay crude oil, it is expected that for oil spills in the Chukchi Sea, within 10 days of a winter spill, 10 percent of the oil would have evaporated, 57 percent would remain on the surface, and 32 percent would be dispersed into the water column. The dispersed and dissolved oil in the water column is that fraction most likely to adversely affect zooplankton, and the surface oil and evaporates should rarely contact the plankton that mostly live beneath the water's surface.

Hydrocarbon concentrations in the water column during and immediately following an oil spill are conservatively assumed to be initially harmful, exceeding 0.1 ppm, to both phyto- and zooplankton, but only for 5 days (Meyer 1990). By one week after the Exxon Valdez oil spill, concentrations of hydrocarbons in the water column were already well below the levels known to be toxic and even below levels that cause sublethal effects in plankton (MMS 2003a).

The likelihood of zooplankton populations being adversely affected by an oil spill would be greatest during the summer in the coastal band of high production. However, it would still likely affect a small portion of the zooplankton population. For example, BOEM (MMS 2003a) estimated that less than one percent of the plankton, in the Beaufort Sea OCS would experience sublethal and/or lethal effects from a very large oil spill, while a 10 percent inter-annual variability that has been observed in the populations of zooplankton prey of bowhead whales (Griffiths and Thomson 2002). Zooplankton recovery from an oil spill would be expected to take about one week in open water (MMS 2003a).

If oil were spilled under the ice and trapped directly beneath it, most epontic organisms living there would probably be killed. This trapped oil would probably become encapsulated within the ice. If oil on, in, or under the ice were released during breakup, this oil would continue to affect the plankton community.

In the FSEIS for Chukchi Sea Lease Sale 193, BOEM (BOEMRE 2011b) concluded that a 2,160,000 bbl VLOS would cause acute and for some species, significant impacts to lower trophic organisms. BOEM further stated that a VLOS would have local effects on zooplankton, lasting one year or less.

In BOEM's EA for Shell's EP Revision 1, the agency determined that effects from a 750,000 bbl VLOS on zooplankton populations would be negligible to minor based on a culmination of factors (listed above) and their potential effects on the slower reproductive biology of zooplankton populations (BOEM 2011a).

Based on the site-specific information and BOEM's prior NEPA analyses, Shell anticipates that the VLOS would result in negligible to minor impacts on zooplankton. The VLOS would not be expected to have a significant impact on lower trophic organisms at the regional population level.

Effects of the VLOS on Lower Trophic Organisms in the Nearshore Environment

Many benthic invertebrate species are food items for high food-web species, such as marine fishes, birds, and mammals. Hence, any significant effect on benthic-level organisms would also affect higher trophic levels. Benthic marine plants and animals are most affected by oil that has been incorporated into the bottom sediments through wave action (MMS 2003a). In marine environments that have distinct intertidal and subtidal floral and faunal communities, the most persistent effects occur when intertidal and shallow subtidal benthic communities are directly contacted by oil. This effect is aggravated in areas with restricted circulation, such as in embayments.

The Chukchi Sea coast is composed primarily of tundra cliffs and gravel beaches but includes a few marshes and tidal flats (Research Planning, Inc. 2002). Even in the marshes, there would not be well developed communities because of the winter ice. The persistence of oil in arctic marshes and tidal flats is discussed in the Beaufort Sea multiple-sale EIS; it concludes that oil would persist on such shorelines for more than a decade (MMS 2003a). Oil has persisted in the tidal and subtidal sediments of Prince William Sound for about one and a half decades (MMS 2004) and in the marsh sediments of New England for about three and half decades (Peacock et al. 2005).

If a large oil spill occurred offshore, the probabilities of such a spill reaching estuaries and saltmarshes along the Chukchi Sea would be very low. When spills take place in open water, the potential for a quick response is higher. *In situ* booming and skimming operations would be effective means to prevent oil spills from reaching sheltered bays where estuaries and saltmarshes typically are found. Due to the low tidal range typical in such environments, stranded oil would be subject to low rates of abrasion and dispersal by littoral processes. Oil deposition above the level of normal wave activity may occur, if the spill takes place during a storm surge. In such case, oil stranded in emergent vegetation is expected to persist for long periods due to the low rates of dispersion and degradation. Impacts would include the destruction of emergent vegetation, if slick oil sinks into the root system (Owens et al. 1983). Effects of offshore oil spills on saltmarsh vegetation and wetlands above the tideline are not assessed in this section.

The annual predominance of shorefast ice prevents marine plant life and most fauna from living along most of the Chukchi Sea shoreline, leaving macrophytes living only above the tideline or below a depth of about 6.0 ft (2.0 m). Kelp beds are found in a few locations in the northeastern Chukchi Sea. Kelp beds are known to occur in the center of Peard Bay, offshore of Skull Cliffs located 12.4 mi (20 km) northeast of Peard Bay, and in an area about 16 mi (25 km) southwest of Wainwright. Most of what is known about the effect of crude oil on marine plants and shoreline substrates has come largely from observations following oil spills (MMS 2003a). One example is the Exxon Valdez spill. Dean et al. (1996) studied the subtidal macroalgae, including the kelp *Laminaria*, population in Prince William Sound, one year after the spill. They found no differences in the total density, biomass, or percentage cover of macroalgae between oiled and control sites. In summary, the benthic plants in heavily oiled areas recovered to pre-spill conditions within three years even though oil has persisted in the shoreline sediments for more than a decade (MMS 2003a). In contrast to Prince William Sound, the Chukchi Sea does not have a traditional intertidal zone.

The amount and toxicity of oil reaching subtidal marine plants is expected to be so low as to have no measurable effect on them (MMS 2003a). The most likely type of oil that could reach these marine plants in the subtidal zone (most are in 5 to 10 m depth) would be highly dispersed oil having no measurable toxicity occurring as a result of heavy wave action and vertical mixing (MMS 2003a).

The dominant marine invertebrates in the Chukchi Sea area include gastropods, mollusks, annelids, echinoderms, and crustaceans. Crude oil can be lethal to marine invertebrates from either a short-term exposure to high hydrocarbon concentrations or a long-term exposure to lower concentrations. Laboratory studies indicate that oil concentrations ranging from 1-4 ppm can be lethal to adult and larval crab and shrimp after 96 hr of exposure (Starr et al. 1981; MMS 2003a). Large oil spills have resulted in the mortality of bivalves (Teal and Howarth 1984), an important member of the food chain as they are food items for many species of marine birds, fish, and mammals. Effects on bivalves can be immediate but declines in abundance may continue for years Thomas 1978).

Because petroleum hydrocarbons are less dense than water, it is expected that some of the spilled oil will eventually drift into shallow water where it will contact the shoreline. The benthic marine invertebrates most likely to come into contact with oil from an offshore oil spill are those that seasonally live along the affected shore. Because of the amount of time that will elapse before the oil reaches shallow water (several days), the most toxic hydrocarbon fractions should have evaporated (MMS 2003a). However, recent studies have shown that oil is extremely persistent in shoreline sediments (MMS 2004). Twelve years after the Exxon Valdez oil spill, 778 bbl of slightly-weather oil remained in the intertidal subsurface sediments (Peterson et al. 2003; Short et al. 2004). Short et al. (2004, 2006) and Ballachey et al. (2007) have demonstrated that Exxon Valdez oil has persisted on the Prince William Sound shoreline through 2003, 14 years after the spill. Peterson et al. (2003) and Ballachey et al. (2007) have also described some long-term effects on the attached intertidal organisms, such as kelp and mussels, and on the animals that consume them, such as fish and birds. Their studies indicate that the oil that becomes buried in shoreline sediments remains toxic (MMS 2004). Kelp beds are known to occur in at least three locations along the northeastern Chukchi Sea coast. The probability of oil from the VLOS reaching these locales is relatively low (about 1.0 percent).

The predominance of shorefast ice along the shoreline excludes all but seasonal shoreline invertebrate fauna down to a water depth of about 6 ft (2 m). In the absence of attached intertidal organisms, the trophic effects seen Prince William Sound are not expected to occur. Subtidal organisms living deeper than about 6.0 ft (2.0 m) would not be expected to come into contact with the surface oil, and the highly dispersed oil that they may come into contact with is expected to have no measurable toxicity as a result of heavy wave action and vertical mixing (MMS 2003a).

In the FSEIS for Chukchi Sea Lease Sale 193, BOEM (BOEMRE 2011b) concluded that a 2,160,000 bbl VLOS would cause acute and for some species, significant impacts to lower trophic organisms. BOEM further stated that a VLOS could have local effects lasting one or more years on invertebrates.

In BOEM’s EA for Shell’s EP Revision 1, the agency determined that effects from a 750,000 bbl VLOS on benthic populations would be minor to moderate based on a culmination of factors (listed above) (BOEM 2011a).

Based on the site-specific information and BOEM’s prior NEPA analyses, Shell anticipates that the VLOS would result in minor to moderate impacts on benthic invertebrates. The VLOS would likely not have a significant impact on regional population levels.

6.3.4 Potential Impacts of the VLOS on Fish and Essential Fish Habitat

Fish resources of the northeastern Chukchi Sea and the Burger Prospect specifically, are described in Section 3.5. Fish of greatest importance due to their predominance in terms of numbers or prominence on the food chain include Arctic cod, saffron cod, sculpin, capelin, and herring.

Effects of the VLOS on Fish in the Offshore Environment

Petroleum is toxic to fish (Dubansky et al. 2013; Incardona et al. 2014; de Soysa et al. 2012). Most fish demonstrate acute toxicity to oil in the range of 1-10 ppm; however, some studies have demonstrated oil induced, sub-lethal effects at concentrations as low as 0.245-0.265 ppm, including reduced growth, feeding efficiency, and larval swimming speed. Lasting effects were not observed after exposure to concentrations of 0.600 ppm or less. However, larvae exposed to concentrations of 4.1 ppm or more did not recover feeding ability within 24 hr after placement in clean water.

Chronic exposures of fish to crude oil at 0.50-0.10 ppm for 12 or 13 weeks have induced dramatic histological modifications of the bronchial tissue that would severely affect respiration, osmoregulation, and resistance to disease. Impacts caused by petroleum spills are due primarily to the more soluble, lower molecular-weight aromatic and aliphatic components. However mean concentrations in water depths 3 to 10 m (10 to 33 ft) below oil slicks have been shown to be on the order of 1-15 ppb. Furthermore, the maximum concentrations reported under the oil slicks were less than 2,000 ppb (McAuliffe 1987).

Fish assimilate (and void) hydrocarbons primarily through the gills when exposed to the water soluble fraction but may also take on hydrocarbon burdens by feeding on oil particles or oil-contaminated prey. Teal and Howarth (1984) reviewed and summarized observed impacts on shellfish and finfish as a result of the large spills associated with the *Florida*, *Arrow*, *Argo Merchant*, Bravo, *Tsesis*, *Amoco Cadiz*, and Ixtoc I offshore oil spills (Table 6.3.4-1).

Table 6.3.4-1 Observed Effects of Large Oil Spills on Fish

Effect	***Florida***	***Arrow***	***Argo Merchant***	***Bravo***	***Tsesis***	***Cadiz***	**Ixtoc I**
Egg/larvae death	0	0	+	0	+	0	0
Decreased spawning	0	0	0	0	+	0	0
Mortalities in adults	0	0	0	0	0	+	0
Decreased growth	0	+	0	0	0	+	0
Contaminated finfish	+	0	-	+	-	+	0
Decreased recruitment	0	0	0	0	0	+	0
Decreased catch	+	0	0	0	0	+	0

[1] Source: Adapted from Teal and Howarth 1984

[2] Key: + = observed effects, - = not observed or observed only occasionally, 0 = no pertinent observations, or data collected but interpretation ambiguous.

Observations at oil spills around the world, including the Exxon Valdez spill in Prince William Sound, consistently indicate that free-swimming fish are rarely at risk from oil spills. Fish move away from spilled oil and this behavior explains why there has never been a commercially important fish-kill on record following an oil spill (MMS 2003b).

Large numbers of fish eggs and larvae have been killed by oil spills. However, fish over-produce eggs on an enormous scale and the majority of them die at an early stage as food for predators. Even a high death toll from an oil spill has no detectable effects on adult populations that are exploited by commercial fisheries. This has been confirmed during and after the Torrey Canyon spill off England and the Argo Merchant spill off Nantucket. In both cases a 90 percent death rate of fish eggs and larvae for pilchard and pollock respectively was observed in the affected area but was found to have no impact on regional commercial fisheries (Baker et al. 1991).

Seasons of low and high susceptibility to impacts can be defined for any species. Oil spill impact levels are most affected by the timing and location of the spill. These two factors, along with winds and currents, which modify spill location, seem to determine whether or not any impact occurs. Spills of significant volumes of petroleum during the spawning season could result in significant mortality to fish eggs and larvae. However, such impacts are generally not great in regards to the total fish population as fish produce large numbers of eggs and larvae over broad areas of the water body.

Prediction of the effects of offshore oil spills on fisheries is subjective at best. The magnitude is determined by the exact combination of biological, physical, and chemical factors at the time of the spill. Adult finfish tend to avoid contaminated areas, however this behavior is not universal. Oil spills that occur in offshore waters can be expected to contact some fish eggs and larvae at any season; however the number of eggs and larvae will vary with the season. Oil spill impacts are more severe for early life stages because the toxicity threshold is lower and because eggs and larvae are unable to avoid oiled waters. The significance of the impact is not generally great because petroleum concentrations in the water below the slick are usually less than the reported toxic concentrations.

No special spawning areas are noted in the vicinity of the Burger Prospect. Many of the most abundant marine fish species in the northeastern Chukchi Sea, including the Arctic cod, which typically represents over 90 percent of the fish captured during fish studies in the Chukchi Sea, spawn under the ice during the winter and diadromous fish spawn in freshwater or brackish water near the shoreline. Therefore little or no effect on eggs of these species would be expected.

Effects of the VLOS on Fish in the Nearshore Environment

Important fish species in the nearshore environment include capelin, herring, pink salmon, chum salmon, and Dolly Varden. Seven streams along the northeastern Chukchi Sea coast have been documented as having small runs of anadromous fish, including pink salmon, chum salmon, coho salmon, and Dolly Varden (Johnson and Daigneault 2008). Effects of oil on these species while in the marine environment would be similar to that described above for other fish species. Oil reaching the spawning areas in the rivers would have greater effect, with lethal and sublethal effects on fish spawning in coastal areas and river mouths, such as capelin, herring, and pink salmon.

Important areas for fish along the northeastern Chukchi Sea coastline include Kasegaluk Lagoon, Peard Bay, and the mouths of streams with anadromous populations. Summer conditional probabilities for oil contact with these areas are indicated in Table 6.3.4-2. The trajectory analyses indicate a probability of <25 percent of the VLOS contacting Peard Bay and <5 percent probability of the VLOS contacting the mouths of anadromous streams within 60 days. Barrier islands prevent oil from reaching Kasegaluk Lagoon except at certain passes. Because the conditional probability of contact is low at 3 days and 10 days, there is sufficient time to mobilize OSR to provide additional protection at these locations before oil reaches the passes.

Table 6.3.4-2 Probabilities of a large spill (3, 10, and 30 days) and VLOS (60 and 360 days) from LA 11 Contacting Certain Areas Important to Fish

ID [3]	*Resource* [3]	Summer Conditional Probability (%) from LA 11 [1,2]				
		3 days	10 days	30 days	60 days	360 days
ERA 102	Opilio Crab EFH	-	1	3	3	3
ERA 103	Saffron Cod EFH	13	33	47	48	49
ERA 104	Kotzebue Sound	-	-	-	-	-
ERA 140	Noatak River	-	-	-	-	-
ERA 141	Cape Krusenstern	-	-	-	-	-
ERA 142	Wulik and Kivalina Rivers	-	-	-	-	-
ERA 151	Kuk River	-	-	-	-	-
LS 40	Mint River	-	-	-	-	-
LS 41	Pinguk River	-	-	-	-	-
LS 42	Upkuarok Creek, Nuluk River, Kugrupaga River, Trout Creek	-	-	-	-	-
LS 43	Shishmaref Airport	-	-	-	-	-
LS 44	Shishmaref Inlet Arctic River, Sanaguich River, Serpentine River	-	-	-	-	-
LS 47	Kitluk River	-	-	-	-	-
LS 49	Kougachuk Creek	-	-	-	-	-
LS 51	Inmachuk River, Kugruk River	-	-	-	-	-
LS 53	Kiwalik River, Buckland River	-	-	-	-	-
LS 54	Baldwin Penn Kobuk River & Channels	-	-	-	-	-
LS 55	Hotham Inlet Ogriveg River	-	-	-	-	-
LS 56	Noatak River	-	-	-	-	-
LS 57	Aukulak Lagoon	-	-	-	-	-
LS 58	Tasaychek Lagoon	-	-	-	-	-
LS 59	Kiligmak Inlet Jade Creek, Rabbit Creek, Imik Lagoon, New Heart Creek, Omikviorok River	-	-	-	-	-
LS 60	Imikruk Lagoon Wulik River, Kivalina River	-	-	-	-	-
LS 64	Kukpuk River	-	-	-	-	-
LS 67	Cape Sabine, Pitmegea River	-	-	-	-	-
LS 70	Kuchaurak and Kuchiak Creek	-	-	-	1	-
LS 72	Point Lay, Siksrikpak Point	-	-	-	-	-
LS 74	Kasegaluk Lagoon, Solivik Isl.	-	-	1	1	1
LS 80	Eluksingiak Point, Kugrua Bay	-	2	3	3	3

[1] Conditional probabilities of <0.5 % indicated by " – "
[2] Source BOEM 2015

Conclusions Regarding Effects of the VLOS on Fish

The VLOS would have the most effect on early life stages of fish and fish in nearshore waters if reached by oil from the VLOS. Offshore, the VLOS would result in destruction of fish larvae and eggs, but would have little effect on regional fish populations.

BOEM (MMS 1990) concluded that the impact of a 160,000 bbl spill from a hypothetical pipeline spill on fish would be very low. The agency also stated that the greatest effect on fish would occur if the oil reached Peard Bay or the Wainwright area. Trajectory analyses indicate a one percent chance of oil reaching Peard Bay and two percent chance of reaching landfall near Wainwright. BOEMRE also concluded in its assessment of a 180,000 bbl VLOS from a hypothetical nearshore blowout in the Beaufort Sea that little mortality would occur offshore, and in nearshore waters the effects would be mostly sublethal consisting of changes in growth, feeding, fecundity, and temporary displacement. Some fish in the immediate area of the spill would occur but measureable effects on fish populations would not be expected.

In the VLOS analysis in the FSEIS for Chukchi Sea Lease Sale 193 (BOEMRE 2011b), BOEM identified direct and indirect effects to fish (which could become significant depending on the timing and trajectory of the spill) as well as significant impacts to some species or life stages of a species (greater than 3 generations to return) at a population level (BOEMRE 2011b). BOEM's trajectory analyses, which relied on an OSRA model, determined that the level of effects associated with a 2,160,000-bbl VLOS would depend on a number of factors, including the following: the life stage affected (egg, larvae, juvenile, adult); species distribution and abundance (widespread, rare); habitat dependence (ocean water column, sea surface, benthos, sea ice, estuarine, freshwater); life history (anadromous, migratory, reproductive behaviors and cycle, longevity, etc.); extent and location of spawning areas in the estuarine or riverine systems species exposure and sensitivity to oil and gas (toxicology, swimming ability); effect on prey species; location of the oil spill (nearshore, further offshore); depth at which the hydrocarbon release occurs (seafloor, mid-column or surface); ratio of the mixture of oil and gas released; and the time of year the oil spill occurs (BOEMRE 2011b). BOEM concluded that the 2,160,000 bbl VLOS could result in significant effects on fish depending on these variables, and was likely to have significant impacts on essential fish habitat for Arctic cod, saffron cod, and all five species of Pacific salmon (BOEMRE 2011b).

In the EA for EP Revision 1, BOEM determined that the analysis from the Chukchi Sea Lease Sale 193 FSEIS was sufficient to analyze the effects of a 750,000-bbl VLOS in the Chukchi Sea (BOEM 2011a). BOEM concluded that a VLOS could result in significant impacts on fish, including population-level effects, depending on the timing and trajectory of the spill (BOEM 2011a). BOEM also concluded that a VLOS was likely to have significant impacts on essential fish habitat for Arctic cod, saffron cod, and all five species of Pacific salmon (BOEM 2011a).

Shell's the trajectory analyses indicate a low probability of oil from Shell's hypothetical VLOS contacting areas important to fish. The hypothetical VLOS would result in mortality of fish eggs and larvae offshore, but is unlikely to affect important spawning habitats in the nearshore. Based on this site-specific information and BOEM's prior NEPA analyses, Shell anticipates that the impacts from the VLOS on fish and essential fish habitat for pink and chum salmon, Arctic cod, saffron cod, sand lance, capelin, nearshore sculpin species, nearshore flounders and plaice, migratory least cisco, migratory Dolly Varden, migratory Arctic char, rainbow smelt, stickleback, and migratory whitefish could be significant if the VLOS contacted areas important to fish, and that impacts to other species and essential fish habitat could be significant depending on timing and the exact trajectory of the VLOS. Additionally, herring, coho, sockeye and king salmon, snailfish, eelblennis, eelpouts, poachers, offshore sculpin, lamprey, and alligatorfish may be affected by a VLOS.

6.3.5 Potential Impacts of the VLOS on Birds

BOEM provided detailed analyses of the effects of a large oil spill on birds in the Chukchi Sea in its EIS, FSEIS, and Final Second SEIS for Chukchi Sea Lease Sale 193 (MMS 2007b, BOEMRE 2011b, BOEM 2015), and analyses of the effects of a very large spill on birds in the Beaufort Sea for Oil and Gas Lease sales 186, 195, and 202 (MMS 2003a). The following summarizes effects of oil spills on birds as found in these documents, with the addition of site-specific information.

Crude oil can potentially affect birds by direct contact with consequent covering of the skin or feathers, inhalation of vapors, ingestion of oil or contaminated prey, consequent reductions in food sources, and by displacement from important feeding or molting areas.

Direct contact with an oil spill is often fatal to birds as their feathers become fouled and matted, with a consequent loss in water repellency, thermal insulation, buoyancy, and ability to fly or forage (Fry and Lowenstine 1985). Effects range from sublethal to lethal. Preening of the oiled feathers often results in significant feather loss that accelerates the loss of body heat. Metabolic rates are increased in an effort to thermoregulate, and oiled birds usually reduce their food intake, resulting in "accelerated starvation." Ingestion or inhalation of oil usually accompanies the preening efforts and can result in secondary toxicological effects. Sublethal effects can lead to such things as immune-suppression, with a consequent increase in susceptibility to disease.

Toxicological effects can result from the ingestion of oil directly, through preening, or through the ingestion of contaminated prey. The effects vary with the type of oil, the amount of oil, and the age and species of bird. Toxicity can be acute with rapid development of physiological abnormalities and organ or tissue damage, or it can produce long-term effects in exposed adults, chicks exposed to oil or contaminated food, or chicks hatched from eggs which were exposed (Fry et al. 1985). Mortality and developmental effects have been observed in avian embryos associated with very small quantities of oil. Birds contaminated with oil during the nesting period typically exhibit decreases in egg production, fertility, and egg hatchability. Exposed chicks often show reduced survival and growth rates. Chick mortality due to nest abandonment by oil-contaminated adults has also been demonstrated. Oil ingestion frequently results in ulceration and hemorrhage of the gastrointestinal tract, and inhibition of digestive and absorptive capabilities.

Oiling can also result in irritation of mucosal tissues leading to ulceration of the cornea and moist surfaces of the mouth. Aspiration pneumonia often occurs when birds inhale oil droplets during preening, and severe and fatal kidney damage has been documented. Toxic destruction of red blood cells with subsequent anemia, and a lowering of immune system function may also result.

The extent to which the oil affects an individual bird differs according to the species, the life stage of the bird, the type of oil involved, the length of time between oil release and contact with the bird, and the length of time of contact with the oil. Direct oiling of true seabirds is often minor; many of these birds are often merely stained due to their foraging behaviors (Vermeer and Vermeer 1975), however it is the primary way that oil could cause avian mortality. In the Second Final SEIS, BOEM identifies key areas of nesting, molting or migration habitat in which marine and coastal birds would be particularly vulnerable to petroleum exposure and habitat loss under the VLOS scenario (BOEM 2015).

Bird species which spend a great deal of time swimming on the water surface and those which congregate into large flocks are considered to be the most vulnerable. The magnitude of bird mortality and other population effects following an oil spill vary with the size of the local bird population at the time of the spill, foraging behavior of the species involved, and the level of aggregation at the time of the spill, rather than the quantity of oil spilled and its persistence in the environment (Burger 1993). For more information on birds with the potential for substantial effects from a VLOS, see BOEM's Final Second SEIS (BOEM 2015).

Effects of the VLOS on Birds in the Offshore Environment

Marine birds are found in relatively low densities in offshore waters of the northeastern Chukchi Sea. Divoky (1987) reported average densities of 23-71 birds/mi^2 (9-28 birds/km^2) and maximum densities of 615-2,255 birds/mi^2 (238-870 birds/km^2). Baseline studies conducted in the Burger Prospect resulted in estimated average densities of 46-119 birds / mi^2 (2-46 birds/km^2) (Gall and Day 2009, 2010). The most abundant species observed during the studies were crested auklet, least auklet, thick-billed murre, glaucous gull, blacklegged kittiwake, short-tailed shearwater, northern fulmar, and Pacific loon. Bird species such as alcids (auklets, murres, puffins), waterfowl (eiders, long-tailed ducks) and loons that spend more time on the water surface and are concentrated in dense flocks have greater vulnerability to such impacts. Others like the larids (gulls, kittiwakes) and tubenoses (shearwaters and fulmars) may be less affected. A 9,000-ac (36.4 km^2) oil slick could potentially oil hundreds to about 2,000 birds, most of which would be the above-referenced species, depending on the interaction of timing and location. We assume that most of the oiled birds would die. ERA 18 (an offshore bird foraging area) has a conditional probability of oil contact of 10 percent. All other offshore ERAs identified as important for birds have a probability of less than one percent, or are important for birds during a time period in which the VLOS would not be extant (e.g. ERA 22 Chukchi Sea Spring Lead 4 in April-June).

Effects of the VLOS on Birds in the Nearshore Environment

The effect of an oil spill from a blowout on birds would depend on if, where, and when it contacts nearshore waters and the shoreline. Bird density in total, and for most species, is greater in nearshore waters. Common eiders, king eiders, long-tailed ducks, and Pacific and red-throated loons are more abundant in these nearshore waters. Important coastal avian habitats along the northeastern Chukchi Sea coast include Peard Bay where large numbers of shorebirds stage, Kasegaluk Lagoon and Ledyard Bay where large numbers of waterfowl and other waterbirds stage and molt, and Cape Lisburne where there are large seabird nesting colonies. Trajectory analyses (Table 6.2-2) indicate a relatively low probability (<5 percent) of contact with Peard Bay and the Cape Lisburne/Cape Thompson area, and a similar probability of contact with Kasegaluk Lagoon (4 percent). A greater probability of contact would be expected at the LBCHU (13 percent) within 30 days. Kasegaluk Lagoon supports relatively rich and diverse bird populations dominated by black brant, long-tailed ducks, glaucous gulls, arctic terns, and shorebirds (Johnson et al. 1993). About 15-49 percent of the total Pacific Flyway population of black brant was observed there in 1989-1991 (Johnson et al. 1993). Waterfowl such as Pacific and red-throated loons, white-fronted goose, long-tailed duck, surf scoter, common eider, and northern pintail would be the most vulnerable and greatly affected species if oil reached this area. Shorebirds are abundant at this locale but are considered to be much less vulnerable to oil spills than many other species (Vermeer and Vermeer 1975).

Effects of the VLOS on Threatened and Endangered Birds

The Steller’s eider and the spectacled eider are both listed as threatened species and are found in and along the northeastern Chukchi Sea. Spectacled eiders are found in offshore waters of the Chukchi Sea and have been documented in very low densities in the Burger Prospect area (Gall and Day 2009, 2010). Small numbers of these species could be affected by a spill in offshore waters. The spectacled eider and Steller’s eider are more common in nearshore waters but still found in low densities.

The LBCHU was established as a unit of critical habitat for the spectacled eider. Most of the female spectacled eiders nesting on the North Slope and about half the males as well as others molt in Ledyard Bay where they are found in large groups. They are flightless for a period of several weeks making them vulnerable to oil spills. A 1995 survey recorded the presence of over 33,000 spectacled eiders in the area. If the oil reached this area during the peak of molting, a relevant portion of the North Slope breeding population of spectacled eiders could be oiled. BOEM trajectory analyses indicate there is a 9 percent chance that oil released from a VLOS in the Burger Prospect area would reach the LBCHU during summer within 60 and 360 day periods (BOEM 2015).

Conclusions Regarding Effects of the VLOS on Birds

The assumed oil spill would have the greatest effect on alcids such as the crested auklet and thick-billed murre in offshore waters, with possible loss of hundreds to thousands of birds. In nearshore waters, where bird density is greater, higher numbers of birds would be affected, with gulls, terns, loons, and sea ducks and other waterfowl being the most affected. Effects would be greatest if quantities of oil reached Kasegaluk Lagoon, however the lagoon is largely protected by barrier islands with few ingress locations for the oil. The long-term effects of oil spill mortality to these species are uncertain. Mortalities to species that have large populations and would experience losses of a few to a few hundred individuals would be difficult to distinguish at a population level.

In their evaluation of the effects of a 180,000 bbl VLOS from a hypothetical blowout in the Beaufort Sea, BOEM (MMS 2003a) concluded that it is reasonable to consider that long-term regional population-level effects would occur should several thousand sea ducks perish as a result of an oil spill. The recovery period is difficult to determine because of the uncertainty associated with the current health of the population of long-tailed ducks and eiders, but recruitment of new individuals is expected to be low and intensified by generally low productivity. Populations of species such as long-tailed ducks and common and king eiders, which are thought to be currently declining, may require several generations to recover if at all (MMS 2003a).

In the Chukchi Sea Lease Sale 193 Final Second SEIS, BOEM determined that a VLOS has the potential for population level effects on birds. In particular, a VLOS has the potential to affect a large numbers of birds due to its toxicity to individuals and their prey and the amount of time these birds spend on the surface of marine and coastal waters (BOEM 2015). As a result, in the FSEIS, BOEM concluded that were a VLOS to occur during periods of peak use, it could affect large numbers of marine and coastal birds and the mortality from a hypothetical VLOS could result in population-level effects for most marine and coastal bird species that would take more than three generations to recover (BOEM 2015). BOEM noted that birds that congregate in potentially affected areas are most susceptible to significant impacts from a 2,160,000-bbl spill. USFWS (2012) concluded in their updated BO for Lease Sale 193 that it is unlikely that (i) exploration / development would occur in the Lease Sale 193 Area, (ii) an oil spill would occur, and (iii) the spill would occur in a location and time where it would reach large numbers of eiders. USFWS concluded that the lease sale would not jeopardize the continued use of the species.

In the EA for EP Revision 1, BOEM determined that the prior analyses remained sufficient to analyze the effects of a hypothetical VLOS in the Chukchi Sea at Shell’s Burger prospect (BOEM 2011a). BOEM concluded that a VLOS could result in significant impacts on marine and coastal birds, particularly where spilled oil reached important habitat areas (BOEM 2011a).

The greatest potential impact would occur if the oil spill reached the large bird colonies in the Cape Lisburne or Cape Thompson areas, or portions of the LBCHU, as a large portion of the North Slope breeding population of the threatened spectacled eider would likely be there at that time. The trajectory analyses indicate a very small probability (1-4 percent) of reaching the bird colonies within 30 days, but a 13 percent chance that it could reach the LBCHU within 30 days. Based on this site-specific information and BOEM’s prior NEPA analyses, Shell anticipates that the impacts from the VLOS on marine and coastal birds could be significant were spilled oil to reach important habitat areas during peak usage times.

6.3.6 Potential Impacts of the VLOS on Marine Mammals

The literature on the effects of oil spills on marine mammals in arctic and subarctic areas has been reviewed and synthesized by Geraci and St. Aubin (1982, 1985, 1990), Richardson et al. (1989), and others. Assessments of the likely impact of an oil spill on marine mammals in the Alaskan Arctic, including the Chukchi Sea and the Beaufort Sea have been conducted by BOEMRE, USFWS, NMFS, and others. BOEMRE provided a detailed analyses of the effects of a large oil spill on marine mammals in the Chukchi Sea in their EIS, FSEIS, and Final Second SEIS for Chukchi Sea Lease Sale 193 (MMS 2007b; BOEMRE 2011b; BOEM 2015) and in analyses of the effects of a very large spill on marine mammals in the Beaufort Sea for Oil and Gas Lease sales 186, 195, and 202 (MMS 2003a). In the EA for EP Revision 1, BOEM determined that prior analyses remain sufficient to analyze the effects of a VLOS in the Chukchi Sea at Shell’s Burger prospect (BOEM 2011a). Shell incorporates the conclusions from prior analyses in this document.

The following section summarizes information presented in the reviews and assessments referenced above and provides a site specific assessment of potential effects of the assumed crude oil spill on marine mammals. Marine mammals found in the northeastern Chukchi Sea include the pinnipeds, ringed seal, bearded seal, spotted seal, and walrus; the cetaceans beluga whale, killer whale, harbor porpoise, bowhead whale, gray whale, fin whale, minke whale, and humpback whale; and the polar bear. Killer whales, fin whales, and humpback whales are extralimital in this area and would be found in such low numbers, if at all, that any impacts would be minor and little species-specific analysis is warranted. Impacts can be categorized into thermoregulatory effects due to contact; toxicological effects due to contact, ingestion, or inhalation; and effects due to changes in food availability. These impact categories are discussed below.

Thermoregulatory Effects

Contact with oil has been found to negatively impact the ability of some animals to thermoregulate by matting and wetting the hair with a consequent loss of insulation. However, marine mammals found in the Lease Sale 193 Area, including whales, seals, and walruses, use a thick layer of blubber as insulation rather than hair or fur. It has been shown that contact with oil would have little or no effect on species that use a blubber layer for insulation (Kooyman et al. 1976; Geraci and Smith 1976). Within two to four weeks of birth, oiling of the fur can be detrimental to newborn seal pups as the pups use special thick fur called "lanugo" to keep them warm until they can build up enough blubber. Oiling of fur in this case could cause heat loss and hypothermia (St. Aubin 1988). However, the assumed crude oil release would occur in August long after pups are born and have shed their lanugo coat.

Toxicological Effects – Contact, Ingestion, and Inhalation

The epidermis of whales has been found to be largely impenetrable by oil (Geraci and St. Aubin 1985) but eyes and mucous membranes could be affected when contact with oil is made. Oil can also affect seal and walrus membranes that are not covered by fur. In a study by Geraci and Smith (1976), seals immersed in oil-covered water exhibited irritation of the eyes, swollen noses, ulcers, and scratches on the cornea. Another study by the same scientists found no tissue damage to ringed seals after being immersed in oil-covered water for 24 hr (Geraci and Smith 1976).

Aromatics and other toxic molecules from oil that are ingested can enter the bloodstream via the intestinal wall and be transferred to major body organs. St. Aubin (1988) found that high levels of toxins would be needed before detrimental effects would be seen. He concluded that ingestion of 0.26 gal (1.0 liter) of crude oil by a seal that was 110 lb (50 kg) would be required in order to see these effects. Ingestion of oil over time has the potential to cause long-term effects on phocids (St. Aubin 1988). Crude oil residues can be stored in lipids inside the body, but there has been no evidence of resulting metabolic or physiologic effects. Because walruses are benthic feeders, it is unlikely that they would feed on prey contaminated by oil. Therefore, ingestion of oil is highly unlikely by walruses. Baleen whale prey could also carry contaminants that could be ingested by whales (Wursig 1990). However, Caldwell and Caldwell (1982) fed small amounts of hydraulic oil to dolphins for three months, and found no detectable effects in the dolphins. These studies indicate that, if ingestion of oily material occurred, effects on whales, seals and walruses would likely be minimal. Ingestion of oil by marine mammals is unlikely and not expected because of the low probability of a large liquid hydrocarbon spill.

The respiratory system of marine mammals in the area, if any, could be compromised by the inhalation of vapors from a large liquid hydrocarbon spill. Other effects of vapor inhalation could potentially include neurological disorders and liver damage (Geraci 1990). Toxins could affect seals, walruses or whales if they inhaled from vapors rising from the oil directly after the spill occurs.

Effects of the VLOS on Marine Mammals in the Offshore Environment

Marine mammals are found in relatively low densities in offshore waters of the northeastern Chukchi Sea (Table 6.3.6-2). Given the low number of past observations of killer whales, harbor porpoises, minke whales, and ribbon seals in the area, it is unlikely that oil would contact individuals of these species, but oil could possibly contact very small numbers. Beluga whales, gray whale, ringed seals, bearded seals, spotted seals, and walruses are considered common; however, based on densities of marine mammals (Table 6.3.6-2) in the northeastern Chukchi Sea calculated from agency and industrial surveys, relatively few of these marine mammals would be contacted by a 9,000-ac (36.4-km^2) oil slick. Most of the contacted animals would be ringed seals, the most abundant marine mammal in the region. Greater numbers of marine mammals such as walruses could be contacted if the slick approached areas of pack ice where walruses congregate.

Walruses enter the Chukchi Sea in the spring time when the sea ice retreats, and return to the Bering Sea in late fall when the Chukchi Sea freezes. A VLOS could contact offshore or onshore areas where walruses may be present. The degree of contact with oil would depend upon the location, timing, and magnitude of the spill. Areas where walruses are largely concentrated at some times of the year and therefore more vulnerable include the HSWUA, and Hanna Shoal as defined by NMFS (2013b). Oil spill response activities will include containing the release and spread of oil, recovering oil as quickly as is safely possible, and keeping oil away from areas identified as important habitats using boom or other resources. Areas identified in spill-response documents and on maps as important habitat for walruses include haulout areas near Point Lay and Cape Lisburne, and the HSWUA (ADEC 2012). BOEM (BOEMRE 2011b; BOEM 2015) identified 21 ERAs, LSs, and GLSs identified as important for walruses located in and along the Chukchi Sea during the time period the VLOS would exist in the water. The conditional probabilities for oil contact at these locations are presented in Table 6.3.6-1.

Table 6.3.6-1 Probabilities of a large spill (3, 10, and 30 days) and VLOS (60 and 360 days) Contacting Certain Areas Important to Walruses

ID [3]	Resource [3]	Summer Conditional Probability (%) from LA 11 [1]				
		3 days	**10 days**	**30 days**	**60 days**	**360 days**
ERA 11	Wrangel Island 12 n mi & Offshore	-	-	3	5	6
ERA 15	Cape Lisburne Seabird Colony Area	-	2	4	4	4
ERA 47	Hanna Shoal Walrus Use Area	27	37	46	47	48
ERA 50	Pt. Lay Walrus Offshore	12	18	21	21	21
ERA 51	Pt. Lay Walrus Nearshore	1	3	5	5	5
ERA 52	Russian Coast Offshore Tagging data	-	2	10	10	11
ERA 58	Russian Coast Nearshore Tagging Data	-	-	3	3	4
ERA 59	Ostrov Kolyuchin	-	-	1	1	1
ERA 66	Herald Island	-	-	1	2	2
LS 28	Ostrov Karkarpko, Mys Vankarem	-	-	1	1	1
LS 29	Mys Onmyn	-	-	1	1	1
LS 38	Mys Unikin	-	-	-	-	-
LS 39	Mys Dezhnev, Mys Peek, Cape Peek	-	-	-	-	-
GLS 133	Mys Blossom	-	-	1	2	3
GLS 134	Bukhta Somnitel’naya	-	-	-	-	-
GLS 136	Ostrov Idlidlya	-	-	1	1	1
GLS 137	Mys Serditse Kamen	-	-	1	1	1
GLS 138	Chukotka Coast Haulout	-	-	1	1	1
GLS 145	Cape Lisburne	-	-	1	1	1
GLS 147	Pt. Lay Haulout	-	1	2	2	2
GLS 174	Russia Chukchi Coast Marine Mammals	-	-	10	12	14

Table 6.3.6-2 Average and Maximum Marine Mammal Densities (S = Summer Densities; F = Fall Densities) and the possible individual marine mammal contacted in the event of a VLOS in the Northeastern Chukchi Sea

Species	Marine Mammal Density mi^2 (km^2)				Possible Individual Marine Mammals Contacted[1]
	Open Water		Ice Margin		
	Avg	Max	Avg	Max	
Beluga whale (F)	0.0080 (0.0031)	0.0137 (0.0053)	0.0321 (0.0124)	0.0549 (0.0212)	0.77
Killer whale (F)	0.0003 (0.0001)	0.0010 (0.0004)	0.0003 (0.0001)	0.0010 (0.0004)	0.01
Harbor porpoise (F)	0.0054 (0.0021)	0.0114 (0.0044)	0.0054 (0.0021)	0.0114 (0.0044)	0.16
Bowhead whale (F)	0.1429 (0.0552)	0.3419 (0.1320)	0.2859 (0.1104)	0.6838 (0.2640)	9.61
Fin whale (F)	0.0003 (0.0001)	0.0010 (0.0004)	0.0003 (0.0001)	0.0010 (0.0004)	0.01
Gray whale (S)	0.0655 (0.0253)	0.0694 (0.0268)	0.0655 (0.0253)	0.0694 (0.0268)	0.98
Humpback whale (F)	0.0003 (0.0001)	0.0010 (0.0004)	0.0003 (0.0001)	0.0010 (0.0004)	0.01
Minke whale (F)	0.0008 (0.0003)	0.0016 (0.0006)	0.0008 (0.0003)	0.0016 (0.0006)	0.02
Bearded seal (F)	0.0277 (0.0107)	0.0526 (0.0203)	0.0368 (0.0142)	0.0699 (0.0270)	0.98
Ribbon seal (F)	0.0018 (0.0007)	0.0073 (0.0028)	0.0018 (0.0007)	0.0073 (0.0028)	0.10
Ringed seal (S)	0.9500 (0.3668)	1.5734 (0.6075)	1.2668 (0.4891)	2.0979 (0.8100)	29.48
Spotted seal (S)	0.0189 (0.0073)	0.0316 (0.0122)	0.0254 (0.0098)	0.0420 (0.0162)	0.59

[1] Based on the maximum density at ice margin; individuals within a VLOS aerial extent of 9,000 ac (36.4 km^2)

Any whales that were to contact the oil would likely experience only nonlethal effects from skin contact, inhalation of vapors, ingestion of oil-contaminated prey, baleen fouling, temporary reduction in food resources, or temporary displacement (NMFS 2008).

Effects of the VLOS on Marine Mammals in the Nearshore Environment

The effect of an oil spill from a blowout on marine mammals would be dependent on the particular geographic areas that are exposed to the released oil. One of the more important areas for marine mammals during the time when such a release could occur is Kasegaluk Lagoon. A number of documented spotted seal haulouts are located on spits associated with passes along the barrier islands in front of Kasegaluk Lagoon. Frost et al. (1993) reported the use of three haulouts along Kasegaluk Lagoon by anywhere from a few to over 1,000 spotted seals in August-November. Kasegaluk Lagoon is also important for belugas, which apparently frequent the lagoon waters for molting, however this use by belugas seems to be restricted to July. Oil reaching these areas would likely result in a substantial increase in the number of animals oiled. BOEM trajectory analyses indicate that there is a 1-4 percent chance of oil released from the hypothetical VLOS in the Burger Prospect, would reach these areas within 60 days (Table 6.2-2). Effects would be similar to those described above.

Effects of the VLOS on Threatened and Endangered Whales

Threatened and endangered species of marine mammals found in the northeastern Chukchi Sea include the bowhead whale, the fin whale, humpback whale, polar bear, and ringed seal. Walruses and bearded seals are candidate species.

Fin whales and humpback whales are rare in the Chukchi Sea. There have been very few recent sightings of fin or humpback whales in the Chukchi Sea. Reiser et al. (2009) reported four humpback whale sightings and one fin whale sighting in the Chukchi Sea in 2007 and Haley et al. (2009) reported one humpback whale sighting during 2008, while conducting monitoring surveys for industry over large portions of the northeastern Chukchi Sea. Green et al. (2007) reported and photographed a humpback whale cow/calf pair east of Barrow near Smith Bay in 2007. Three fin whale sightings were made in 2008 from industry vessels and NMFS/NMML survey aircraft in the northern Chukchi Sea off of Ledyard Bay indicating that the range of fin whales may be expanding. Reiser et al. (2009) reported a fin whale sighting during vessel-based surveys in the Chukchi Sea in 2006. It is possible that small numbers of humpback whales could be contacted by an oil spill in the northeastern Chukchi Sea, but unlikely.

Densities of these whales are thought to be less than 0.0010/mi^2 (0.0026/km^2). At these densities, a 9,000-ac (36.4-km^2) oil slick would contact less than 0.01 fin or humpback whales. Because the northeastern Chukchi Sea is at the edge of the range, or outside of the range of these species, the temporary effects on habitat would not be substantial for these species.

Bowhead whales are found regularly throughout the northeastern Chukchi but at relatively low densities. They migrate northward through the Chukchi Sea in the spring, before a spill could occur. They are found in relatively low densities throughout the Chukchi Sea during summer and fall. Much of the bowhead whale population migrates from the Beaufort Sea through the Chukchi Sea to the Bering Sea in September-October. This fall migration could be exposed to the oil slick, but the migration occurs across a broad area of the Chukchi Sea. Densities in the area of Shell's Burger Prospect are on the order of 0.1429-0.6838/mi^2 (0.0552-0.2640/km^2). At these densities 0.19-9.61 bowhead whales could contact the oil associated with a 9,000-ac (36.4-km^2) oil slick. ERAs identified by BOEM (BOEM 2015) as important for whales in August-October include ERAs 20-22, 24-29, 56, 61, 65, 70, 74, 82, 83, 91, 108, 109, and 122-124. Trajectory analyses (Table 6.6-2) of BOEM's (2011b) OSRA indicate a relatively high probability (1-54 percent chance) that the VLOS could contact these areas within 60 days. These areas are primarily used during fall migration as bowheads move from the Beaufort Sea through the Chukchi Sea to the Bering Sea. The majority of this fall migration in the Chukchi Sea takes place in October-November, thus, the VLOS could be on the surface during migration and whales could be contacted by oil.

Any whales that were to contact the oil would likely experience only nonlethal effects from skin contact, inhalation of vapors, ingestion of oil-contaminated prey, baleen fouling, temporary reduction in food resources, or temporary displacement (NMFS 2013).

Effects on other Threatened and Endangered Pinnipeds

Ringed seals are listed as threatened and the Pacific walrus and bearded seal are candidate species but these species are discussed above with other marine mammals.

Effects on Polar Bears

Polar bear density is relatively low in the northeastern Chukchi Sea during the time period of the assumed spill; however, the VLOS could contact some polar bears. Polar bears are extremely sensitive to both external contact with oil and ingestion of oil (MMS 1990).

Trajectory analyses indicate a very low to moderate probability that the VLOS would contact polar bear barrier islands, which are important habitat for polar bears, in such locations as Wainwright and Kasegaluk Lagoon barrier islands (Table 6.3.6-3). BOEM (BOEMRE 2011b; BOEM 2015) identified 19 ERAs, LSs, and GLSs identified as important for polar bears; of these, only 7 are located in and along the Chukchi Sea and are important to polar bears during the time period the VLOS would exist in the water. These are Wrangel Island, Point Barrow/Plover Islands, Kolyuchin Island in Russia, Herald Island, Barrow/Browerville/Elson Lagoon, Bukhta Somnitel'naya, and the Russian coastline. The conditional probabilities for oil contact at these locations are very low except for the US Chukchi Sea coastline; however, few polar bears would be expected along this coastline in August-October.

Table 6.3.6-3 Probabilities of a large spill (3, 10, and 30 days) and VLOS (60 and 360 days) Contacting Certain Areas Important to Polar Bears

ID [1]	Resource	Summer Conditional Probability (%) from LA 11				
		3 days	10 days	30 days	60 days	360 days
ERA 11	Wrangel Island 12 nmi & Offshore	-	-	3	5	6
ERA 55	Point Barrow, Plover Islands	-	-	1	1	1
ERA 59	Ostrov Kolyuchin	-	-	1	1	1
ERA 66	Herald Island	-	-	1	2	2
LS 85	Barrow, Browerville, Elson Lagoon	-	4	6	6	7
GLS 134	Bukhta Somnitel'naya	-	-	-	-	-
GLS 174	Russia Chukchi Coast Marine Mammals	-	-	10	12	14

[1] ERAs and GLSs (grouped land segments) identified by BOEM (BOEM 2015) as important for polar bears July-October

Conclusions Regarding Effects of the VLOS on Marine Mammals

Based on estimated densities of marine mammals in the northeastern Chukchi Sea, a relatively small number of marine mammals would be contacted by oil from the VLOS. The literature indicates that cetaceans may not be very sensitive to oil and no lethal effects would be expected. Whale deaths directly attributable to oil contact have not been reported. The literature also indicates that seal and walrus species found in the northeastern Chukchi Sea may be resistant to the effects of petroleum; however, some of these animals fouled in oil may die. Polar bears are thought to be extremely sensitive to oil contact and ingestions, and polar bears oiled by contact would likely die, but that this would be a small number of bears.

Whales

In BOEM's Lease Sale 193 FSEIS and Final Second SEIS, BOEM conducted an extensive analysis of the impacts of a VLOS on various species of whales (BOEMRE 2011b; BOEM 2015). According to BOEM, direct contact with spilled oil resulting from a VLOS would have the greatest potential to adversely affect cetacean species when toxic fumes from fresh oil are inhaled at times and places where aggregations of cetaceans may be exposed (BOEMRE 2011b). Presence of oil on and in the water may be avoided by some and not other cetaceans. Cetaceans as a general group would likely experience some loss of seasonal habitat, reduction of prey, and contamination of prey. Consumption of contaminated prey may adversely affect distribution, abundance and health of cetaceans. Human activities brought about by cleanup and remediation activities may displace cetaceans from preferred feeding habitats and preferred migration paths during cleanup activities, as cetaceans are likely would avoid OSR and cleanup activities. A variety of adverse effects on cetaceans could result from contact with and exposure to a VLOS event ranging from simple avoidance to mortality of large numbers of cetaceans depending on timing, location, cetacean species involved, and circumstances unique to a given spill event. BOEM determined that the impacts vary by the type of cetacean; these are discussed in more detail below.

Mysticetes

- Bowhead whales could experience contact with fresh oil during summer and fall feeding event aggregations and migration. Contact could result in skin and eye contact, various skin disorders, inhalation of toxic aromatic hydrocarbon vapors that could impair endocrine system function and reduced reproductive function and/or bowhead mortality (however rapid dissipation of toxic fumes is expected). Exposure of aggregations of bowheads, especially if calves are present, could result in multiple mortalities. Surface feeding bowheads would likely ingest surface and near surface oil fractions with their prey, which may be contaminated, as well as ingestion of oil in bottom sediments during near-bottom feeding. Ingestion of oil may result in temporary and permanent damage to bowhead endocrine function and reproductive system function. Population level effects are not expected; however in a very low probability, high impact circumstance where large numbers of whales experience prolonged exposure to toxic fumes and/or ingest large amounts of oil, injury and mortality is possible to a population level effect. In an unlikely winter spill scenario with oil trapped in ice, exposure could occur during the spring migration, during which large numbers of calves could die and recovery from the loss of a large portion of an age class cohort and its contribution to recruitment and species population growth could take decades. Finally, cleanup response activities could affect bowhead whales; however, bowheads would be expected to avoid vessel supported activities resulting in temporary and non-lethal effects from the human activities that would be related to VLOS response, cleanup, remediation, and recovery. Frequent encounters with VLOS activities and lost feeding opportunities could result in reduced body condition, reproductive performance, increased reproductive interval, decreased in vivo and neonatal calf survival, and increased age of sexual maturation in some bowheads. Effects associated with spill response are not expected to result in population level effects.

- A few individual fin whales could experience similar effects as noted for bowheads above if contacted by oil. Fin whale prey could also be reduced or contaminated. Temporary and/or permanent injury and non-lethal effects are likely and mortality or population level effects are considered unlikely. Fin whales would likely avoid the noise related to VLOS response, cleanup and post-event human activities similar to that noted for bowhead whales.
- A few individual humpback whales could experience similar effects as noted for bowheads above if contacted by oil. Humpback whale prey could be reduced and/or contaminated. Temporary and/or permanent injury and non-lethal effects are likely and mortality or population level effects are considered unlikely. If prey populations, presence, productivity and distribution are reduced due to VLOS effects, humpback habitat value could be lost. In general, humpback whales could be vulnerable to a spill. Specifically, if one or more individuals from the Western North Pacific stock suffered an injury or loss, it may take three generations or more to restore that distribution and abundance.
- Gray whale aggregations have consistently occurred near shore in areas likely to be the location of cleanup operations. Avoidance of intense activities could displace gray whales from preferred feeding areas. Oil contamination of gray whale prey (benthic sediments and/or mortality of benthic invertebrates) could result in a recovery period of many years, and result in abandonment of these primary summer feeding areas. Gray whales could experience population level adverse effects from loss or reduction of prey resources nearshore, or oiling of whales, which in turn could affect gray whale distribution, habitat use, and/or presence in the Chukchi Sea.
- Individual minke whales could experience similar effects as noted for bowheads above if contacted by oil. Minke whale prey could be reduced or contaminated, leading to a modified distribution of minke whales or ingestion of oil contaminated prey. Temporary and/or permanent and non-lethal effects are likely and mortality or population level effects are considered to be unlikely. Changes in distribution of minke whales in the Alaska Chukchi Sea are not likely. Minke whales would likely avoid the noise related to VLOS response, cleanup, and post-event human activities they may encounter, similar to that noted for bowhead whales.

In BOEM’s EA for EP Revision 1, BOEM considered VLOS impacts on mysticete whales (bowhead, gray, fin, humpback, and minke whales) as a group (BOEM 2011a). For mysticetes, BOEM referenced the detailed analysis in the Sale 193 FSEIS (summarized above) and noted that potential direct and indirect effects could become significant under certain circumstances. BOEM concluded that the analyses from Lease Sale 193 FSEIS remain sufficient to analyze the effects of a VLOS for EP Revision 1.

Based on available site-specific information and BOEM’s prior NEPA analyses, Shell anticipates that the impacts from the VLOS on mysticetes could become significant under certain circumstances, and the level of impacts would depend on the same factors identified by BOEM in the prior NEPA analyses.

Odontocetes

- Beluga whales are vulnerable to contact with a VLOS when large aggregations are gathered in the lagoons and nearshore habitats along the Alaska Chukchi Sea coast during molting and nursing. The fate of beluga prey would affect seasonal habitat use, determine if toxic amounts of contaminated fish are ingested, or possibly change distribution of these whales until fisheries recovery occurs. Temporary and/or permanent injury and non-lethal effects are likely. Toxic levels of ingestion could alter endocrine system function and reproductive system function and in severe cases result in mortality of individual whales. Belugas would come into contact with the human activities associated with cleanup operations; avoidance behavior and stress to belugas in coping with concentrated cleanup activities is likely. Belugas could also experience inhalation of fumes of fresh spilled oil and any prolonged inhalation of toxic fumes or accidental inhalation of surface oil could result in temporary and/or permanent injury or mortality to some individuals. Displacement from or avoidance of important nearshore habitats are anticipated and could redistribute seasonal use of the Chukchi Sea nearshore areas to less optimal molting and nursing areas and potentially reduce population productivity and recruitment. Post spill recovery of belugas to pre-spill abundance and habitat use patterns would depend upon the recovery periods necessary to restore pre-spill levels of prey populations and the quality of near-shore preferred habitats. Recovery would also depend on the level of human activity in and adjacent to preferred habitats.
- Individual harbor porpoise could experience similar effects as noted for bowheads above if contacted by oil. Harbor porpoise prey could be reduced or contaminated, leading to modified distribution of harbor porpoise or ingestion of oil contaminated prey. Temporary and/or permanent injury and non-lethal effects are likely and mortality or population level effects are considered to be unlikely. Harbor porpoise would likely avoid the noise related to VLOS response, cleanup, and post-event human activities. Ingestion of contaminated fish could reach toxic levels and result in impaired endocrine function, reproductive impairment, or mortality. Reduction or loss of harbor porpoise in this region requires pioneering individuals or the memory of individuals now using the area to “teach” others that the region is available. A substantial reduction in the low numbers that occur in offshore Alaska Chukchi Sea may take greater than three generations to recover due to the remoteness of this part of their range and the pioneering behavior required.
- Individual killer whales could experience similar effects as noted for bowheads above if contacted by oil. Killer whale marine mammal prey abundance and distribution could be reduced, or contaminated, leading to modified distribution of killer whales and/or ingestion of oil contaminated prey. Temporary and/or permanent injury and non-lethal effects are likely and mortality or population level effects are considered to be unlikely. Killer whales would likely avoid the noise related to VLOS response, cleanup and post-event human activities they may encounter, similar to that noted for bowhead whales.

In BOEM’s EA for EP Revision 1, BOEM considered VLOS impacts on odontocetes (beluga, harbor porpoise and killer whales) as a group. For odontocetes, BOEM referenced the Sale 193 FSEIS, noting that impacts from a VLOS could result in exposure to oil for odontocetes: through skin, inhalation, or ingestion of contaminated prey. BOEM noted that effects from this exposure in open water are likely to be limited to short term non-lethal effects such as skin irritation, resulting in moderate impacts to odontocetes (BOEM 2011a).

Based on available site-specific information and BOEM’s prior NEPA analyses, Shell anticipates that the impacts from the VLOS on odontocetes could result in moderate impacts, depending on the same factors identified by BOEM in the prior NEPA analyses.

Walrus

In BOEM's Lease Sale 193 FSEIS and Final Second SEIS, BOEM noted that a VLOS could affect Pacific walruses at sea, on sea ice, or at coastal haulouts. Effects could result from direct contact with oil, inhalation or exposure to toxic fumes from the oil, ingestion of oil or contaminated prey, habitat loss, or prey loss. BOEM determined significant impacts to the walrus population in the Chukchi Sea would be most likely to occur if large scale contamination of prey and habitat persisted for years (BOEMRE 2011b; BOEM 2015).

In BOEM's EA for Shell's EP Revision 1, the agency determined that moderate to major impacts on walruses could occur depending on whether the spill was located near large walrus concentrations or carried to an area near the pack ice edge where walruses gather (BOEM 2011a).

Based on available site-specific information and BOEM's prior NEPA analyses, Shell anticipates that the impacts from the VLOS on walruses could result in moderate to major impacts, depending on the same factors identified by BOEM in the prior NEPA analyses. Therefore, impacts on walruses from a VLOS could be significant.

Seals

In BOEM's Lease Sale 193 FSEIS and Final Second SEIS, BOEM conducted a trajectory analysis to determine how ice seals could be affected by a VLOS. BOEM determined that ice seals could be adversely affected to varying degrees, depending on habitat use, densities, season, and various spill characteristics (BOEMRE 2011b; BOEM 2015). In particular, were a VLOS to reach a polynya or lead system, there could be serious effects on local ringed and bearded seal sub-populations, potentially oiling or even killing hundreds to thousands of bearded and/or ringed seals. In addition, a VLOS has the potential to affect large numbers of seals in part due to the effects their prey and the local food-web. Mortality from a hypothetical VLOS could result in temporary population-level effects for bearded, ringed, and spotted seals, and to a much lesser degree ribbon seals due to their scarcity in the analysis area.

In BOEM's EA for Shell's EP Revision 1, the agency determined that a VLOS could have short-term population effects on seals (BOEM 2011a).

Based on available site-specific information and BOEM's prior NEPA analyses, Shell anticipates that a VLOS could have short-term population effects on seals (BOEM 2011a).

Polar Bear

In the BOEM's Lease Sale 193 FSEIS and Final Second SEIS, BOEM identified possible impact to polar bear as including direct contact with oil, inhalation or exposure to toxic fumes from the oil, ingestion of oil or contaminated prey, habitat loss or a lack of available prey; additional effects could occur during cleanup (e.g., inhalation or exposure to toxic fumes from cleanup products, fouling of fur, disturbance at important on ice or terrestrial sites, and continued contamination or loss of prey species or contamination of important coastal or sea ice habitats). Based upon a trajectory analysis, BOEM determined that if a VLOS resulted in the loss of large numbers of polar bears, particularly adult breeding age females, there would be a resulting significant impact on the southern Beaufort Sea and/or Chukchi/Bering Sea stocks of polar bears. BOEM concluded that significant impacts on polar bears could occur if large numbers are contacted or otherwise affected (BOEMRE 2011b; BOEM 2015).

In the EA for Shell's EP Revision 1, BOEM determined that moderate to major impacts on polar bears could occur depending on the relationship of the spill location to polar bears and prey (BOEM 2011a). The agency further concluded that there would be adverse impacts to then-identified polar bear critical habitat (BOEM 2011a).

Based on available site-specific information and BOEM's prior NEPA analyses, Shell anticipates that a VLOS could have moderate to major impacts on polar bears depending on the location of the spill.

6.3.7 Impacts of the VLOS on Subsistence, Community Health, Socioeconomics, and Environmental Justice

Effects on subsistence, community health, socioeconomics, and environmental justice could occur as a result of a VLOS as assumed in this section.

Potential Impacts of the VLOS on Subsistence

Access to subsistence resources, subsistence hunting, and the use of subsistence resources could be affected by changes in subsistence resource availability or desirability. The animals commonly hunted by Natives in Chukchi Sea coastal communities are bowhead and beluga whales, walruses, seals, polar bears, freshwater and marine fish, waterfowl, and seabirds. As discussed above, direct and indirect effects on marine mammals, freshwater and marine fish, and most birds are expected to be minor, localized, and short term and have no regional population effects. Although subsistence resources are migratory by nature and dispersed throughout large ranges or habitat, subsistence activities are concentrated in time and location. The potential for impacts due to a VLOS considered in this section, therefore, would be dependent on the spill trajectory, the time of year and the location of various spill response activities. Trajectory analyses indicate that the assumed hypothetical VLOS would have a very low probability of contacting Point Hope or Barrow subsistence areas (1-8 percent) and a 5percent probability that the VLOS would contact Point Lay subsistence use areas within 60 days (Table 6.3.7-1).

Table 6.3.7-1 Probabilities of the large spill (3, 10, and 30 days) and VLOS (60 and 360 days)Contacting Certain Subsistence Areas[1]

ID [3]	Resource [3]	Summer Conditional Probability (%) from LA 11 [1]				
		3 days	10 days	30 days	60 days	360 days
ERA 38	Point Hope Subsistence Area	-	-	1	1	1
ERA 39	Point Lay Subsistence Area	1	3	5	5	5
ERA 40	Wainwright Subsistence Area	14	27	34	34	35
ERA 42	Barrow Subsistence Area 2	-	4	-7	8	8

[1] Sources : MMS 2007b, BOEMRE 2011b, BOEM 2015

Point Lay and Wainwright hunts for beluga typically are terminated before the date the VLOS would commence; therefore the VLOS would be unlikely to have direct effects on these hunts. Point Lay and Wainwright residents hunt for bowhead whales primarily in the spring, with these hunts also being concluded before the hypothetical VLOS would occur, negating any chance of direct effects. Wainwright conducted their first successful fall hunt for bowheads in more than 90 years in October 2010. Wainwright subsequently harvested one bowhead whale in the fall of 2011, one in 2012, and three in 2013. If the VLOS were to contact these areas, the fall hunt could be disrupted or terminated because of avoidance by the animals, disturbance from cleanup efforts, or lack of interest by the subsistence users. Subsistence users from these villages might also forego fishing and subsistence hunting for waterfowl, seals, and walruses in these coastal waters if oil from the VLOS contacted these subsistence use areas. Trajectory analyses indicate that the assumed hypothetical VLOS would have a moderate probability of contacting Wainwright subsistence areas (1-35 percent) (Table 6.3.7-1).

Surface oil and/or disturbance due to spill response and cleanup activities offshore could cause marine mammals to avoid areas where they are normally harvested or to become more wary and difficult to hunt. Subsistence users may avoid the area or harvest of resources in the area due to real or perceived contamination of tainting of the animals flesh. The uses of subsistence resources by Wainwright and Point Lay are described in Section 3.11.6. Marine subsistence resources are of particular importance to these villages with marine mammals representing 36-72 percent of the total harvest (Tables 3.11.6-2 and 3.11.6-3).

In the unlikely event that oil reaches the shoreline, sections of coast would also not be used by subsistence users for some time following a spill. The duration of avoidance by subsistence users would vary depending on the volume of the spill, the effectiveness of spill response containment and recovery, the persistence of unrecovered oil in the environment, and the extent of impact on ecological resources important for subsistence. A VLOS, as described in this section, may hinder the harvest of subsistence resources or cause suspensions of subsistence activities for a period longer than a single harvest season, especially for the communities of Barrow, Wainwright, Point Lay, and Point Hope.

BOEM concluded in its FSEIS and Final Second SEIS for Chukchi Lease Sale 193 (BOEMRE 2011b, 2015) that if a hypothetical VLOS were to contact any part of the bowhead whale migration route, it could taint the resource. Any actual or perceived disruption of the bowhead whale harvest from oil spills and any actual or perceived impacts anywhere during the bowhead's spring migration, summer feeding, and fall migration could disrupt the bowhead hunt for an entire season even though whales still would be available. Traditional cultural concerns of tainting could make bowheads less desirable and alter or stop the subsistence harvest of bowheads and belugas for at least two seasons. Concerns over the safety of subsistence foods could persist for many years past any actual harvest disruption, resulting in a significant adverse effect. BOEM (BOEMRE 2011b) stated that these same concerns could extend to walruses, seals, polar bears, fish, and birds, and would be a significant adverse effect. Major impacts were also expected from a VLOS when contamination of the shoreline, tainting concerns, cleanup disturbance, and disruption of subsistence practices are factored together.

In the EA for EP Revision 1, BOEM determined a VLOS at Shell's prospect would have similar effects on subsistence to those described in detail in the Chukchi Lease Sale 193 EIS and FSEIS (BOEM 2011a).

Based on available site-specific information and BOEM's prior NEPA analyses, Shell anticipates that a VLOS could potentially have a significant adverse effect on short-term or long-term subsistence activity.

Potential Impacts of the VLOS on Community Health

Contamination and the perception of contamination may result in reduced or abandoned harvests and changes in traditional diets that would have some nutritional consequence. In addition, concern about the effects of consuming tainted food and concerns about availability of subsistence resources may increase levels of social stress. Users may resume hunting activities following some period of time. The duration of avoidance by subsistence users would vary depending on their confidence in assurances that resources were safe to eat. Due to the nature of Iñupiat culture, however, it is anticipated that impacted subsistence users would be invited to share harvesting and processing of subsistence products with unaffected communities.

In the FSEIS and Final Second SEIS for Chukchi Sea Lease Sale 193, BOEM discussed the public health impacts in the context of environmental justice. BOEM noted potential effects to air quality, water quality, subsistence resources, and other environmental resources could cause impacts from the following: contact with contaminants, which could occur mainly through inhalation, skin contact, or intake of contaminated subsistence foods; reduced availability or acceptability of subsistence resources; periodic interference with subsistence-harvest patterns from oil spills and oil spill cleanup; and stress due to fears of the long-term implications of a spill and the disruptions it would cause.

In the EA for EP Revision 1, BOEM determined that analyses on the effects of a VLOS in the Chukchi Lease Sale 193 EIS and FSEIS were sufficient to analyze the effects of a VLOS at Shell's Burger prospect (BOEM 2011a).

Based on available site-specific information and BOEM's prior NEPA analyses, Shell anticipates that a VLOS could potentially have a significant adverse impact on public health.

Potential Impacts of the VLOS on Sociocultural Resources and Socioeconomics

Disruption of subsistence-harvest resources, such as that created by a VLOS analyzed in this section, would have predictable and manageable consequences to several sociocultural aspects of life in Northern Alaska (Luton 1985). Subsistence users may experience more costs if users travel farther than normal to hunt. A VLOS could also affect the local cash economy by creating additional employment during the duration of the spill response and subsequent restoration.

In the BOEM's Lease Sale 193 FSEIS, BOEM discussed how impacts from a VLOS would be expected to adversely impact sociocultural systems to the extent they adversely impacted subsistence harvests and practices. Sociocultural impacts of oil spills include multiple types. The first is the result of direct effects on resources that are used in some way by local residents (i.e., subsistence, tourism, recreation, and elements of quality of life). There are also indirect effects that could result in long-term, major impacts on sociocultural systems as a result of longer term disruptions to the subsistence as a way of life: breakdowns in family ties, a community's sense of well-being, and damage sharing linkages with other communities and could seriously curtail community activities and traditional practices for harvesting, sharing, and processing subsistence resources. Another impact is from 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. BOEM also discussed the economic impacts from a VLOS. A VLOS would generate several thousand direct, indirect, and induced jobs, and millions of dollars in personal income associated with OSR and cleanup, which would be significant in the short term. Revenue impacts from a VLOS event include additional property tax revenues accruing to NSB from any additional onshore OSR infrastructure, and a decline in Federal, State, and local government revenues from displacement of other oil and gas production. A VLOS could also have significant adverse impacts on economic activity that does not currently take place in the area but could exist in the future (e.g., commercial and recreational fishing, tourism) (BOEMRE 2011b).

In the EA for Shell's EP Revision 1, BOEM considered the socioeconomic and economic analysis in the Sale 193 FSEIS, and found that this analysis remained sufficient to analyze the effects of a VLOS for EP Revision 1 (BOEM 2011a).

Based on available site-specific information and BOEM's prior NEPA analyses, Shell anticipates that socioeconomic impacts associated with a VLOS could be significant, major and long-term were subsistence harvests to be disrupted. A VLOS could also have short-term significant positive impacts on jobs and income associated with the cleanup activity, and that these impacts would be offset by significant adverse impacts on other economic activity that could last longer.

Environmental Justice

An unlikely VLOS that significantly impacts subsistence harvest areas such as fishing areas nearshore or marine mammal migration areas offshore could result in impacts under Environmental Justice; that is, a disproportionately high adverse impact on Alaskan Natives.

In the Lease Sale 193 FSEIS and Final Second SEIS, BOEM determined that were a 2,160,000-bbl spill in the Chukchi Sea to have significant adverse impacts on subsistence harvests or sociocultural values, this would in turn result in significant environmental justice impacts to low-income, minority populations in the region who would be affected disproportionately. BOEM concluded that a VLOS could result in high adverse environmental and health impacts to Alaska Inupiat Natives (BOEMRE 2011b; BOEM 2015).

In the EA for Revision 1, BOEM determined that effects on Environmental Justice from a hypothetical 750,000-bbl spill at Shell's Burger prospect would be similar to those described in detail in the Chukchi Sea Lease Sale 193 EIS and FSEIS (MMS 2007b; BOEMRE 2011b).

Based on available site-specific information and BOEM's prior NEPA analyses, Shell anticipates that environmental justice impacts associated with a VLOS could be highly adverse and significant.

7.0 LEASE STIPULATIONS

The leases planned for exploration drilling were obtained under the Chukchi Sea Oil and Gas Lease Sale 193. These leases contain stipulations (MMS 2008b) with regard to how the lessor must operate in order to mitigate negative impacts. The lease stipulations for Sale 193 are as follows:

- Stipulation No. 1 – Protection of Biological Resources
- Stipulation No. 2 – Orientation Program
- Stipulation No. 3 – Transportation of Hydrocarbons
- Stipulation No. 4 – Industry Site-Specific Monitoring Program for Marine Mammal Subsistence Resources
- Stipulation No. 5 – Conflict Avoidance Mechanisms to Protect Subsistence Whaling and Other Marine Mammal Subsistence-Harvesting Activities
- Stipulation No. 6 – Pre-Booming Requirements for Fuel Transfers
- Stipulation No. 7 – Measures to Minimize Effects to Spectacled and Steller's Eiders During Exploration Activities

Stipulation 3 does not apply to Shell's planned exploration drilling program as no pipeline or production facilities are involved. Further, exploration wells drilled during this program will not be produced. All wells will be plugged and abandoned in compliance with BSEE regulations when drilling is concluded. Stipulation 4 also does not apply to Shell's planned exploration drilling program in EP Revision 2 as the leases planned for exploration drilling are located seaward and outside of the designated stipulation area (Figure 1.1-1); however, Shell has voluntarily prepared and will implement programs and procedures to address these stipulations in its goal to be a good neighbor. In the expanded discussion of the lease stipulations below, the source for the italicized text is the OCS Chukchi Sea Planning Area Oil and Gas Lease Sale 193.

Stipulation No. 1 – Protection of Biological Resources

If previously unidentified biological populations or habitats that may require additional protection are identified in the lease area by the BOEM Regional Supervisor, Field Operations (RS/FO), the RS/FO may require the lessee to conduct biological surveys. to determine the extent and composition of biological populations or habitats that may require additional protection. Under Stipulation No. 1, the RS/FO shall give written notification to the lessee of the RS/FO's decision to require such surveys.

Based upon this survey the lessor may be required to:

- *Relocate the site of operations*
- *Establish, on the basis of a site-specific survey, that operations will not have a major adverse effect upon the resource identified or that a special biological resource does not exist*
- *Operate during times, as established by the RS/FO. that do not adversely affect the biological resources*
- *Modify operations to ensure that major biological populations or habitats deserving protection are not adversely affected (MMS 2008b)*

If the lessee discovers an area of biological significance during lease operations, they are required to notify the lessor and to act to preserve the area until they obtain further direction from the lessor. The *lessee is required not to take action that may affect such biological resources until written directions regarding permitted actions are obtained from the lessor.*

Stipulation No. 1 further requires the lessee to submit all data obtained during the biological survey(s) with the locational information for drilling or other activity to the RS/FO. *The lessee may take no action that might affect the biological populations or habitats surveyed until the RS/FO provides written directions to the lessee with regard to permissible actions.*

Shell Proposed Actions:

BOEM has not requested that Shell conduct any biological resource surveys in the area of the planned drill sites. No areas of special biological significance have been identified within or near the blocks identified in this EP Revision 2. Historical shallow hazards surveys as well as Shell's current shallow hazards surveys have not identified any hard bottom or relief or unique features that would indicate the possible existence of special biological resources. Video reconnaissance surveys conducted in conjunction with historical shallow hazards surveys at Burger Prospect locations revealed only sediment types and benthic communities that are typical of broad areas of the Chukchi Shelf. Shell conducted or participated in the funding or in the facilitation of several types of environmental studies in and near the prospects in 2008 through 2013 to gather baseline data regarding resources in the project area. These studies included coastline surveys to assess the relative environmental sensitivity of Chukchi Sea coastline segments, walrus tagging and monitoring studies, seal tagging and monitoring studies, bird and marine mammal surveys, assessments of the benthic invertebrate communities, oceanographic studies, and sediment quality assessments at the planned drill sites. The results of the marine mammal and bird surveys are summarized in Section 3. These studies also indicated that there are no areas of special biological significance in the vicinity of the drill sites.

Stipulation No. 2 – Orientation Program

Stipulation No. 2 requires the lessee to include in any EP, a proposed orientation program to inform personnel of specific environmental, social, and cultural concerns related to the lease sale and adjacent areas. The orientation program will emphasize the importance of archaeological and biological resources and habitats, including but not limited to endangered species, fisheries, bird colonies, and marine mammals. The program will provide guidance on how to avoid disturbance of these resources, and will be designed to increase sensitivity on the part of program personnel to values, customs, and lifestyles of communities in the program areas. It will also provide guidance to avoid conflicts with subsistence activities and applicable mitigation.

Shell has developed and is currently implementing an approved orientation program for Shell and contractor personnel involved in Shell's Alaska Venture exploration drilling program that was first approved by the Alaska OCS Region of the BOEM RS/FO on 15 February 2007. An outline of the program was again submitted to BOEM with the initial Chukchi Sea EP, and found by the BOEM RS/FO on 7 December 2009 to satisfy the requirements of Stipulation No. 2. Shell revised the orientation program based on BOEM comments regarding the 2009 orientation program, and submitted the complete orientation program to BOEM for approval on 9 June 2011. The same orientation program was submitted with the Chukchi Sea EP Revision 1 and was approved by BOEM June 2012.

Shell will periodically make minor changes to the orientation program content to maintain its currency (e.g., updates in safety statistics, permitting requirements and those changes will be rolled into EP revisions as required.) Another update to the approved orientation program will be submitted to BOEM for approval prior to beginning the next drilling season. This update will be substantially the same as the current approved orientation program.

All Shell and contractor personnel involved in field exploration drilling activities will attend an initial training orientation for all personnel and an annual refresher for field deployed personnel. All Alaska office-based Shell and contractor personnel will attend the program at least once at the time they join the team (within 1 year of before deploying to field). Field deployed personnel traveling to onshore or offshore locations north of Fairbanks, Alaska will attend annual refresher training. Visitors traveling to land locations (i.e., trips performing low-risk activities less than three days) will receive an abbreviated fit-for purpose orientation as related to their visit. Contractors hired by Shell who reside in an area north of Fairbanks (i.e., a village) may receive a slightly modified version of the cultural awareness orientation that is fit for purpose or allow comparable training (e.g., attendance at Alaska Federation of Natives convention).

Shell will retain and maintain a record, for at least 2 years, of all personnel who attend the program, including relevant attendee and program information. Shell has designed a specific program that addresses environmental, social, and cultural concerns related to the project area. The program is designed to increase sensitivity and understanding by Shell and its contractors of community values, customs, and lifestyles in the area they will be working, and how to avoid conflicts with subsistence activities. The program stresses the importance of not disturbing archaeological and biological resources and habitats, including endangered species, fisheries, bird colonies, and marine mammals and provides guidance on how to avoid disturbance.

Shell's Cultural Awareness Program addresses the following:

- Alaska Native ethnic groups and cultures
- Brief history of land claims
- Formation of regional corporations, and region within which Shell is working
- History of the North Slope
- Cultural diversity
- Comparison of cultural values Patterns of language
- Communication skills and body language
- Guidelines on cultural artifacts
- Local community values and customs
- Whaling

Shell has developed a very robust Health, Safety, Security and Environment (HSSE) Awareness Program, of which the requirements listed in Lease Stipulation 2 are a component of this training. The following areas are highlighted to address the requirement in Lease Stipulation 2.

- Environmental Awareness
  - ESA – Major Provisions
  - ESA of 1973
  - MMPA of 1972
  - Marine mammal interactions
  - Sensitive Habitats on the North Slope
  - Wildlife interactions
  - Prohibited activities of hunting, trapping and fishing
  - Environmental requirements, for air, spills, and waste
  - Environmental training

The awareness level orientations may be given as face-to-face training, video and computer slides, or via computer based training. Annual refreshers will include the general content noted above but adapted for those already familiar with basic information.

Stipulation No. 4 – Industry Site-Specific Bowhead Whale Monitoring Program

A lessee proposing to conduct exploration operations, including ancillary seismic surveys, on a lease within the blocks identified below during the periods of subsistence use related to bowhead whales, beluga whales, ice seals, walrus, and polar bears will be required to conduct a site-specific monitoring program approved by the RS/FO; unless, based on the size, timing, duration, and scope of the proposed operations, the RS/FO, in consultation with appropriate agencies and co-management organizations, determines that a monitoring program is not necessary. Organizations currently recognized by the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) for the co-management of the marine mammals resources are the Alaska Eskimo Whaling Commission, the Alaska Beluga Whale Committee, the Alaska Eskimo Walrus Commission, the Ice Seal Commission, and the Nanuuq Commission. The RS/FO will provide the appropriate agencies and co-management organizations a minimum of 30 calendar days, but no longer than 60 calendar days to review and comment on a proposed monitoring program prior to Minerals Management Service (MMS) approval. The monitoring program must be approved each year before exploratory drilling operations can be commenced.

The monitoring program will be designed to assess when bowhead and beluga whales, ice seals, walrus, and polar bears are present in the vicinity of lease operations and the extent of behavioral effects on these marine mammals due to these operations. In designing the program, the lessee must consider the potential scope and extent of effects that the type of operation could have on these marine mammals. Experiences relayed by subsistence hunters indicate that, depending on the type of operations, some whales demonstrate avoidance behavior at distances of up to 35 miles. The program must also provide for the following:

1. *Recording and reporting information on sighting of the marine mammals of concern and the extent of behavioral effects due to operations;*
2. *Coordinating the monitoring logistics beforehand with the MMS Bowhead Whale Aerial Survey Project (BWASP) and other mandated aerial monitoring programs;*
3. *Inviting a local representative to be determined by consensus of the appropriate co-management organizations to participate as an observer in the monitoring program;*
4. *Submitting daily monitoring results to the RS/FO;*
5. *Submitting a draft report on the results of the monitoring program to the RS/FO within 90 days following the completion of the operation. The RS/FO will distribute this draft report to the appropriate agencies and co-management organizations;*
6. *Allowing 30 days for independent peer review of the draft monitoring report; and*
7. *Submitting a final report on the results of the monitoring program to the RS/FO within 30 days after the completion of the independent peer review. The final report will include a discussion of the results of the peer review of the draft report. The RS/FO will distribute this report to the appropriate agencies and co-management organizations.*

The RS/FO may extend the report review and submittal timelines if the RS/FO determines such an extension is warranted to accommodate extenuating circumstances.

The lessee will be required to fund an independent peer review of a proposed monitoring plan and the draft report on the results of the monitoring program for bowhead whales. The lessee may be required to fund an independent peer review of a proposed monitoring plan and the draft report on the results of the monitoring program for other co-managed marine mammal resources. This peer review will consist of independent reviewers who have knowledge and experience in statistics, monitoring marine mammal behavior, the type and extent of the proposed operations, and an awareness of traditional knowledge. The *peer reviewers will be selected by the RS/FO from experts recommended by the appropriate agencies and co-management resource organizations. The results of these peer reviews will be provided to the RS/FO for consideration in final MMS approval of the monitoring program and the final report, with copies to the appropriate agencies and co-management organizations.*

In the event the lessee is seeking a Letter of Authorization (LOA) or Incidental Harassment Authorization (IHA) for incidental take from NMFS and/or USFWS, the monitoring program and review process required under the LOA or IHA may satisfy the requirements of this stipulation. The lessee must advise the RS/FO when it is seeking an LOA or IHA in lieu of meeting the requirements of this stipulation and provide the RS/FO with copies of all pertinent submittals and resulting correspondence. The RS/FO will coordinate with the NMFS and/or USFWS and will advise the lessee if the LOA or IHA will meet these requirements.

The MMS, NMFS, and USFWS will establish procedures to coordinate results from site-specific surveys required by this stipulation and the LOA's or IHA's to determine if further modification to lease operations are necessary.

This stipulation applies to the following blocks:

NR02-06, Chukchi Sea

6624, 6625, 6674, 6675, 6723-6725, 6773-6775, 6822, 6823, 6872

NR03-02, Posey

6872, 6873, 6918-6923, 6967-6973, 7016-7023, 7063-7073, 7112-7123

NR03-03, Colbert

6674, 6723, 6724, 6771-6774, 6820-6824, 6869-6874, 6918-6924, 6966-6974,

7015-7024, 7064-7074, 7113-7124

NR03-04, Solivik Island

6011-6023, 6060-6073, 6109-6122, 6157-6171, 6206-6219, 6255-6268, 6305-6317,

6354-6365, 6403-6414, 6453-6462, 6502-6511, 6552-6560, 6601-6609, 6651-6658,

6701-6707, 6751-6756, 6801-6805, 6851-6854, 6901-6903, 6951, 6952, 7001

NR03-05, Point Lay West

6014-6024, 6062-6073, 6111-6122, 6160-6171, 6209-6221, 6258-6269, 6307-6317,

6356-6365, 6406-6414, 6455-6462, 6503-6510, 6552-6558, 6602-6606, 6652-6655, 6702, 6703

NR04-01, Hanna Shoal

6223, 6267-6273, 6315-6323, 6363-6373, 6411-6423, 6459-6473, 6507-6523,

6556-6573, 6605-6623, 6654-6671, 6703-6721, 6752-6771, 6801-6819, 6851-6868,

6901-6916, 6951-6964, 7001-7010, 7051-7059, 7101-7107

NR04-02, Barrow

6003-6022, 6052-6068, 6102-6118, 6151-6164, 6201-6214, 6251-6262, 6301-6312,

6351-6359, 6401-6409, 6451-6456, 6501-6506, 6551, 6552, 6601, 6602

NR04-03, Wainwright

6002-6006, 6052, 6053

NS04-08, (Unnamed)

6816-6822, 6861-6872, 6910-6922, 6958-6972, 7007-7022, 7055-7072, 7104-7122

This stipulation applies during the time periods for subsistence-harvesting described below for each community.

Subsistence Whaling and Marine Mammal Hunting Activities by Community

Barrow*: Spring bowhead whaling occurs from April to June; Barrow hunters hunt from ice leads from Point Barrow southwestward along the Chukchi Sea coast to the Skull Cliff area. Fall whaling occurs from August to October in an area extending from approximately 10 miles west of Barrow to the east side of Dease Inlet. Beluga whaling occurs from April to June in the spring leads between Point Barrow and Skull Cliff; later in the season, belugas are hunted in open water around the barrier islands off Elson Lagoon. Walrus are harvested from June to September from west of Barrow southwestward to Peard Bay. Polar bear are hunted from October to June generally in the same vicinity used to hunt walrus. Seal hunting occurs mostly in winter, but some open water sealing is done from the Chukchi coastline east as far as Dease Inlet and Admiralty Bay in the Beaufort Sea.*

Wainwright*: Bowhead whaling occurs from April to June in the spring leads offshore of Wainwright, with whaling camps sometimes as far as 10 to 15 miles from shore. Wainwright hunters hunt beluga whales in the spring lead system from April to June but only if no bowheads are in the area. Later in the summer, from July to August, belugas can be hunted along the coastal lagoon systems. Walrus hunting occurs from July to August at the southern edge of the retreating pack ice. From August to September, walrus can be hunted at local haulouts with the focal area from Milliktagvik north to Point Franklin. Polar bear hunting occurs primarily in the fall and winter around Icy Cape, at the headland from Point Belcher to Point Franklin, and at Seahorse Island.*

Point Lay*: Because Point Lay's location renders it unsuitable for bowhead whaling; beluga whaling is the primary whaling pursuit. Beluga whales are harvested from the middle of June to the middle of July. The hunt is concentrated in Naokak and Kukpowruk Passes south of Point Lay where hunters use boats to herd the whales into the shallow waters of Kasegaluk Lagoon where they are hunted. If the July hunt is unsuccessful, hunters can travel as far north as Utukok Pass and as far south as Cape Beaufort in search of whales. When ice conditions are favorable, Point Lay residents hunt walrus from June to August along the entire length of Kasegaluk Lagoon, south of Icy Cape, and as far as 20 miles offshore. Polar bear are hunted from September to April along the coast, rarely more than 2 miles offshore.*

Point Hope*: Bowhead whales are hunted from March to June from whaling camps along the ice edge south and southeast of the point. The pack-ice lead is rarely more than 6 to 7 miles offshore. Beluga whales are harvested from March to June in the same area used for the bowhead whale hunt. Beluga whales can also be hunted in the open water later in the summer from July to August near the southern shore of Point Hope close to the beaches, as well as areas north of the point as far as Cape Dyer. Walruses are harvested from May to July along the southern shore of the point from Point Hope to Akoviknak Lagoon. Point Hope residents hunt polar bears primarily from January to April and occasionally from October to January in the area south of the point and as far out as 10 miles from shore.*

This stipulation will remain in effect until termination or modification by the Department of the Interior after consultation with appropriate agencies.

Shell Proposed Actions:

Although none of the blocks listed in Stipulation No. 4 are included in those planned for exploration drilling in Shell's EP Revision 2, Shell voluntarily submitted to the BOEM a site-specific 4MP with EP Revision 1, and provided the 4MP to support its request for MMPA authorization. The 4MP will be updated to reflect the revised drilling program in EP Revision 2, but remains substantially the same as the 4MP that is part of the approved EP Revision 1. The 4MP is located in EP Revision 2 Appendix B.

Shell intends to use contractors based in the NSB, Northwest Arctic Borough (NWAB) and potentially the Bering Straits region that will in turn provide job opportunities to local residents, including recruitment and training of SAs and PSOs. Summaries of key components of the program are presented below.

Protected Species Observers

Vessel-based monitoring for marine mammals will be done throughout the period of exploration drilling operations to comply with expected provisions in the MMPA authorizations that Shell receives. Those provisions will be implemented during the exploration drilling program by a team of trained PSOs. The presence of PSOs onboard drilling and transiting support vessels will be a core component of compliance with the 4MP. The PSOs will be responsible for collecting basic data on observations of marine mammals and for implementing mitigation measures including vessel avoidance measures and factored into decisions concerning operational shutdown. The observations made by PSOs serve as the primary basis for estimation of impacts to marine mammals. Because their ranks include representatives of the Alaska Native community, the PSOs also serve as an important means of providing local hire and local oversight of the monitoring program. PSOs will be stationed on both drilling units, ice management vessels, anchor handlers and other drilling support vessels engaged in transit to and between drill sites, exploration drilling, and other operational and intermittent activities to monitor for marine mammals.

Aerial Survey Program

Offshore aerial wildlife monitoring photographic surveys (aka PSO flights) are proposed to start as soon as the ice management, anchor handler and drilling units are at or near the first drill site and would continue throughout the drilling period and until the drilling related vessels have left the exploration drilling area. If in the event vessels enter the Chukchi Sea on or about 1 July, surveys would be initiated on or about 3 July. This start date differs from past practices of beginning five days prior to initiation of an activity and continuing until five days after cessation of the activity because the presence of vessels with helidecks in the area where overflights will occur is one of the main mitigations that will allow for supporting a safe operation of the overflight program this far offshore. A nearshore/coastal saw-tooth pattern also may be flown. The offshore aerial wildlife monitoring photographic surveys will be based out of Barrow and the same aircraft will conduct the offshore surveys around the drilling units and the nearshore/coastal saw-tooth pattern.

Photographic surveys are proposed to be flown daily, weather permitting, throughout the drilling program. The offshore survey transects over the drilling area would be the default priority each day, as opposed to the nearshore/coastal sawtooth pattern. The nearshore/coastal survey pattern would be flown only in instances when conditions offshore are not conducive for flying and coastal conditions would, however, support an overflight. There also may be isolated instances during the season when the nearshore/coastal survey would be identified as the priority due to a unique biological or operational scenario (e.g., walrus aggregations).

Acoustic Recorders

A combination of acoustic recorder technologies will be employed to document the distribution of marine mammals; the distribution of marine mammals in relation to activities; to add clarity to the characterization of exploration drilling sound levels, character, and propagation; and to document presence of marine mammals in subsistence hunting areas. This will be accomplished by deploying several acoustic recorder buoys in a wide area surrounding the planned locations. Acoustic monitoring instruments have been deployed in the Chukchi Sea in past years in late July. With drilling proposed to commence in early July, the deployment date would be pushed forward to occur after ice out and before exploration drilling. Over-wintering sonobuoys have also been located in the proposed exploration drilling area since 2007. In that early drilling related activities would be initiated upon arrival and while the arrays are being deployed, these over-wintered recorders would capture the sound associated with early activities.

Sound Modeling

Sound modeling will be conducted during the exploration drilling program in the Chukchi Sea.

Sound Source Verification

Field measurement of sound propagation profiles of vessels and the drilling unit will be conducted during different operational modes, so as to determine those activities that produce the greatest opportunities for mitigation. Shell plans to conduct sound source verification (SSV) on the vessels which did not have a prior SSV in the Chukchi Sea. Since sound levels generated by drilling operations do not exceed sound levels where mitigation measures are required, the utility of SSVs, which are normally used to verify and adjust mitigation distances, is limited. Shell is also utilizing distributed arrays around the drilling location to measure cumulative sound impacts throughout the drilling process. These arrays are generating more useful information than individual SSVs.

Regarding the drilling units, as noted in the 4MP, exploration drilling sounds are expected to vary significantly with time due to variations in the level of operations and the different types of equipment used at different times onboard the drilling units. The goals of these measurements are to quantify the absolute sound levels produced by exploration drilling and to monitor their variations with time, distance and direction from the drilling unit; and to measure the sound levels produced by an end-of-hole ZVSP survey using a stationary sound source.

Additional Studies

Shell plans to participate in additional studies of marine resources in the Chukchi Sea to enable us to increase our understanding of: (1) baseline conditions and the distribution of critical resources; (2) interactions between industry activities and marine resources; and (3) resource status and conservation/management needs. The list of potential studies and monitoring projects includes:

- Baseline studies of the air quality, oceanography, sediment chemistry, benthic and planktonic communities, fish, marine birds, and marine mammals in the Burger Prospect area
- Marine mammal distribution and response to industry activities in the northeastern Chukchi Sea
- Participation in, and funding of, walrus and ringed seal tagging studies
- Collection of subsistence use of coastal and offshore waters though a system of Subsistence Advisors; and
- Drilling waste discharge and benthic community monitoring

With the exception of the discharge monitoring, Shell has been participating in these studies since 2006. Information on the studies is provided in EIA Section 3. Discharge monitoring studies Shell expects to conduct are described in EP Revision 2 Section 10.0.

Stipulation No. 5 – Lease Sale 193 Conflict Avoidance Mechanisms to Protect Subsistence Whaling and Other Subsistence-Harvesting Activities

Exploration and development and production operations shall be conducted in a manner that prevents unreasonable conflicts between the oil and gas industry and subsistence activities. This stipulation applies to exploration, development, and production operations on a lease within the blocks identified below during periods of subsistence use related to bowhead whales, beluga whales, ice seals, walruses, and polar bears. The stipulation also applies to support activities, such as vessel and aircraft traffic, that traverse the blocks listed below or Federal waters landward of the sale during periods of subsistence use regardless of lease location. Transit for human safety emergency situations shall not require adherence to this stipulation.

This stipulation applies to the following blocks:

NR02-06, Chukchi Sea

6624, 6625, 6674, 6675, 6723-6725, 6773-6775, 6822, 6823, 6872

NR03-02, Posey

6872, 6873, 6918-6923, 6967-6973, 7016-7023, 7063-7073, 7112-7123

NR03-03, Colbert

6674, 6723, 6724, 6771-6774, 6820-6824, 6869-6874, 6918-6924, 6966-6974,

7015-7024, 7064-7074, 7113-7124

NR03-04, Solivik Island

6011-6023, 6060-6073, 6109-6122, 6157-6171, 6206-6219, 6255-6268, 6305-6317,

6354-6365, 6403-6414, 6453-6462, 6502-6511, 6552-6560, 6601-6609, 6651-6658,

6701-6707, 6751-6756, 6801-6805, 6851-6854, 6901-6903, 6951, 6952, 7001

NR03-05, Point Lay West

6014-6024, 6062-6073, 6111-6122, 6160-6171, 6209-6221, 6258-6269, 6307-6317,

6356-6365, 6406-6414, 6455-6462, 6503-6510, 6552-6558, 6602-6606, 6652-6655,

6702, 6703

NR04-01, Hanna Shoal

6223, 6267-6273, 6315-6323, 6363-6373, 6411-6423, 6459-6473, 6507-6523,

6556-6573, 6605-6623, 6654-6671, 6703-6721, 6752-6771, 6801-6819, 6851-6868,

6901-6916, 6951-6964, 7001-7010, 7051-7059, 7101-7107

NR04-02, Barrow

6003-6022, 6052-6068, 6102-6118, 6151-6164, 6201-6214, 6251-6262, 6301-6312,

6351-6359, 6401-6409, 6451-6456, 6501-6506, 6551, 6552, 6601, 6602

NR04-03, Wainwright

6002-6006, 6052, 6053

NS04-08, (Unnamed)

6816-6822, 6861-6872, 6910-6922, 6958-6972, 7007-7022, 7055-7072, 7104-7122

Stipulation No. 5 requires lessees to conduct oil and gas exploration and development in a manner that prevents unreasonable conflicts between the oil and gas industry and subsistence activities, and applied to oil and gas exploration operations within listed blocks during periods of subsistence use related to marine mammals, Shell's planned drill sites are not located within the listed OCS blocks to which the stipulation applies; however, some associated operations such as vessel and aircraft traffic would occur within the listed blocks during this time period.

<u>Shell Proposed Actions</u>:

Shell has actively engaged the NSB, NWAB, and the subsistence communities of Kaktovik, Nuiqsut, Barrow, Wainwright, Point Lay, Point Hope, Kivalina, Kotzebue, Shishmaref, Kiana, Savoonga, and Gambell, and co-management organizations, including the AEWC, Alaska Beluga Whale Committee, the Alaska Eskimo Walrus Commission, the Ice Seal Commission, and the Alaska Nanuuq Commission, to discuss potential conflicts between planned oil and gas activities and subsistence use activities. Shell's EP lease blocks do not lie within the stipulation area, but support activities associated with the exploration drilling program will transit the stipulation area.

<u>Plan of Cooperation</u>

Shell began consulting with potentially affected subsistence communities, stakeholders and Federal, State, and local agencies in 2006, prepared a POC for its Chukchi Sea exploration drilling program and has continued these consultations through 2014. Shell will continue to engage with subsistence stakeholders to build on its past efforts to inform and engage the communities that could be potentially affected by exploration drilling activities in the Chukchi Sea. It is also noted that a POC is required for a MMPA authorizations from the NMFS and USFWS. Shell's POC, 4MP, and other mitigation measures are designed to minimize adverse impacts to subsistence use activities.

Shell met with public and community leaders beginning in January-April 2009 specifically to discuss the planned 2010 exploration drilling program in the Chukchi Sea, as detailed in the initial Chukchi Sea EP, and to hear their concerns. Shell prepared a written POC based on that effort, which described when and where the meetings were held, what was presented by Shell, the comments received, and Shell's responses to these comments. The POC also identified mitigation measures that Shell prepared in response to these concerns. A copy of the POC was attached as an appendix to the initial Chukchi Sea EP, and was forwarded to NMFS as part of the MMPA authorization requirements. Shell's consultation efforts have continued since that time, and in July - August of 2014, Shell held a series of meetings specifically to discuss the exploration drilling activities outline in EP Revision 2. The dates and locations of the meetings held since 2012 as part of the consultation effort associated with exploration drilling in the Chukchi Sea, along with the persons Shell met with, are listed below in Table 7.0-1. Shell has prepared an addendum to the POC originally submitted with the initial Chukchi Sea EP. The POC addendum included with EP Revision 2 provides information on the meetings held specifically to address the EP Revision 2. The POC addendum is attached in EP Revision 2 Appendix D.

Table 7.0-1 Dates and Locations of Meetings Held Regarding Shell's Chukchi Sea Exploration Drilling Program for the Development of the POC

2012	**Meeting Location**	**Meeting Attendees**
23 October	Point Lay	Plan of Cooperation Community Meeting
24 October	Wainwright	Plan of Cooperation Community Meeting
26 October	Kaktovik	Plan of Cooperation Community Meeting
29 October	Barrow	Plan of Cooperation Community Meeting
30 October	Nuiqsut	Plan of Cooperation Community Meeting
6 November	Barrow	NSB Assembly Workshop Meeting
2013	**Meeting Location**	**Meeting Attendees**
29 July	Kotzebue	NWAB, City of Kotzebue, KIC and IRA representatives
5 November	Barrow	NSB Assembly
5 November	Wainwright	Plan of Cooperation Community Meeting
6 November	Point Lay	Plan of Cooperation Community Meeting
8 November	Barrow	Plan of Cooperation Community Meeting
12 November	Point Hope	Plan of Cooperation Community Meeting
2014	**Meeting Location**	**Meeting Attendees**
28 January	Kotzebue	Plan of Cooperation Community Meeting
16 June	Barrow	Stakeholder Meeting
16 June	Wainwright	Stakeholder Meeting
30 June	Barrow	Plan of Cooperation Community Meeting
1 July	Wainwright	Plan of Cooperation Community Meeting
7 July	Point Lay	Plan of Cooperation Community Meeting
8 July	Point Hope	Plan of Cooperation Community Meeting
9 July	Kotzebue	Plan of Cooperation Community Meeting
17 July	Deering	Plan of Cooperation Community Meeting
3 November	Barrow	Plan of Cooperation Community Meeting
6 November	Point Lay	Plan of Cooperation Community Meeting
2015	**Meeting Location**	**Meeting Attendees – Position**
12 January	Kotzebue	Plan of Cooperation Community Meeting
13 January	Wainwright	Plan of Cooperation Community Meeting
22 January	Buckland	Plan of Cooperation Community Meeting
22 January	Deering	Plan of Cooperation Community Meeting

[1] IRA = Indian Reorganization Act, KIC = Kikiktagruk Inupiat Corporation, NSB = North Slope Borough, NWAB = Northwest Arctic Borough,

Marine Mammal Co-Management Groups

Shell facilitated meetings with the co-management groups including the AEWC, Alaska Beluga Whale Committee, the Alaska Eskimo Walrus Commission, the Ice Seal Commission, and the Alaska Nanuuq Commission beginning in June 2006, and continues to meet with these groups regularly. Shell will meet with representatives of these co-management groups again to discuss EP Revision 2 to inform them of our planned activities and discuss potential conflicts that could arise with regards to the siting, timing, and method of the planned operations as well as mitigation measures designed to avoid or minimize any such effects.

Shell has actively engaged the NSB, NWAB, and affected subsistence communities of Kaktovik, Nuiqsut, Barrow, Anaktuvuk Pass, Atqasuk, Wainwright, Point Lay, Point Hope, Kivalina, Kotzebue, Shishmaref, Kiana, Deering, Savoonga, and Gambell, and co-management organizations, including the AWEC, Alaska Beluga Whale Committee, the Alaska Eskimo Walrus Commission, the Ice Seal Commission, and the Alaska Nanuuq Commission, to discuss potential conflicts between planned oil and gas activities and subsistence use activities.

Stipulation No. 6 – Pre-Booming Requirements for Fuel Transfers

Fuel transfers from barges (excluding gasoline transfers) of 100 bbl or more require pre-booming of the fuel vessel(s). The lessee's oil-spill-contingency plans must include procedures for the pre-transfer booming of the fuel vessel(s). Shell has prepared and will implement fuel transfer procedures as part of its oil spill contingency plan. Shell's fuel transfer procedures extend to all fuel transfers, regardless of volume. A copy of the FTP is attached to EP Revision 2, as Appendix I.

Stipulation No. 7 – Measures to Minimize Effects on Spectacled and Steller's Eiders during Exploration Activities

This stipulation will minimize the likelihood that spectacled and Steller's eiders will strike drilling structures or vessels. The stipulation also provides additional protection to eiders within the blocks listed below and Federal waters landward of the sale area, including the Ledyard Bay Critical Habitat Area, during times when eiders are present.

(A) General conditions: *The following conditions apply to all exploration activities.*

(1) *An EP must include a plan for recording and reporting bird strikes. All bird collisions (with vessels, aircraft, or drilling structures) shall be documented and reported within 3 days to MMS. Minimum information will include species, date/time, location, weather, identification of the vessel, and aircraft or drilling structure involved and its operational status when the strike occurred. Bird photographs are not required, but would be helpful in verifying species. Lessees are advised that the USFWS does not recommend recovery or transport of dead or injured birds due to avian influenza concerns.*

(2) *The following conditions apply to operations conducted in support of exploratory and delineation drilling.*

(a) *Surface vessels (e.g., boats, barges) associated with exploration and delineation drilling operations should avoid operating within or traversing the listed blocks or Federal waters between the listed blocks and the coastline between April 15 and June 10, to the maximum extent practicable. If surface vessels must traverse this area during this period, the surface vessel operator will have ready access to wildlife hazing equipment (including at least three Breco buoys or similar devices) and personnel trained in its use; hazing equipment may located onboard the vessel or on a nearby OSR vessel, or in Point Lay or Wainwright. Lessees are required to provide information regarding their operations within the area upon request of MMS. The MMS may request information regarding number of vessels and their dates of operation within the area.*

(b) *Except for emergencies or human/navigation safety, surface vessels associated with exploration and delineation drilling operations will avoid travel within the Ledyard Bay Critical Habitat Area between July 1 and November 15. Vessel travel within the Ledyard Bay Critical Habitat Area for emergencies or human/navigation safety shall be reported within 24 hours to MMS.*

(c) Aircraft supporting drilling operations will avoid operating below 1,500 feet above sea level over the listed blocks or Federal waters between the listed blocks and the coastline between April 15 and June 10, or the Ledyard Bay Critical Habitat Area

between July 1 and November 15, to the maximum extent practicable. If weather prevents attaining this altitude, aircraft will use pre-designated flight routes. Predesignated flight routes will be established by the lessee and MMS, in collaboration with the USFWS, during review of the EP. Route or altitude deviations for emergencies or human safety shall be reported within 24 hours to MMS.

(B) Lighting Protocols: *The following lighting requirements apply to activities conducted between April 15 and November 15 of each year.*

(1) Drilling Structures: *Lessees must adhere to lighting requirements for all exploration or delineation drilling structures so as to minimize the likelihood that migrating marine and coastal birds will strike these structures. Lessees are required to implement lighting requirements aimed at minimizing the radiation of light outward from exploration or delineation drilling structures to minimize the likelihood that birds will strike those structures. These requirements establish a coordinated process for a performance-based objective rather than pre-determined prescriptive requirements. The performance-based objective is to minimize the radiation of light outward from exploration/delineation structures while operating on a lease or if staged within nearshore Federal waters pending lease deployment.*

Measures to be considered include but need not be limited to the following:

- *Shading and/or light fixture placement to direct light inward and downward to living and work structures while minimizing light radiating upward and outward;*
- *Types of lights;*
- *Adjustment of the number and intensity of lights as needed during specific activities;*
- *Dark paint colors for selected surfaces;*
- *Low-reflecting finishes or coverings for selected surfaces; and*
- *Facilities or equipment configuration.*

Lessees are encouraged to consider other technical, operational, and management approaches that could be applied to their specific facilities and operations to reduce outward light radiation. Lessees must provide MMS with a written statement of measures that will be or have been taken to meet the lighting objective, and must submit this information with an EP when it is submitted for regulatory review and approval pursuant to 30 CFR 550.203.

(2) Support Vessels: *Surface support vessels will minimize the use of high-intensity work lights, especially when traversing the listed blocks and federal waters between the listed blocks and the coastline. Exterior lights will be used only as necessary to illuminate active, on-deck work areas during periods of darkness or inclement weather (such as rain or fog), otherwise they will be turned off. Interior lights and lights used during navigation could remain on for safety.*

For the purpose of this stipulation, the listed blocks are as follows:

NR02-06, Chukchi Sea

6624, 6625, 6674, 6675, 6723-6725, 6773-6775, 6822, 6823, 6872

NR03-02, Posey

6872, 6873, 6918-6923, 6967-6973, 7016-7023, 7063-7073, 7112-7123

NR03-03, Colbert

6674, 6723, 6724, 6771-6774, 6820-6824, 6869-6874, 6918-6924, 6966-6974, *7015-7024, 7064-7074, 7113-7124*

NR03-04, Solivik Island

6011-6023, 6060-6073, 6109-6122, 6157-6171, 6206-6219, 6255-6268, 6305-6317, 6354-6365, 6403-6414, 6453-6462, 6502-6511, 6552-6560, 6601-6609, 6651-6658, 6701-6707, 6751-6756, 6801-6805, 6851-6854, 6901-6903, 6951, 6952, 7001

NR03-05, Point Lay West

6014-6024, 6062-6073, 6111-6122, 6160-6171, 6209-6221, 6258-6269, 6307-6317, 6356-6365, 6406-6414, 6455-6462, 6503-6510, 6552-6558, 6602-6606, 6652-6655, 6702, 6703

NR04-01, Hanna Shoal

6223, 6267-6273, 6315-6323, 6363-6373, 6411-6423, 6459-6473, 6507-6523, 6556-6573, 6605-6623, 6654-6671, 6703-6721, 6752-6771, 6801-6819, 6851-6868, 6901-6916, 6951-6964, 7001-7010, 7051-7059, 7101-7107

NR04-02, Barrow

6003-6022, 6052-6068, 6102-6118, 6151-6164, 6201-6214, 6251-6262, 6301-6312, 6351-6359, 6401-6409, 6451-6456, 6501-6506, 6551, 6552, 6601, 6602

NR04-03, Wainwright

6002-6006, 6052, 6053

NS04-08, (Unnamed)

6816-6822, 6861-6872, 6910-6922, 6958-6972, 7007-7022, 7055-7072, 7104-7122

Nothing in this stipulation is intended to reduce personnel safety or prevent compliance with other regulatory requirements (e.g., U.S. Coast Guard (USCG) or Occupational Safety and Health Administration) for marking or lighting of equipment and work areas.

Shell Proposed Actions:

Stipulation No. 7 has four parts. Part A(1) mandates that EPs for exploration drilling anywhere in the Chukchi include a plan for recording and reporting bird strikes, and therefore applies to Shell. Parts A(2) and B(2) place restrictions and lighting requirements on vessel and aircraft operations in certain listed blocks, in federal waters shoreward of those blocks, and in the Ledyard Bay Critical Habitat Unit (LBCHU), during specific dates, and these restrictions would apply to any activities associated with Shell’s EP Revision 2 that would take place in these areas during these dates. Part B(1) places lighting requirements on drilling structures and applies to the use of drilling structures anywhere in the Chukchi Sea, and therefore applies to Shell’s EP Revision 2. Part B(2) also places restrictions on the use of lights on support vessels in the listed blocks and federal waters shoreward of these blocks, and these restrictions would apply to any vessel traffic associated with Shell’s EP Revision 2 that would occur in these specific areas.

Shell has developed a Bird Strike Avoidance and Lighting Plan (EP Revision 2 Appendix E) that covers the planned exploration drilling program. In development of the plan, Shell considered all the measures identified for consideration in the stipulation, and selected the most proven and practical measures to minimize the likelihood that marine birds will strike the drilling unit or support vessels.

Shell's plan includes:

- Bird strike monitoring will include recording and reporting bird strikes for the collection of information on bird strikes and lighting configuration. This information can be used to better understand methods to reduce bird strikes.
- Installing shading and directing some drilling unit lights inward and downward to living and work structures to minimize the amount of light radiating from the drilling unit.
- Minimizing the use of high-intensity work lights on support vessels.
- Restricting aircraft and vessel traffic such as restrictions on travel routes and flight altitudes, including: the avoidance of travel within the LBCHU between 1 July and 15 November by the drilling unit and all support vessels.

The risk of Shell's exploration drilling program having an effect on marine birds, especially Steller's eiders and spectacled eiders, due to collisions, is minimal because exploration drilling would occur after the spring migration of most of these species, and more than 64 statute mi (103 km) offshore where the bird presence is relatively low.

THIS PAGE
INTENTIONALLY LEFT BLANK

8.0 CONSULTATION

In preparation for its revised Chukchi Sea exploration drilling program, Shell has engaged in an active consultation program with both Federal and State regulatory agencies, as well as local governments and interested residents of the NSB communities. Shell's ongoing consultation efforts are guided by requirements from various Federal agencies. BOEM, NMFS, and USFWS, in particular, require a POC to document consultation held between Shell and the potentially affected subsistence stakeholders. These requirements focus on the development of conflict avoidance measures between Shell and potentially affected subsistence user groups and individuals. Additionally, Shell has, and will continue to, engage with all relevant federal, state, and local agencies in regards to permitting requirements, appropriate mitigation and status of operations. Consultation with interested residents of the NSB and NWAB Communities is documented in Shell's Chukchi Sea Plan of Cooperation (Plan of Cooperation Addendum Revised Outer Continental Shelf Lease Exploration Plan Chukchi Sea) and summarized below, Shell has consulted, and/or will consult, with: BOEM, BSEE, NMFS, USFWS, USACE, USCG, EPA, interested members of Congress (including the members of the Alaska Congressional Delegation), the SOA (including the Governor's Office, the ADNR (including, ADEC, and ADF&G, and the NSB).

8.1 Plan of Cooperation

BOEM Lease Sale Stipulation No. 5 requires that all exploration operations be conducted in a manner that prevents unreasonable conflicts between oil and gas exploration activities and subsistence resources and activities. This stipulation also requires adherence to USFWS and NMFS regulations, which require an operator to implement a POC to mitigate the potential for conflicts between the proposed activity and traditional subsistence activities (50 CFR 18.124(c)(4) and 50 CFR216.104(a)(12)). A POC was prepared and was submitted with the Initial Chukchi EP. The following is a summary of the POC Addendum for EP Revision 2, which updates the POC with information regarding proposed changes in the exploration drilling program, and documentation of meetings undertaken specifically to inform the stakeholders of the revised exploration drilling program and obtain their input. The POC Addendum builds upon the previous POC. The entire POC comprises Appendix D of the Revised EP 2.

The POC identifies the measures that Shell has developed in consultation with North Slope communities and subsistence user groups and will implement during its planned Chukchi Sea exploration drilling program to minimize any adverse effects on the availability of marine mammals for subsistence uses. In addition, the POC details Shell's communications and consultations with local communities concerning its proposed exploration drilling program beginning in the summer of 2015, potential conflicts with subsistence resources and hunting activities, and means of resolving any such conflicts (50 CFR 18.128(d) and 50 CFR 216.104(a) (12) (i), (ii), (iv)). Shell has documented its contacts with North Slope communities, as well as the substance of its communications with subsistence stakeholder groups. The POC Addendum may be supplemented, as appropriate, to reflect additional engagements with local subsistence users and any additional or revised mitigation measures that are adopted as a result of those engagements. Shell will implement the POC Addendum, and the mitigation measures set forth in the document, for its Chukchi Sea exploration program.

8.1.1 Potentially Affected Subsistence Community Meetings

Potentially affected subsistence communities that were consulted regarding Shell's planned exploration drilling activities in the Chukchi Sea include: Barrow, Wainwright, Point Lay, and Point Hope. Shell conducted POC meetings in the Chukchi Sea communities of Wainwright, Point Lay and Point Hope to discuss a planned Chukchi Sea exploration drilling program, while also describing the mobilization of Chukchi Sea exploration drilling program vessels through the Bering Sea to and from the Chukchi Sea. Additionally, Shell met with subsistence groups including the AEWC, the Nanuuq Commission, the Eskimo Walrus Committee, the Beluga Commission, the Ice Seal Commission, and presented information regarding the proposed activities to the NSB and NWAB Assemblies, and NSB and NWAB Planning Commissions.

Beginning in early January 2009, Shell held one-on-one meetings with representatives from the NSB, subsistence-user group leadership, the ICAS, and Village Whaling Captain Association representatives. These meetings took place at the convenience of the community leaders and in various venues. Meetings were held starting on 12 January 2009 and have continued regularly to date. Shell's primary purpose in holding individual meetings was to inform key leaders, prior to the public meetings, so that they would be prepared to give appropriate feedback on planned activities. Meetings that either have taken place since EP Revision 1 are identified below in the Table 8.1-1.

Table 8.1-1 POC Meetings Held in 2012-2014 for the Chukchi Sea EP Revision 2

2012	**Meeting Location**	**Meeting Attendees**
23 October	Point Lay	Plan of Cooperation Community Meeting
24 October	Wainwright	Plan of Cooperation Community Meeting
26 October	Kaktovik	Plan of Cooperation Community Meeting
29 October	Barrow	Plan of Cooperation Community Meeting
30 October	Nuiqsut	Plan of Cooperation Community Meeting
6 November	Barrow	NSB Assembly Workshop Meeting
2013	**Meeting Location**	**Meeting Attendees**
29 July	Kotzebue	NWAB, City of Kotzebue, KIC & IRA representatives
5 November	Barrow	NSB Assembly
5 November	Wainwright	Plan of Cooperation Community Meeting
6 November	Point Lay	Plan of Cooperation Community Meeting
8 November	Barrow	Plan of Cooperation Community Meeting
12 November	Point Hope	Plan of Cooperation Community Meeting
2014	**Meeting Location**	**Meeting Attendees**
28 January	Kotzebue	Plan of Cooperation Community Meeting
16 June	Barrow	Stakeholder Meeting
16 June	Wainwright	Stakeholder Meeting
30 June	Barrow	Plan of Cooperation Community Meeting
1 July	Wainwright	Plan of Cooperation Community Meeting
7 July	Point Lay	Plan of Cooperation Community Meeting
8 July	Point Hope	Plan of Cooperation Community Meeting
9 July	Kotzebue	Plan of Cooperation Community Meeting
17 July	Deering	Plan of Cooperation Community Meeting
3 November	Barrow	Plan of Cooperation Community Meeting
6 November	Point Lay	Plan of Cooperation Community Meeting
2015	**Meeting Location**	**Meeting Attendees – Position**
12 January	Kotzebue	Plan of Cooperation Community Meeting
13 January	Wainwright	Plan of Cooperation Community Meeting
22 January	Buckland	Plan of Cooperation Community Meeting
22 January	Deering	Plan of Cooperation Community Meeting

[1] IRA = Indian Reorganization Act, KIC = Kikiktagruk Inupiat Corporation, NSB = North Slope Borough, NWAB = Northwest Arctic Borough

9.0 REFERENCES

Aagaard, K. 1984. The Beaufort undercurrent. pp 47- 71 *in* P. Barnes and E. Reimnitz (eds.) The Alaskan Beaufort Sea: ecosystems and environment. Academic Press, New York.

Aars, J., N.J. Lunn, and A.E. Derocher eds. 2006. Polar bears: proceedings of the 14th working meeting of the IUCN/SSC Polar Bear Specialist Group. 20–24 June 2005, Seattle, Washington, USA. IUCN, Gland, Switzerland and Cambridge, UK.

ACI and SRBA. 1984. Subsistence study of Alaska Eskimo bowhead whaling villages. Report prepared by Alaska Consultants, Inc. and Stephen Braund & Associates for the U.S. Minerals Management Service, Alaska OCS Region, Anchorage, AK.

ACI, C.S. Courtnage, and SRBA. 1984. Barrow arch socioeconomic and sociocultural description. Technical Report 101. NTIS Access No. A99/PB 85-150019. Prepared by Alaska Consultants, Inc., C.S. Courtnage, and Stephen Braund & Associates for the Minerals Management Service, Alaska OCS Region, Anchorage 641 pp.

Arctic Climate Impact Assessment (ACIA). 2004. Impacts of a warming Arctic: Arctic climate impact assessment. Cambridge University Press, Cambridge UK. 139 pp.

ACIA. 2005. Arctic climate impact assessment. Cambridge University Press, Cambridge, UK 1,042 pp. available at http://www.acia.uaf.edu/pages/scientific.html.

ADCA. 2008. Alaska community database community information summaries. Alaska Division of Community Advocacy, Alaska Department of Commerce, Community and Economic Development website accessed at http://www.commerce.state.ak.us/dca/commdb/CF_CIS.htm, July 2008.

ADCA. 2013. Alaska community database community information summaries. Alaska Division of Community Advocacy, Alaska Department of Commerce, Community and Economic Development. Website accessed at http://commerce.state.ak.us/cra/DCRAExternal/community. March 2013.

ADCCED. 2007a. Community information summaries. Alaska Department of Commerce, Community and Economic Development, Division of Community.

ADCCED. 2007b. Northwest Arctic Borough: economic overview. Alaska Department of Commerce, Community and Economic.

ADCCED. 2013. Community information summaries. Alaska Department of Commerce, Community and Economic Development, Division of Community Advocacy website accessed March 2013 at http://commerce.state.ak.us/cra/DCRAExternal/community.

Addison, E.M., J.D. Smith, R.F. McLaughlin, D.J.H. Fraser, and D.G. Loachim. 1990. Calving sites of moose in central Ontario. Alces 26:142–153.

ADEC. 2006. Alaska's final 2006 integrated water quality monitoring and assessment report. December 29, 2006. Alaska Department of Environmental Conservation, Juneau.

ADEC. 2007. Comments on the air quality sections in the Northeast NPR-A Draft Supplemental Amended IAP/EIS submitted by the Alaska Department of Environmental Conservation, Juneau, to the Bureau of Land Management on 11/6/2006.

ADEC. 2008. Summary report of improvements to the Alaska greenhouse gas emission inventory. draft. January 2008. Alaska Department of Environmental Conservation, Juneau.

ADEC (Alaska Department of Environmental Conservation) 2012. North Slope Subarea Contingency Plan, Sensitive Areas Section. Juneau, AK.

ADEC. 2013a. State of Alaska Ambient Air Quality Standards. Alaska Department of Environmental Conservation, Air Quality Control regulations 18 AAC 50.010 as amended through January 4, 2013.

ADEC. 2013b. State of Alaska Air quality designations, classifications, and control regions. Alaska Department of Environmental Conservation, Air Quality Control regulations 18 AAC 50.015 as amended through January 4, 2013.

ADF&G. 1995. An investigation of the sociocultural consequences of Outer Continental Shelf Development in Alaska. OCS study 95-0015 prepared by Alaska Department of Fish and Game, Division of Subsistence, for Minerals Management Service, Alaska OCS Region, Anchorage.

ADF&G. 1996. Community profile database update to Volume 5, Arctic Region. Alaska Department of Fish and Game, Division of Subsistence, Juneau.

ADF&G. 1998. Essential fish habitat assessment report for salmon fisheries in the EEZ off the coast of Alaska. Report prepared by Alaska Department of Fish & Game, National Marine Fisheries Service, and North Pacific Fishery Management Council for the North Pacific Fishery Management Council, Anchorage, Alaska.

ADF&G. 2000. Community profile database 3.04 for Access 97. Alaska Department of Fish and Game, Division of Subsistence, Anchorage.

ADF&G. 2008. Community subsistence information system: CSIS. Public Review Draft. Alaska Department of Fish and Game, Division of Subsistence, Anchorage.

ADH&SS. 2004a. Use of traditional foods in a health diet in Alaska: the risks in perspective. Second Edition, Vol. 1, Polychlorinated biphenyls PCBs. Alaska Department of Health and Human Services Epidemiology Bulletins 8(8):1-68.

ADH&SS. 2004b. Use of traditional foods in a healthy diet in Alaska: the risks in perspective. Second Edition, Vol. 2 Mercury Alaska Department of Health and Human Services Epidemiology Bulletins 8(11):1-48.

ADH&SS. 2007. HIV Infection in Alaska through 2005. Alaska Department of Health and Human Services Epidemiology Bulletins 11(2):1-45.

Adler, A.I., E.J. Boyko, C.D. Schraer, and N.J. Murphy. 1996. The negative association between traditional physical activities and the prevalence of glucose intolerance in Alaska Natives. Diabetic Medicine 136:555-560.

AECOM, Inc. 2009a. Wainwright near-term ambient air quality monitoring program first quarter data report November 2008 through January 2009 final. Unpublished report prepared by AECOM, Inc. for ConocoPhillips Alaska, Inc., Anchorage, Alaska.

AECOM, Inc. 2009b. Wainwright near-term ambient air quality monitoring program second quarter data report February through April 2009 final. Document No. 01865-104-3220 prepared by AECOM, Inc. for ConocoPhillips Alaska, Inc., Anchorage, Alaska.

AECOM, Inc. 2009c. Wainwright near-term ambient air quality monitoring program third quarter data report May through July 2009 final. Document No. 01865-104-3230 prepared by AECOM, Inc. for ConocoPhillips Alaska, Inc., Anchorage, Alaska.

AECOM, Inc. 2009d. Wainwright near-term ambient air quality monitoring program fourth quarter data report August through October 2009 final revision 02. Unpublished report prepared by AECOM, Inc. for ConocoPhillips Alaska, Inc., Anchorage, Alaska.

AECOM, Inc. 2009e. Wainwright permanent ambient air quality monitoring program fourth quarter data report September through December 2009 final. Unpublished report prepared by AECOM, Inc. for ConocoPhillips Alaska, Inc., Anchorage, Alaska.

AECOM, Inc. 2010a. Wainwright near-term ambient air quality monitoring program annual data report November 2008 through November 2009 final. Unpublished report prepared by AECOM, Inc. for ConocoPhillips Alaska, Inc. Anchorage, Alaska.

AECOM, Inc. 2010b. Wainwright permanent ambient air quality monitoring program first quarter data report January through March 2010 final. Unpublished report prepared by AECOM, Inc. for ConocoPhillips Alaska, Inc., Anchorage, Alaska.

AECOM, Inc. 2010c. Wainwright permanent ambient air quality monitoring program second quarter data report April through June 2010 draft. Unpublished report prepared by AECOM, Inc. for ConocoPhillips Alaska, Inc., Anchorage, Alaska.

AECOM, Inc. 2010d. Wainwright permanent ambient air quality monitoring program third quarter data report July through September 2010 draft. Unpublished report prepared by AECOM, Inc. for ConocoPhillips Alaska, Inc., Anchorage, Alaska.

AECOM, Inc. 2011a. Wainwright permanent ambient air quality monitoring program fourth quarter data report October through December 2010 draft. Unpublished report prepared by AECOM, Inc. for ConocoPhillips Alaska, Inc., Anchorage, Alaska.

AECOM, Inc. 2011b. Wainwright permanent ambient air quality monitoring program annual data report January 2010 through December 2010 final. Unpublished report prepared by AECOM, Inc. for ConocoPhillips Alaska, Inc. Anchorage, Alaska.

Aerts, L.A.M., A. Kirk, C. Schudel, K. Lomac-Macnair, A. McFarland, B. Sesier, and C. Watts. 2011. Marine mammal distribution and abundance in the northeast Chukchi Sea, July-October 2008-2010. Final Report. prepared for ConocoPhillips Company, Shell Exploration and Production Company, and Statoil USA E&P, Inc. by Lama Ecological, OASIS Environmental Inc. and Fairweather Science, Anchorage, AK.

Aerts, L.A.M., A. Kirk, C. Schudel, B. Watts, P. Sesier, A. McFarland, and K. Lomac-Macnair. 2012. Marine mammal distribution and abundance in the northeast Chukchi Sea, July-October 2008-2011. Draft Report. Prepared for ConocoPhillips Company, Shell Exploration and Production Company, and Statoil USA E&P, Inc. by Lama Ecological, OASIS-ERM, ABR Inc., and Fairweather Science. 69 pp.

Aerts, L.A.M.,W. Hetrick, S. Sitkiewicz, C.S. Schudel, D. Snyder, and R. Gumtow. 2013. Marine mammal distribution and abundance in the northeastern Chukchi Sea during summer and early fall 2008-2012. Prepared by Lama Ecological for ConocoPhillips Company, Shell Exploration and Production Company, and Statoil USA E&P, Inc., Anchorage, AK. 69 pp.

Aerts, L.A.M., C.L. Christman, C.A. Schudel, W. Hetrick, and D. Snyder. 2014. Marine mammal distribution and abundance in the northeastern Chukchi Sea from shipboard surveys during summer and early fall, 2008–2013. Final report prepared by LAMA Ecological, Anchorage, AK for ConocoPhillips Company, Shell Exploration & Production Company, and Statoil USA E&P, Inc., Anchorage, AK. 71 pp.

AES-RTS. 2009. Subsistence advisor program summary North Slope, Alaska. Report dated April 2009 prepared by ASRC Energy Services, Regulatory and Technical Services for Shell Exploration and Production Company, Anchorage, AK.

Ahrens, C. D. 2013. Meteorology Today: An Introduction to Weather, Climate, and the Environment. Tenth ed. Belmont, California: Brooks/Cole.

Ahtuangaruak, R. 2003. Public testimony at the public hearing on the draft integrated activity plan/Environmental Impact Statement for the Northwest National Petroleum Reserve-Alaska. Washington, D.C., March 13, 2003 in Wernham, Aaron 2007 Inupiat Health and Proposed Alaskan Oil Development: Results of the First Integrated Health Impact Assessment/ Environmental Impact Statement for Proposed Oil Development on Alaska's North Slope. EcoHealth 4:500–513.

Air Sciences Inc. 2015. Shell Revised Outer Continental Shelf Lease Exploration Plan, Chukchi Sea, Alaska, Revision 2: Appendix K – AQRP and NEPA Emission Inventories. February 6, 2015. Prepared for Shell Gulf of Mexico Inc. 105 pp.

Alaska Beluga Whale Committee. 2002. E-mail dated Jun. 6, 2002, from K. Frost to M. Burwell, MMS Alaska OCS Region; subject: harvest figures for beluga whales at Point Lay and Wainwright.

Alaska Beluga Whale Committee. 2006. Email dated March 6, 2006, to Michael Burwell, MMS Alaska OCS Region from Kathy Frost, State of Alaska, Dept. of Fish and Game; subject: updated beluga whale subsistence-harvest information for the communities of Barrow, Wainwright, Point Lay, Point Hope, and Kivalina from 1980 through 2005.

Alaska Native Health Board, Inc. 1999. Alaska pollution issues. Alaska Native Health Board, Anchorage, AK.

Alaska Native Medical Center. 2008. Diabetes program. diabetes maps.

Alaska Shorebird Working Group. 2008. Alaska shorebird conservation plan. Version II. Alaska Shorebird Group, Anchorage, Alaska. Accessed March 27, 2009 at http://alaska.fws.gov/mbsp/mbm/shorebirds/plans.htm.

Albert, T.A., ed. 1981. Some thoughts regarding the possible effects of oil contamination on bowhead whales, *Balaena Mysticetus*. pp. 945-953 *in* Tissue structural studies and other investigations on the biology of endangered whales in the Beaufort Sea. OCSEAP Final Report for the period Apr. 1, 1981-Jun. 30, 1981, Vol. 1. Anchorage, AK: USDOI, BLM, Alaska OCS Office.

Aldredge, A., M. Elias, and C. Gotschalk. 1986. Effects of drilling muds and mud additives on the primary production of natural assemblages of marine phytoplankton. Marine Environmental Research 19:157-176.

Alexander, V., R. Horner, and R. Clasby. 1974. Metabolism of arctic sea ice organisms. IMS Report R74-4. Fairbanks: UAF.

Allen, B.M. and R.P. Angliss. 2010. Alaska marine mammal stock assessments, 2009. U. S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-206, 276 p. NTIS No. PB2010-107408. Preface or View Online (.pdf, 14.5 MB).

Allen, B. M. and R. P. Angliss. 2011. Alaska marine mammal stock assessments, 2010. U.S. Dep. Commer., NOAA Tech. Memo. NMFSAFSC-223, 292 p.

Allen, B. M. and R. P. Angliss. 2012. Alaska marine mammal stock assessments, 2011. U.S. Dep. Commer., NOAA Tech. Memo. NMFSAFSC-234, 288 p.

Allen, B.M. and R.P. Angliss. 2014. Alaska marine mammal stock assessments, 2003. U. S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-277.

Alliston, W. 1980. The distribution of ringed seals in relation to winter ice-breaking activities near McKinley Bay, N.W.T., January-June 1980. Report prepared by LGL Ltd., Toronto, Ontario for Petro-Canada, Calgary, Alberta, CA. 13 pp.

Alliston, W. 1981. The distribution of ringed seals in relation to winter ice-breaking activities in Lake Melville, Labrador. Report prepared by LGL Ltd., St. Johns, Newfoundland for the Arctic Pilot Project, Dome Petroleum Ltd., Calgary, Alberta, CA. 52 pp.

Alverson, D.L. and N.J. Wilimovsky. 1966. Fishery investigations of the southeastern Chukchi Sea. Vol. 2, Chap. 31, pp 843-860 i*n:* N.J. Wilimovsky and J.N. Wolfe (eds.). Environment of the Cape Thompson Region, Alaska. U.S. Atomic Energy Commission, U.S. Dep. Commerce, Springfield, VA.

AMAP. 1998. AMAP assessment report: arctic pollution issues. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway. xii+859 pp.

AMAP. 2006. Arctic pollution 2006. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway (www.amap.no).

Amstrup, S.C. 1995. Movements, distribution, and population dynamics of polar bears in the Beaufort Sea. PhD Dissertation, University of Alaska, Fairbanks, AK. 299 pp.

Amstrup, S.C. 2003. Polar bear Ursus maritimus. pp 587-610 in: G.A. Feldhamer, B.C. Thompson, and J.A. Chapman (eds.) Wild mammals of North America: biology, management, and conservation. Johns Hopkins University Press. Baltimore, MD.

Amstrup, S.C. and C. 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, and T.L. McDonald. 2005. Allocating harvest among polar bear stocks in the Beaufort Sea. Arctic. 58:247-259.

Amstrup, S.C., B.G. Marcot, and D.C. Douglas. 2007. Forecasting the range-wide status of polar bears at selected times in the 21st Century. U.S. Geological Survey, Reston, Virginia 126 pp.

Anderson, B.A., R.J. Ritchie, A.A. Stickney, J.E. Shook, J.P. Parrett, and L.B. Attanas. 2004. Avian studies in the Kuparuk Oilfield, Alaska, 2003. Final Report. Prepared for ConocoPhillips Alaska, Inc., Anchorage, AK and The Kuparuk River Unit by ABR, Inc., Fairbanks, AK.

Anderson, C.M., and R.P. LaBelle. 2000. Update of comparative occurrence rates for offshore oil spills. Spill Science Technology Bulletin 6(5/6):303-321.

Andriyashev, A.P. 1954. Ryby severnykh morei SSSR (Fish of northern Soviet Seas). Izadatel' stuo AN SSSR, Moscow. (Transl. by Israel Sci. Transl., Springfield, VA, OTS63-11160).

Angliss, R.P. and R.B. Outlaw. 2008. Alaska marine mammal stock assessments, 2007. Final Report. Seattle, WA: USDOC, NMFS, NMFS-AFSC-180. pp. 252.

ANTHC. 2008a. Alaska native injury: atlas of morbidity and mortality. Anchorage, AK: Alaska Native Tribal Health Consortium. *in*: USDOI, MMS. 2008. Draft Environmental Impact Statement. Beaufort and Chukchi Sea Planning Areas Oil and Gas Lease Sales 209, 212, 217, and 221, OCS EIS/EA MMS 2008-0055. Anchorage, AK: USDOI, MMS, Alaska OCS Region.

ANTHC. 2008b. Regional health profile: arctic slope native association. Unpublished preliminary report. Anchorage, AK: Alaska Native Tribal Health Consortium.

Arhonditsis, G.B., G. Perhar, and W. Zhang. 2008. Addressing equifinality and uncertainty in eutrophication models. Water Resources Research (in press, electronic version available).

ASCG. 2005. North Slope Borough comprehensive transportation plan. Prepared by ASCG Incorporated. August 2005.

ASRC. 2007. Communities. Arctic Slope Regional Corporation.
http://www.asrc.com/communities/Pages/Communities.aspx. (Accessed March 2007).

ASRC Energy Services. 2009. Subsistence Advisor Program summary North Slope, Alaska. Report dated April 2009. Prepared by ASRC Energy Services for Shell Exploration and Production Company, Anchorage, Alaska.

ASRC Energy Services. 2010. Subsistence Advisor Program summary North Slope, Alaska. Report. Prepared by ASRC Energy Services for Shell Exploration and Production Company, Anchorage, Alaska.

ATSDR. 2003. Health consultation review of burbot samples US Army USACE Umiat Air Force Station, Prudhoe Bay, North Slope Borough, Alaska EPA Facility ID: USDHHS Public Health Service/Agency for Toxic Substances and Disease Registry Division of Health Assessment and Consultation Atlanta, Georgia 30333.

Au, W.W.L., A.N. Popper, and R.R. Fay. 2000. Hearing by whales and dolphins. Springer-Verlag, New York, NY. 458 p.

Audubon. 2009. Alaska Region. Birds of the Chukchi Sea. http://ak.audubon.org/chukchi-sea (accessed May 12, 2009).

Austin, M. and G. Warner. 2010. Acoustic monitoring of the drillship Frontier Discoverer. Version 1.0 Dated 01 February 2010. Technical Report prepared by Jasco Applied Sciences, Victoria, B.C. for Shell International Exploration and Production, Inc., Houston, TX. 45 p.

Austin, M., A. McCrodan, C. O'Neill, Z. Li, and A. MacGillivray. 2013. Underwater sound measurements. (Chapter 3) in: Bisson, L.N., H.J. Reider, H.M. Patterson, M. Austin, J.R. Brandon, T. Thomas, and M.L. Bourdon. 2013. Marine mammal monitoring and mitigation during exploratory drilling by Shell in the Alaskan Chukchi and Beaufort seas, July–November 2012: Draft 90-Day Report. Editors: D.W. Funk, C.M. Reiser, and W.R. Koski. LGL Rep. P1272D–1. Rep. from LGL Alaska Research Associates Inc., Anchorage, AK, USA, and JASCO Applied Sciences, Victoria, BC, Canada, for Shell Offshore Inc., Houston, TX, USA, Nat. Mar. Fish. Serv., Silver Spring, MD, USA, and U.S. Fish and Wild. Serv., Anchorage, AK. 266 p. + app.

Awbrey, F.T. and B.S. Stewart. 1983. Behavioral responses of wild beluga whales (*Delphinapterus leucas*) to noise from oil drilling. Journal of the Acoustical Society of America, 74, S54.

Ayers, R., T. Sauer, Jr., and D. Steubner. 1980a. An environmental study to assess the effect of drilling fluids on water quality parameters during high rate, high volume discharge to the ocean. pp 351-416 *in*: Proceedings of Symposium, Research on Environmental Fate and Effects of Drilling Fluids and Cuttings, Vol. I, January 21-24, 1980, Lake Buena Vista, Florida. American Petroleum Institute, Washington, DC.

Ayers Jr., R., T. Sauer, Jr., R. Meek, and G. Bowers. 1980b. An environmental study to assess the impact of drilling discharges in the mid-Atlantic. I. Quantity and fate of discharges. pp 382-416 *in*: Symposium on Research on Environmental Fate and Effects of Drilling Fluids and Cuttings. American Petroleum Institute, Washington, DC.

Bailey, A. 1948. Birds of arctic Alaska. Colorado Museum Natural History Pop. Ser. No.8, 317 pp.

Baker, C., L. Herman, B. Bays, and G. Bauer. 1983. The impact of vessel traffic on the behavior of humpback whales in southeastern Alaska. National Marine Mammal Laboratory, Seattle, Washington 30 pp.

Baker, J.M., R.B. Clark, and P.F. Kingston. 1991. Two years after the spill: Environmental recovery in Prince William Sound and the Gulf of Alaska. Institute of Offshore Engineering, Heriot-Watt University, Edinburgh, EH14 4AS, Scotland. 31 pp.

Balcomb, K.C., III and D.E. Claridge. 2001. A mass stranding of cetaceans caused by naval sonar in the Bahamas. Bahamas J. Sci. 8(2):2-12.

Ballachey, B.E., J.L. Bodkin, D. Esler, D. Irons, and D. Snyder. 2007. Evaluating the long-term exposure of nearshore vertebrates to lingering oil from the Exxon Valdez oil spill. *in:* J. Massey (ed.) Proceedings papers: effect of oil on wildlife 2007. Ninth International Effects of Oil on Wildlife Conference, Monterey, CA. Published by the UC Davis Wildlife Health Center, Davis, CA.

Ballard, W.B., J.S. Whitman, and D.J. Reed. 1991. Population dynamics of moose in south central Alaska. Wildlife Monographs 30: 6-45.

Barber, D. G., J. V. Lukovich, J. Keogak, S. Baryluk, L. Fortier, and G. Henry. 2009. The Changing Climate of the Arctic. Arctic. 61 (5): 7-26.

Barber, W., M. Vallarino, and R. Smith. 1994. Fish and fish assemblages of the northeastern Chukchi Sea, Alaska. pp 9-1 to 9-22 *in:* W. Barber, R. Smith and T. Weingartner (eds.) Fisheries Oceanography of the Northeast Chukchi Sea. OCS Study MMS 93-0051, Minerals Management Service, Alaska OCS Region, Anchorage, AK.

Barber, W., R. Smith, M. Vallarino, and R. Meyer. 1997. Demersal fish assemblages of the northeastern Chukchi Sea, Alaska. Fishery Bulletin 95:195-209.

Barry, T. and R. Spencer. 1976. Wildlife response to oil well drilling. Canadian Wildlife Service Notes No.67, 15 pp.

Bates, N.R. 2007. Interannual variability of the oceanic CO_2 sink in the subtropical gyre of the North Atlantic Ocean over the last two decades. Journal of Geophysical Research (Oceans), 112 (C9), C09013, doi:2006JC003759, May 4, 2007.

Bates, N.R. and J.T. Mathis. 2009. The Arctic Ocean marine carbon cycle: Evaluation of air-sea carbon dioxide exchanges, ocean acidification impacts and potential feedbacks. Biogeosciences, 6(11), 2433-2459.

Bates, N.R., J.T. Mathis, and L. Cooper. 2009. The effect of ocean acidification on biologically induced seasonality of carbonate mineral saturation states in the Western Arctic Ocean. Journal of Geophysical Research (Oceans), 114, C11007, DOI: 10.1029/2008JC004862.

Batelle Memorial Institute, Exponent, Inc., Florida Institute of Technology, Neff and Associates. 2010. Environmental Studies in the Chukchi Sea 2008. Prepared for ConocoPhillips Alaska, Inc. and Shell Exploration and Production. Anchorage, AK.

Beland, J.A., D.S. Ireland, L.N. Bisson, and D. Hannay, editors. 2013. Marine mammal monitoring and mitigation during a marine seismic survey by ION Geophysical in the Arctic Ocean, October-November 2012: 90-day report. LGL Rep. P1236. Rep. from LGL Alaska Research Associates Inc., LGL Ltd., and JASCO Research Ltd. for ION Geophysical, National Marine Fisheries Service, and U.S. Fish and Wild. Service. 156 pp, plus appendices.

Bélanger, L. and J. Bédard. 1989. Responses of staging greater snow geese to human disturbance. Journal of Wildlife Management. 53:713-719.

Bendock, T. 1977. Beaufort Sea estuarine fishery study. pp 670-729 *in* Environmental assessment of the Alaskan Continental Shelf, Final Report of the Principal Investigators, Volume 4 Biological Studies, March 1979. National Ocean and Atmospheric Administration, Outer Continental Shelf Environmental Assessment Program, Boulder, CO.

Bengston, J., L. Hiruki-Raring, M. Simpkins, and P. Boveng. 2005. Ringed and bearded seal densities in the eastern Chukchi Sea, 1999-2000. Polar Biology. 28:833-845.

Bent, A.C. 1987. Life histories of North American waterfowl. Dover Publications, Inc., New York.

Bentzen, T.W., E.H. Follmann, S.C. Amstrup, G.S. York, M.J. Wooller, and T.M. O'Hara. 2007. Variation in winter diet of southern Beaufort Sea polar bears inferred from stable isotope analysis. Can. J. Zool. 85(5):596–608.

Bercha Group. 2006. Alternative oil spill occurrence estimators and their variability for the Chukchi Sea – fault tree method. Final Task 1 Report. OCS Study MMS 2006-033 prepared by Bercha International Inc., Calgary, Alberta, Canada for the Minerals Management Service, Alaska OCS Region, Anchorage, Alaska.

Bercha Group. 2008. Alternative Oil Spill Occurrence Estimators and Their Variability for the Alaskan OCS- Fault Tree Method: Update of GOM OCS Statistics to 2006. OCS Study MMS 2008-025. U.S. Department of the Interior Minerals Management Service, Alaska Outer Continental Shelf Region, Anchorage. October 2008.

Bercha Group, Inc. 2014. Loss of Well Control Occurrence and Size Estimators for Alaska OCS. OCS Study, BOEM 2014-772. Anchorage, AK. USDOI, BOEM, Alaska OCS Region, 99pp.

Bergen, S., G.M. Durner, D.C. Douglas, and S.C. Amstrup. 2007. Predicting movements of female polar bears between summer sea ice foraging habitats and terrestrial denning habitats of Alaska in the 21st century: proposed methodology and pilot assessment. U.S. Geological Survey. Administrative Report.

Bersamin, A., B. Luick, E. Ruppert, J. Stern, and S. Zidenberg-Cherr. 2006. Diet quality among Yup'ik eskimos living in rural communities is low: the center for Alaska native health research pilot study Journal of the American Dietetic Association 106(7):1055-1063.

Bessiere, A, C. Nozais, S. Brugel, S. Demers, and G. Desrosiers. 2007. Metazoan meiofauna dynamics and pelagic-benthic coupling in the southeastern Beaufort Sea, Arctic Ocean. Polar Biology 30:1123-1135.

Bigelow, N.H. and W.M.R. Powers. 2001. Climate, vegetation, and archaeology 14,000-9000 cal yr B.P. in Central Alaska. Arctic Anthropology 38(2):171-195.King, Thomas F. 1998. Cultural resource law & practice: An introductory guide. Heritage Resource Management Series. Series editor: Don Fowler. Altamira Press. New York, NY.

Bisson, L.N., H.J. Reider, H.M. Patterson, M. Austin, J.R. Brandon, T. Thomas, and M.L. Bourdon. 2013. Marine mammal monitoring and mitigation during exploratory drilling by Shell in the Alaskan Chukchi and Beaufort seas, July–November 2012: Draft 90-Day Report. Editors: D.W. Funk, C.M. Reiser, and W.R. Koski. LGL Rep. P1272D–1. Rep. from LGL Alaska Research Associates Inc., Anchorage, AK, USA, and JASCO Applied Sciences, Victoria, BC, Canada, for Shell Offshore Inc., Houston, TX, USA, Nat. Mar. Fish. Serv., Silver Spring, MD, USA, and U.S. Fish and Wild. Serv., Anchorage, AK, USA. 266 pp, plus appendices.

Bjerregaard, T.K. Young, E. Dewailly, and S. Ebbesson. 2004. Indigenous health in the Arctic: an overview of the circumpolar Inuit population. Scandinavian Journal of Public Health 325:390-395.

Blackwell, S.B., and C.R. Greene, Jr. 2002. Acoustic measurements in Cook Inlet, Alaska, during August 2001. Report prepared by Greeneridge Sciences, Inc., Santa Barbara, CA, for the National Marine Fisheries Service, Anchorage, AK.

Blackwell, S.B., and C.R. Greene, Jr. 2005. Underwater and in–air sounds from a small hovercraft. Journal of the Acoustical Society of America 118(6):3646–3652.

Blackwell, S.B., and C.R. Greene, Jr. 2006. Sounds from an oil production island in the Beaufort Sea in summer: characteristics and contribution of vessels. Journal of the Acoustical Society Of America119(1):182–196.

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. Journal of the Acoustical Society of America 116:3199-3219.

Blackwell, S., W. Burgess, R. Norman, C. Greene, Jr., W. M. McLennan, and J. Richardson. 2008. Chapter 2: acoustic monitoring of bowhead whale migration, autumn 2007. *in*: L. Aerts and W.J. Richardson (eds.). 2008. Monitoring of industrial sounds, seals, and bowhead whales near BP's Northstar Oil Development, Alaskan Beaufort Sea, 2007: Annual Summary Report. LGL Rep. P1005b. Rep. from LGL Alaska Research Associates (Anchorage, AK), Greeneridge Sciences Inc. (Santa Barbara, CA) and Applied Sociocultural Research (Anchorage, AK) for BP Exploration (Alaska) Inc., Anchorage, AK.

Blackwell, S.B., C.R. Greene, H.K. Kim, T.L. McDonald, C.S. Nations, R.G. Norman, and A. Thode. 2010. Beaufort Sea acoustic monitoring program. Chapter 9 *in*: D.W. Funk, D.S. Ireland, R. Rodrigues, and W.R. Koski (eds.). 2010. Joint Monitoring Program in the Chukchi and Beaufort seas, open-water seasons, 2006–2008. LGL Alaska Report P1050-3, Report from LGL Alaska Research Associates, Inc., LGL Ltd., Greeneridge Sciences, Inc., and JASCO Research, Ltd., for Shell Offshore, Inc. and Other Industry Contributors, and National Marine Fisheries Service, U.S. Fish and Wildlife Service. 499 p. plus Appendices.

Blackwell S. B. et al. 2013. Effects of airgun sounds on bowhead whale calling rates in the Alaskan Beaufort Sea. Marine Mammal Science 29(4):E342-E365.

Blanchard, A.L. and A.L. Knowlton. 2014. Chukchi Sea Environmental Studies Program: Benthic Ecology of the Northeastern Chukchi Sea, 2008-2013. Final Report. Prepared For ConocoPhillips Company, Shell Exploration & Production Company, and Statoil USA E&P, Inc. by University of Alaska, Fairbanks, AK.

Blanchard, A.L., and A. Knowlton. 2013a. Chukchi Sea Environmental Studies Program 2008-2011: Benthic ecology of the northeastern Chukchi Sea. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil USA E&P, Inc. by University of Alaska, Fairbanks, AK.

Blanchard, A. and A. Knowlton. 2013b. Benthic ecology of the Northeastern Chukchi Sea. Chukchi Sea Environmental Studies Program 2008-2012. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil USA E&P, Inc. by University of Alaska, Fairbanks, AK.

Blanchard, A.L., H. Nichols, and C. Parris. 2010a. Benthic ecology of the Burger and Klondike survey areas: 2008 environmental studies program in the northeastern Chukchi Sea. Prepared for

ConocoPhillips Alaska, Inc. and Shell Exploration & Production Company, by University of Alaska, Fairbanks, AK.

Blanchard, A.L., C. Parris, and H. Nichols. 2010b. Benthic ecology of the Burger and Klondike survey areas: 2009 environmental studies program in the northeastern Chukchi Sea. Prepared for ConocoPhillips Alaska, Inc. and Shell Exploration & Production Company, by University of Alaska, Fairbanks, AK.

Blanchard, A.L., C. Parris, and A.L. Knowlton. 2011. Benthic ecology of the Northeastern Chukchi Sea. Chukchi Sea Environmental Studies Program 2008-2010. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil USA E & P, Inc. by University of Alaska, Fairbanks, AK.

Blaxter, J.H.S., E.J. Denton, and J.A.B. Gray. 1981. The auditory bullae-swimbladder system in late stage herring larvae. Journal of the Marine Biological Association of the United Kingdom 61:315–326.HYPERLINK http://icesjms.oxfordjournals.org/cgi/external_ref?access_num=A1981LP96500004&link_type=ISI.

Blees, M.K., K.G. Hartin, D.S. Ireland, and D. Hannay. 2010. Marine mammal monitoring and mitigation during open water seismic exploration by Statoil USA E&P Inc. in the Chukchi Sea, August-October 2010: 90-day report. LGL Rep. P119. Report from LGL Alaska Research Associates Inc., LGL Ltd., and JASCO Research Ltd. for Statoil USA E&P Inc., National Marine Fisheries Service, and U.S. Fish and Wildlife Service. 102 pp+ App.

BLM. 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. USDOI Bureau of Land Management, Alaska State Office, Anchorage, AK.

BLM. 2003. Northwest National Petroleum Reserve–Alaska Integrated Activity Plan/Environmental Impact Statement. USDOI Bureau of Land Management, Fairbanks, AK in cooperation with USDOI Minerals Management Service, Anchorage, AK. 3 Volumes.

BLM. 2013. National Petroleum Reserve-Alaska Integrated Activity Plan: Record of Decision. Prepared by U.S. Department of the Interior, Bureau of Land Management. Anchorage, Alaska.

Boehm, P.D. and D.L. Fiest. 1980. Aspects of the transport of petroleum hydrocarbons to the offshore benthos during the Ixtoc-I blowout in the Bay of Campeche. pp 207-238 *in:* Proceedings of a Symposium. Preliminary results from the September 1979 Researcher/Pierce Ixtoc-I Cruise. National Oceanic and Atmospheric Administration, Washington, DC.

BOEM 2013. Alaska Outer Continental Shelf Shell Gulf of Mexico, Inc. (Shell) 2013 Ancillary Activities Survey; Chukchi Sea, Environmental Assessment. OCS EIS/EA 2013-01161, U.S. Department of Interior, Bureau of Ocean Energy Management, Alaska OCS Region, Office of Environment, Anchorage, AK.

BOEM. 2011a. Chukchi Sea Planning Area, Shell Gulf of Mexico, Inc., Shell revised Chukchi Sea exploration plan Burger Prospect: Posey Area Blocks 6714, 6762, 6764, 6812, 6912, 6915, Chukchi Lease Sale 193, Environmental Assessment. OCS EIS/EA BOEM 2011-061, Bureau of Ocean Energy Management, Alaska OCS Region, Anchorage, AK. 153 p. + app.

BOEM. 2011b. Letter Seeking SHPO Review and Concurrence with BOEMs finding of "no effect on historic properties" for Shell's proposed drilling at the Burger Prospect. *Letter from* David Johnston (BOEM) *to* Judith Bittner (SHPO). Letter dated November 2011. U.S. Department of Interior. Bureau of Ocean Energy Management.

BOEM. 2012. Outer Continental Shelf Oil and Gas Leasing Program: 2012-2017, Final Programmatic Environmental Impact Statement. http://www.boem.gov/Five-Year-Program-2012-2017.

BOEM. 2015. Alaska Outer Continental Shelf. Chukchi Sea Planning Area. Oil and Gas Lease Sale 193 in the Chukchi Sea, Alaska. Final Second Supplemental Environmental Impact Statement. OCS EIS/EA BOEM 2014-669. U.S. Department of Interior, Bureau of Ocean Energy Management, Alaska OCS Region, Office of Environment, Anchorage, AK.

BOEMRE. 2010. Modifications to suspension of deepwater drilling operations environmental assessment and finding of no significant impact, page 45. October 12. Bureau of Ocean Energy Management, Regulation and Enforcement.

BOEMRE. 2011a. Chukchi Sea Planning Area: Statoil USA E&P Inc. 2011 ancillary activities, Chukchi Sea, Alaska: Environmental Assessment. OCS EIS/EA BOEMRE 2011-036. USDOI, Bureau of Ocean Energy Management, Regulation and Enforcement, Alaska OCS Region, Anchorage, AK. 62 p. + app.

BOEMRE. 2011b. Chukchi Sea Planning Area: oil and gas lease sale 193 in the Chukchi Sea. Final Supplemental Environmental Impact Statement. OCS EIS/EA BOEMRE 2011-041. USDOI, Bureau of Ocean Energy Management, Regulation and Enforcement, Alaska OCS Region, Anchorage, AK.

Bogoslovskaya, L., L. Votrogov, and T. Semenova. 1981. Feeding habits of the gray whale off Chukotka. SC/32/PS20 Report of the International Whaling Commission 31:507-510.

Boness, D.J. and D.W. Bowen. 1996. The evolution of maternal care in pinnipeds. Bioscience 46(9):645-654.

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(3):171-178.

Boudreau, B. 1989. Biological clearance for Burger and Crackerjack prospects. U.S. Govt. Memorandum, to District Office Supervisor from Regional Supervisor, Field Operations, Minerals Management Service, Alaska OCS Region, Anchorage.

Boveng, PL, 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*). U.S. Department of Commerce, NOAA Tech. Memo. NMFS-AFSC-191. http://alaskafisheries.noaa.gov/protectedresources/seals/ice/ribbon/statusreview08.pdf.

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*). U.S. Department of Commerce, NOAA Tech. Memo. NMFS-AFSC-200. http://www.afsc.noaa.gov/publications/AFSC-TM/NOAA-TM-AFSC-200.pdf.

Bowles, A.E., M. 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 96:2469-2484.

Bowman, T.D. 2004. Field guide to bird nests and eggs of Alaska's coastal tundra. Alaska Sea Grant College Program, University of Alaska Fairbanks, AK.

Bowyer, R.T., M.C. Nicholson, M. Molvar, and J. Faro. 1999. Moose on Kalgin Island: are density-dependent processes related to harvest. Alces 35:73-89.

BPXA. 1996. Northstar development project – conceptual engineering report. BP Exploration [Alaska], Inc.

BPXA. 2004. Request for a letter of authorization pursuant to Section 101 (a) 5 of the Marine Mammal Protection Act covering taking of marine mammals incidental to the operation of the Northstar facility in the U.S. Beaufort Sea. Prepared by LGL Alaska Research Associates, Inc., Anchorage, AK and LGL Limited, King City, Ontario for BP Exploration (Alaska) Inc., Anchorage, AK. p. 103.

Braham, H.W. 1984. Distribution and migration of gray whales in Alaska. pp 249-266 *in:* M.L. Jones, S.L. Swartz, and S. Leatherwood (eds.) The gray whale *Eschrichtius robustus*. Academic Press, Orlando, FL 600pp.

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(9-10):36-46.

Brandsma, M., L. Davis, R. Ayers, Jr., and T. Sauer, Jr. 1980. A computer model to predict the short-term fate of drilling discharges in the marine environment. pp 588 - 608 *in:* Proceedings of symposium, research on environmental fate and effects of drilling fluids and cuttings, January 21-24, 1980, Lake Buena Vista, Florida American Petroleum Institute, Washington, DC.

Bratton, G.R., C.B. Spainhour, W. Flory, M. Reed, and K. Jayko. 1993. Presence and potential effects of contaminants. pp 701-744 *in:* J. Burns, J.J. Montague, and C.J. Cowles (eds.) The bowhead whale book. Special Publication No. 2, The Society for Marine Mammalogy, Lawrence, KS.

Braund, S.R. and D.C. Burnham. 1984. Subsistence economics and marine resource use patterns. *in* J.C. Truett (ed.). The Barrow arch environment and possible consequences of planned offshore oil and gas development. Proceedings of a Synthesis Meeting, Girdwood, AK., Oct. 30-Nov. 1, 1983. USDOC, NOAA, OCSEAP, and Minerals Management Service, Alaska OCS Region, Anchorage, Alaska.

Brewer, K., M. Gallagher, P. Regos, P. Isert, and J. Hall. 1993. ARCO Alaska, Inc. Kuvlum #1 exploration prospect site specific monitoring program final report. Report prepared by Coastal & Offshore Pacific Corporation, Walnut Creek, California for ARCO Alaska Inc., Anchorage, Alaska. 80 pp.

Brigham-Grette, J., A.V. Lozhkin, P.M. Anderson, and Oyu Glushkova. 2004, **“**Paloenvironmental Conditions in Western Beringia before and during the Last Glacial Maximum**”** in Madsen, D.B., editor, Entering America: Northeast Asia and Beringia before the Last Glacial Maximum, University of Utah Press, Salt Lake UT,. Chapter 2, pg. 29-61.

Brooks, A.E. 2008. Arctic Journal – Part 1. 4/7/2008 7;02:00 AM. Coast Guard Journal.

Brower, G. 2005. Testimony of Gordon Brower, Barrow, Alaska, in comments on MMS' 2007-2012 Proposed 5-Year OCS Oil and Gas Leasing Program.

Brown, R.D., P. Cote. 1992. Interannual Variability of Landfast Ice Thickness in the Canadian High Arctic, 1950-1989. *Arctic*. Vol. 45, Pgs. 273-284.

Brown, S., C. Hickey, B. Harrington, and R. Gill, eds. 2001b. The U.S. shorebird conservation plan, 2nd ed. Manomet Center for Conservation Sciences, Manomet, MA 50 pp.

Brueggeman, J. 2009a. Marine mammal surveys at the Klondike and Burger survey areas in the Chukchi Sea during the 2008 open water season. Report prepared by Canyon Creek Consulting, Seattle, Washington and provided to ConocoPhillips Alaska, Inc. and Shell Offshore Inc. 45pp.

Brueggeman, J. 2009b. 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 for ConocoPhillips Alaska, Inc. by Canyon Creek Consulting LLC, Seattle, WA.

Brueggeman, J. 2010. Marine mammal surveys at the Klondike and Burger survey areas in the Chukchi Sea during the 2009 open water season.

Brueggeman, J., C. Malme, R. Grotefendt, D. Volsen, J. Burns, D. Chapman, D. Ljungblad, and G. Green. 1990. Shell Western E&P Inc. 1989 walrus monitoring program: the Klondike, Burger, and Popcorn Prospects in the Chukchi Sea final report. Report prepared by Ebasco Environmental, Bellevue, WA for Shell Western E&P Inc., Houston, TX. 121 pp plus appendices.

Brueggeman, J., D. Volsen, R. Grotefendt, G. Green, J. Burns, and D. Ljungblad. 1991a. Shell Western E&P Inc. 1990 walrus monitoring program: the Popcorn, Burger, and Crackerjack Prospects in the Chukchi Sea. Report prepared by Ebasco Environmental, Bellevue, WA for Shell Western E&P Inc. 109 pp plus appendices.

Brueggeman, J., D. Volsen, R. Grotefendt, G. Green, J. Burns, and D. Ljungblad. 1991b. Shell Western E&P Inc. Chukchi Sea 1990 marine mammal monitoring program (whales and seals): the Popcorn, Burger, and Crackerjack Prospects in the Chukchi Sea. Appendix A in Shell Western E&P Inc. 1990 walrus monitoring program: the Popcorn, Burger, and Crackerjack Prospects in the Chukchi Sea. Report prepared by Ebasco Environmental, Bellevue, WA for Shell Western E&P Inc. 109 pp plus appendices.

Brueggeman, J., R. Grotefendt, M. Smultea, G. Green, R. Rowlett, C. Swanson, D. Volsen, C. Bowlby, C. Malme, R. Mlawski, and J.J. Burns. 1992a. 1991 Marine mammal monitoring program (whales and seals) Crackerjack and Diamond Prospects, Chukchi Sea. Report prepared by Ebasco Environmental, Bellevue, WA for Shell Western E&P Inc. and Chevron USA, Inc. 62 pp plus appendices.

Brueggeman, J., R. Grotefendt, M. Smultea, G. Green, R. Rowlett, C. Swanson, D. Volsen, C. Bowlby, C. Malme, R. Mlawski, and J.J. Burns. 1992b. Chukchi Sea 1991 marine mammal monitoring program (walrus and polar bear) Crackerjack and Diamond Prospects. Report prepared by Ebasco

Environmental, Bellevue, WA for Shell Western E&P Inc. and Chevron USA, Inc. 109 pp plus appendices.

Bryden, H.L., H.R. Longworth, and S.A. Cunningham. 2005. Slowing of the Atlantic meridional overturning circulation at 250 N. Nature 438:655-657.

Buerkle, U. 1968. Relation of pure tone thresholds to background noise level in the Atlantic cod (*Gadus morhua*). Journal of the Fisheries Research Board of Canada 25:1155-1160.

Burger. A.E. 1993. Estimating the mortality of seabirds following oil spills: effects of volume. Marine Pollution Bulletin 26 (3): 140-143.

Burns, J.J. 1967. The Pacific bearded seal. Pittman-Robertson Project. Rep. W-6-R and W-14-R, Alaska Department of Fish and Game, Anchorage 66 pp.

Burns, J.J. 1970. Remarks on the distribution and natural history of pagophilic pinnipeds in the Bering and Chukchi Seas. Journal of Mammalogy 51:445-454.

Burns, J.J. 1973. Marine mammal report. Alaska Department of Fish and Game, Pittman-Robertson Project. Rep. W-17-3, W17-4, and W-17-5.

Burns, J.J. 1981a. Ribbon seal - *Phoca fasciata*. pp. 89-109 *in*: S.H. Ridgway and R.J. Harrison (eds.) Handbook of marine mammals, Vol. 2. Academic Press, New York.

Burns, J.J. 1981b. Bearded seal Erignatus barbatus Erxleben, 1777. pp 145-170 in: S. H. Ridgway and R. J. Harrison (editors) Handbook of marine mammals. Volume 2: Seals. Academic Press, New York, NY.

Burns, J.J. 1994a. Spotted seal. *in* ADF&G Wildlife Notebook Series. Alaska Department of Fish and Game. Juneau, AK.

Burns, J.J. 1994b. Bearded seal. in ADF&G Wildlife Notebook Series. Alaska Department of Fish and Game. Juneau, AK.

Burns, J.J. 1994c. Ribbon seal. *in* ADF&G Wildlife Notebook Series. Alaska Department of Fish and Game. Juneau, AK.

Burns, J.J. 2009. Arctic marine mammals. pp 48-54 in W.F. Perrin, B.G. Wursig, and J.G.M. Thewissen (eds.) Encyclopedia of marine mammals, 2nd edition. Academic Press, San Diego, CA.

Burns, J. and S. Harbo. 1972. An aerial census of ringed seals, northern coast of Alaska. Arctic 25(4):279-290.

Burns, J., J. Montague, and C. Cowles (eds.). 1993. The bowhead whale. Special Publication of The Society for Marine Mammalogy No.2. The Society for Marine Mammalogy. Lawrence, KS.

Burns, J.J. and G.A. Seaman. 1986. Investigations of belukha whales in coastal waters of western and northern Alaska II. Biology and ecology. pp 221-357 *in:* Outer Continental Shelf Environmental Assessment Program: Final Reports of Principal Investigators, Volume56. National Ocean and Atmospheric Administration, and OCS Study MMS 88-0048 U.S. Department of Interior, Minerals Management Service, Anchorage, AK.

Burns, J.J. and K.J. Frost. 1979. The natural history and ecology of the bearded seal (Erignathus barbatus). pp 311-392 in Environmental Assessment of the Alaskan Continental Shelf Final Reports of Principal Investigators, Volume 19, December 1983 National Ocean and Atmospheric Administration, Outer Continental Shelf Environmental Assessment Program, Juneau, AK.

Bustnes, J.O. and G.H. Systad. 2001. Comparative feeding ecology of Steller's eider and long-tailed duck in winter. Waterbirds 24(3):407-412.

Butler, J.N., B.F. Morris, and T.D. Sleeter. 1976. The fate of petroleum in the open ocean. pp 287–297 *in*: Sources, effects, and sinks of hydrocarbons in the aquatic environment. The American Institute of Biological Sciences, Washington, D.C.

Byrne, R.H., S. Mecking, R.A. Feely, and Z. Liu. 2010. Direct observations of basin-wide acidification of the North Pacific Ocean. Geophysical Research Letters, 37, L02601, DOI:10.1029/2009GL040999.

Calambokidis, J. and S.D. Osmek. 1998. Marine mammal research and mitigation in conjunction with air gun operation for the USGS SHIPS seismic surveys in 1998. Draft rep. from Cascadia Research, Olympia, WA, for U.S. Geological Survey, National Marine Fisheries Service, and Minerals Management Service

Caldiera, K. and M.E. Wickett. 2003. Anthropogenic carbon and ocean pH. Nature 425(6956), 365.

Caldiera, 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 – Oceans, 110(C9), C09S04, doi:10.1029/2004JC002671.

Caldwell, M. and D. Caldwell. 1982. A study of the effects of oil ingestion on a bottlenose dolphin, *Tursiops truncates*. pp. 224-237 *in*: Geraci, J. and D. St Aubin (eds.) Study of effects of oil on cetaceans. Final Report from University of Guelf for Bureau of Land Management, Washington, D.C. 274 pp. NTIS PB83-152991.

Cameron, M.F., J.L. Bengtson, P.L. Boveng, J.K. Jansen, B.P. Kelly, S.P. Dahle, E.A. Logerwell, J.E. Overland, C.L. Sabine, G.T. Waring, and J.M. Wilder. 2010. Status review of the bearded seal (Erignathus barbatus). U.S. Department of Commerce, NOAA Tech. Memo. NMFS-AFSC-211. http://www.afsc.noaa.gov/publications/AFSC-TM/NOAA-TM-AFSC-211.pdf.

Cameron, R.D. and K.R. Whitten. 1979. Seasonal movements and sexual segregation of caribou determined by aerial surveys. Journal of Wildlife Management 43:626-633.

Cameron, R.D. and W.T. Smith. 1992. Distribution and productivity of the central arctic herd in relation to petroleum development: case history studies with a nutritional perspective. Research Progress Report. Alaska Department of Fish and Game.

Capuzzo, J.M. 1987. Biological effects of petroleum hydrocarbons: assessments from experimental results. Chapter 8 pp 343-410 *in:* D. Boesch and N. Rabalais (eds.) Long-term environmental effects of offshore oil and gas development. Elsevier Applied Science, London.

Carney, K.M., and W.J. Sydeman. 1999. A review of human disturbance effects on nesting colonial waterbirds. Waterbirds 22:68–79.

Carroll, G. 2007. Unit 26A, Teshekpuk caribou herd. pp 262-283 *in:* P. Harper (ed.) Caribou management report of survey and inventory activities 1 July 2004-30 June 2006. Alaska Department of Fish and Game. Project 3.0. Juneau, Alaska, USA.

Carroll, G. 2009. Unit 26A brown bear management report. pp 325-336 *in:* P. Harper (ed.) Brown bear management report of survey and inventory activities 1 July 2006 - 30 June 2008. Alaska Department of Fish and Game, Juneau, Alaska.

Carroll, G. 2010. Unit 26A moose management report. pp 643-665 *in:* P. Harper (ed.) Moose management report of survey and inventory activities 1 July 2007 – 30 June 2009. Alaska Department of Fish and Game,]. Project 1.0. Juneau, Alaska, USA.

Cate, J.R., M. Smultea, M. Blees, M. Larson, S. Simpson, T. Jefferson and D. Steckler. 2014. 90-Day Report of Marine Mammal Monitoring and Mitigation during a 2D Seismic Survey by TGS in the Chukchi Sea, August through October 2013. AES Doc. No. 15416-04 13-185. Prepared by ASRC Energy Services, Smultea Environmental Sciences, Clymene Enterprises and Entiat River Technologies for TGS-NOPEC Geophysical Company, National Marine Fisheries Service and U.S. Fish and Wildlife Service. 122 p. + Appendices.

CBD. 2001. Petition to list Kittlitz's murrelet (*Brachyramphus brevirostris*) as endangered under the Endangered Species Act. Center for Biological Diversity, Tucson, AZ. 9 May, 2001.

CBD. 2008. Petition to list the Pacific walrus (*Odobenus rosmarus divergens*) as a threatened or endangered species under the Endangered Species Act. Center for Biological Diversity, San Francisco, CA 94 pp.

CDFO. 2004. Review of scientific information on impacts of seismic sound on fish, invertebrates, marine turtles and marine mammals. Habitat Status Report 2004/002, Canadian Department of Fisheries and Oceans, Canadian Science Advisory Secretariat 15 pp.

Cederlund, G., F. Sandegren, and K. Larsson. 1987. Summer movements of female moose and dispersal of their offspring. Journal of Wildlife Management 51: 342-352.

CEMML. (2006). Integrated Cultural Resources Management Plan Distant Early Warning (DEW) System, Alaska (2006). Prepared for United States Air Force 611th Civil Engineer Squadron, Elmendorf Air Force Base, Alaska. Fort Collins, CO: Center for Environmental Management of Military Lands, Colorado State University.

Centaur & Associates, Inc. 1984. Sea floor conflicts between oil and gas pipelines and commercial trawl fisheries on the California outer continental shelf. OCS Study MMS 84-0058, U.S. Department of the Interior, Washington D.C. 270 pp.

CEQ. 1997. Guidance regarding consideration of global climatic change in environmental documents prepared pursuant to the National Environmental Policy Act – 1997 Draft. Memorandum to heads of federal agencies from Kathleen McGinty, Chairman, Council on Environmental Quality, Washington, DC 8 pp.

Chapman, C.J. and A.D. Hawkins. 1973. A field study of hearing in the cod, *Gadus morhua* L. Journal of Comparative Physiology 85:147-167.

Chernyak, S.M., C.P. Rice, and L.L. McConnell. 1996. Evidence of currently used pesticides in air, ice, fog, seawater and surface microlayer in the Bering and Chukchi Seas. Marine Pollution Bulletin. 32(5):410-419.

Christie, K., C. Lyons, and W.R. Koski. 2010. Beaufort Sea aerial monitoring program. Chapter 7 *In*: Funk, D.W, D.S. Ireland, R. Rodrigues, and W.R. Koski (eds.). Joint Monitoring Program in the Chukchi and Beaufort seas, open-water seasons, 2006–2008. LGL Alaska Report P1050-3, Report from LGL Alaska Research Associates, Inc., LGL Ltd., Greeneridge Sciences, Inc., and JASCO Research, Ltd., for Shell Offshore, Inc. and Other Industry Contributors, and National Marine Fisheries Service, U.S. Fish and Wildlife Service. 499 p. plus Appendices.

Citta, J. and Lowry, L.F. 2008. Beluga whale. In Wildlife Notebook Series. Alaska Department of Fish and Game. Juneau, AK. http://www.adfg.alaska.gov/index.cfm?adfg=beluga.main. Citta, J.J., Quakenbush, L.T., George J.C., Small, R.J., Heide-Jorgensen M.P., Brower H., Adams, B. and Brower, L. 2012. Winter movements of bowhead whales (Balaena mysticetus) in the Bering Sea. Arctic 65:1. Clarke, A. 1988. Seasonality in the Antarctic marine environment. Comparative Biochemistry and Physiology 90b:461-473.

Clarke, J.T and M.C. Ferguson. 2010. Aerial surveys of large whales in the northeastern Chukchi Sea, 2008-2009, with review of 1982-1991 data. Paper SC/61/BRG13 presented at the International Whaling Commission Scientific Committee Meetings, Morocco, June 2010. 18 pp.

Clarke, J., S. Moore, and D. Ljungblad. 1989. Observations on the gray whale (*Eschrichtius robustus*) utilization and patterns in the northeast Chukchi Sea, July-October 1982-1987. Canadian Journal of Zoology 67:2646-2653.

Clarke, J.T., M.C. Ferguson, C.L. Christman, S.L. Grassia, A.A. Brower and L.J. Morse. 2011. Chukchi Offshore Monitoring in Drilling Area (COMIDA) Distribution and Relative Abundance of Marine Mammals: Aerial Surveys. Final Report, OCS Study BOEMRE 2011-06. National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, F/AKC3, Seattle, WA 98115-6349.

Clarke, J.T., C.L. Christman, A.A. Brower, and M.C. Ferguson. 2012. Distribution and Relative Abundance of Marine Mammals in the Alaskan Chukchi and Beaufort Seas, 2011. Annual Report, OCS Study BOEM 2012-009. National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, F/AKC3, Seattle, WA 98115-6349. 344 pp

Clarke, J., C. Christman, A. Brower, M. Ferguson. 2013. Distribution and Relative Abundance of Marine Mammals in the Northeastern Chukchi and Western Beaufort Seas, 2012. National Oceanic and Atmospheric Administration. National Marine Mammal Laboratory. Alaska Fisheries Science Center, NMFS. OCS Study BOEM 2013-00117. May 2013.

Clarke, J.T., A.A. Brower, C.L. Christman, and M.C. Ferguson. 2014. Distribution and Relative Abundance of Marine Mammals in the Northeastern Chukchi and Western Beaufort Seas, 2013. Annual Report, OCS Study BOEM 2014-018. National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, F/AKC3, Seattle, WA 98115-6349.

Coachman, L. K., K. Aagaard, and R. B. Tripp. 1975. The Bering Strait: regional physical oceanography. University of Washington Press, Seattle, Washington. 172 pages.

Colinvaux, P. A. (1996). Reconstructing the Environment. In F. H. West (Ed.), American Beginnings: The Prehistory and Palaeoecology of Beringia (pp. 13-20). Chicago, IL: University of Chicago Press.

Comiso, J.C. 2006. Arctic warming signals from satellite observations. Weather. 51(3:)70-76.

Committee on the Assessment of U.S. Coast Guard Polar Icebreaker Roles and Future Needs. 2005. Polar icebreaker roles and U.S. future needs: a preliminary assessment. National Academies Press.

Conover, R.J. 1971. Some relations between zooplankton and bunker C oil in Chedabueto Bay following the wreck of the tanker Arrow. Journal Fisheries Research Board Canada 28:1327-1330.

Cook, J. 2005. Exploring for offshore oil and gas. Atlantic Oil & Gas Works Online.

Cooper, L.W., and J.M. Grebmeier. 2012. Sedimentation Rate analyses *in*: K.H. Dunton (ed.), Chukchi Sea Offshore Monitoring in the Drilling Area (COMIDA): Chemical and Benthos (CAB) Final Report. Bureau of Ocean Energy Management, Department of the Interior. OCS Study BOEM 2012-012.

Cooper, L.W., C.J. Ashjian, S.L. Smith, L.A. Codispoti, J.M. Grebmeier, R.C. Campbell, and E.B. Sherr. 2006. Rapid seasonal sea–ice retreat in the Arctic should be affecting Pacific walrus (*Odobenus rosmarus divergens*) recruitment. Aquatic Mammals 32(1):98–102.

Coyle, K.O., J.A. Gillispie, R.L. Smith, and W.E. Barber. 1997. Food habits of four demersal Chukchi Sea fishes. pp 310-318 *in:* J. Reynolds (ed) Fish ecology in arctic North America. American Fisheries Society Symposium 19, Bethesda, Maryland.

Craig, P. 1989b. Subsistence fisheries at coastal villages in the Alaskan Arctic 1970-1986. Biological Papers of the University of Alaska 24:131-152.

Craig, P., and L. Haldorson. 1986. Pacific salmon in the North American Arctic. Arctic. 39:2–7.

Craig, P., W. Griffiths, L. Halderson, and H. McElderry. 1982. Ecological studies of arctic cod (*Boreogadus saida*) in Beaufort Sea coastal waters, Alaska. Canadian Journal of Fisheries and Aquatic Science 39(3):395-406.

Craig, P.C. 1984a. Fish use of coastal waters of the Alaskan Beaufort Sea: A Review. Transactions of the American Fisheries Society 113:265-282.

Craig, P.C. 1984b. Fish resources. pp. 117-131 in J.C. Truett (ed.). Proceedings of a synthesis meeting: The Barrow Arch environment and possible consequences of planned offshore oil and gas development (Sale 85), Girdwood, AK., Oct.30-Nov. 1, 1983. Anchorage, AK: US Department of Commerce, NOAA, Outer Continental Shelf Environmental Assessment Program, and USDOI, Minerals Management Service, Anchorage, AK.

Craig, P.C. and P. Skvorc. 1982. Fish resources of the Chukchi Sea: status of existing information and field program design. Outer Continental Shelf Environmental Assessment Program: Final Report of the Principal Investigators Volume 63 August 1989. National Ocean and Atmospheric Administration, and OCS Study MMS 89-0071 U.S. Department of Interior, Minerals Management Service, Anchorage, AK

Craig, P., W. Griffiths, S. Johnson, and D. Schell. 1984. Trophic dynamics in an arctic lagoon. pp 347-380 *in:* P. Barnes, D. Schell, and E. Reimnitz (eds.) The Alaskan Beaufort Sea ecosystems and environments. Academic Press, Inc. New York.

Craighead, J.J., and J.A. Mitchell. 1982. Grizzly bear. pp 515-556 *in:* J. A. Chapman and G. A. Feldhamer (eds.) Wild mammals of North America. The Johns Hopkins University Press, Baltimore and London.

Crippen, R.W., G. Green, and S.L. Hodd. 1980. Metal levels in sediment and benthos resulting from a drilling fluid discharge into the Beaufort Sea. In: Proceedings of symposium for research on environmental fate and effects of drilling fluids and cuttings, Vol. 1. American Petroleum Institute, Washington, D.C.

Cripps, G.C., and J. Shears. 1997. The fate in the marine environment of a minor diesel fuel spill from an Antarctic research station. Environmental Monitoring and Assessment 46 (3):221-232.

Cummings, W.C., D.V. Holliday, and B.J. Lee. 1984. Potential impacts of man-made noise on ringed seals: vocalizations and reactions. pp 95-230 *in* Outer Continental Shelf Environmental Assessment Program Final Report of the Principal Investigators Volume 37 March 1986, U.S. Department of Commerce, NOAA, and U.S. Department of Interior, Minerals Management Service, Anchorage, AK NTIS PB87-107546.

D'Entremeont, M.V, H.J. Reider, and D. Funk. 2013. Shell exploratory drilling: 2012 bird strike and avoidance report. Unpublished report by LGL Alaska Research Associates, Anchorage, AK for Shell Offshore Inc., Anchorage, AK. 33 p.

Dalen, J., and G.M. Knutsen. 1986. Scaring effects in fish and harmful effects on eggs, larvae and fry by offshore seismic exploration. pp. 93–102 *in*: H.M. Merklinger (ed.), Progress in underwater acoustics. Plenum Press, New York,.

Dalen J., E. Ona, A.V. Soldal, and R. Sætre. 1996. Seismic investigations at sea; an evaluation of consequences for fish and fisheries. Havforskninginstituttet (Institute of Marine Research), Bergen, Norway. Fisken og Havet. 9: 26 pp. (In Norwegian, English summary).

Dallaire, F., E. Dewailly, C. Laliberté, G. Muckle, and P. Ayotte. 2002. Temporal trends of organochlorine concentrations in umbilical cord blood of newborns from the Lower North Shore of the St. Lawrence River (Québec, Canada). Environmental Health Perspectives 110(8): 835-838.

Darnis, G., D. Robert, C. Pomerleau, H. Link, P. Archambault, R.J. Nelson, M. Geoffroy, J.É. Tremblay, C. Lovejoy, and S.H. Ferguson. 2012. Current State and Trends in Canadian Arctic Marine Ecosystems: II. Heterotrophic Food Web, Pelagic-Benthic Coupling, and Biodiversity. *Climatic Change*. June, 2012: 1-27.

Dau, J.R. 2007. Units 21D, 22A, 22B, 22C, 22D, 22E, 23, 24, and 26A Caribou Management Report. pp. 174-308 *in*: C. Brown (ed.) Caribou Management Report of Survey and Inventory Activities 1 July 2004-30 June 2006, Project 3.0. Juneau, AK: Alaska Department of Fish & Game, Division of Wildlife Conservation,.

Dau, C. P., and A. Kistchinski. 1977. Seasonal movements and distribution of the Spectacled Eider and wildfowl 28:65-75.

Dau, C.P. and W.W. Larned. 2005. Aerial population survey of common eiders and other waterbirds in near shore waters and along barrier islands of the arctic coastal plain of Alaska, 24-27 June 2005. Division of Migratory Bird Management, U.S. Fish and Wildlife Service, Anchorage, Alaska.

Dau, C.P. and W.W. Larned. 2006. Aerial population survey of common eiders and other waterbirds in near shore waters and along barrier islands of the Arctic Coastal Plain of Alaska, 25-27 June 2006. Division of Migratory Bird Management, U.S. Fish and Wildlife Service, Anchorage, Alaska.

Dau, C.P. and W.W. Larned. 2007. Aerial population survey of common eiders and other waterbirds in near shore waters and along barrier islands of the Arctic Coastal Plain of Alaska, 22-24 June 2007. Division of Migratory Bird Management, U.S. Fish and Wildlife Service, Anchorage, Alaska.

Dau, C.P. and W.W. Larned. 2008. Aerial population survey of common eiders and other waterbirds in near shore waters and along barrier islands of the Arctic Coastal Plain of Alaska, 24-26 June 2008. Division of Migratory Bird Management, U.S. Fish and Wildlife Service, Anchorage, Alaska.

Davis, R.A. 1987. Integration and summary report. pp 1-52 *in:* Responses of bowhead whales to an offshore drilling operation in the Alaskan Beaufort Sea, Autumn 1986. Report by LGL Ltd., King City, Ontario, and Greeneridge Sciences, Santa Barbara, California, for Shell Western E&P Inc., Anchorage, Alaska.

Davis, R.A. and D.H. Thomson. 1984. Marine Mammals. Chapter 4, pp. 47-49 *in*: J.C. Truett (ed.) Proceedings of a synthesis meeting: The Barrow arch environment and possible consequences of planned offshore oil and gas development (Sale 85), Girdwood, AK, Oct. 30-Nov. 1, 1983. Anchorage, AK: USDOC, NOAA, OCSEAP, and USDOI, MMS.

Day, R.H., A.K. Prichard, J.R. Rose, and A.A. Stickney. 2003. Migration and collision avoidance of eiders and other birds at Northstar Island, Alaska, 2001 and 2002. Prepared for BP Exploration (Alaska) Inc. Prepared by ABR, Inc.-Environmental Research & Services, Fairbanks, AK 142 pp.

Day, R., A. Prichard, and J. Rose. 2005. Migration and collision avoidance of eiders and other birds at Northstar Island, Alaska, 2001-2004: final report. Prepared by ABR, Inc. – Environmental and Research Services for BP Exploration (Alaska) Inc. Fairbanks, Alaska.

Day, G., E. Provost, and A. Lanier. 2006. Alaska native mortality update 1999-2003. ANTHS, Alaska Native Epidemiology Center Anchorage, AK.

de Soysa, T.Y., A. Ulrich, T. Friedrich, D. Pite, S. Compton, D. Ok, R. Bernardos, G. Downes, S. Hsieh, R. Stein et al. 2012. Macondo Crude Oil From The Deepwater Horizon Oil Spill Disrupts Specific Developmental Processes During Zebrafish Embryogenesis. BMC Biology. 10(1):40.

Dean T.A., M.S. Stekoll, and R. Smith. 1996. Kelps and oil: the effects of the Exxon Valdez oil spill on subtidal algae. In: Rice SD, Spies RB, Wolfe DA, Wright BA (eds) Proceedings of the Exxon Valdez oil spill symposium. Am Fish Soc Symp 18. American Fisheries Society. Bethesda, p 412-423

Del Hoyo, J., A. Elliot, and J. Sargatal (eds.). 1996. Handbook of the birds of the world. Vols. 1 and 3, Lynx Edicions, Barcelona, Spain.

Delarue, J, M. Laurinolli, and B. Martin. 2009. Acoustic detections of fin whales in the Chukchi Sea. Talk presented at the Arctic Acoustics Workshop, 18th Biennial Conference on the Biology of Marine Mammals, Quebec, Canada. October 2009.

Delarue, J., J. MacDonnell, B. Martin, X. Mouy, D. Hannay, N.E. Chorney, and J. Vallarta. 2012a. Northeastern Chukchi Sea Joint Acoustic Monitoring Program 2010–2011. JASCO Applied Sciences Document 00301, Version 1.0. Technical report for ConocoPhillips Company, Shell Exploration & Production Company, and Statoil USA E&P, Inc. by JASCO Applied Sciences.

DeMarban, Alex. 2013. "Deepwater Port in Nome or Port Clarence to Support Arctic Shipping?" Alaska Dispatch. February 1. http://www.alaskadispatch.com/article/deepwater-port-nome-or-port-clarence-support-arctic-shipping (accessed March 5, 2013).

DeMaster, D.P., W. Perryman, and L.F. Lowry. 1998. Beluga whale surveys in the eastern Chukchi Sea, July, 1998. Alaska Beluga Whale Committee Rep. 98-2. 16 pp.

Denlinger, L. 2006. Alaska seabird information series. Unpublished Report, Division of Migratory Bird Management, Nongame Program, U.S. Fish and Wildlife Service, Anchorage, Alaska.

Derksen, K., E. Taylor, M. Miller, and M. Weller. 1992. Effects of aircraft on behavior and ecology of molting black brant near Teshekpuk Lake, Alaska. Alaska Fish and Wildlife Research Center, U.S. Fish and Wildlife Service, Anchorage, Alaska. 227 pp.

Divoky, G. 1976. The pelagic feeding habits of ivory and Ross' gulls. Condor 78: 85-90.

Divoky, G.J. 1978. Breeding bird use of barrier islands in the northern Chukchi and Beaufort seas. pp 482-548 in Environmental Assessment of the Alaskan Continental Shelf. Annual Reports of the Principal Investigators, Vol. 1. National Oceanic and Atmospheric Administration, Outer Continental Shelf Environmental Assessment Program, Boulder, CO.:

Divoky, G.J. 1983. The pelagic and nearshore birds of the Alaskan Beaufort Sea. Pages 397-513 in Environmental Assessment Alaskan Continental Shelf, Final Report of the Principal Investigators, Vol. 23. National Oceanic and Atmospheric Administration, Outer Continental Shelf Environmental Assessment Program, Juneau, Alaska.

Divoky, G.J. 1987. The distribution and abundance of birds in the eastern Chukchi Sea in late summer and early fall. Outer Continental Shelf Environmental Assessment Program Research Unit 196. Unpublished final report. Outer Continental Shelf Environmental Assessment Program Fairbanks, AK 91 pp. (NTIS PB88-156922/AS) RU 0196.

DOI, U.S. Geological Survey. 1980. Oil and Gas and Sulphur Operations in the Outer Continental Shelf. Federal Register 45 (47, 7 Mar.):15128-15146

Dorsey, E.M., S.J. Stern, A.R. Hoelzel, and J. Jacobsen. 1990. Minke whale (*Balaenoptera acutorostrata*) from the west coast of North America: individual recognition and small scale site fidelity. Report of the International Whaling Commission, Special Issue 12:357-368.

Doughton, S. 2007. Aging fleet slows U.S. in arctic 'chess game.' The Seattle Times. Thursday, September 20, 2007. http://seattletimes.com/html/localnews/2003893175_icebreakers20m.html. Accessed May 15, 2008.

DTI. 2003. Strategic environmental assessment: area north and west of Orkney and Shetland. Strategic Environmental Assessment No.4, Consultation Document, Report to the United Kingdom Department of Trade and Industry, 90 pp.

Dubansky B, A. Whitehead, J.T. Miller, C.D. Rice, F. Galvez. 2013. Multitissue Molecular, Genomic, and Developmental Effects of the Deepwater Horizon Oil Spill on Resident Gulf Killifish (Fundulus grandis). Environmental Science & Technology. 47(10):5074-82.

Dumond, D. E. (2001). "The Archaeology of Eastern Beringia: Some Contrasts and Connections." *Arctic Anthropology*. 38(2): 171-195.

Dunn, J.R., and A.C. Matarese. 1984. Gadidae: development and relationships. pp. 283-299 *in* H.G. Moser, W.J. Richards (eds) Ontogeny and systematics of fishes. Special Publication No 1, American Society of Ichthyologists and Herpetologists, Allen Press, Lawrence, Kansas.

Dunton, K.H., and S.V. Schonberg. 1980. Receptors - birds, plankton, littoral, benthos. in: Environmental Assessment of the Alaskan Continental Shelf Annual Reports of Principal Investigators for the Year Ending March 1980. Vol. I. U.S. Department of Commerce, National Oceanic and Atmospheric Administration and U.S. Department of Interior, Bureau of Land Management.

Dunton, K., J. Grebmeier, D. Maidment, and S. Schonberg. 2003. SBI I final report: benthic community structure and biomass in the western arctic: linkage to biological and physical properties. Final project report to National Science Foundation.

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, Part II, 52:3462–3477.

Dunton, K., S. Schonberg, and N. McTigue. 2009. Characterization of benthic habitats in Camden Bay (Sivulliq Prospect and Hammerhead drill sites), Beaufort Sea Alaska. Report prepared for Shell by University of Texas Marine Science Institute, Port Aransas, TX for Shell Exploration & Production Company, Anchorage, Alaska. 67 pp.

Dunton, K.H., J. Grebmeier, L. Cooper, J. Trefry. 2012. The COMIDA-CAB project: an overview of the biological and chemical characteristics of the northern Chukchi Sea benthos. Pp 6-19 in K.H. Dunton (editor). Chukchi Sea Offshore Monitoring in Drilling Area (COMIDA): Chemical and Benthos (CAB). Final Report. OCS Study BOEM 2012-012 USDOI Bureau of Ocean Energy Management, Anchorage, AK.

Dunton, K., C. Ashjian, R. Campbell, L. Cooper, J. Grebmeier, R. Harvey, B. Konar, D. Maidment, S. Schonberg, J. Trefry, and T. Weingartner. 2013. An Integrated Ecosystem Field Study of Hanna Shoal, Northern Chukchi Sea, Alaska. Alaska Marine Science Symposium, January 21-25, 2013. Anchorage, Alaska.

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. OCS Study MMS 2004-014 Minerals Management Service, Alaska OCS Region, Anchorage, Alaska.

Durner, G.M., D.C. Douglas, R.M. Nielson, S.C. Amstrup, and T.L. McDonald. 2007. Predicting the future distribution of polar bear habitat in the polar basin from resource selection functions applied to 21st century general circulation model projections of Sea Ice. U.S. Geological Survey. Administrative Report.

Earnst, S.L. 2004. Status assessment and conservation plan for the yellow-billed Loon (*Gavia adamsii*). Scientific Investigations Report 2004-5258,U.S. Geological Survey. 42 pp.

Earnst, S.L., R.A. Stehn, R.M. Platte, W.W. Larned, and E.J. Mallek. 2005. Population size and trends of yellow-billed loons in northern Alaska. Condor 107:289-304.

Eide, S. and S. Miller. 1994. Alaska Department of Fish and Game Wildlife Notebook Series: Brown Bear. Alaska Department of Fish and Game. Juneau, AK.

Eley Jr., T.J., 1994a. Ringed Seal. Alaska Wildlife Notebook Series. Alaska Department of Fish and Game. Juneau, AK. Eley Jr., T.J. 1994b. Bearded Seal. Alaska Wildlife Notebook Series. Alaska Department of Fish and Game. Juneau, AK.

Eley, T. and L. Lowry. 1978. Marine mammals. *in*: Environmental assessment of the Alaskan Continental Shelf, interim synthesis: Beaufort/Chukchi. National Oceanic and Atmospheric Administration. OCSEAP. Boulder, CO.

Elias, Scott A., and Julie Brigham-Grette. (2007). Late Pleistocene Events in Beringia. In *Encyclopedia of Quaternary Science,* ed. Scott A. Elias, 1057-1066. Volume 2. Elsevier Science Publishers.

Elliott, A.J., N. Hurford, and C.J. Penn. 1986. Shear diffusion and the spreading of oil slicks. Marine Pollution Bulletin 17:308-313.

Engas, A., S. Lokkeborg, A.V. Soldal, and E. Ona. 1993. Comparative trials for cod and haddock using commercial trawl and longline at two different stock levels. Journal of Northwestern Atlantic Fisheries Scientist 19:83-90.

Engas, A., S. Lokkeborg, E. Ona, and A. V. Soldal. 1996. Effects of seismic shooting on local abundance and catch rates of cod *Gadus morhua* and haddock *Melanogrammus aeglefinus*. Canadian Journal of Fisheries and Aquatic Science 53: 2238–2249.

Englehardt, F. 1983. Petroleum effects on marine mammals. Aquatic Toxicology, 4(3):199-217.

ENVIRON. 2015a. Shell OCS Exploration Program – Chukchi Sea Air Quality Technical Report Onshore Areas. Prepared for Shell Gulf of Mexico Inc.

ENVIRON. 2015b. Shell OCS Exploration Program – Chukchi Sea Air Quality Technical Report Offshore Subsistence Area. Prepared for Shell Gulf of Mexico Inc.

EPA. 1985. Assessment of environmental fate and effects of discharges from offshore oil and gas operations. U.S. Environmental Protection Agency. Monitoring and Data Support Division, Office of Water Regulations and Standards. Washington D.C.

EPA. 1986. Bacteriological ambient water quality criteria for marine and fresh recreational waters. EPA 440/5-84-002. U.S. Environmental Protection Agency, Office of Research and Development, Cincinnati, OH.

EPA. 1999a. Consideration of Cumulative Impacts in EPA Review of NEPA Documents. (2252A) EPA 315-R-99-002/May 1999. U.S. Environmental Protection Agency, Office of Federal Activities. 27 p.

EPA. 1999b. Understanding oil spills and oil spill response. Chapter 1: The behavior and effects of oil spills in aquatic environments. Office of Emergency and Remedial Response. EPA-K-99-007.

EPA. 2006a. Authorization to discharge under the National Pollutant Discharge Elimination System (NPDES) for oil and gas exploration facilities on the outer continental shelf and contiguous state waters. Permit No. AKG-28-0000. http://yosemite.epa.gov/R10/WATER.NSF/NPDES+Permits/General+NPDES+Permits#Oil%20and%20Gas.

EPA. 2006b. Final ocean discharge criteria evaluation of the arctic NPDES general permit for oil and gas exploration (Permit No. AKG-28-0000). Prepared by: Tetra Tech, Inc. Finalized by: U.S. Environmental Protection Agency, Region 10, Office of Water and Watersheds, Seattle, WA.

EPA. 2008. U.S. Environmental Protection Agency 2008. Final issuance of National Pollutant Discharge Elimination System (NPDES) Vessel General Permit (VGP) for discharges incidental to the normal operation of vessels fact sheet. U.S. Environmental Protection Agency, December 18, 2008. 119 p.

EPA. 2012a. Authorization to discharge under the National Pollutant Discharge Elimination System (NPDES) for oil and gas exploration facilities on the Outer Continental Shelf, Chukchi Sea. United Stated Environmental Protection Agency, Region 10, Seattle, WA. 79 p.

EPA. 2012b. Ocean discharge criteria evaluation for oil and gas exploration facilities on the Outer Continental Shelf in the Chukchi Sea, Alaska (NPDES Permit No.: AKG-28-8100). Prepared by: Tetra Tech, Inc., Anchorage, AK, Revised by: U.S. Environmental Protection Agency, Region 10, Office of Water and Watersheds, Seattle, WA.

EPA. 2012c. Biological Evaluation In Support of the Chukchi Sea Oil and Gas Exploration NPDES General Permit (NPDES Permit No.: AKG-28-8100). United States Environmental Protection Agency.

EPA. 2013a. National ambient air quality standards (NAAQS). http://epa.gov/air/criteria.html.

EPA. 2014. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2012. U.S. Environmental Protection Agency. Washington DC. *Accessed online on* August 22, 2014 *at*: http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2014-Chapter-Upfront.pdf.

Evans, P., E. Lewis, and P. Fisher. 1993. A study of the possible effects of seismic testing upon cetaceans in the Irish Sea. Rep. by Sea Watch Foundation, Oxford, for Marathon Oil UK, Ltd. Aberdeen. 35pp.

Exponent. 2010. Chukchi Sea environmental studies baseline program 2009 fish sampling – chemistry results.

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 Science 65zz;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(4):160–171.

Fadely, B.S., J.F. Piatt, S.A. Hatch, and D.G. Roseneau. 1989. Populations, productivity, and feeding habits of seabirds at Cape Thompson, Alaska. OCS Study MMS 89-0014, Minerals Management Service, Alaska OCS Region, Anchorage, AK. 429 pp.

Fay, F.H. 1982. Ecology and biology of the Pacific walrus (Odobenus rosmarus divergens). North American Fauna 74. U.S. Fish and Wildlife Service, Washington, DC. 279 pp.

Fay, F.H. and J.J. Burns. 1988. Maximal feeding depths of walruses. Arctic 413:239-240.

Fay, F., B. Kelly, P. Gehnrich, J. Sease, and A. Hoover. 1984. Modern populations, migrations, demography, trophics, and historical status of the Pacific walrus. OCS Study MMS 86-002, Final Report of the Principal Investigators (1986) Volume 37:231-376, National Oceanic Atmospheric Administration, Outer Continental Shelf Environmental Assessment Program, Anchorage, Alaska.

Fay, F.H., B.P. Kelly, and J.L. Sease. 1989. Managing the exploitation of Pacific walruses: a tragedy of delayed response and poor communication. Marine Mammal Science 5:1-16.

Fay, F.H., L.L. Eberhardt, B.P. Kelly, J.J. Burns, and L.T. Quakenbush. 1997. Status of the Pacific walrus population, 1950-1989. Marine Mammal Science 13(4):537-565.

Fechhelm, R., P. Craig, J. Baker, and B. Galloway. 1984. Fish distribution and use of nearshore waters in the northeastern Chukchi Sea. Final Reports of Principal Investigators, Volume 32:121-297, NOAA Outer Continental Shelf Environmental Assessment Program, Juneau, AK.

Feder, H., A. Naidu, J. Hameedi, S. Jewett, and W. Johnson. 1989. The Chukchi Sea continental shelf: benthos environmental interactions. Final Report to NOAA-Ocean Assessment Division (Anchorage), and Institute of Marine Science, University of Alaska Fairbanks. 247 pp + app.

Feder, H., N.R. Foster, S.C. Jewett, T.J. Weingartner, and R. Baxter. 1994a. Mollusks in the northeastern Chukchi Sea. Arctic. 47:145-163.

Feder, H.M., A.S. Naidu, S.C. Jewett, J.M. Harneedi, W.R. Johnson, and T.E. Whitledge. 1994b. The northeastern Chukchi Sea: benthos-environmental interactions. Marine Ecology-Progress Series 111: 171-190.

Feder, H., Stephen C. Jewett, and Arny L. Blanchard. 2007. Southeastern Chukchi Sea (Alaska) macrobenthos. Polar Biology. 30:261-275.

Fernández, A., M. Arbelo, E. Degollada, M. André, A. Castro-Alonso, R. Jaber, V. Martín, P. Calabuig, P. Castro, P. Herraez, F. Rodríguez and A. Espinosa de los Monteros. 2003. Pathological findings in beaked whales stranded massively in the Canary Islands (2002). p. 227-228 *in*: 17th

Conference European Cetacean Society, Las Palmas, March 2003/Conf. Guide & Abstr. European Cetacean Society.

Fernández, A., J.F. Edwards, F. Rodriquez, A.E. de los Monteros, P. Herráez, P. Castro, J.R. Jaber, V. Martin and M. Arbelo. 2005. "Gas and fat embolic syndrome" involving a mass stranding of beaked whales (Family Ziphiidae) exposed to anthropogenic sonar signals. Vet. Pathol. 42(4):446-457.

Finley, K.J. and R.A. Davis. 1984. Reactions of beluga whales and narwhals to ship traffic and ice-breaking along ice edges in the eastern Canadian High Arctic, 1982-1984: An overview. Environmental Studies No. 37. Ottawa, Ontario, Canada: Canadian Dept. of Indian Affairs and Northern Development, Northern Environmental Protection Branch, Northern Affairs Program, 42 pp.

Finley, K.J., G.W. Miller, R.A. Davis, and C.R. Greene. 1990. Reactions of belugas (*Delphinapterus leucas*) and Narwhals (*Monodon monoceros*) to ice-breaking ships in the Canadian high Arctic. Canadian Bulletin Fisheries and Aquatic Science 224:97–117.

Finneran, J.J. and C.E. Schlundt. 2004. Effects of intense pure tones on the behavior of trained odontocetes (SPAWAR Systems Command Technical Report #1913). San Diego: U.S. Navy.

Finneran, J.J., C.E. Schlundt, D.A. Carder, J.A. Clark, J.A. Young, J.B. Gaspin, and S.H. Ridgway. 2000. Auditory and behavioral responses of bottlenose dolphins (Tursiops truncatus) and beluga whale (*Delphinapterus leucas*) to impulsive sounds resembling distant signatures of underwater explosions. Journal Acoustical Society America 108(1):417-431.

Finneran, J.J., C.E. Schlundt, R. Dear, D.A. Carder, and S.H. Ridgway. 2002. Temporary shift in masked hearing thresholds in odontocetes after exposure to single underwater impulses from a seismic watergun. Journal Acoustical Society of America 111(6):2929-2940.

Finneran, J.J., D.A. Carder, C.E. Schlundt, and S.H. Ridgway. 2005. Temporary threshold shift in bottlenose dolphins (*Tursiops truncatus*) exposed to mid-frequency tones. Journal Acoustical Society of America 118(4):2696-2705.

Finneran, J.J. and A.K. Jenkins. 2012. Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis. Space and Naval Warfare Systems Center Pacific.: i-60.

Finney, H. 1989. Summary biological reconnaissance Burger prospect, sale 109, Chukchi Sea, Alaska. Summary report prepared by H. Finney, Fugro-McClelland Marine GeoSciences, Inc. for Shell Western E&P Inc., Houston, Texas.

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(11):1395–1405.

Fischbach, A.S., D.H. Monson and C.V. Jay. 2009. Enumeration of Pacific walrus carcasses on beaches of the Chukchi Sea in Alaska following a mortality event, September 2009. US Geological Survey Open-File Report 2009-1291, Reston, VA. 10 p.

Fischer, J.B., T.J. Tiplady, and W.W. Larned. 2002. Monitoring Beaufort Sea waterfowl and marine birds, aerial survey component. Outer Continental Shelf study, MMS 2002–002. U.S. Fish and Wildlife Service, Anchorage Alaska.

Fischer, J.B., R.A. Stehn, and G. Walters. 2007. Nest population size and potential production of geese and Spectacled Eiders on the Yukon-Kuskokwim Delta, Alaska 2007. U.S. Fish and Wildlife Service. Unpublished report.

Fissel, D.B., A. Kanwar, K. Borg, T. Mudge, J. Marko, A. Bard. 2010. Automated Detection of Hazardous Sea Ice Features from Upward Looking Sonar Data. Icetech, 2010. Anchorage, AK, USA.

Fjeld, P., G. Gabrielson, and J. Orbak. 1988. Noise from helicopters and its effect on a colony of Brunnich's gullemoty (*Uria lomvia*) on Svalbard, Norwegian Polar Institute, Rolfstanangveien.

Fluid Dynamix. 2014a. Drill Cuttings, Drill Fluids, and Muds Discharge Modeling for Burger J Well. Drilled by a Subsea ROV and the Drill Ship Noble Discoverer. Located Offshore Chukchi Sea, Alaska. Prepared for Shell Alaska Venture by Fluid Dynamix. Maynard, MA.

Fluid Dynamix. 2014b. Drill Cuttings, Drill Fluids, and Muds Discharge Modeling for Burger J Well. Drilled by a Subsea ROV and the Drill Ship Polar Pioneer. Located Offshore Chukchi Sea, Alaska. Prepared for Shell Alaska Venture by Fluid Dynamix. Maynard, MA.

Fluid Dynamix. 2014c. Drill Cuttings, Drill Fluids, and Muds Discharge Modeling for Burger J Well. Drilled by the Drill Ship Polar Pioneer. Located Offshore Chukchi Sea, Alaska. Prepared for Shell Alaska Venture by Fluid Dynamix. Maynard, MA.

Fluid Dynamix. 2014d. Drill Cuttings, Drill Fluids, and Muds Discharge Modeling for Burger J Well. Drilled by the Drill Ship Noble Discoverer. Located Offshore Chukchi Sea, Alaska. Prepared for Shell Alaska Venture by Fluid Dynamix. Maynard, MA.

Fluid Dynamix. 2014e. Thermal Dispersion Modeling for Non-Contact Cooling Water Discharges from the Drill Ship the Noble Discoverer. Burger Field. Located Offshore Chukchi Sea, Alaska. Prepared for Shell Alaska Venture by Fluid Dynamix. Maynard, MA.

Fluid Dynamix. 2014f. Thermal Dispersion Modeling for Non-Contact Cooling Water Discharges from the Drill Ship the Polar Pioneer. Burger Field. Located Offshore Chukchi Sea, Alaska. Prepared for Shell Alaska Venture by Fluid Dynamix. Maynard, MA.

Forney, K.A., and R.L. Brownell. 1996. Preliminary report of the 1994 Aleutian Island marine mammal survey. Unpubl. Doc. Submitted to International Whaling Commission SC/48.O 11. 15pp.

Fraker, M., D. Sergeant, and W. Hoek. 1978. Bowhead and White whales in the southern Beaufort Sea. Sidney, British Columbia: Beaufort Sea Project, Department of Fisheries and the Environment.

Frame, G.W. 1972. Occurrence of polar bears in the Chukchi and Beaufort Seas, Summer 1969. Journal of Mammalogy 53(1):187.

Francis, J., E. Hunter, J. Key, and X Wang. 2005. Clues to variability in Arctic minimum sea ice extent. Journal Geophysical Research. 32:L21501.

Frankel, A.S., and C.W. Clark. 1998. Results of low-frequency playback of M-sequence noise to humpback whales, *Megaptera novaeangliae*, in Hawai'i. Canadian Journal of Zoology 76:521-535.

Frantzis, A. 1998. Does acoustic testing strand whales? Nature 392(6671):29.

Franzman, A.W. and C.C. Schwartz. 1985. Moose twinning rates: a possible population condition assessment. Journal of Wildlife Management 49:394-396.

Fredrickson, K, PA1. 2008. Arctic air. Coast Guard Magazine. U.S. Coast Guard. Issue 2. 2008.

Frost, K. and L. Lowry. 1983. Demersal fishes and invertebrates trawled in the northeastern Chukchi and Western Beaufort Seas, 1976-1977. National Oceanic and Atmospheric Administration National Marine Fisheries Service Technical Report SSRF- 764. Seattle, Washington.

Frost, K. and L. Lowry. 1984. Trophic relationships of vertebrate consumers in the Alaskan Beaufort Sea. In The Alaskan Beaufort Sea, Ecosystems and Environments. Peter W. Barnes, Donald M. Schell, and Erk Reimnitz, eds. Orlando: API.

Frost, K. and L. Lowry. 1990. Use of Kasegaluk Lagoon by marine mammals. pp 93-100 *in*: Third Information Transfer Meeting Conference Proceedings, OCS Study MMMS 90-0041, Alaska OCS Region, Minerals Management Service, Anchorage, AK. 223 pp.

Frost, K. and R. Suydam. 2010. Subsistence harvest of beluga or white whales (*Delphinapterus leucas*) in northern and western Alaska, 1987–2006. J. Cetacean Research and Management. 11(3): 293–299, 2010.

Frost, K., L. Lowry, and G. Carroll. 1993. Beluga and spotted seal use of a coastal lagoon system. Arctic 46(1):8-16.

Frost, K., L. Lowry, G. Pendleton, and H.R. Nute. 2002. Monitoring distribution and abundance of ringed seals in northern Alaska. OCS Study MMS 2002-043 USDOI, Minerals Management Service, Alaska OCS Region, Anchorage, AK. 66 pp.

Frost, K., L. Lowry, G. Pendleton, and H.R. Nute. 2004. Factors affecting the observed densities of ringed seals, *Phoca hispida*, in the Alaskan Beaufort Sea, 1996-99. Arctic 57:115-128.

Fry, D.M. and L.J. Lowenstine. 1985. Pathology of common murres and Cassin's auklets exposed to oil. Archives Environmental Contamination and Toxicology 14:725-737.

Fry, D., J. Swenson, L. Addiego, C. Grau, and A. Kang. 1985. Reduced reproduction of wedge-tailed shearwaters exposed to weathered Santa Barbara crude oil. Archives of Environmental Contamination and Toxicology 15:153-160.

Fugro. 1989a. Summary report, high-resolution geophysical survey and assessment of potential shallow drilling hazards, Burger Prospect, Chukchi Sea, Alaska. Report by Fugro-McClelland Marine Geosciences, Inc., Houston, TX to Shell Western E&P, Inc., Houston, Texas.

Fugro. 1989b. High-resolution geophysical survey and assessment of potential shallow drilling hazards, Tourmaline Prospect, Chukchi Sea, Alaska. Report to Texaco Overseas Holdings, Inc. Bellaire, Texas.

Fugro. 1990a. High-resolution geophysical survey and assessment of potential shallow drilling hazards, Burger prospect, Chukchi Sea, Alaska. Report to Shell Western E&P, Inc. Houston, Texas.

Fugro. 1990b. High-resolution geophysical survey and assessment of potential shallow drilling hazards, Azurite prospect, Chukchi Sea, Alaska. Report by Fugro-McClelland Marine Geoscience, Inc., Bellaire, Texas to Shell Western E&P, Inc. Houston, Texas.

Fugro. 1990c. High-resolution geophysical survey and assessment of potential shallow drilling hazards, Ruby prospect, Chukchi Sea, Alaska. Report by Fugro-McClelland Marine Geoscience, Inc., Bellaire, Texas to Texaco Producing Inc. Bellaire, Texas.

Fugro. 1990d. High-resolution geophysical survey and assessment of potential shallow drilling hazards, Popcorn prospect, Chukchi Sea, Alaska. Report by Fugro-McClelland Marine Geoscience, Inc., Bellaire, Texas to Shell Western E&P, Inc. Houston, Texas.

Fugro GeoConsulting, Inc. 2009. Drill site clearance letters, proposed drill sites C & F blocks 6764 OCS-Y-2280 & 6714 OCS-Y-2267, Chukchi Sea, Alaska. Prepared by Fugro Geoconsulting, Inc., Houston, TX for Shell Gulf of Mexico Inc., Houston, TX.

Fugro GeoConsulting, Inc. 2010a. Shallow hazards and archaeological assessment Burger Site Survey 1 OCS Lease Sale 193 area Chukchi Sea, Alaska. Report No. 27.2009-2327 prepared by Fugro GeoConsulting, Inc., Houston, TX for Shell Gulf of Mexico Inc., Houston, TX.

Fugro GeoConsulting, Inc. 2010b. Drill site clearance letter proposed Burger A drill site Block 6764 OCS-Y-2280 Posey Area, Chukchi Sea, Alaska. Report No. 27.2010-2375-1 prepared by Fugro GeoConsulting, Inc., Houston, TX for Shell Gulf of Mexico Inc., Houston, TX.

Fugro GeoConsulting, Inc. 2010c. Drill site clearance letter proposed Burger F drill site Block 6714 OCS-Y-2267 Posey Area, Chukchi Sea, Alaska. Report No. 27.2010-2375-3 prepared by Fugro GeoConsulting, Inc., Houston, TX for Shell Gulf of Mexico Inc., Houston, TX.

Fugro GeoConsulting, Inc. 2010d. Drill site clearance letter proposed Burger S drill site Block 6762 OCS-Y-2278 Posey Area, Chukchi Sea, Alaska. Report No. 27.2010-2375-4 prepared by Fugro GeoConsulting, Inc., Houston, TX for Shell Gulf of Mexico Inc., Houston, TX.

Fugro GeoConsulting, Inc. 2010e. Shallow hazards and archaeological assessment Burger Site Survey 3 OCS Lease Sale 193 area Chukchi Sea, Alaska. Report No. 27.2010-2342 prepared by Fugro GeoConsulting, Inc., Houston, TX for Shell Gulf of Mexico Inc., Houston, TX.

Fugro GeoConsulting, Inc. 2010f. Drill site clearance letter proposed Burger V drill site Block 6915 OCS-Y-2324 Posey Area, Chukchi Sea, Alaska. Report No. 27.2010-2375-6 prepared by Fugro GeoConsulting, Inc., Houston, TX for Shell Gulf of Mexico Inc., Houston, TX.

Fugro GeoConsulting, Inc. 2011a. Shallow hazards and archaeological assessment Burger Site Survey 4 OCS Lease Sale 193 area Chukchi Sea, Alaska. Report No. 27.2010-2343, v. 1 & 2 prepared by Fugro GeoConsulting, Inc., Houston, TX for Shell Gulf of Mexico Inc., Houston, TX.

Fugro GeoConsulting, Inc. 2011b. Drill site clearance letter proposed Burger R drill site Block 6812 OCS-Y-2294 Posey Area, Chukchi Sea, Alaska. Report No. 27.2010-2375-7 prepared by Fugro GeoConsulting, Inc., Houston, TX for Shell Gulf of Mexico Inc., Houston, TX.

Fuller, A., and J. George. 1997. Evaluation of subsistence harvest data from the North Slope Borough 1993 census for eight North Slope villages: for the calendar year 1992. Second Edition. Department of Wildlife Management, North Slope Borough, Barrow, Alaska.

Funk, D.W., R. Rodrigues, D.S. Ireland, and W.R. Koski (eds.). 2007. Joint monitoring program in the Chukchi and Beaufort Seas, July-November 2006. LGL Alaska Report P891-2, Report from LGL Alaska Research Associates, Inc., LGL Ltd., Greeneridge Sciences, Inc., Bioacoustics Research Program, Cornell University, and Bio-Wave Inc. for Shell Offshore, Inc., ConocoPhillips Alaska, Inc., and GX Technology, and National Marine Fisheries Service, U.S. Fish and Wildlife Service. 316 p. plus Appendices.

Funk, D.W., D.S. Ireland, R. Rodrigues, and W.R. Koski (eds.). 2010. Joint monitoring program in the Chukchi and Beaufort seas, open-water seasons, 2006–2008. LGL Alaska Report P1050-2, Report from LGL Alaska Research Associates, Inc., LGL Ltd., Greeneridge Sciences, Inc., and JASCO Applied Sciences, for Shell Offshore, Inc. and Other Industry Contributors, and National Marine Fisheries Service, U.S. Fish and Wildlife Service. 462 pp. plus Appendices.

Funk, D.W., D.S. Ireland, R. Rodrigues, and W.R. Koski (eds.). 2011a. Joint monitoring program in the Chukchi and Beaufort Seas, open-water seasons, 2006–2009. LGL Alaska Report P1050-2, Report from LGL Alaska Research Associates, Inc., LGL Ltd., Greeneridge Sciences, Inc., and JASCO Applied Sciences, for Shell Offshore, Inc. and Other Industry Contributors, and National Marine Fisheries Service, U.S. Fish and Wildlife Service. 462 pp. plus Appendices.

Funk, D.W., C.M. Reiser, D.S. Ireland, R. Rodrigues, and W.R. Koski (eds.). 2011b. Joint Monitoring Program in the Chukchi and Beaufort seas, 2006–2010. LGL Alaska Draft Report P1213-1, Report from LGL Alaska Research Associates, Inc., LGL Ltd., Greeneridge Sciences, Inc., and JASCO Research, Ltd., for Shell Offshore, Inc. and Other Industry Contributors, and National Marine Fisheries Service, U.S. Fish and Wildlife Service. 592 p. plus Appendices.

Fyfe, J.D. 2003. Separating extratropical zonal wind variability and mean change. Journal of Climate 1655:863-874.

Gailey, G., B. Würsig, and T.L. McDonald. 2007. Abundance, behavior, and movement patterns of western gray whales in relation to a 3-D seismic survey, northeast Sakhalin Island, Russia. Environ. Monit. Assess. 134(1-3):75-91. DOI: 10.1007/s10661-007-9812-1.

Gales, R. 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, CA 79 pp.

Gall, A. and B. Day. 2009. Distribution and abundance of seabirds in the northeastern Chukchi Sea, 2008. Prepared for ConocoPhillips Company, Shell Exploration & Production Company, and Statoil USA E&P, Inc., Anchorage AK by ABR, Inc. Environmental Services, Fairbanks, AK. 55 pp.

Gall A. and B. Day. 2010. Distribution and abundance of seabirds in the northeastern Chukchi Sea, 2008 and 2009. Prepared for ConocoPhillips Company, Shell Exploration & Production Company, and Statoil USA E&P, Inc., Anchorage AK by ABR, Inc. Environmental Services, Fairbanks, AK. 68 pp.

Gall A. and B. Day. 2011. Distribution and abundance of seabirds in the northeastern Chukchi Sea, 2008 - 2010. Prepared for ConocoPhillips Company, Shell Exploration & Production Company, and Statoil USA E&P, Inc., Anchorage AK by ABR, Inc. Environmental Services, Fairbanks, AK. 74 pp.

Gall A. and B. Day. 2012. Distribution and abundance of seabirds in the northeastern Chukchi Sea, 2008 - 2011. Draft Report prepared for ConocoPhillips Company, Shell Exploration & Production Company, and Statoil USA E&P, Inc., Anchorage AK by ABR, Inc. Environmental Services, Fairbanks, AK. 42 pp. + app.

Gall A. and B. Day. 2013. Distribution and abundance of seabirds in the northeastern Chukchi Sea, 2008 - 2012. Draft Report prepared for ConocoPhillips Company, Shell Exploration & Production Company, and Statoil USA E&P, Inc., Anchorage AK by ABR, Inc. Environmental Services, Fairbanks, AK.

Gall A. B. Day. T. Morgan. 2013. Distribution and abundance of seabirds in the northeastern Chukchi Sea, 2008 - 2012. Prepared for ConocoPhillips Company, Shell Exploration & Production Company, and Statoil USA E&P, Inc., Anchorage AK by ABR, Inc. Environmental Services, Fairbanks, AK. 100 pp.

Gall A., T.C. Morgan, and B. Day. 2014. Distribution and Abundance of Seabirds in the Northeastern Chukchi Sea, 2008-2013. Prepared for ConocoPhillips Company, Shell Exploration & Production Company, and Statoil USA E&P, Inc., Anchorage AK by ABR, Inc. Environmental Services, Fairbanks, AK. 94 pp.

Gallagher, M., K. Brewer, and J. Hall. 1992. Site specific monitoring plan Galahad Prospect: final report. Report prepared for Amoco Production Company by Coastal and Offshore Pacific Corp., Walnut Creek, CA. 50 pp.

Gallaway, B.J., B.L. Norcross, R.M. Meyer, S.W., Raborn, B.A. Holladay. 2011. Chapter 1 Introduction in A synthesis of diversity, distribution, abundance, age, size and diet of fishes in the Lease Sale 193 area of the northeastern Chukchi Sea. Final Report prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, Statoil USA E&P, Inc.

Galt, J.A., G.Y. Watabayshi, D.L. Dalton, and J.C. Pearson. 1991. Trajectory analysis for the Exxon Valdez: Hindcast Study. In: Proceedings of the 1991 International Oil Spill Conference (Prevention, Behavior, Control, Cleanup), San Diego, Calif., Washington, DC.

Garlich-Miller, J., J. MacCracken, J. Snyder, R. Meehan, M. Myers, J. Wilder, E. Lance, and A. Matz. 2011a. Status review of the Pacific walrus (*Odobenus rosmarus divergens*). Anchorage, AK, and Fairbanks, AK: U.S. Department of Interior, U.S Fish and Wildlife Service.

Garlich-Miller, J., W. Neakok, and R. Stimmelmayr. 2011b. Field report: walrus carcass survey, Point Lay, Alaska September 11-15, 2011. U.S. Fish and Wildlife Service, Marine Mammals Management, Anchorage, AK. 16 p.

Gausland, I., 2003. Seismic surveys impact on fish and fisheries. Report for Norwegian Oil Industry Association (OLF): Stavanger, Norway.

GEMS. 2009. Shallow Hazards and Archaeological Assessment, Burger J Drill Site, Posey Block NR3-02 6912, Chukchi Sea, Alaska. Report by Geoscience Earth & Marine Services, Inc., Houston, Texas to Shell Gulf of Mexico, Inc. Houston, Texas.

George, J.C., L.M. Philo, R. Suydam, R. Tarpley, and T.F. Albert. 1992. Summary of the 1989 and 1990 subsistence harvest of bowhead whales *Balaena mysticetus* by Alaska eskimos. Report International Whaling Commission 42, SC/43/PS18. Cambridge, UK.

George, J.C., T. O'Hara, H. Brower, Jr., and R. Suydam. 1998. Results of the 1997 subsistence harvest of bowhead whales by Alaskan Eskimos with observations on the influence of environmental conditions on the success of hunting bowhead whales off Barrow, Alaska. Rep. Int. Whal. Comm., Paper SC/50/AS9. Cambridge, UK.

George, J.C., T. O'Hara, and R. Suydam. 1999. Observations on the 1998 subsistence harvest of bowhead whales by Alaskan Eskimos with a note on the late 1998 and early 1999 environmental conditions near Barrow, Alaska. Rep. Int. Whal. Comm., Paper SC/51/AS22. Cambridge, UK.

George, J.C., R. Suydam, T. O'Hara, and G. Sheffield. 2000. Subsistence harvest of bowhead whale by Alaskan Eskimos during 1999. Rep. Int. Whal. Comm., Paper SC/51/AS24. Cambridge, UK.

George, J.C., L.M. Philo, K. Hazard, D. Withrow, G.M. Carroll, and R. Suydam. 1994. Frequency of killer whale (*Orcincus orca*) attacks and ship collisions based on scarring on bowhead whales (*Balaena mysticetus*) of the Bering-Chukchi-Beaufort Sea stock. Arctic 47(3):247-255.

George, J.C. and R. Tarpley. 1986. Observations in the 1984 and 1985 subsistence harvest of bowhead whales, *Balaena mysticetus*, with a note on the fall 1983 harvest. Report International Whaling Commission 36, SC/37/PS16. Cambridge, UK.

George, J.C., G.M. Carroll, R.J. Tarpley, T.F. Albert, and R. Yackley. 1987. Report of field activities pertaining to the spring 1986 census of bowhead whales, *Balaena mysticetus*, off Point Barrow, Alaska with observations on the subsistence hunt. SC/38/PS5, Report to the International Whaling Commission 37:301-308, Cambridge, UK.

George, J.C., G.M. Carroll, R. Tarpley, T.F. Albert, and R.L. Yackley. 1988. Report of field activities pertaining to the spring 1986 census of bowhead whales, *Balaena mysticetus*, off Point Barrow, Alaska with observations on the subsistence hunt. Report International Whaling Commission 37, SC/38/PS5. Cambridge, UK.

George, J.C., G.M. Carroll, L.M. Philo, and T.F. Albert. 1990. Report of field activities of the spring 1988 census of bowhead whales, (*Balaena mysticetus)* off Point Barrow, Alaska with observations on the subsistence hunt. Report International Whaling Commission 40, SC/41/PS7. Cambridge, UK.

George, J.C., R.S. Suydam, L.M. Philo, T.F. Albert, J.E. Zeh, and G. Carroll. 1995. Report of the spring 1993 census of bowhead whales *Balaena mysticetus* off Point Barrow, Alaska with observations on the subsistence hunt of bowhead whales by Alaska eskimos. Report International Whaling Commission 45, SC/46/AS17. Cambridge, UK.

George, J.C., J. Zeh, R. Suydam, and C. Clark. 2004. Abundance and population trend (1978-2001) of western arctic bowhead whales surveyed near Barrow, Alaska. Marine Mammal Science. 20(4): 755-773.

Geraci, J. 1988. Physiologic and toxicologic effects on cetaceans. pp. 167-202 *in*: J. Geraci, and D. St. Aubin (eds.) Synthesis of effects of oil on marine mammals. OCS Study MMS 89-0049 prepared by Battelle Memorial Institute for USDOI Minerals Management Service Atlantic OCS Region.

Geraci, J. 1990. Physiologic and toxic effects on cetaceans. *in*: J.R. Geraci and D.J. St Aubin (eds.) Sea mammals and oil: confronting the risks. Academic Press: San Diego. 282 pp.

Geraci, J. and D. St. Aubin. 1982. Study of the effects of oil on cetaceans. Final Report. USDOI Bureau of Land Management, Washington, D.C. 274 pp.

Geraci, J. and D. St. Aubin. 1985. Expanded studies of the effects of oil on cetaceans. Final Report. Part I. USDOI Minerals Management Service, Washington, D.C. 144 pp.

Geraci, J. and D.J. St. Aubin. 1990. Sea mammals and oil: confronting the risks. San Diego, CA: Academic Press, Inc. 282 pp.

Geraci, J. and T. Smith. 1976. Direct and indirect effects of oil on Ringed Seals (*Phoca Hispida*) of the Beaufort Sea. Journal of Fisheries Research Board Canada 33 (9):1976-1984.

Gerber, L.R., A.C. Keller, and D.P. DeMaster. 2007. Ten thousand and increasing: Is the western Arctic population of bowhead whale endangered? Biological Conservation 137:577–583.

GESAMP. 1997. Report of the twenty-seventh session of GESAMP.

Gibson, J.A.E., W.F. Vincent, B. Nieke, and R. Pienitz. 2000. Biological exposure to UV radiation in the Arctic Ocean: the relative importance of ozone versus riverine dissolved organic carbon. Arctic 53:372-382.

Gilbert, J. R. 1999. Review of previous Pacific walrus surveys to develop improved survey designs. *in:* G.W. Garner, S.C. Amstrup, J.L. Laake, B.F.J. Manly, L.L. McDonald, and D.G. Robertson (eds.) Marine mammal survey and assessment methods. A.A. Balkema, Rotterdam. 287 pp.

Gilbert, J.R., G.A. Fedoseev, D. Seagars, E. Razlivalov, and A. LaChugin. 1992. Aerial census of Pacific Walrus, 1990. USFWS R7/MMM Technical Report 92-1. 33 pp.

Gillispie, J.A.G. 1997. The biology and ecology of Arctic Cod. M.S. Thesis, University of Alaska, Fairbanks, AK. 82 pp.

Gillispie, J.G., R.L. Smith, L.E. Barbour, and W.E. Barber. 1997. Distribution, abundance, and growth of arctic cod in the northeastern Chukchi Sea. pp. 81-89. In Fish Ecology in Arctic North America. Edited by J.B. Reynolds. American Fisheries Society Symposium No. 19.

Givens, G.H., S. L. Edmondson, J.C. George, R. Suydam, R.A. Charif, A. Rahaman, D. Hawthorne, B. Tudor, R.A. DeLong, and C.W. Clark. 2013. Estimate of 2011 Abundance of the Bering-Chukchi-Beaufort Seas bowhead whale population. SC/65a/BRG01 International Whaling Commission.

Goldsmith, S., J. Angvik, H. Lowe, A. Hill and L. Leask. 2004. The status of Alaska natives report 2004. Institute of Social and Economic Research, University of Alaska Anchorage, Anchorage, AK.

Gollop, M.A., J.R Goldsberry, and R.A. Davis. 1974a. Disturbance studies of breeding black brant, common eiders, glaucous gulls, and arctic terns at Nunaluk Spit and Phillips Bay, Yukon Territory, July 1972. pp.153-200 *in*: W.W.H. Gunn and J.A. Livingston (eds.) Arctic Gas Biological Report Series Volume 14.

Goodman, S., J. June, and K. Antonelis. 2012. 2011 Fish and invertebrate trawl surveys in the Chukchi Sea Environmental Studies Program. Prepared by Natural Resource Consultants, Inc., Seattle, WA for Olgoonik Fairweather, LLC.

Goodman, Scott E., J.A. June, K.L. Antonelis, A.L. Antonelis. 2013. Acoustic Survey of Fishes-Environmental Studies Program 2012. Prepared for Olgoonik Fairweather. Sponsored by ConocoPhillips Company, Shell Exploration and Production, Statoil USA E&P Inc.

Goold, J.C. 1996a. Acoustic assessment of common dolphins off the west Wales coast, in conjunction with 16th round seismic surveying. Rep. from School of Ocean Sciences, Univ. Wales, Bangor, Wales, for Chevron UK Ltd, Repsol Explor. (UK) Ltd., and Aran Energy Explor. Ltd. 22 p.

Goold, J.C. 1996b. Acoustic assessment of populations of common dolphin Delphinus delphis in conjunction with seismic surveying. J. Mar. Biol. Assoc. U.K. 76:811-820.

Goold, J.C. 1996c. Acoustic cetacean monitoring off the west Wales coast. Rep. from School of Ocean Sciences, Univ. Wales, Bangor, Wales, for Chevron UK Ltd, Repsol Explor. (UK) Ltd, and Aran Energy Explor. Ltd. 20 p.

Goold, J.C. and P.J. Fish. 1998. Broadband spectra of seismic survey air-gun emissions, with reference to dolphin auditory thresholds. Journal of the Acoustical Society of America 103(4):2177-2184.

Gradinger, R. 2008. *Sea Ice*. Arctic Ocean Synthesis: Analysis of Climate Change Impacts in the Chukchi and Beaufort Seas with Strategies for Future Research. Edited by R. Hopcroft and B. Bluhm. University of Alaska Fairbanks, Institute of Marine Sciences.

Gradinger, R., K. Meiners, G. Plumley, Q. Zhang, and B. Bluhm. 2005. Abundance and composition of the sea-ice Meiofauna in off-shore pack ice of the Beaufort Gyre in summer 2002 and 2003. Polar Biology. 28:171-181.

Grebmeier, J. and K. Dunton. 2000. Benthic processes in the northern Bering/Chukchi Seas: status and global change. pp. 61-71 *in*: Impacts of change in sea ice and other environmental parameters in the Arctic. Marine Mammal Workshop, Girdwood, AK., Feb. 15-17, 2000. Marine Mammal Commission, Bethesda, MD.

Grebmeier, J.M., L.W. Cooper, H.M. Feder, and B.I. Sirenko. 2006a. Ecosystem dynamics of the Pacific-influenced northern Bering and Chukchi seas in the Amerasian Arctic. Progress in Oceanography 71: 331–361.

Green, G., K. Hashagen, and D. Lee. 2007. Marine mammal monitoring program: FEX barging project. 2007. Unpublished report prepared for ASRC Lynx Enterprises, Inc., Anchorage, Alaska by Tetra Tech EC, Inc., Bothell, Washington.

Greene, C. 1985. Characteristics of waterborne industrial noise, 1980-1984. pp. 197-253 in: W. Richardson (ed.) Behavior, disturbance responses and distribution of bowhead whales Balaena mysticetus in the Eastern Beaufort Sea, 1980-1984. OCS Study MMS 85-0034. Rep. prepared by LGL Ecol. Res. Assoc. Inc., Bryan, TX, for UDOI Minerals Management Service, Reston, VA. 306 pp.

Greene, C.R., Jr. 1986. Underwater sounds from a semisubmersible drill rig SEDCO 708 drilling in the Aleutian Islands. Section1 in: API Publication 4438, American Petroleum Institute, Washington DC.

Greene, C. 1987a. Acoustical studies of underwater noise and localization of whale calls. *in*: Responses of bowhead whales to an offshore drilling operation in the Alaskan Beaufort Sea, Autumn 1986. Report prepared by LGL Limited, King City, Ont. and Greeneridge Sciences, Inc., Santa Barbara, CA for Shell Western E&P Inc., Anchorage AK.

Greene, C. 1987b. Characteristics of oil industry dredge and drilling sounds in the Beaufort Sea. Journal of the Acoustical Society of America 82(4):1315-1324.

Greene, C.R., Jr. and S.E. Moore. 1995. Man made noise. Chapter 6 pp. 101-158 *in*: W.J. Richardson, C.R. Greene, Jr., C.I. Malme, and D.H. Thomson (eds.). Marine mammals and noise. Academic Press, San Diego, CA. 576 pp.

Greene, C.R., Jr. and W.R. Richardson. 1988. Characteristics of marine seismic survey sounds in the Beaufort Sea. Journal of the Acoustical Society of America 83(6):2246-2254.

Greene, C.R., Jr., N.S. Altman, and W.J. Richardson. 1999. Bowhead whale calls. pp. 6-1 to 6-23 *in*: W.J. Richardson (ed.), Marine mammal and acoustical monitoring of Western Geophysical's open-water seismic program in the Alaskan Beaufort Sea, 1998. LGL Rep. TA2230-3. Rep. from LGL Ltd., King City, ON, and Greeneridge Sciences Inc., Santa Barbara, CA, for Western Geophysical, Houston, TX, and U.S. Nat. Mar. Fish. Serv., Anchorage, AK, and Silver Spring, MD. 390 p.

Griffiths, F., Huebert, R., and Lackenbauer, P. 2011. Canada and the Changing Arctic: Sovereignty, Security and Stewardship. Forewords by Bill Graham and Hugh Segal.Wilfrid Laurier University Press. 301 pp. Waterloo, ON, Canada.

Griffiths, W.B. and D.H. Thomson. 2002. Zooplankton: summary and conclusion. Chapter 7 *in*: W. Richardson, W.J. and D.H. Thomson (eds.). 2002. Bowhead whale feeding in the eastern Alaskan Beaufort Sea: update of scientific and traditional information. OCS Study MMS 2002-012; LGL Rep. TA2196-7. Rep. from LGL Ltd., King City, Ont., for USDOI Minerals Management Service, Anchorage, AK, and Herndon, VA. Vol. 1, xliv + 420 p; Vol. 2, 277 p.

Gross, P.L., and J.S. Mattson. 1977. The Argo Merchant oil spill, a preliminary scientific report. U.S. Department Commerce, National Oceanic and Atmospheric Administration, Washington, DC.

Gulliksen, B. and O.J. Lonne. 1989. Distribution, abundance, and ecological importance of marine symnpagic fauna in the Arctic. Rapp. PV Reun. Cons. Int. Explor. Mer. 188:133-138.

Haidvogel, D.B., K.S. Hedstrom, and J. Francis. 2001. Numerical simulations of atmosphere/ocean/sea ice interaction in the Arctic Ocean 1982-1996. OCS Study MMS 2001-069. USDOI Minerals Management Service, Alaska OCS Region, Anchorage, AK.

Haldorson, L. and P. Craig. 1984. Life history and ecology of a Pacific-Arctic population of rainbow smelt in coastal waters of the Beaufort Sea. Transactions of the American Fisheries Society 113:33-38.

Haley, B., C. Reiser, J. Beland, and D. Savarese. 2009. Chukchi Sea vessel-based seismic monitoring. (Chapter 5) *In*: Ireland, D.S., R. Rodrigues, D. Funk, W. Koski, D. Hannay. (eds.) 2009. Marine mammal monitoring and mitigation during open water seismic exploration by Shell Offshore Inc. in the Chukchi and Beaufort Seas, July–October, 2008: 90-day repot. LGL Rep P1049-1. Rep. from LGL Alaska Research Associates Inc., LGL Ltd., and JASCO Research Ltd. for Shell Offshore Inc., National Marine Fisheries Service and U.S. Fish and Wild. Serv. 277 pp, plus appendices.

Hall, J., M. Gallagher, K. Brewer, P. Regos, and P. Isert. 1994. Arco Alaska, Inc. 1993 Kuvlum exploration prospect site specific monitoring program final report. Report prepared for Arco Alaska, Inc. by Coastal and Offshore Pacific Corp., Walnut Creek, CA. 218 pp.

Hannay, D., B. Martin, M. Laurinolli, and J. Delarue, 2009. Chukchi Sea acoustic monitoring program. In: Funk, D.W., Funk, D.S., Rodrigues, R., and Koski, W.R. (eds.). Joint monitoring program in the Chukchi and Beaufort seas, open water seasons 2006-2008. LGL Alaska Report P1050-1, Report from LGL Alaska Research Associates, Inc., LGL Ltd., Greenridge Sciences, Inc., and JASCO Research, Ltd., for Shell Offshore, Inc. and other industry contributors, and National Marine Fisheries Service, U.S. Fish and Wildlife Service. 288 p. + app.

Hansen, D. 1985. The potential effects of oil spills and other chemical pollutions on marine mammals occurring in Alaskan waters. OCS Report MMS 85-0031. USDOI Minerals Management Service, Alaska OCS Region, Anchorage, AK.

Hansen, D.J. 1992. Potential effects of oil spills on marine mammals that occur in Alaskan waters. OCS Report MMS 92-0012. USDOI, Minerals Management Service, Alaska OCS Region, Anchorage, AK. 25 pp.

Harris, G.P. 1986. Phytoplankton ecology: structure function and fluctuation. Chapman and Hill. London, England.

Harris, R.E., G.W. Miller, and W.J. Richardson. 2001. Seal responses to airgun sounds during summer seismic surveys in the Alaskan Beaufort Sea. Marine Mammal Science 17(4):795-812.

Hart Crowser, Inc. 2000. Estimation of oil spill risk from Alaska North Slope, Trans Alaska Pipeline and Arctic Canada oil spill data sets. OCS Study MMS 2000-007. USDOI Minerals Management Service, Alaska OCS Region, Anchorage Alaska.

Hart, J. 1973. Pacific fishes of Canada. Bulletin of Fisheries Research Board of Canada 180. 740p.

Hartin K.G., L.N. Bisson, S.A. Case, D.S. Ireland, and D. Hannay. (eds.) 2011. Marine mammal monitoring and mitigation during site clearance and geotechnical surveys by Statoil USA E&P Inc. in the Chukchi Sea, August–October 2011: 90-day report. LGL Rep. P1193. Rep. from LGL Alaska Research Associates Inc., LGL Ltd., and JASCO Research Ltd. for Statoil USA E&P Inc., Nat. Mar. Fish. Serv., and U.S. Fish and Wild. Serv. 202 p, + app.

Hartline, K., P. Lenz, and C. Herren. 1996. Physiological and behavioural studies of escape responses in Calanoid copepods. Marine and Freshwater Behavior and Physiology 27:199-212.

Harvey, J.T. and M.E. Dahlheim. 1994. Cetaceans in oil. pp. 257-264 *in*: T.R. Loughlin (ed.) Marine mammals and the Exxon Valdez. Academic Press, San Diego, CA.

Harwood, L.A., F. McLaughlin, R.M. Allen, J. Illasiak, Jr., and J. Alikamik. 2005. First-ever marine mammal and bird observations in the deep Canada Basin and Beaufort/Chukchi Seas: expeditions during 2002. Polar Biology 28:250-253.

Hastings, M.C., A.N. Popper, J.J. Finneran and P.J. Lanford. 1996. Effect of low frequency underwater sound on hair cells of the inner ear and lateral line of the teleost fish *Astronotus ocellatus*. Journal of the Acoustical Society of America 99:1759-1766.

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.

Hawkins, A.D. 1981. The hearing abilities of fish. pp.109-133 *in*: W.N. Tavolga, A.N. Popper and R.R. Fay (eds.) Hearing and sound communication in fishes. Springer. New York.

Hawkins A. and A. Popper. 2012. Effects of Noise on Fish, Fisheries, and Invertebrates in the U.S. Atlantic and Arctic from Energy Industry Sound-Generating Activities: Literature Synthesis. Prepared for USDOI, BOEM Fish and Sound Workshop, Feb. 2012. 135 pp.

Hay K.A., and A.W. Mansfield. 1989. Narwhal - *Monodon monoceros* Linnaeus, 1758. pp. 145 - 176 *in*: S.H. Ridgway and S.R. Harrison (eds.) Handbook of marine mammals. Vol. 4: River dolphins and the larger toothed whales. Academic Pres, London,.

Hemming, J. 1971. The distribution and movement patterns of caribou in Alaska. Alaska Division of Fish and Game Technical Bulletin No. 1:1-60.

Hicks, M.V. 1998. Moose. Federal aid in wildlife restoration management report: Survey-inventory activities 1 July 1993 - 30 June 1995. Division of Wildlife Conservation, Alaska Department of Fish and Game.

Hill, J.C., and N W Driscoll. 2008. Paleodrainage on the Chukchi shelf reveals sea level history and meltwater discharge. Marine Geology, 129-151.

Hills, S. and J.R. Gilbert. 1994. Detecting Pacific walrus population trends with aerial survey – a review. Transactions North American Wildlife and Natural Resource Conference.

Hobbs, L. and M. Goebel. 1982. Bowhead Whale radio-tagging feasibility study and review of large cetacean tagging. NOAA Technical Memo NMFS F/NWC-21. U.S. National Marine Mammal Laboratory, National Marine Fisheries Service, Seattle, WA. 68 pp.

Hodges, J.I. and W.D. Eldridge. 2001. Aerial surveys of eiders and other waterbirds on the eastern Arctic Coast of Russia. Wildfowl 52:127-142.

Hoferkamp L., M. Hermanson, and C.G. Muir Derek. 2010. Current use pesticides in Arctic media; 2000–2007. Science of the Total Environment 408:2985-2994.

Hoffecker, J.F., and S. A. Elias. 2003. Environment and archeology in Beringia. Evolutionary Anthropology: Issues, News, and Reviews, 34-49.

Hogarth, W.T. 2002. Declaration of William T. Hogarth in opposition to plaintiff's motion for temporary restraining order, 23 October 2002. Civ. No. 02-05065-JL. U.S. District Court, Northern District of California, San Francisco Div.

Holand, P. 1997. Offshore blowouts causes and control. Gulf Publishing Company, Houston, TX.

Holliday, D.V., R.E. Pieper, M.E. Clarke, and C.F. Greenlaw. 1987. The effect of airgun energy releases on the eggs, larvae and adults of the northern anchovy (Engravis mordan). API Publication 4453. Report by Tracor Applied Science for American Petroleum Institute, Washington, DC.

Holmes, C.E. 2001. Tanana River valley archaeology circa 14,000 to 9000BP. Arctic Anthropology. 38(2):154-170.

Hopcroft, R., J. Questel, P. Hariharan, C. Stark, C. Clarke-Hopcroft. 2013a. Oceanographic assessment of the planktonic communities in the northeastern Chukchi Sea: report for survey year 2011. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil E&P USA, Anchorage, AK by the Institute of Marine Science, University of Alaska, Fairbanks.

Hopcroft, R., P. Hariharan, J. Questel, J. Lamb, E. Lessard, M. Foy, and C. Clarke-Hopcroft. 2013b. Oceanographic assessment of the planktonic communities in the northeastern Chukchi Sea: report for survey year 2012. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil E&P USA, Anchorage, AK by the Institute of Marine Science, University of Alaska, Fairbanks and School of Oceanography, University of Washington, Seattle.

Hopcroft, R., J. Questel, and C. Clarke-Hopcroft. 2009. Oceanographic assessment of the planktonic communities in the Klondike and Burger survey areas of the Chukchi Sea: report for survey year 2008.

Hopcroft, R., J. Questel, and C. Clarke-Hopcroft. 2010. Oceanographic assessment of the planktonic communities in the Klondike and Burger survey areas of the Chukchi Sea: report for survey year 2009.

Hopcroft, R., J. Questel, and C. Clarke-Hopcroft. 2011. Oceanographic assessment of the planktonic communities in the northeastern Chukchi Sea: report for survey year 2010. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil E&P USA, Anchorage, AK by the Institute of Marine Science, University of Alaska, Fairbanks.

Hopcroft, R., J. Questel, P. Hariharan, C. Stark, and C. Clarke-Hopcroft. 2012. Oceanographic assessment of the planktonic communities in northeastern Chukchi Sea: report for survey year 2011. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil E&P USA, Anchorage, AK by the Institute of Marine Science, University of Alaska, Fairbanks.

Hopcroft, R., J. Questel, J. Lamb, and C. Clarke-Hopcroft. 2014. Oceanographic assessment of the planktonic communities in northeastern Chukchi Sea: report for survey year 2013. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil E&P USA, Anchorage, AK by the Institute of Marine Science, University of Alaska, Fairbanks.

Horner, R.A., K.O. Coyle, and D.R. Redburn. 1974. Ecology of the plankton of Prudhoe Bay, Alaska. IMS Report No. R76-2, Sea Grant Report No. 73-15. University of Alaska, Institute of Marine Science.

Hunter, C.M., H. Caswell, M.C. Runge, E.V. Regehr, S.C. Amstrup, and I. Stirling. 2007. Polar bears in the southern Beaufort Sea II: demography and population growth in relation to sea ice conditions. Administrative Report, Alaska Science Center, U.S. Geological Survey, Anchorage, AK. 46 pp.

Hunter, M.L. 1996. Fundamentals of conservation biology. Blackwell Science, Cambridge, MA. 482 pp. Huntington, H.P.. 1999. Traditional knowledge of the ecology of beluga whales (*Delphinapterus leucas*) in the eastern Chukchi and northern Bering seas, Alaska. Arctic 52(1):49–61.

Hurley, G. and J. Ellis. 2004. Environmental effects of exploratory drilling offshore Canada: Environmental effects of monitoring data and literature review. Final Report. Regulatory Advisory Committee, Canada Environmental Assessment Agency, Ottawa, CA. 114 pp.

Incardona J.P., L.D. Gardner, T.L. Linbo, T.L. Brown, A.J. Esbaugh, E.M. Mager, J.D. Stieglitz, B.L. French, J.S. Labenia, C.A. Laetz et al. 2014. Deepwater Horizon Crude Oil Impacts The Developing Hearts of Large Predatory Pelagic Fish. Proceedings of the National Academy of Sciences of the United States of America: In Press.

Impact Assessment, Inc. 1989. Point Lay Case Study. OCS Study MMS 89-0093. USDOI Minerals Management Service, Alaska OCS Region, Anchorage, AK. 532 pp.

IPCC. 2001a. Summary for policymakers. *In*: Notes from the UN climate change 2001 report. Intergovernmental Panel on Climate Change.
http://www.grida.no/publications/other/ipcc_tar/ Accessed May 2009.

IPCC. 2001b. Notes from the climate change 2001 report.
http://www.grida.no/publications/other/ipcc_tar/
Accessed May 2009.

IPCC. 2007. Climate change 2007: The physical science basis. Contribution of working group I to the fourth assessment report of the intergovernmental panel of climate change., S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Avery, M. Tignor, and H.L. Miller (eds.). Cambridge University Press, New York. 996 pp.

Ireland, D.S., D.W. Funk, R. Rodrigues, and W.R. Koski (eds.). 2008. Joint monitoring program in the Chukchi and Beaufort Seas, July-November 2007. LGL Alaska Report P1050-3, Report from LGL Alaska Research Associates, Inc., LGL, Ltd., Greeneridge Sciences, Inc., and JASCO Research, Ltd. and for Shell Offshore, Inc., ConocoPhillips Alaska, Inc., and National Marine Fisheries Service, U.S. Fish and Wildlife Service. 445 p. plus Appendices.

Ireland, D., R. Rodrigues, D. Funk, W. Koski, and D. Hannay, editors. 2009. Marine Mammal Monitoring and Mitigation during open water seismic exploration by Shell Offshore Inc. in the Chukchi and Beaufort seas, July-October 2008: 90-Day Report. LGL Report P1049-1 prepared by LGL Alaska Research Associates, Inc., Anchorage AK, LGL Ltd. Environmental Research Associates, King City Ont., CA, and Jasco Research Ltd., Victoria, B.C. for Shell Offshore Inc., Houston TX, National Marine Fisheries Service, Silver Springs, MD, and U.S. Fish and Wildlife Service, Anchorage, AK.

IT Alaska, Inc. 2001. Oil spill air emissions modeling (COA-3), Valdez Marine Terminal, Valdez, Alaska, prepared for Alyeska Pipeline Service Company, Anchorage, Alaska, Nov.

IUCN 2014. IUCN Red List of Threatened Species. Version 2012.2. <www.iucnredlist.org>. Downloaded on 11 March 2013.

IWC. 1996. Report of the scientific committee. Rep. International Whaling Commission. 46:51-97.

IWC. 1997. Chairman's report of the 48th annual meeting. Report of the International Whaling Commission 47, pp. 17-55. Cambridge, UK.

IWC. 2004. Report of the scientific committee. International Whaling Commission. Cambridge, UK.

IWC. 2005. Report of the scientific committee. International Whaling Commission. Cambridge, UK.

IWC. 2010. Aboriginal subsistence whaling management advice (Annex F). Vol 11, Supplement 2, April 2010. (p. 22).

Izon, D., E.P. Danenberger, M. Mayes, and MMS. 2007. Absence of fatalities in blowouts encouraging in MMS study of OCS incidents 1992-2006. Drilling Contractor, July/August 2007, 84-90. Retrieved from http://drillingcontractor.org/dcpi/dc-julyaug07/DC_July07_MMSBlowouts.pdf.

Jangaard, P.M. 1974. The capelin (*Mallotus villosus*): biology, distribution, utilization, and composition. Bulletin of the Fisheries Research Board of Canada No. 186. 70 pp.

JASCO Applied Sciences, Inc., and Greeneridge Sciences, Inc. 2014. Acoustic monitoring of oil and gas industry noise sources. (Chapter 4) *In*: LGL Alaska Research Associated, Inc., JASCO Applied Sciences, Inc., and Greeneridge Sciences, Inc. 2014. Joint Monitoring Program in the Chukchi and Beaufort Seas, 2012. LGL Alaska Final Report P1272-2 for Shell Offshore, Inc. ION Geophysical, Inc., and Other Industry Contributors, National Marine Fisheries Service, and U.S. Fish and Wildlife Service. 320 p. plus Appendices.

Jay, C.V. and S. Hills. 2005. Movements of walruses radio-tagged in Bristol Bay, Alaska. Arctic 58:192-202.

Jay, C.V., A.S. Fischbach, and A.A. Kochnev. 2012. Walrus areas of use in the Chukchi Sea during sparse sea ice cover. Marine Ecology Progress Series. 468:1-13.

Jepson, P.D., M. Arbelo, R. Deaville, I.A.P. Patterson, P. Castro, J.R. Baker, E. Degollada, H.M. Ross, P. Herráez, A.M. Pocknell, F. Rodríguez, F.E. Howie, A. Espinosa, R.J. Reid, J.R. Jaber, V. Martin, A.A. Cunningham and A. Fernández. 2003. Gas-bubble lesions in stranded cetaceans. Nature 425(6958):575-576.

Johansson, S. 1980. Impact of oil on the pelagic ecosystem. pp. 61-80 *in*: J.J. Kineman, R. Elmgren, and S. Hansson (eds.) The Tsesis oil spill. US Department of Commerce, National Oceanic and Atmospheric Administration, Washington, DC.

Johansson, S., U. Larsson, and P. Boehm. 1980. The Tsesis oil spill, Marine Pollution Bulletin 11:284-291.

Johnson, S.R. 2002. Marine mammal mitigation and monitoring program for the 2001 Odoptu 3-D seismic survey, Sakhalin Island Russia: Executive summary. Rep. from LGL Ltd, Sidney, B.C., for Exxon Neftegas Ltd., Yuzhno-Sakhalinsk, Russia. 49 p. Also available as Working Paper SC/02/WGW/19, Int. Whal. Comm., Western Gray Whale Working Group Meeting, Ulsan, South Korea, 22-25 October 2002. 48 p.

Johnson, J., and M. Daigneault. 2008. Catalog of waters important for spawning, rearing, or migration of Anadromous fishes – Interior Region, Effective June 2, 2008. Special Publication No. 08-04, Alaska Department of Fish and Game, Anchorage.

Johnson, J., and M. Daigneault. 2012. Fish Resource Monitor. Catalog of waters important for spawning, rearing, or migration of Anadromous fishes. Alaska Department of Fish and Game, Anchorage.

Johnson, S.R. and D.R. Herter. 1989. The birds of the Beaufort Sea. BP Exploration (Alaska) Inc., Anchorage, AK.

Johnson, S.R. and W.J. Richardson. 1981. Beaufort Sea barrier island-lagoon ecological process studies: final report, Simpson Lagoon. Part 3. Birds. pp. 109-383 in: Environmental Assessment of the Alaskan Continental Shelf. Final Reports, Biological Studies, Vol. 7. National Oceanic and Atmospheric Administration, Boulder, CO.

Johnson, S.R. and W.J. Richardson. 1982. Waterbird migration near the Yukon and Alaskan coast of the Beaufort Sea: II. Moult migration of seaducks. **Arctic** 35(2):291-301.

Johnson, S.R., K.J. Frost, and L.F. Lowry. 1992. Use of Kasegaluk Lagoon, Chukchi Sea, Alaska, by marine birds and mammals, Volume I: An overview. OCS Study MMS 92-0028. USDOI, Minerals Management Service, Alaska OCS Region Anchorage, AK. pp. 4-56.

Johnson, S.R., D. Wiggins, and P. Wainwright. 1993. Late summer abundance and distribution of marine birds in Kasegaluk Lagoon, Chukchi Sea, Alaska. Arctic. 46(3) 212-227.

Johnson, J., R.B. Lanctot, B.A. Andres, J.R. Bart, S.C. Brown, S.J. Kendall, and D.C. Payer. 2007a. Distribution of breeding shorebirds on the Arctic coastal plain of Alaska. Arctic. 60:277-293.

Johnson, S.R., W.J. Richardson, S.B. Yazvenko, S.A. Blokhin, G. Gailey. M.R. Jenkerson, S.K. Meier, H.R. Melton, M.W. Newcomer, A.S. Perlov, S.A. Rutenko, B. Wursig, C.R., Martin, and D.E. Egging. 2007b. A western gray whale mitigation and monitoring program for a 3-D seismic survey, Sakhalin Island Russia. Environmental Monitoring and Assessment 134:1-19.

Jones, M.L. and S.L. Swartz. 1984. Demography and phenology of gray whales and evaluation of whale watching activities in Laguna San Ignacio, Baja California Sur, Mexico. pp. 309–374 *in*: M.L. Jones, S.L. Swartz and S. Leatherwood (eds) The gray whale, *Eschrichtius robustus*. Academic Press, Inc., Orlando, FL.

Jones, P.D. and A. Moberg. 2003. Hemispheric and large-scale surface air temperature variations: an extensive revision and an Update to 2001. Journal of Climate 16.

Jordan, R.E. and J.R. Payne. 1980. Fate and weathering of petroleum spills in the marine environment: A literature review and synopsis. Ann Arbor Science Publishers, Inc., Ann Arbor, MI. 174 pp.

Juneau Empire. 2009. “On Board the Polar Sea.” Juneau Empire. Posted Thursday, November 19.

Kanik, B., M. Winsby, and R. Tanasichuk. 1980. Observations of marine mammal and seabird interaction with icebreaking activities in the high Arctic July 2-12, 1980. Report prepared by Hatfield Consultants Ltd., West Vancouver, B.C. for Petro-Canada, Calgary, Alberta, CA. 53 pp.

Karoly, D.J., K. Braganza, P.A. Stott, J.M. Arblaster, G.A. Meehl, A.J. Broccoli, and K.W. Dixon. 2003. Detection of a human influence on North American climate. Science 302:1200-1203.

Kastak, D., R.L. Schusterman, B.L. Southall and C.J. Reichmuth. 1999. Underwater temporary threshold shift induced by octave-band noise in three species of pinnipeds. Journal of the Acoustical Society of America 106:1142-1148.

Keigwin, L. D., J. P. Donnelly, M. S. Cook, N. W. Driscoll, and J. Brighem-Grette. (2006). "Rapid Sea-level Rise and Holocene Climate in the Chukchi Sea." *Geology.* 34(10): 861. DOI: 10.1130/G22712.1.

Kelly, B. P. 1988b. Ribbon seal. Pages 95-106 in: J. W. Lentfer, editor. Selected Marine Mammals of Alaska : Species Accounts with Research and Management Recommendations. Marine Mammal Commission, Washington, D.C.

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. 2010. Status review of the ringed seal (Phoca hispida).NOAA Tech. Memo. NMFS-AFSC-212.

Kertell, K. 1991. Disappearance of the Steller's Eider from the Yukon-Kuskokwim Delta, Alaska. Arctic 44:177-187.

Ketten. D.R. 1995. Estimates of blast injury and acoustic trauma zones for marine mammals from underwater explosions. pp. 391-407 in R.A. Kastelein, J.A. Thomas, and P.E. Natchigall (eds.) Sensory systems of aquatic mammals. De Spil Publ., Woerden, Netherlands. 588 pp.

Ketten, D.R., J. Lien, and S. Todd. 1993. Blast injury in humpback whale ears: evidence and implications. Journal of the Acoustical Society of America 94(3, Pt. 2):1849-1850.

Ketten, D.R., J. O'Malley, P.W.B. Moore, S. Ridgway and C. Merigo. 2001. Aging, injury, disease, and noise in marine mammal ears. Journal of the Acoustical Society of America 110(5, Pt. 2):2721.

King, Thomas F. 1998. Cultural resource law & practice: An introductory guide. Heritage Resource Management Series. Series editor: Don Fowler. Altamira Press. New York, NY.

Kingston, P., M. Dixon, S. Hamilton, and D. Moore. 1995. The impact of the Braer oil spill on the macrobenthic fauna on the sediments off the Shetland Islands. Marine Pollution Bulletin 30:445-459.

Kinney, P.J., ed. 1985. Environmental characterization and biological utilization of Peard Bay. OCS Study MMS 85-0102. USDOI Minerals Management Service, Alaska OCS Region, Anchorage, AK. pp. 97-440.

Kleinfield, J., J. Kruse, and R. Travis. 1983. Iñupiat participation in the wage economy: Effects of culturally adapted jobs. Arctic Anthropology. 20(1).

Kochnev, A.A. 2004. Warming of eastern Arctic and present status of the Pacific Walrus (Odobenus Rosmarus Divergens) population. pp. 284-288 in: V.M. Belkovich (ed.). Marine mammals of the Holarctic. Papers of the Third International Conference. Marine Mammal Council, Moscow, Russian Federation.

Kooyman, G., R. Gentry, and W. McAllister. 1976. Physiological impact of oil on pinnipeds. Report Northwest Fisheries Center, National Marine Fisheries Service, Seattle, WA. 23pp.

Kosheleva, V. 1992. The impact of airguns used in marine seismic exploration on organisms living in the Barents Sea. Fisheries and Offshore Petroleum Exploitation, 2nd Annual International Conference, Bergen, Norway.

Koski, W. and S. Johnson. 1987. Behavioral studies and aerial photogrammetry. Section 4 *in*: Responses of bowhead whales to an offshore drilling operation in the Alaskan Beaufort Sea, autumn 1986. Report by LGL Limited, King City, Ont. And Greeneridge Sciences Inc., Santa Barbara, CA for Shell Western E & P Inc., Anchorage, AK 371 pp.

Koski, W.R., R.A. Davis, G.W. Miller, and D.E. Withrow. 1993. Reproduction. pp. 239-274 in: J.J. Burns, J.J. Montague, and C.J. Cowles (eds.) The bowhead whale. Society of Marine Mammalogists, Special Publication No. 2.

Koski, W.R, D. Funk, D. Ireland, C. Lyons, K. Christie, A.M. Macrander, and S. Blackwell. 2009. An Update on feeding by bowhead whales near an offshore seismic survey in the central Beaufort Sea. IWC Paper SC/61/BRG3 presented to the International Whaling Commission

Koski, W.R., Zeh, J., Mocklin, J., Davis, A.R., Rugh, D.J., George, J.C., and Suydam, R. 2010. Abundance of Bering-Chukchi-Beaufort bowhead whales (*Balaena mysticetus*) in 2004 estimated from photo-identification data. J. Cetacean Res. Manage. 11(2):89–99.

Kostyuvchenko, L.P. 1973. Effects of elastic waves generated in marine seismic prospecting on fish eggs in the Black Sea. Hydroboil, J 9: 45-48.

Kovacs, K.M., C. Lydersen and I. Gjertz. 1996. Birth-site characteristics and prenatal molting in bearded Seals (Erignathus barbatus). Journal of Mammalogy 77:1085-1091.

Krasnova, V.V., V.M. Bel'kovich, and A.D. Chernetsky. 2005. Mother-infant spatial relationships in wild Beluga (*Delphinapterus leucas*) during postnatal development under natural conditions. Biology Bulletin Vol. 33(1):53-58.

Kruse, J.A. 1991. Alaska Inupiat subsistence and wage employment patterns: Understanding Individual Choice. Human Organization 504.

Kryter, K.D. 1985. The effects of noise on man. Orlando, FL: Academic Press.

Kwok, R. 2004. Annual cycles of multiyear sea ice coverage of the Arctic Ocean: 1999-2003. Journal of Geophysical Research Letters 109:C11004, doi:10.1029/2003JC002238.

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, *Geophys. Res. Lett.*, 37, L20501, doi:10.1029/2010GL044678.

Lacroix, D.L., Lanctot, R.B., Reed, J.A., and T.L. McDonald. 2003. Effect of underwater seismic surveys on molting male long-tailed ducks in the Beaufort Sea, Alaska. Canadian Journal of Zoology 81:1862-1875.

Lanier, A.P., J.J. Kelly, J. Maxwell, T. McEvoy, and C. Homan. 2003. Cancer in Alaska Natives 1969-2003: A 35 year report. Alaska Native Tribal Health Consortium, Anchorage, AK.

Larned, W., G.R. Balogh, and M.R. Petersen. 1995. Distribution and abundance of spectacled eiders (Somateria fischeri) in Ledyard Bay, Alaska. Unpublished report. U.S. Fish and Wildlife Service, Migratory Bird Management, Anchorage, AK. 11pp.

Larned, W., R. Stehn, and R. Platte. 2005. Eider breeding population survey Arctic coastal plain, Alaska, 2005. U.S. Fish and Wildlife Service, Migratory Bird Management. Anchorage, AK.

Larned, W.W., R. Stehn, and R. Platte. 2006. Eider Breeding Population Survey Arctic Coastal Plain, Alaska. USFWS, Migratory Bird Management, Waterfowl Branch. 56 pp.

Larned, W., R. Stehn, and R. Platte. 2007. Waterfowl breeding population survey Arctic coastal plain, Alaska 2007. U.S. Fish and Wildlife Service, Migratory Bird Management, Waterfowl Management Branch, Soldotna and Anchorage, AK.

Larned, W.W., R. Platte and R. Stehn. 2009. Waterfowl breeding population survey, Arctic Coastal Plain, Alaska, 2008. Unpublished report, U.S. Fish and Wildlife Service, Anchorage, Alaska. 42 pp.

Larned, W., R. Stehn, and R. Platte. 2012. Waterfowl breeding population survey Arctic coastal plain, Alaska 2011. U.S. Fish and Wildlife Service, Migratory Bird Management, Waterfowl Management Branch, Soldotna and Anchorage, AK.

Lawhead, B.E. 1997. Caribou and oil development in northern Alaska: lessons from the central Arctic herd. pp. 7-5 to 7-7 *in*: NPR-A symposium proceedings, science, Traditional Knowledge, and the Resources of the Northeast Planning Area of the National Petroleum Reserve-Alaska, D. Yokel, comp., Anchorage, AK, Apr. 16-18, 1997. OCS Study MMS 97-0013. USDOI Bureau of Land Management and Minerals Management Service Alaska OCS Region, Anchorage, AK.

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. U.S. Department of Commerce, NOAA Technical Report Circular 444. 245 pages.

Leatherwood, S., A.E. Bowles, and R.R. Reeves. 1986. Aerial Surveys of Marine Mammals in the Southeastern Bering Sea. OCSEAP Final Reports of Principal Investigators 42: 147-490.

Lehnhausen, W. and S. Quinlan. 1981. Bird migration and habitat use at Icy Cape, Alaska. Unpublished Report. U.S. Fish and Wildlife Service, Fairbanks, Alaska. 298 pp.

Lenart, E.A. 2003. Unit 26A and 26B Caribou management report. pp. 304-326 *in*: C. Healy (ed.) Caribou management report of survey and inventory activities 1 July 2000-30 June 2002. Alaska Department of Fish and Game, Juneau, AK.

Lentfer, J.W. 1972. Polar bear-sea ice relationships. International Conference on Bear Research and Management 2:165-171.

Lentfer, J.W. and R.J. Hensel. 1980. Alaska polar bear denning. Pp. 101-108 *in:* C.J. Martinka and K.L. McArthur (eds.) Bears - their biology and management. Fourth International Conference on Bear Research and Management, 1977, Kalispell, Montana. Bear Biology Association Conference Series No. 3.

Leuterman, A., I. Still, J. Christie, and N. Butcher. 1997. A study of trace metals from barites: their concentration, bioavailability, and potential for bioaccumulation. Offshore Mediterranean Conference and Exhibition, Ravenna, Italy 19-21 March 1991. pp. 357369.

LGL. 2007. Joint monitoring program in the Chukchi and Beaufort Seas, July-November 2006. Report prepared for Shell Offshore Inc., ConocoPhillips Alaska Inc., and GX Technology by LGL Alaska Research Associates Inc. Anchorage, AK. 325 pp plus app.

LGL and Greeneridge. 1987. Responses of bowhead whales to an offshore drilling operation in the Alaskan Beaufort Sea, autumn 1986. Rep. from LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA for Shell Western E & P Inc., Anchorage, AK. 371 p.

LGL and Greeneridge. 1996. Northstar marine mammal monitoring program, 1995: baseline surveys and retrospective analyses of marine mammal and ambient noise data from the central Alaskan Beaufort Sea

LGL Alaska Research Associates, Inc., JASCO Applied Sciences, Inc., and Greeneridge Sciences, Inc. 2014. Joint Monitoring Program in the Chukchi and Beaufort Seas, 2012. LGL Alaska Final Report P1272-2 for Shell Offshore, Inc. ION Geophysical, Inc., and Other Industry Contributors, National Marine Fisheries Service, and U.S. Fish and Wildlife Service. 354 p. plus Appendices.

LGL Alaska Research Associates, Inc. and JASCO Applied Sciences, Inc. 2013. Marine Mammal Monitoring and Mitigation During Shell's Activities in the Chukchi Sea, July-September 2013: Draft 90-day report. LGL Alaska Report P1272-2 for Shell Offshore, Inc., National Marine Fisheries Service, and U.S. Fish and Wildlife Service. 198 p. plus Appendices.

LGL Alaska Research Associates, Inc., JASCO Applied Sciences, Inc., and Greeneridge Sciences, Inc. 2013. Joint Monitoring Program in the Chukchi and Beaufort Seas, 2012. LGL Alaska Draft Report P1272-2 for Shell Offshore, Inc. ION Geophysical, Inc., and Other Industry Contributors, National Marine Fisheries Service, and U.S. Fish and Wildlife Service. 320 p. plus Appendices.

Lindsay, R.W. and J. Zhang. 2005. The thinning of Arctic sea ice 1998-2003: have we passed a tipping point. Journal of Climate 18:4879-4894.

Ljungblad, D.K., S.E. Moore, J.T. Clarke, and J.C. Bennett. 1986. Aerial surveys of endangered whales in the northern Bering, eastern Chukchi, and Alaskan Beaufort Seas, 1985: with a seven year review, 1979-85. OCS Study MMS 86-0002. USDOI, Minerals Management Service, Alaska OCS Region, Anchorage, AK 142 pp.

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.

Løkkeborg, S. and A.V. Soldal. 1993. The influence of seismic exploration with airguns on cod (*Gadus morhua*) behavior and catch rates. ICES Marine Science Symposium 196:62-67.

Long, E.R., D.D. MacDonald, S.L. Smith, and F.D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Environmental Management 19:81-97.

Lowry, L.F. 1993. Foods and feeding ecology. pp. 201-238 *in*: J.J. Burns, J.J. Montague, and C.J. Cowles (eds.) The bowhead whale. Society Marine Mammalogists, Special Publication No. 2.

Lowry, L. and F. Fay. 1984. Seal eating by walruses in the Bering and Chukchi Seas. Polar Biology 3:11-18.

Lowry, L.F. and K.J. Frost. 1981. Distribution, growth, and foods of arctic cod (*Boreogadus saida*) in Bering, Chukchi, and Beaufort Seas. Canadian Field Naturalist. 95:186-191.

Lowry, L.F., R.R. Nelson, and K.J. Frost. 1987. Observations of killer whales, Orcinus orca, in western Alaska: Sightings, strandings, and predation on other marine mammals. Canadian Field-Naturalist 101(1):6–12.

Lowry, L.F. and K. Frost. 2002. Beluga whale surveys in the eastern Chukchi Sea, July 2002. Alaska Beluga Whale Committee Report 02-2 submitted to National Marine Fisheries Service, Juneau, AK. 10 pp.

Lowry, L.F. and G. Sheffield. 2002. Stomach contents of bowhead whales harvested in the Alaskan Beaufort Sea. pp. 18-1 to 18-28 In: W.R. Richardson and D.H. Thomson (eds.) Bowhead whale feeding in the eastern Alaskan Beaufort Sea: Update of Scientific and Traditional Information, vol. 1. OCS Study MMS 2002-012; LGL Report TA2196-7. Report from LGL Ltd., King City, Ontario for USDOI Minerals Management Service, Anchorage, AK and Herndon, VA.

Lowry, L.F., K.J. Frost, and J.J. Burns. 1980. Variability in the diet of ringed seals, *Phoca hispida,* in Alaska. Canadian Journal of Fisheries and Aquatic Science 37(12): 2254-2261.

Lowry, L.F., J.J. Burns, and K.J. Frost. 1989. Recent harvests of beluga whales, *Delphinapterus leucas*, in western and northern Alaska and their potential impact on provisional management stocks. Report of the International Whaling Commission 39 pp. 335-339, Cambridge, UK.

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 in the Bering Sea. Canadian Journal of Zoology 78:1959-1971.

Loy, Wesley. 2012. “CG Details Arctic Shield.” Petroleum News. Week of June 3. http://www.petroleumnews.com/pntruncate/405662166.shtml (accessed March 4, 2013).

Lunn, N.J., S.L. Schliebe, and E.W. Born. 2002. Polar bears: proceedings of the 13th working meeting of the IUCN/SSC polar bear specialist group. Gland, Switzerland: IUCN—The World Conservation Union, 153 pp.

Luton, H.H. 1985. Effects of renewable resource harvest disruptions on socioeconomic and sociocultural systems: Wainwright, Alaska. Technical Report 91. USDOI, Minerals Management Service, Alaska OCS Region, Anchorage, AK 603 pp.

Lydersen, C., K.M. Kovacs, S. Ries, and M. Knauth. 2002. Precocial diving and patent foramen ovale in bearded seal (*Erignathus barbatus*) pups. Journal of Comparative Physiology 172:713-717.

Lyons, C., W.R. Koski, and D.S. Ireland. 2009. Beaufort Sea aerial marine mammal monitoring program. (Chapter 7) In: Ireland, D.S., D.W. Funk, R. Rodrigues, and W.R. Koski (eds.). Joint monitoring program in the Chukchi and Beaufort seas, open water seasons, 2006–2007. LGL

Alaska Report P971-2. Report from LGL Alaska Research Associates, Inc., Anchorage, AK, LGL Ltd., environmental research associates, King City, Ont., JASCO Research Ltd., Victoria, B.C., and Greeneridge Sciences, Inc., Santa Barbara, CA, for Shell Offshore, Inc., Anchorage AK, ConocoPhillips Alaska, Inc., Anchorage, AK, and the National Marine Fisheries Service, Silver Springs, MD, and the U.S. Fish and Wildlife Service, Anchorage, AK. 485 pp. + app.

Lysne, L., E. Mallek, and C. Dau. 2004. Near shore surveys if Alaska's Arctic coast, 1999-2003. U.S. Fish and Wildlife Service. Division of Migratory Bird Management, Fairbanks, Alaska 12 pp. + app.

MacCracken, J.G. 2012. Pacific walrus and climate change: observations and predictions. Ecology and Evolution 2:2072–2090.

MacCracken, J.G., V. Van Ballenberghe, and J.M. Peek. 1997. Habitat relationships of moose on the Copper River Delta in coastal south-central Alaska. Wildlife Monograph 136:1–52.

MacDonald, I.R., W.W. Sager, and M.B. Peccini. 2003. Gas hydrate and chemosynthetic biota in mounded bathymetry at mid-slope hydrocarbon seeps, Northern Gulf of Mexico. Marine Geology 198:133-158.

MacDonald, I.R., B. Bluhm, K. Iken, S. Gagaev, and S. Robinson. 2005. Benthic community composition and seabed characteristics of a Chukchi Sea pockmark. Eos. Trans. AGU, 86 (52 Fall Meeting Supplement OS51B-0564.

MacDonald, J., C. O'Neil, R. Bohan, and D. Hannay. 2008. Underwater sound level measurements of airgun sources and support vessels from the Shell 2008 MV Gilavar survey at Chukchi Sea Site A. Unpublished report prepared by JASCO Research Ltd., Victoria, BC.

Mackay, D. 1985. The physical and chemical fate of spilled oil. pp. 37-59 *in*: F.R. Engelhardt (ed.) Petroleum effects in the arctic environment. Elsevier Applied Science, New York.

MacLean, E.A. 1980. Inupiallu Tannillu Uqalunisa Ilanich = Abridged Inupiaq and English Dictionary. Fairbanks, Alaska: Alaska Native Language Center, University of Alaska.

Madsen, J. 1985. Impact of disturbance on field utilization of pink-footed geese in West Jutland, Denmark. Biological Conservation 33:53-63.

Madsen, P.T., B. Mohl, B.K. Nielsen and M. Wahlberg. 2002. Male sperm whale behavior during exposures to distant seismic survey pulses. Aquatic Mammals 28(3):231-240.

Mahoney, A., H. Eicken, A.G. Gaylord, and L. Shapiro. 2007. Alaska landfast sea ice: links with bathymetry and atmospheric circulation Journal Geophysical Research 112:C02001, doi:10.1029/2006JC003559.ACIA. 2005.
Arctic climate impact assessment. Cambridge University Press, Cambridge, UK 1042 pp. available at http://www.acia.uaf.edu/pages/scientific.html.

Mallek E., R. Platte, and R. Stehn. 2007. Aerial breeding pair surveys of the Arctic coastal plain of Alaska, 2006. Unpublished Report. U.S. Fish and Wildlife Service, Fairbanks, Alaska. 25 pp.

Malme, C., P. Miles, C. Clark, P. Tyack, and J. 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. Rep. from Bolt Beranek & Newman Inc., Cambridge, MA, for USDOI Minerals Management Service, Anchorage, AK. Var. pages. NTIS PB86-218377.

Malme, C.I., B. Würsig, J.E. Bird, and P.L. Tyack. 1986. Behavioral responses of gray whales to industrial noise: Feeding observations and predictive modeling. pp. 393-600 *in:* Final Reports of Principal Investigators Volume 56, NOAA Outer Continental Shelf Environmental Assessment Program. BBN Report No. 6265, OCS Study MMS 88-0048.

Malme, C.I., B. Würsig, J.E. Bird, and P. Tyack. 1988. Observations of feeding gray whale responses to controlled industrial noise exposure. pp. 55-73 *in*: W.M. Sackinger, M.O. Jeffries, J.L. Imm and S.D. Treacy (eds.), Port and Ocean Engineering under Arctic Conditions, Vol. II. Geophysical Institute. University of Alaska, Fairbanks, AK. 111 p.

Mann, M.E., R.S. Bradley, and M.K. Hughes. 1999. Northern hemisphere temperatures during the past millennium: Inferences, uncertainties, and limitations. Geophysical Research Letters 26:759-762.

Manville, R.H. and S.P. Young. 1965. Distribution of Alaskan mammals. Bird and Mammal Laboratories , Division of Wildlife Research. Circular 211. Published by the Bureau of Sport Fisheries and Wildlife, Washington. 70 pp.

MAR, Inc., SL Ross Environmental Research Ltd., DF Dickens Associates Ltd. 2008. Empirical Weathering Properties of Oil in Ice and Snow. OCS Study MMS 2008-033. U.S. Department of the Interior Minerals Management Service, Alaska Outer Continental Shelf Region.

Marchand, M., G. Conan, and L. D'Ozouville. 1979. Brian ecologique de la pollution de la l'Amoco Cadiz. Publ. NEXO Rapp. Sci. Tech. No. 40. 60pp.

Martel, V.M. n.d. Summary of the report on the atypical mass stranding of beaked whales in the Canary Islands in September 2002 during naval exercises. Society for the Study of Cetaceans in the Canary Islands.

Martin, B., M. Laurinolli, D. Hannay, and R. Bohan. 2008. Chukchi Sea acoustic monitoring program. *In:* Funk, D.W., Rodrigues, R., Funk, D.S., and Koski, W.R. (eds). Joint monitoring program in the Chukchi and Beaufort seas, July-November 2007. LGL Alaska Report P971-1, Report from LGL Alaska Research Associates, Inc., LGL Ltd., JASCO Research, Ltd., and Greeneridge Sciences, Inc., for Shell Offshore, Inc., ConocoPhillips Alaska, Inc., and National Marine Fisheries Service, U.S. Fish and Wildlife Service. 445 pp. plus Appendices.

Martin, B., D. Hannay, C. Whitt, X. Mouy, and R. Bohan. 2010. Chukchi Sea acoustic monitoring program. Chapter 5 in: Funk, D.W, D.S. Ireland, R. Rodrigues, and W.R. Koski (eds.) Joint Monitoring Program in the Chukchi and Beaufort seas, open-water seasons, 2006–2008. LGL Alaska Report P1050-3, Report from LGL Alaska Research Associates, Inc., LGL Ltd., Greeneridge Sciences, Inc., and JASCO Research, Ltd., for Shell Offshore, Inc. and Other Industry Contributors, and National Marine Fisheries Service, U.S. Fish and Wildlife Service. 499 p. plus Appendices.

Martin, P. 1997. Personal Communication as cited in U.S. Department of Interior, Bureau of Land Management, 2003, Biological assessment for threatened and endangered species with respect to the proposed Northwest National Petroleum Reserve-Alaska Integrated Activity Plan. U.S. Fish and Wildlife Service, Anchorage, Alaska.

Maslanik, J.A., C. Fowler, J. Stroeve, S. Drobot, J. Zwally, D. Yi, W. Emery. 2007. A Younger, Thinner Arctic Ice Cover: Increased Potential for Rapid, Extensive Sea-Ice Loss. *Geophysical Research Letters*. Vol. 34, Issue 24. December 22, 2007.

Mate, B.R., and J.T. Harvey. 1987. Acoustical deterrents in marine mammals conflicts with fisheries. Workshop, 17-18 February, 1986, Newport Oregon. Oregon State University, Publ. No. ORESU-W-86-001, 116 p.

Mathis, J.T. 2011. Seasonal observations of carbonate chemistry and ocean acidification in 2010. Prepared for ConocoPhillips Company, Shell Exploration and Production Company, Statoil USA E&P, Inc. December 2011.

Mathis, J.T. 2012. Seasonal observations of carbonate chemistry and ocean acidification in 2011. Prepared for ConocoPhillips Company, Shell Exploration and Production Company, Statoil USA E&P, Inc. October 2012.

Mathis, J.T, and J.M. Questel. 2013. Assessing seasonal changes in carbonate parameters across small spatial gradients in the Northeastern Chukchi Sea. Continental Shelf Research. Elsevier Ltd. Oxford, UK.

Mathis, J.T. and N.M. Monacci. 2014. Seasonal Observations of Carbonate Chemistry and Ocean Acidification in the Northeastern Chukchi Sea in 2013. Prepared for ConocoPhillips Company, Shell Exploration and Production Company, Statoil USA E&P, Inc. by Ocean Acidification Research Center. School of Fisheries and Ocean Sciences. University of Alaska Fairbanks. August 2014.

Mathis, J.T., R.S. Pickart, D.A. Hansell, D. Kadko, and N.R. Bates. 2007. Eddy transport of organic carbon and nutrients from the Chukchi Shelf: Impact on the upper halocline of the western Arctic Ocean. Journal of Geophysical Research, 112:C05011, DOI: 10.1029/2006JC003899.

Mathis, J.T., D.A. Hansell, and N.R. Bates. 2009. Interannual variability of dissolved inorganic carbon distribution and net community production during the Western Arctic Shelf-Basin Interactions Project. Deep-Sea Research II 56(17):1213-1222, doi:10.1016/j.dsr2.2008.10.017.

Matishov, G.G. 1992. The reaction of bottom-fish larvae to airgun pulses in the context of the vulnerable Barents Sea ecosystem. Contr. Petro Piscis II '92 F-5, Bergen Norway, 6-8 April, 1992. 2s.

McAuliffe, C. 1987. Organism exposure to volatile/soluble hydrocarbons from crude oil spills a field and laboratory comparison. pp. 275-288 *in*: Proceedings of the 1987 international oil spill conference. American Petroleum Institute, Washington, DC.

McCauley, R. 1998. Radiated underwater noise measured from the drilling rig Ocean General, rig tenders Pacific Ariki and Pacific Frontier, fishing vessel reef venture and natural sources in the Timor Sea, northern Australia. Prepared for: Shell Australia, Shell House Melbourne, Project CMST Report C98-20, Centre for Marine Science and Technology, Curtin University of Technology, Western Australia 6102

McCauley, R.D., J. Fewtrell, A.J. Duncan, C. Jenner, M.N. Jenner, J.D. Penrose, R.I.T. Prince, A. Adihyta, J. Murdoch, and K. McCabe. 2000. Marine seismic surveys: analysis and propagation of air gun signals; and effects of exposure on humpback whales, sea turtles, fishes and squid. Prepared for the Australian Petroleum Exploration and Production Association from the Centre for Marine Science and Technology, Curtin University. CMST R99-15, 185, unpublished.

McCauley, R., J. Fewtrell, and A.N. Popper. 2003. High intensity anthropogenic sound damages fish ears. Journal of the Acoustical Society of America 113: 638-642.

McConnaughey, R.A., K.L. Mier, and C.B. Dew. 2000. An examination of chronic trawling effects on soft–bottom benthos of the eastern Bering Sea. ICES Journal of Marine Science 57:1377–1388.

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, Pt.1):712-721.

McManus, D., J. Kelly, and J. Creager. 1969. Continental shelf sedimentation in an arctic environment. Geological Society of America Bulletin 80: 1961-1984.

Mecklenburg, C.W., T.A. Mecklenburg, and L.K. Thorsteinson. 2002. Fishes of Alaska. American Fisheries Society, Bethesda, MD.

Melillo, J.M., T.V. Callaghan, F.I. Woodward, E. Salati, and S.K. Sinha. 1990. Effects on ecosystems, pp. 285-310 *in*: J.T. Houghton, G.J. Jenkins, and J.J. Ephramus (eds.) Climate change, the IPCC scientific assessment. Cambridge University Press, Great Britain.

Melton, H., J. Smith, C. Martin, T. Nedwed, H. Maris, and D.Raught. 2000. Offshore discharge of drilling fluids and cuttings – a scientific perspective on public policy. Paper IBP44900 presented at the Rio Oil & Gas Expo and Conference, 16-19 October 2000, Rio deJenairo, Brazil. 13 pp. 2000.

Meyer, R. 1990. Assessing the risk to Pacific herring from offshore gas and oil development in the southeastern Bering Sea. pp. 545-568 *in*: Westpestad V, Collie J, Collie E, (eds.) Proceedings of the International Herring Symposium, Anchorage, AK., October 23-25, 1990, Anchorage, Alaska. Alaska Sea Grant College Program Report No. 91-01. Alaska Sea Grant College Program, University of Alaska, Fairbanks, Alaska, USA.

Milankovitch, M. 1998. [1941]. Canon of insolation and the ice age problem. Belgrade: Zavod za Udžbenike i Nastavna Sredstva.

Miller, F.L. 1982. Caribou. pp. 923-959 *in* J.A. Chapman and G.A. Feldhamer (eds.) Wild mammals of North America. The Johns Hopkins University Press, Baltimore and London.

Miller, G.W., R.E. Elliott, and W.J. Richardson. 1998. Whales. *in*: Marine mammal and acoustical monitoring of BP Exploration (Alaska)'s Open-Water Seismic Program in the Alaskan Beaufort Sea, 1997, LGL and Greeneridge, eds. LGL Report TA 2150-3. King City, Ont., Canada: LGL Ecological Research Associates, Inc., 124 pp.

Miller, G.W., R.E. Elliott, W.R. Koski, V.D. Moulton, and W.J. Richardson. 1999. Whales. pp. 5-1 to 5-109 *in*: W.J. Richardson (ed.), Marine mammal and acoustical monitoring of Western Geophysical’s open-water seismic program in the Alaskan Beaufort Sea, 1998. LGL Rep. TA2230-3. Rep. from LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA, for Western Geophysical, Houston, TX and U.S. Nat. Mar. Fish. Serv., Anchorage, AK, and Silver Spring, MD. 390 pp.

Miller, G.W., R.A. Davis, V.D. Moulton, A. Serrano, and M. Holst. 2002. Integration of monitoring results, 2001. In Marine Mammal and Acoustical Monitoring of Anderson Exploration Limited's Open-Water Seismic Program in the Southeastern Beaufort Sea, 2001. LGL Report TA 2618-1. King City, Ont., Canada: LGL Ecological Research Associates, Inc., 207 pp.

Miller, G.W., V.D. Moulton, R.A. Davis, M. Holst, P. Millman, A. MacGillivray and D. Hannay. 2005. Monitoring seismic effects on marine mammals—southeastern Beaufort Sea, 2001-2002. p. 511-542 *in*: S.L. Armsworthy, P.J. Cranford, and K. Lee (eds.) Offshore Oil and Gas Environmental Effects Monitoring/Approaches and Technologies. Battelle Press, Columbus, OH.

Miller, M.W. 1994. Route selection to minimize helicopter disturbance of molting Pacific black brant: a simulation. Arctic 47:341-349.

MI-SWACO. 2013. Shell Gulf of Mexico & MI-SWACO drilling fluids plan (DFP) NPDES AKG-28-8100 permit for Chukchi Sea exploration drilling. Revision 1.1, 18 December 2013.

MI-SWACO. 2014. Shell Gulf of Mexico & MI-SWACO drilling fluids plan (DFP) NPDES AKG-28-8100 permit for Chukchi Sea exploration drilling.

Mitchell, E.D. 1975. Report on the meeting on small cetaceans, Montreal, April 1-11, 1974. Journal of Fisheries Research Board of Canada 32:914-91.

Mitchell, T., 2004: Arctic Oscillation (AO) time series, 1899- June 2002. Joint Institute for the Study of the Atmosphere and Ocean (JISAO), Univ. Washington. Published at: jisao.washington.edu/ao/.

Mitson, R.B., and H.P. Knudsen. 2003. Causes and effects of underwater noise on fish abundance estimation. Aquatic Living Resources 16: 255–263.

MMS. 1987a. Alaska outer continental shelf Chukchi Sea oil & gas lease sale 109 – Final Environmental Impact Statement (OCS EIS/EA MMS 87-0110). USD0I, Minerals Management Service, Alaska OCS Region, Anchorage, AK.

MMS. 1987b. Alaska outer continental shelf Chukchi Sea oil & gas lease sale 97 – Final Environmental Impact Statement. USDOI, MMS, Alaska OCS Region, Anchorage, AK

MMS. 1990. Alaska outer continental shelf Chukchi Sea planning area, oil and gas lease sale 126: Final Environmental Impact Statement. U.S. Department of the Interior, Minerals Management Service, Alaska OCS Region, OCS EIS/EA MMS 90-0095.

MMS. 1991. Alaska outer continental shelf Chukchi Sea oil & gas lease sale 126, Final Environmental Impact Statement. US Department of the Interior, Minerals Management Service, Alaska OCS Region, OCS EIS/EA MMS 90-0095.

MMS. 1996. Alaska outer continental shelf Beaufort Sea Planning Area, oil and gas lease sale 144. Final Environmental Impact Statement. OCS EIS/EA MMS 96-0012. U.S. Department of Interior, Minerals Management Service, Alaska OCS Region.

MMS. 1998. Beaufort Sea planning area oil and gas lease sale 170 Final Environmental Impact Statement. OCS EIS/EA, MMS 98-0007. USDOI MMS Alaska OCS Region. Anchorage, Alaska.

MMS. 2001. Liberty Development & Production Plan, Draft Environmental Impact Statement. U.S. Department of Interior. Minerals Management Service. OCS EIS/EA. MMS 2001-002.

MMS. 2002b. Liberty development and production plan, Final Environmental Impact Statement. OCS EIS/EA MMS 2002-019. USDOI Minerals Management Service, Alaska OCS Region, Anchorage, AK. 3 Volumes.

MMS. 2002c. Proposed final program outer continental shelf oil & gas leasing program: 2002-2007. April 2002. U.S. Department of the Interior Minerals Management Service. Herndon, Va. 106 pp + app.

MMS. 2002d. Outer continental shelf oil & gas leasing program: 2002-2007 Final Environmental Impact Statement. April 2002 U.S. Department of the Interior Minerals Management Service April 2007 OCS EIS/EA MMS 2002-006.

MMS. 2003a. Beaufort Sea planning area, oil and gas lease sales 186, 195, 202, Final Environmental Impact Statement. OCS EIS/EA MMS 2003-001 UDOI Minerals Management Service, Alaska OCS Region, Anchorage, AK.

MMS. 2003b. Gulf of Mexico OCS oil and gas lease sales 189 and 197, eastern planning area, Final Environmental Impact Statement. OCS EIS/EA MMS 2003-020 USDOI Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA.

MMS. 2004. Environmental assessment proposed oil and gas lease sale 195 Beaufort Sea planning area. OCS EIS/EA MMS 2004-028, USDOI Minerals Management Service, Alaska OCS Region, Anchorage, Alaska.

MMS. 2006a. Chukchi sea planning area oil and gas lease sale 193 draft Environmental Impact Statement. OCS EIS/EA MMS 2006-060. USDOI Minerals Management Service, Alaska OCS Region, Anchorage, AK. Vols. 1-3.

MMS. 2006b. Biological evaluation of Steller’s eider (*Polysticta stelleri*), spectacled eider (*Somateria fischeri*), and Kittlitz’s murrelet (*Brachyramphus brevirostris*) for seismic surveys in the northeast Chukchi Sea and western Beaufort Sea Planning Areas. March 2006. USDOI Minerals Management Service, Alaska OCS Region, Anchorage, AK.

MMS. 2006c. Environmental assessment: proposed lease sale 202 Beaufort Sea Planning Area. OCS EIS/EA MMS 2006-001, USDOI Minerals Management Service Alaska OCS Region, Anchorage.155 pp. + app.

MMS. 2007a. Environmental assessment Shell Offshore Inc. Beaufort Sea exploration plan Beaufort Sea OCS-Y-1743, 1805, 1807, 1808, 1809,1817, 1828, 1834, 1841, 1842, 1845, and 1849. Minerals Management Service, Alaska OCS Region, Anchorage, AK. 87 pp.

MMS. 2007b. Chukchi Sea planning area-oil and gas lease sale 193 and seismic surveying activities in the Chukchi Sea. Final Environmental Impact Statement. Vol. I-III. OCS EIS/EA MMS 2007-026. USDOI Minerals Management Service, Alaska OCS Region, Anchorage, AK.

MMS. 2007c. Seismic surveys in the Beaufort and Chukchi Seas, Alaska. Draft Programmatic Environmental Impact Statement. OCS EIS/EA MMS 2007-001. Minerals Management Service, Alaska OCS Region, Anchorage, Alaska.

MMS. 2007d. Outer continental shelf oil & gas leasing program: 2007-2012. Final Environmental Impact Statement. April 2007 U.S. Department of the Interior Minerals Management Service April 2007 OCS EIS/EA MMS 2007-003.

MMS. 2007e. Proposed final program outer continental shelf oil & gas leasing program: 2007-2012. April 2007. USDOI Minerals Management Service, Herndon, VA.

MMS. 2008a. 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, Alaska OCS Region, Minerals Management Service, Alaska OCS Region, Anchorage, Alaska.

MMS. 2008b. Final lease stipulations oil and gas lease sale 193 Chukchi Sea. USDOI Minerals Management Service, Alaska OCS Region, Anchorage, AK. February 6, 2008.

MMS 2008c. Empirical Weathering Properties of Oil in Ice and Snow. MAR, Inc., SL Ross Environmental Research Ltd., DF Dickens Associates Ltd. October 2008. OCS Study MMS 2008-033. U.S. Department of the Interior Minerals Management Service, Alaska Outer Continental Shelf Region.

MMS. 2009. Shell Gulf of Mexico, Inc. 2010 exploration drilling program Burger, Crackerjack, and SW Shoebill Prospects, Chukchi Sea, Alaska, Chukchi Sea OCS Leases OCS-Y-2280, OCS-Y-2267, OCS-Y-2321, OCS-Y-2111, and OCS Y-2142. Office of Leasing and Environment, USDOI Minerals Management Service, Alaska OCS Region, Anchorage, AK. December 2009. 113 pp. + app.

Mohr, J.L., N.J. Wilimovsky, and E.Y. Dawson. 1957. An arctic Alaskan kelp bed. Arctic 19:45-54.

Monson D.H., M.S. Udevitz, C.V. Jay. 2013. Estimating age ratios and size of Pacific walrus herds on coastal haulouts using video imaging. Plos One 8(7):e69806.Moore, S.E. 2000. Variability of cetacean distribution and habitat selection in the Alaskan Arctic, autumn 1982-91. Arctic 534:448-460.

Moore, S.E. and R.R. Reeves. 1993. Distribution and movement. pp. 313-386 in: J.J. Burns, J.J. Montague, and C.J. Cowles (eds.) The bowhead whale book. Special Publication No. 2, The Society for Marine Mammalogy, Lawrence, KS.

Moore S.E. and D.P. DeMaster. 1997. Cetacean habitats in the Alaskan Arctic. Journal of Northwest Atlantic Fishery Science 22:55-69.

Moore, G.D. and R. Quimby. 1975. Environmental considerations for the polar bear (Ursus maritimus), of the Beaufort Sea. Arctic Gas Biological Report Series 32(2).

Moore, S.E., J.T. Clarke, and M.M. Johnson. 1993. Beluga distribution and movements offshore northern Alaska in spring and summer, 1980–84. Report of the International Whaling Commission 43:375-386.

Moore, S.E., K.E.W. Shelden, L.K. Litzky, B.A. Mohoney, and D.J. Rugh. 2000. Beluga, *Delphinapterus leucas,* habitat associations in Cook Inlet, Alaska. Marine Fisheries Review 623:60-80.

Moore, S.E., J.M. Waite, N.A. Friday and T. Honkalehto. 2002. Distribution and comparative estimates of cetacean abundance on the central and south-eastern Bering Sea shelf with observations on bathymetric and prey associations. Progress in Oceanography 55(1-2):249-262.

Moore, S.E., J.M. Grebmeier and J.R. Davies. 2003. Gray whale distribution relative to forage habitat in the northern Bering Sea: current conditions and retrospective summary. Canadian Journal of Zoology 81(4):734-742.

Moriyasu, M., R. Allain, K. Benhalima, and R. Claytor. 2004. Effects of seismic and marine noise on invertebrates: a literature review. Canadian Science Advisory Secretariat, Fisheries and Oceans, Canada. 43 pp. http://www.dfo-mpo.gc.ca/csas/.

Morris, B. 1981. Living marine resources of the Chukchi Sea: A resource report for the Chukchi Sea oil and gas lease sale #85. Report by U.S. Department of Commerce, NOAA, National Marine Fisheries Service to the USDOI, Bureau of Land Management, Anchorage, AK. 117 p.

Morrow, J.E. 1980. The freshwater fishes of Alaska. Alaska Northwest Publishing Co., Anchorage, AK. 248 pp.

Mosbech, A. and C. Glahder. 1991. Assessment of the impact of helicopter disturbance on moulting pink-footed geese, *Anser brachyrhynchus*, and barnacle geese, *Branta leucopsis*, in Jameson Land, Greenland. Ardea 79:233-237.

Mosbech, A. D. Boertmann. 1999. Distribution, Abundance and Reaction to Aerial Surveys of Post-Breeding King Eiders (Somateria spectabilis) in western Greenland. Arctic. Vol. 52. pgs. 188-203.

Morseth, M.C. 1997. Twentieth-Century Changes in Beluga Whale Hunting and Butchering by the Kanigmiut of Buckland, Alaska. Arctic, Vol. 50, No. 3 (September 1997) P. 241-255.

Moulton, V.D. and G.W. Miller. 2005. Marine mammal monitoring of a seismic survey on the Scotian Slope, 2003. pp. 29-40 *in*: K. Lee, H. Bain and G.V. Hurley (eds.) 2005. Acoustic monitoring and marine mammal surveys in the Gully and Outer Scotian Shelf before and during active seismic programs. Environmental Studies Research Funds Report No. 151. 154 p.

Moulton V., J. Richardson, R. Elliot, T. McDonald, C. Nations, and T. Williams. 2002. Effects of an offshore oil development on local abundance and distribution of ringed seals (Phoco hispida) of the Alaskan Beaufort Sea. Marine Mammal Science 21(2):217-242.

Moulton, V. D., W.J. Richardson, M.T. Williams, and S.B. Blackwell. 2003. Ringed seal densities and noise near and icebound artificial island with construction and drilling. Acoustics Research Letters Online-ARLO 4:112-117.

Moulton, V.D., J. Christian, R.A. Pitt, B.D. Mactavish, and R.A. Buchanan. 2005a. Orphan basin 3-D seismic program, environmental assessment update, 2005. LGL Rep. SA839. Rep. by LGL Limited and Canning & Pitt Associates Inc., St. John's, NL, for Chevron Canada Limited, Calgary, AB, ExxonMobil

Moulton, V., W. Richardson, R. Elliot, N. McDonald, and M. Williams. 2005b. Effects of an offshore oil development on local abundance and distribution of ringed Seals (*Phoca hispida*) of the Alaskan Beaufort Sea. Marine Mammal Science 21(2):217-242.

Mudge, T., D. Fissel, M. Martinez de Saavedra Alvarez, J. Marko. 2010. An Analysis of Sea Ice Condition to Determine Ship Transits Through the Northwest Passage. *Proc. IceTech 2010 Conference*, Sept. 2010, Anchorage, Alaska.

Murphy, N.J., C.D. Schraer, M.C. Thiele, E.J. Boyko, L.R. Bulkow, B.J. Doty, and A.P. Lanier. 1995. Dietary change and obesity associated with glucose intolerance in Alaska Natives. Journal of the American Diatetic Association 956:676-682.

NAC. 2012. 2012 Schedule of Shipping. Effective 11/03/2012.

Nachtigall, P.E., J.L. Pawloski, and W.W.L. Au. 2003. Temporary threshold shifts and recovery following noise exposure in the Atlantic bottlenosed dolphin (*Tursiops truncatus*). Journal of the Acoustical Society of America 113:3425-3429.

Naidu, A. 1988. Marine surficial sediments. Section 1.2 *in*: Bering, Beaufort and Chukchi Seas, coastal and ocean zones strategic assessment: data atlas. U.S. Department of Commerce NOAA/SAB, Rockville, MD.

Naidu, A.S., A. Blanchard, J.J. Kelley, J.J. Goering, M.J. Hameed, and M. Baskaran. 1997. Heavy metals in Chukchi Sea sediments as compared to selected circum-arctic shelves. Marine Pollution Bulletin 35:260 – 269. Elsevier Science Ltd. Great Britain.

Nakken, O. 1992. Scientific basis for management of fish resources with regard to seismic exploration. Fisheries and Offshore Petroleum Exploitation 2nd International Bergen, Norway, 6-8 April 1992.

NAS. 1985. Oil in the sea—inputs, fates, and effects. National Academy of Sciences, National Academy Press, Washington, DC.

NASA. 2005. Arctic warming signals from satellite observations. Josefino C. Comiso. Cryospheric Sciences Branch, NASN Goddard Space Flight Center

National Snow and Ice Data Center. 2009. The Arctic oscillation. https://nsidc.org/cryosphere/arctic-meteorology/weather_climate_patterns.html#arctic_oscillation.

Nedwed, T.J., J.P. Smith, and M.G. Brandsma. 2004. Verification of the OOC mud and produced water discharge model using lab-scale plume behavior experiments. Environmental Modeling & Software 19(7-8):655-670.

Neff, J.M. 1991. Long-term trends in the concentrations of polycyclic aromatic hydrocarbons in the water column of Prince William Sound and the western Gulf of Alaska following the Exxon Valdez oil spill. pp. 27-38 *in*: Fourteenth Annual Arctic and Marine Oilspill Program Technical Seminar. Vancouver, BC, Canada, Jun. 12-14, 1991. Environment Canada, Ottawa, Canada.

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. Report prepared for the Petroleum Environmental Research Forum and American Petroleum Institute, by Battelle, Duxbury, MA. 69 pp. + app.

Neff, J. 2010. Fate and behavior of water based drilling muds and cuttings in cold-water environments. Neff & Associates LLC.

Neff, J.M., M.H. Bothner, N.J. Maciolek, and J.F. Grassle. 1989a. Impacts of exploratory drilling for oil and gas on the benthic environment of Georges Bank. Marine Environmental Research 27:77-114.

Neff, J.M., R.J. Breteler, and R.S. Carr. 1989b. Bioaccumulation, food chain transfer, and biological effects of barium and chromium from drilling muds by flounder (Pseudopleuronectes americanus) and lobster (*Homarus americanus*). pp. 439-460 *in*: F.R. Engelhardt, J.P. Ray, and A.H. Gillam, (eds.) Drilling wastes. Elsevier Applied Science Publishers, London.

Neff, J.M., R.E. Hillman, and J.J. Waugh. 1989c. Bioaccumulation of trace metals from drilling mud barite by benthic marine animals. pp. 461-480 In: F.R. Engelhardt, J.P. Ray, and A.H. Gillam, (eds.) Drilling wastes. Elsevier Applied Science Publishers, London.

Neff, J., G. Durell, J. Trefry, and J. Brown. 2010. Environmental studies in the Chukchi Sea 2008: chemical characterization. Volume 1. Final Report August 2010 prepared by Battelle Memorial Institute, Exponent, Inc., Florida Institute of Technology, and Neff & Associates for ConocoPhillips Alaska Inc. and Shell Exploration & Production, Anchorage, AK. 135 pp.

NEI. 2011. Potential national-level benefits of Alaska OCS development. Prepared by Northern Economics Inc. and Institute of Social and Economic Research, University of Alaska, Anchorage for Shell Exploration and Production. February.

Nelson C.H., R.L. Phillips, J. ,McRea Jr. , J.H. Barber Jr., M.W. McLaughlin, and J.L. Chin. 1994. Gray whale and Pacific walrus benthic feeding grounds and sea floor interaction in the Chukchi Sea. U.S. Geological Survey, Menlo Park, California. Technical report for minerals management service / IA No. 1417. OCS Study MMS 93–0042. 51 pp.

Nelson, R. 1979. Cultural values of the land. National Petroleum Reserve in Alaska native livelihood and dependence - a study of land use values through time. Prepared by North Slope Borough Contract Staff for National Petroleum Reserve in Alaska Work Group 1. U.S. Department of the Interior, Anchorage, AK. June 1979.

Nelson, R.R., J.J. Burns, and K.J. Frost. 1985. The Bearded Seal (Erignathus barbatus). pp. 55-60 in: J.J. Burns, K.J. Frost, and L.F. Lowry (eds.) Marine Mammal Species Accounts. Alaska Department of Fish and Game, Juneau, AK.

Nerini, M.K., H.W. Braham, W.M. Marquette, and D.J. Rugh. 1984. Life history of the bowhead whale, Balaena mysticetus (Mammalia: Cetacea). Journal of Zoology 204:443-468.

Nghiem, S.V., D.K. Hall, I.G. Rigor, P. Li and G. Neumann, 2014: Effects of Mackenzie River discharge and bathymetry on sea ice in the Beaufort Sea. Geo, Res Lets, DOI 10.1002/2013GL058956.

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.

NMFS (National Marine Fisheries Service). 1991. Recovery Plan for the Humpback Whale (Megaptera novaeangliae). Prepared by the Humpback Whale Recovery Team for the National Marine Fisheries Service, Silver Spring, MD. 105pp.

NMFS. 1995. Small takes of marine mammals incidental to specified activities; offshore seismic activities in southern California. Federal Register 60(200, 17 Oct.):53753-53760.

NMFS. 2000. Small takes of marine mammals incidental to specified activities; marine seismic-reflection data collection in southern California/Notice of receipt of application. Federal Register 65(60, 28 Mar.):16374-16379.

NMFS. 2001. Small takes of marine mammals incidental to specified activities; oil and gas exploration drilling activities in the Beaufort Sea/Notice of issuance of an incidental harassment authorization. Federal Register 66(26, 7 Feb.):9291-9298.

NMFS. 2006. Biological Opinion, endangered species act section 7 consultation, oil and gas leasing and exploration activities in the U.S. Beaufort and Chukchi Seas, Alaska; and authorization of small takes under the Marine Mammal Protection Act. National Marine Fisheries Service, Washington D.C. 140 pp.

NMFS. 2008. Endangered Species Act- Section 7 Consultation: Biological Opinion. http://www.fakr.noaa.gov/protectedresources/whales/bowhead/biop0708.pdf.

NMFS. 2012a. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion. Oil and Gas Leasing and Exploration Activities in the U.S. Beaufort and Chukchi Seas, Alaska. National Marine Fisheries Service. NMFS Consultation Number: F/AKR/2011/0647.

NMFS. 2012b. Final Environmental Assessment for the Issuance of Incidental Harassment Authorizations for the Take of Marine Mammals by Harassment Incidental to Conducting Exploratory Drilling Programs in the U.S. Beaufort and Chukchi Seas. National Oceanic and Atmospheric Administration. National Marine Fisheries Service. May 2012. NMFS. 2013a. Endangered and Threatened Wildlife; 90-day Finding on a Petition to List 44 Species of Corals as Threatened or Endangered Under the Endangered Species Act. Federal Register 78 (31, 14 Feb.): 10601-10606.

NMFS. 2013b. Endangered Species Act Section 7(a)(2) Biological Opinion: Oil and Gas Leasing and Exploration Activities in the U.S. Beaufort and Chukchi Seas, Alaska (April 2, 2013).

NMFS. 2013c. Biological Opinion for the Issuance of Incidental Harassment Authorization under 101(a)(5)(a) of the Marine Mammal Protection Act to Shell for Geophysical Surveys, and Equipment Recovery and Maintenance Activities in the U.S. Chukchi Sea, Alaska, During the 2013 Open Water Season. National Marine Fisheries Service.

NMFS. 2013d. Final Environmental Impact Statement for Issuing Annual Quotas to the Alaska Eskimo Whaling Commission for a Subsistence Hunt on Bowhead Whales for the Years of 2013 through 2018. Prepared By U.S. Department of Commerce. National Oceanic and Atmospheric Administration. National Marine Fisheries Service. January 2013.

NMFS. 2014. Endangered Species Act Section 7 Consultation Biological Opinion. Authorization of the Alaska Groundfish Fisheries Under the Proposed Revised Steller Sea Lion Protection Measures. U.S. Department of Commerce. National Oceanic and Atmospheric Administration. National Marine Fisheries Service.

NOAA. 2006. Fact sheet: small diesel spills (500-5,000 gallons). NOAA Scientific Support Team, Hazardous Materials Response and Assessment Division, National Oceanic and Atmospheric Administration. Seattle, Washington 2 pp.

NOAA. 2013a. Sea Raspberry Synopsis. National Oceanic and Atmospheric Administration, Alaska Fisheries Science Center. Accessed March 4, 2013 at http://www.afsc.noaa.gov/groundfish/HAPC/SeaRaspberry_synopsis.htm.

NOAA. 2013b. Effects of oil and gas activities in the Arctic Ocean: Supplemental Draft Environmental Impact Statement. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources.

NOAA. 2013c. Draft guidance for assessing the effects of anthropogenic sound on marine mammals: acoustic threshold levels for onset of permanent and temporary threshold shifts. Draft: December 2013. United States Department of Commerce, National Oceanic and Atmospheric Administration. 76 pp.

NOAA and USN. 2001. Joint interim report: Bahamas marine mammal stranding event of 14–16 March 2000. U.S. Dep. Commer., Nat. Oceanic Atmos. Admin., Nat. Mar. Fish. Serv., Sec. Navy, Assis. Sec. Navy, Installations and Envir. 61 p.

Nobmann, E. D., R. Ponce, C. Mattil, R. Devereux, B. Dyke, S.O.E. Ebbesson, S. Laston, J. MacCleur, D. Robbins, G. Ruotolo, C.R. Wenger, and B.V. Howard. 2005. Dietary intakes vary with age among Eskimo adults of northwest Alaska in the GOCADAN Study, 2000–2003. Journal Nutritional Epidemiology 135:856-862.

Noel, L.E., R.J. Rodrigues, and S.R. Johnson. 2002. Nesting status of the common eider in the central Alaskan Beaufort Sea, Summer 2001. Prepared for BP Exploration Alaska Inc. LGL Alaska Research Associates, Inc. and LGL Limited, Environmental Research Associates.

Norcross, B. 2011. A synthesis of diversity, distribution, abundance, age, size, and diet of fish in the Lease Sale 193 Area of the northeastern Chukchi Sea. Final Report. Prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil E&P USA, Anchorage, AK

Normandeau Associates, Inc. 2012. Effects of noise on fish, fisheries, and invertebrates in the U.S. Atlantic and Arctic from energy industry sound-generating activities. A literature synthesis. for the U.S. Dept. of the Interior, Bureau of Ocean Energy Management. Contract # M11PC00031. 153 p.

Nortec. 1982. Above-ice drilling effluent disposal tests, Sag River No. 7, Sag Delta No. 8, and Challenge Island No. 1 Wells, Beaufort Sea, Alaska. Prepared by Northern Technical Services for Sohio Alaska Petroleum Company.

North, M.R. 1994. Yellow-billed Loon. No. 121 *in*: A. Poole and F. Gill (eds.) The birds of North America. The Academy of Natural Sciences, Philadelphia, and The American Ornithologists Union, Washington, D.C.

Northern Economics, Incorporated. 2006. North Slope economy, 1965 to 2005. Prepared for the USDOI Minerals Management Service, Alaska OCS Region, Anchorage, AK. April 2006.

Nowacek, D.P., M.P. Johnson, and P.L. Tyack. 2004. North Atlantic right whales (*Eubalaena glacialis*) ignore ships but respond to alerting stimuli. Proceedings of the Royal Society of London Series B: Biological Sciences 271:227-231.

Nowak, R. 1999. Walker's mammals of the World, 6th Ed. Vol II. Baltimore: John Hopkins University Press.

NPFMC. 2009. Fishery management plan for fish resources of the arctic management area. North Pacific Fishery Management Council, Anchorage AK. 76 pp. + app.

NPS. 2002. Abandoned shipwreck act of 1987. In Federal Preservation Laws. National Center for Cultural Resources. National Park Service. U.S. Department of the Interior. Washington D.C.

NPS. 2007. National Historic Landmarks in Alaska: Birnirk Site, North Slope Borough (near Barrow). Cultural Resources Team. Alaska Regional Office. National Park Service. http://www.nps.gov/akso/cr/akrcultural/CulturalMain/2ndLevel/NHL/ NHLBirnirk.htm. (Accessed March 2007).

NPS. 2008b. National Register Information System. http://www.nps.gov/nr/research/. Accessed July 21, 2008.

NPS. 2008c. Ipiutak Site. National Historic Landmarks Program. http://tps.cr.nps.gov/nhl/detail.cfm?ResourceId=79&ResourceType=Site. Accessed July 21, 2008.

NPS. 2010. New Fossil Preservation Law. Retrieved May 31, 2012, from National Fossil Day. May 20, 2010. Explore Nature: http://www.nature.nps.gov/geology/nationalfossilday/prpa.cfm.

NRC. 1983. Drilling discharges in the marine environment. National Research Council. National Academy Press, Washington D.C.

NRC. 1985. Oil in the sea: Inputs, fates, and effects. National Research Council, National Academy Press, Washington, DC. 601 pp.

NRC. 1996. The Bering Sea ecosystem. National Academy Press, Washington, D.C.

NRC. 1999. The community development quota program in Alaska. National Research Council, The National Academy Press, Washington, D.C.

NRC. 2003a. Cumulative environmental effects of oil and gas activities on Alaska's North Slope. National Research Council, National Academies Press, Washington, DC.

NRC. 2003b. Oil in the sea III: Inputs, fates, and effects. National Research Council, The National Academies Press, Washington, DC. 265 pp.

NRC. 2012. 2011 Fish and Invertebrate Trawl Surveys in the Chukchi Sea Environmental Studies Program. Prepared for Olgoonik Fairweather, LLC.

NSB. 2005. North Slope Borough comprehensive plan. Issues, goals, objectives, and policies. Adopted by the NSB Assembly under Ordinance 75-6-48 on Oct. 11, 2005. Prepared by URS Corporation for North Slope Borough Planning Department, Barrow, AK.

NSB. 2008a. Native Village of Barrow community information. http://www.north-slope.org/our-communities/barrow. Accessed November 2008.

NSB. 2008b. Native Village of Wainwright. http://www.north-slope.org/our-communities/wainwright. Accessed November 2008.

NSB. 2008c. Native Village of Point Lay. http://www.north-slope.org/our-communities/point-lay. Accessed November 2008.

NSB. 2008d. Native Village of Point Hope. http://www.north-slope.org/our-communities/point-hope. Accessed November 2008.

NSB. 2010. 2010 Economic Profile and Census Report. http://www.north-slope.org/your-government/census--2010. Accessed March 2013.

NSB. 2012. Community Health Impact Report. http://www.north-slope.org/departments/health-social-services/baseline-community-health-analysis-report. Accessed March 2013.

Nweeia, M.T., N. Eidelman, F.C. Eichmiller, A.A. Giuseppetti, Y.G. Jung, and Y. Zhang. 2005 Hydrodynamic sensor capabilities and structural resilience of the male narwhal tusk. 16th Biennial Conference on the Biology of Marine Mammals, Dec. 13, 2005, San Diego, CA.

Offut, G.C. 1974. Structures for the detection of acoustic stimuli in Atlantic Cod, *Gadus morhua*. Journal of the Acoustical Society of America 56:665-671.

Olsen, K. 1979. Observed avoidance behaviour in herring in relation to passage of an echo survey vessel. ICES Journal of Marine Science 18: 21 pp.

Olsen, K., J. Angell, F. Pettersen, and A. Lovik. 1983. Observed fish reactions to a surveying vessel with special reference to herring, cod, capelin, and polar cod. FAO Fisheries Report 300: 131-138.

Ona, E. 1988. Observations of cod reaction to trawling noise. ICES FAST WG-meeting, Oostende, 20-22.

Ona, E. and O.R. Godo. 1990. Fish reaction to trawling noise; the significance for trawl sampling. Rapp. O-v Reun. Coast. Int. Explor. Mer. 189:159-166.

Ona, E. and R. Toresen. 1988. Reaction of herring to trawl noise. ICES. CM 1988/B-36:1-8.

Ona, E., O.R. Godø, N.O. Handegard, V. Hjellvik, R. Patel, and G. Pedersen. 2007. Silent research vessels are not quiet. The Journal of the Acoustical Society of America 121: 145–150.

O'Reilly, J., T. Sauer, R. Ayers, Jr., M. Brandsma, and R. Meek. 1989. Field verification of the OOC mud discharge model. pp. 647-666 *in*: F. Engelhardt, J. Ray, and A. Gillam (eds.) Drilling wastes. Elsevier Applied Science, New York.

Orr, J.C., V.J. Fabry, O. Aumont, L. Bopp, S.C. 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(7059):681–686.

Overpeck, J., K. Hughen, D. Hardy, R. Bradley, R. Case, M. Douglas, B. Finney, K. Gajewski, G. Facoby, A. Jennings, S. LAmoureaux, A. Lasca, G. MacDonald, J. Moore, M. Retelle, S. Smith, A. Wolfe, and G. Zielinski. 1997. Arctic environmental change of the last four centuries. Science 278:252-1,256.

Ovsyanikov, N. 2003. Polar bears in Chukotka. WWF Arctic Bulletin 2:13-14.

Owens, E.H., C.R. Foget, J.R. Harper, and W. Robson. 1983. Shoreline experiments and the persistence of oil on Arctic beaches. pp. 261-268 *in*: Proceedings of the 1983 Oil-Spill Conference, American Petroleum Institute, Washington DC.

Owens, N.W. 1977. Responses of wintering brent geese to human disturbance. Wildfowl 28:5-14.

Palka, D. and P.S. Hammond. 2001. Accounting for responsive movement in line transect estimates of abundance. Canadian Journal of Fisheries and Aquatic Sciences 58:777-787.

Parkinson, A.J., B.D. Gold, L. Bulkow, R.B. Wainwright, B. Swaminathan, B. Khanna, K.M. Petersen, and M.A. Fitzgerald. 2000. High prevalence of *Helicobacter pylori* in the Alaska Native population and association with low serum ferritin levels in young adults. Clinical and Diagnostic Laboratory Immunology 76:885-888.

Parks S.E., C.W. Clark, 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.

Parrett, L.S. 2009. Unit 26A, Teshkpuk caribou herd. pp. 271-298 *in* P. Harper (ed.) Caribou management report of survey and inventory activities 1 July 2006 - 30 June 2008. Alaska Department of Fish and Game. Project 3.0 Juneau, Alaska, USA. found at: http://www.adfg.alaska.gov/static/home/library/pdfs/wildlife/mgt_rpts/09_caribou.pdf.

Patenaude, N.J., W.J. Richardson, M.A. Smultea, W.R. Koski, and G.W. Miller. 2002. Aircraft sound and disturbance to bowhead and beluga whales during spring migration in the Alaskan Beaufort Sea. Marine Mammal Science 18(2):309–335.

Patin. S. 1999. Environmental impact of the offshore oil and gas industry. Eco-Monitoring Publishing, East Northport, NY. ISBN 0-967 1836-0-X.

Peacock, E., R.K. Nelson, A.R. Solow, J.D. Warren, J.L. Baker, and C.M. Reddy. 2005. The west Falmouth oil spill – 100 Kg of oil found to persist decades later. Environmental Forensics 6:273-281.

Pearson, W., J. Skalski, and C. Malme. 1992. Effects of sounds from a geophysical survey device on behavior of captive rockfish (*Sebastes* spp.). Canadian Journal Fisheries and Aquatic Science 49(7):1343-1356

Peek, J.M. 1997. Habitat relationships. pp. 351–375 in A.W. Franzmann and C.C. Schwartz (eds.) Ecology and management of the North American moose. Smithsonian Institute Press, Washington, D.C.

Pelletier, M.C., R.M. Burgess, K.T. Ho, A. Kuhn, R.A. McKinney, and S.A. Ryba. 1997. Phototoxicity of individual polycyclic aromatic hydrocarbons and petroleum to marine invertebrate larvae and juveniles. Environmental Toxicology and Chemistry 1610:2190-2199.

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.

Perry, J.A. and D. Renouf. 1987. Further studies of the role of harbor seal (*Phoca vitulina*) pup vocalizations in preventing separation of mother-pup pairs. Canadian Journal of Zoology. 66:934-938.

Petersen, M.R. and P.L. Flint. 2002. Population structure of Pacific common eiders breeding in Alaska. Condor 104:780-787.

Petersen, M.R., W.W. Larned, and D.C. Douglas. 1999. At-sea distributions of Spectacled Eiders: a 120 year-old mystery resolved. Auk 116:1009–1020.

Petersen, M.R., J.B. Grand, and C.P. Dau. 2000. Spectacled eider (Somateria fischeri), The birds of North America online. A Poole, Ed. Ithaca: Cornell Lab of Ornithology. Date of use: 18 July 2011.

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.

Peterson, T.C. and R.S. Vose. 1997. An overview of the global historical climatology network temperature database. Bulletin of the American Meteorological Society 78:2837-2849.

Phillips, L.M. 2005. Migration ecology and distribution of king eiders. M.S. Thesis. University of Alaska, Fairbanks.

Phillips, R.L., T.E. Reiss, E.W. Kempema, E. Reimnitz, E, and B. Richards. 1982. Marine geologic investigations northeast Chukchi Sea, Wainwright to Skull Cliff, in National Oceanic and Atmospheric Administration, Environmental Assessment of the Alaska Continental Shelf: Annual Reports of Principal Investigators for the year ending March, 1982, p. C1-C32.

Phillips, R.L. and T.E. Reiss. 1985a. Nearshore marine geologic investigations, Icy Cape to Wainwright, northeast Chukchi Sea. Open File Report 84-828, U.S. Geological Survey, Menlo Park, CA. 27 pp.

Phillips, R.L., and T.E. Reiss. 1985b. Nearshore marine geologic investigations, Point Barrow to Skull Cliff, northeast Chukchi Sea. Open File Report 85-50. U.S. Geological Survey, Menlo Park, CA. 22 pp.

Platt, C. and A.N. Popper. 1981. Fine structure and function of the ear. pp. 3-38 *in*: W.N. Tavolga, A.N. Popper, and R.R. Fay (eds.) Hearing and sound communication in fishes. Springer, New York, NY.

Pollard, R.H. and L.E. Noel. 1994. Caribou distribution and parasitic insect abundance in the Prudhoe Bay oil field, summer 1993. Final report prepared by LGL Alaska Research Associates, Inc., for BP Exploration (Alaska) Inc., P.O. Box 196612, Anchorage, Alaska 99519-6612. 65 p. + maps.

Polyakov. I., L. Timokhov, I. Dmitrenko, V. Ivanov, H. Simmons, A. Beszczynska-Moller, R. Dickson, E. Fahrbach, L. Fortier, J. Gascard, J. Holemann, N.P. Holliday, E. Hansen, C. Mauritzen, J. Piechura, R. Pickart, U. Schauer, W. Walczowski, M. Steele. 2007. Observational Program Tracks Arctic Ocean Transition to a Warmer State. Eos, Transactions American Geophysical Union, Vol. 88, Issue 40, pgs. 398-399. October 2, 2007. doi:10.1029/2007EO400002.

Polyakov, I.V., J.E. Walsh, R. Kwok. 2012. Recent Changes of Arctic Multiyear Sea Ice Coverage and the Likely Causes. *American Meteorological Society*. February 2012.

Potter, J.R., M. Thillet, C. Douglas, M.A. Chitre, Z. Doborzynski, and P.J. Seekings. 2007. Visual and passive acoustic marine mammal observations and high-frequency seismic source characteristics recorded during a seismic survey. IEEE Journal of Oceanic Engineering 32(2):469-483.

Powell, A.N., L. Phillips, E.A. Rexstad, and E.J. Taylor. 2005. Importance of the Alaskan Beaufort Sea to king eiders (*Somateria spectabilis*). OSC Study MMS 2005-057. Report prepared by the Coastal Marine Institute, University of Alaska for USDOI Minerals Management Service, Alaska OCS Region, Anchorage.

Priest, J.T., S.T. Crawford, R.M. Meyer, S.W. Raborn, and B.J. Gallaway. 2011. Fish community observation for three locations in the Chukchi Sea, 2010. Annual report prepared by LGL Alaska Research Associates, Inc., Anchorage, Alaska for Olgoonik-Fairweather. 95 p.

Priest, J.T., S.W. Raborn. 2011. Chapter 2 Species composition and assemblage structure of demersal fishes in the northeastern Chukchi Sea in A synthesis of diversity, distribution, abundance, age, size and diet of fishes in the Lease Sale 193 area of the northeastern Chukchi Sea. Final Report prepared for ConocoPhillips Alaska, Inc., Shell Exploration & Production Company, and Statoil USA E&P, Inc.

Pruter, A.T. and D.L. Alverson. 1962. Abundance, distribution and growth of flounders in the southeastern Chukchi Sea. Journal du Conseil International pour l'Exploration de la Mer 27:81-99.

Quakenbush, L.T. 1988. Spotted seal, *Phoca largha*. pp. 107-124 *in*: J.W. Lentfer (ed.) Selected marine mammals of Alaska / species accounts with research and management recommendations. Marine Mammal Commission, Washington, DC. 275 pp.

Quakenbush, L.T., R.S. Suydam, K.M. Fluetsch, and C.L. Donaldson. 1995. Breeding biology of Steller's eiders nesting near Barrow, Alaska, 1991-1994. Technical Report NAES-TR-95-03, U.S. Fish and Wildlife Service and North Slope Borough, Department of Wildlife Management. Fairbanks, AK.

Quakenbush, L.T., J.J. Citta, J.C. George, R.J. Small, and M.P. Heide-Jorgensen. 2010. Fall and winter movements of bowhead whales (*Balaena mysticetus*) in the Chukchi Sea and within a potential petroleum development area. Arctic 63:289-307.

Quakenbush, L.T., R.J. Small, and J.J. Citta. 2013. Satellite tracking of bowhead whales: movements and analysis from 2006 to 2012. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Alaska Outer Continental Shelf Region, Anchorage, AK. OCS Study BOEM 2013-01110. 60 pp + app.

Quast, J.C. 1972. Preliminary report on the fish collected on WEBSEC-70. pp. 203-206. *in*: WEBSEC-70, an ecological survey in the eastern Chukchi Sea, September-October 1970. U.S. Coast Guard, Oceanographic Report No. 50. 206 pp.

Quast, J.C. 1974. Density distribution of juvenile Arctic cod, Boreogadus saida, in the eastern Chukchi Sea in the fall of 1970. Fishery Bulletin 72(4):1094-1195.

Rausch R.A. and B. Gasaway. 1994. Moose. Alaska Department of Fish and Game Wildlife Notebook Series.

Ray, G, E. Mitchell, D. Wartzok, V. Koziki, and R. Maiefski. 1978. Radio tracking of a fin whale (*Balaeoptera physalus*). Science 202(4367):521-524.

Read, A.J. 1999. Harbor porpoise *Phocoena phocoena* (Linnaeus, 1758). pp. 323-355 *in*: S.H. Ridgway and R. Harrison (eds.) Handbook of marine mammals, Vol. 6 The second book of dolphins and the porpoises. Academic Press, Inc. San Diego, CA. 486 pp.

Reeves R.R., B.S. Stewart, and S. Leatherwood. 1992. The Sierra Club handbook of seals and sirenians. Hong Kong: Dai Nippon Printing Co. Ltd.

Reeves, R.R. 2002. National Audubon Society guide to marine mammals of the world. Alfred A. Knopf, ed. New York. 527 p.

Reeves, R.R., R.J. Hofman, G.K. Silber, and D. Wilkinson. 1996. Acoustic deterrence of harmful marine -mammal-fishery interactions: proceedings of a workshop held in Seattle, Washington, 20-22 March 1996. NOAA Technical Memorandum NMFS-OPR-10. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, WA.

Regehr, E.V., S.C. Amstrup, and I. Stirling. 2006. Polar bear population status in the southern Beaufort Sea. Open–File Report 2006–1337. U.S. Geological Survey.

Regehr, E.V., C.M. Hunter, H. Caswell, S.C. Amstrup, and I. Stirling. 2007. Polar bears in the southern Beaufort Sea I: Survival and breeding in relation to sea ice conditions, 2001-2006. U.S. Geological Survey. Administrative Report. U.S. Geological Survey, Anchorage, AK. 45 pp.

Reider, H.J., L.N. Bisson, M. Austin, A. McCrodan. J. Wladichuk, C.M. Reiser, K.B. Matthews, J.R. Brandon, K. Leonard, and H.M. Patterson. 2013. Marine mammal monitoring and mitigation during Shell's activities in the Chukchi Sea, July–September 2013: 90-Day Report. LGL Report P1272D–2. Report from LGL Alaska Research Associates Inc., Anchorage, AK, USA, and JASCO Applied Sciences, Victoria, BC, Canada, for Shell Gulf of Mexico, Houston, TX, USA, National Marine Fisheries Service, Silver Spring, MD, USA, and U.S. Fish and Wildlife Service, Anchorage, AK, USA. 198 pp, plus appendices.

Reiser, C., B. Haley, D. Savarese, and D.S. Ireland. 2009. Chukchi Sea vessel-based monitoring program. Chapter 3 *in*: Ireland, D.S., D.W. Funk, R. Rodrigues, and W.R. Koski (eds.). Joint monitoring program in the Chukchi and Beaufort seas, open water seasons, 2006–2007. LGL Alaska Report P971-2. Report from LGL Alaska Research Associates, Inc., Anchorage, AK, LGL Ltd., environmental research associates, King City, Ont., JASCO Research Ltd., Victoria, B.C., and Greeneridge Sciences, Inc., Santa Barbara, CA, for Shell Offshore, Inc., Anchorage AK, ConocoPhillips Alaska, Inc., Anchorage, AK, and the National Marine Fisheries Service, Silver Springs, MD, and the U.S. Fish and Wildlife Service, Anchorage, AK. 485 p. plus Appendices.

Reiser, C., D. Funk, R. Rodrigues and D. Hannay (eds.). 2010. Marine mammal monitoring and mitigation during open water shallow hazards and site clearance survey by Shell Offshore Inc. in the Alaskan Chukchi Sea, July - October 2009: 90-day report. LGL Report P1112-1. LGL Alaska Research Associates, Inc., Anchorage, AK, and JASCO Research Ltd., Victoria, BC, for Shell Offshore, Inc. Houston, TX, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD, and U.S. Fish and Wildlife Service, Marine Mammal Management, Anchorage, AK.

Research Planning, Inc. 2002. Environmental sensitivity index shoreline classification of the Alaskan Beaufort Sea and Chukchi Sea. OCS Study MMS 2003-006. USDOI Minerals Management Service, Alaska OCS Region, Anchorage, AK. 11 pp. + app.

Reynolds, H.V. 1989. Grizzly bear population ecology in the western Brooks Range, Alaska (Progress report 1988). Alaska Department of Fish and Game and U.S. National Park Service, Fairbanks.

Rice, D.W. 1998. Marine mammals of the world, systematics and distribution. Society for Marine Mammalogy, Special Publication No.4. Allen Press, Lawrence, KS. 231 p.

Rice, D.W. and A.A. Wolman. 1971. The life history and ecology of the gray whale (*Eschrichtius robustus*). The American Society of Mammalogists, Special Publication No. 3. Seattle, WA. 142 pp.

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. 1998. Study of late summer and fall movements and dive behaviour of Beaufort Sea belugas, using satellite telemetry: 1997. MMS OCS Study 98-0016. USDOI Minerals Management Service, Alaska OCS Region, Anchorage. 25 pp.

Richard, P.R., A.R. Martin, and R. Or. 2001. Summer and autumn movements of belugas of the Eastern Beaufort Sea Stock. Arctic 54(3):223–236.

Richardson, W.J. (ed.). 2008. Monitoring of industrial sounds, seals, and bowhead whales near BP's Northstar Oil Development, Alaskan Beaufort Sea, 1999–2004. [Comprehensive Report, 3rd Update, Feb. 2008.] LGL Rep. P1004. Rep. from LGL Ltd. (King City, Ont.), Greeneridge Sciences Inc. (Santa Barbara, CA), WEST Inc. (Cheyenne, WY) and Applied Sociocultural Research (Anchorage, AK) for BP Explor. (Alaska) Inc., Anchorage, AK. xxix + 427 p., plus Appendices A–V on CD-ROM.

Richardson, W.J. and C.I. Malme. 1993. Man-made noise and behavioral responses. pp. 631-787p *in*: J.J. Burns, J.J. Montague, and C.J. Cowles (eds.) The bowhead whale book. Special Publication of No.2., The Society for Marine Mammalogy. Lawrence, KS.

Richardson, W.J., M.A. Fraker, B. Wursig, and R.S. Wells. 1985a. Behavior of bowhead whales, *Balaena mysticetus*, summering in the Beaufort Sea: reactions to industrial activities. Biological Conservation 32(3):195-230.

Richardson, W.J., R.S. Wells, and B. Wursig. 1985b. Disturbance responses of Bowheads, 1980-1984. pp. 255-306 *in*: W.J. Richardson (ed.) Behavior, disturbance responses, and distribution of bowhead whales, *Balaena mysticetus* in the Eastern Beaufort Sea, 1980-84. OCS Study MMS 85-0034. USDOI, Minerals Management Services, Alaska OCS Region, Anchorage, AK.

Richardson, W.J., B. Würsig, and C.R. Greene. 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., D.B. Fissel, J.R. Marko, J.R. Birch, G.A. Borstad, D.N. Truax, R. Kerr, W.B. Griffiths, D.H. Thomson, B. Wursig, G.W. Miller, D.M. Schell, S.M. Saupe, N. Haubenstock, J. Goodyear, and D.R. Schmidt. 1987. Importance of the eastern Alaskan Beaufort Sea to feeding bowhead whales, 1985-1986. OCS Study MMS 87-0037, Contract no. 14-12-0001-30233. Prepared for the USDOI Minerals Management Service by LGL, Ltd., Arctic Sciences Ltd., BioSonics, Inc., G.A. Borstad Associates Ltd., and University of Alaska, Fairbanks. Bryan: LGL, Ltd.

Richardson, W.J., J.P. Hickie, R.A. Davis, D. Thomson, and C.R. Greene. 1989. Effects of offshore petroleum operations on cold water marine mammals: a literature review. API Publication No. 4485. American Petroleum Institute, Washington, D.C. 384 pp.

Richardson, W.J., C.R. Greene, Jr., W.R. Koski, C.I. Malme, G.W. Miller, M.A. Smultea, et al. 1990. Acoustic effects of oil production activities on bowhead and white whales visible during spring migration near Pt. Barrow, Alaska—1989 phase. OCS Study MMS 90- 0017. (NTIS PB91-105486). LGL Ltd. report prepared for USDOI Minerals Management Service, Herndon, VA. 284 pp.

Richardson, W., C. Greene, W. Koski, M. Smultea, C. Holdsworth, G. Miller, T. Woodley, and B. Wursig. 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. USDOI Minerals Management Service, Herndon, VA 311 pp.

Richardson, W.J., C.R. Greene, Jr., C.I. Malme, and D.H. Thomson. 1995a. Marine mammals and noise. San Diego, CA: Academic Press, Inc. 576 pp.

Richardson, W.J., C.R. Greene, Jr., J.S. Hanna, W.R. Koski, G.W. Miller, N.J. Patenaude, and M.A. Smultea. 1995b. Acoustic effects of oil production activities on bowhead and white whales visible during spring migration near Pt. Barrow, Alaska-1991 and 1994 phases: Sound propagation and whale responses to playbacks of icebreaker noise. OCS Study MMS 95-0051. USDOI Minerals Management Service, Alaska OCS Region, Anchorage, AK. 392 pp. + app.

Richardson, W.J., 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, Pt. 2):2281.

Richardson, W.J., T.L. McDonald, C.R. Greene, Jr., and S.B. Blackwell. 2008. Effects of Northstar on distribution of calling bowhead whales 2001-2004. Chapter 10 *In:* Richardson, W.J. (ed.). 2008. Monitoring of industrial sounds, seals, and bowhead whale calls near BP's Northstar Oil Development, Alaskan Beaufort Sea, 1999-2004. Comprehensive Report, 3rd Update, Feb. 2008. LGL Rep. P1004. Rep. from LGL Ltd. (King city, Ont.), Greeneridge Sciences, Inc. (Santa Barbara, CA), WEST, Inc. (Cheyene, WY), and Applied Sociocultural Research (Anchorage, AK), for BP Explor. (Alaska) Inc. (Anchorage, AK).

Rigor, I.G. and J.M. Wallace. 2004. Variations in the age of Arctic Sea-ice and summer sea-ice extent. Geophysical Research Letters, 31, L09401, doi:10.1029/2004GL019492.

RISE Alaska, LLC. 2011. USACE/DOT&PF Alaska Deep-Draft Arctic Ports Planning Charrette. Held in Anchorage, Alaska May 16-17. www.dot.state.ak.us/stwddes/desports/assets/pdf/port_study.pdf (accessed March 5, 2013).

Ritter, L., K.R. Solomon, J. Forget, M. Stemeroff, and C. O'Leary. 1995. Persistent organic pollutants. an assessment report on DDT, aldrin, dieldrin, endrin, chlordane, heptachlor, hexachlorobenzene, mirex, toxaphene, polychlorinatedbiphenyls, dioxins and furans. International Programme on Chemical Safety (IPCS). PCS 95.38., Gen_eve, 43 pp. Available from

Rode, K.D., S.C. Amstrup, and E.V. Regehr. 2007. Polar bears in the southern Beaufort Sea III: stature, mass, and cub recruitment in relationships to time and sea ice extent between 1982 and 2006. Administrative Report. U.S. Geological Survey, Reston, VA. 28 pp.

Rode, K.D., E.V. Regehr, D.C. Douglas, G. Durner, A.E. Derocher, G.W. Thiemann, S.M. Budge. 2013. Variation in the response of an Arctic top predator experiencing habitat loss: feeding and reproductive ecology of two polar bear populations. Global Change Biology. Accepted Article

Rodgers, J., Jr. and S. Schwikert. 2002. Buffer zone distances to protect foraging and loafing waterbirds from disturbances by personal watercraft and outboard-powered boats. Conservation Biology 16:216-224

Roessig, J.M., CM. Woodley, J.J. Cech Jr., and L.J. Hansen. 2004. Effects of global climate change on marine and estuarine fishes and fisheries. Reviews in Fish Biology and Fisheries 14:251–275.

Rogers, J. (2012). Archaeological Assessment of Geotechnical Cores and Materials, 2011 Statoil Ancillary Activities, Chukchi Sea. Prepared for Statoil USA E&P, Inc. by Alaska Maritima with assistance from ASRC Energy Services. (June 2012).

Rojek, N.A. 2005. Breeding biology of Steller's eiders nesting near Barrow, Alaska, 2004. Technical Report. U.S. Fish & Wildlife Service, Fairbanks, Alaska. 47pp.

Rojek, N.A. 2006. Breeding biology of Steller's eiders nesting near Barrow, Alaska, 2005. Technical Report. U.S. Fish and Wildlife Service, Fairbanks, AK. 53 pp.

Rojek, N.A. 2007. Breeding biology of Steller's eiders nesting near Barrow, Alaska, 2006. Technical Report. U.S. Fish and Wildlife Service, Fairbanks Fish and Wildlife Field Office, Fairbanks, AK. 53 pp.

Rojek, N.A. 2008. Breeding biology of Steller's eiders nesting near Barrow, Alaska, 2007. Technical Report. U.S. Fish and Wildlife Service, Fairbanks Fish and Wildlife Field Office, Fairbanks, AK. 45 pp.

Rojek, N.A. and P.D. Martin. 2003. Breeding biology of Steller's eiders nesting near Barrow, Alaska, 2003. U.S. Fish and Wildlife Service, Fairbanks Fish and Wildlife Field Office, Fairbanks, AK. Technical Report. 35 pp.

Rojek, N, M. Parker, H. Carter, and G. McChesny. 2007. Aircraft disturbance and vessel disturbance to common murres *Uria aalge* at breeding colonies in central California 1997-1999. Marine Ornithology 35:61–69.

Romano, T.A., M.J. Keogh, C. Kelly, P. Feng, L. Berk, C.E. Schlundt, et al. 2004. Anthropogenic sound and marine mammal health: Measures of the nervous and immune systems before and after intense sound exposure. Canadian Journal of Fisheries and Aquatic Sciences 61:1124-1134.

Rosa, C. 2009. A summary of dead, stranded bowhead whales reported in the Chukchi and Beaufort seas over the last twenty-five years. IWC paper #SC/61/E12. International Whaling Commission.

Rose, G.A., B. deYoung, D.W. Kulka, S.V. Goddard and G.L. Fletcher. 2000. Distribution shifts and overfishing the northern cod (Gadus morhua): A view from the ocean. Canadian Journal of Fisheries and Aquatic Science 57:644-663.

Roseneau, D. 1996. Population studies of murres and kittiwakes at Cape Lisburne and Cape Thompson. in: T. Newbury (ed.) Proceedings of the 1995 Arctic Synthesis Meeting: USDOI Minerals Management Service, Alaska OCS Region, Anchorage, AK

Roseneau, D. and D. Herter. 1984. Marine and coastal birds. pp. 81-115 *in*: J.C. Truett (ed) Proceedings of a Synthesis Meeting: The Barrow Arch environment and possible consequences of planned offshore oil and gas development (Sale 85), Girdwood, AK., Oct.30-Nov. 1, 1983. U.S. Department of Commerce, NOAA, OCSEAP and USDOI Minerals Management Service, Alaska OCS Region, Anchorage, AK.

Roseneau, D.G., M.F. Chance, P. Chance, and V. Byrd. 2000. Monitoring seabird populations in areas of oil and gas development in the Alaskan continental shelf: Cape Lisburne and Cape Thompson seabird studies 1995-1997. MMS 99-001. Alaska Maritime National Wildlife Refuge, Homer, AK. 147 pp.

Ross, D. 1976. Mechanics of underwater noise. Pergamon, New York. 375 pp. (Reprinted 1987, Peninsula Publ., Los Altos, CA).

Rostad, A., S. Kaartvedt, T.A. Klevjer, and W. Melle. 2006. Fish are attracted to vessels. ICES Journal of Marine Science 63:1431-1437.

Rothrock, D. and J. Zhang. 2005. Arctic ocean sea ice volume: what explains its recent depletion? Journal of Geophysical Research. 110:CO1002.

Rothrock, D., Y. Yu, and G. Maykut. 1999. Thinning of the arctic sea ice cover. Geophysical Research Letters 2623:3469-3472.

Rozell, 1996: Arctic haze: An Uninvited Spring Guest. Alaska Science Forum, Article #1279. Available at: http://www2.gi.alaska.edu/ScienceForum/ASF12/1279.htmlRPS. 2013. Protected Species Mitigation and Monitoring Report: Plate boundaries around the Chukchi borderland: An integrated geophysics cruise to test models for the formation of the Canada Basin. Coakley Marine Geophysical Survey in the Arctic Ocean. Prepared for Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY and National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD by RPS, Houston, TX.

Rugh, D.J., and Fraker, M.A. 1981. Gray whale (Eschrichtius robustus) sightings in Eastern Beaufort Sea. Arctic 34(2): 186-187.

Rugh, D., K. Sheldon, D. Withrow, H. Braham, and R. Angliss. 1993. Spotted seal summer distribution and abundance in Alaska. p. 94 *in*: Abstracts of 10th Biennial Conference of Marine Mammals, Galveston, Texas. November 1993. 130 pp.

Rugh, D. J., K.E.W. Shelden, and D.E. Withrow. 1995. Spotted seal sightings in Alaska 1992-93: Final report. Annual report to the MMPA Assessment Program, Office of Protected Resources, NMFS, NOAA, 1335 East-West Highway, Silver Spring, MD 20910.

Rugh, D.J., K.W. Shelden, and D.E. Withrow. 1997. Spotted seals, *Phoca lar*gha, in Alaska. Marine Fisheries Review 591:1-18.

Rugh, D.J., R.C. Hobbs, J.A. Lerczak and J.M. Breiwick. 2005. Estimates of abundance of the eastern North Pacific stock of gray whales 1997-2002. J. Cetacean Res. Manage. 7(1):1-12.

Rugh, D.J., K.E.W. Shelden, C.L. Sims, B.A. Mahoney, B.K. Smith, L.K. Litzky, and R.C. Hobbs. 2005. Aerial surveys of belugas in Cook Inlet, Alaska, June 2001, 2002, 2003, and 2004. NOAA Technical Memorandum NMFS-AFSC-149. U.S. Department of Commerce, NOAA, National Marine Fisheries Service, Alaska Fisheries Science Center, Juneau, AK

Ruiz, G. M. and C. H. Hewitt. 2009. Latitudinal patterns of biological invasions in marine ecosystems: A polar perspective pp. 347-358 *in*: I. Krupnik, M. A. Lang, and S.E. Miller (eds.) Smithsonian at the Poles: Contributions to International Polar Year Science.

Salmon, J. S. (2011). Protecting America: Cold War Defensive Sites A National Historic Landmark Theme Study. Washington D.C.: The National Historic Landmarks Program, Cultural Resources, National Park Service.

Salter, R.E. 1979. Site utilization, activity budgets, and disturbance responses of Atlantic walruses during terrestrial haul-out. Canadian Journal of Zoology 57(6):1169-1180.

Sand, O. and H.E. Karlsen. 1986. Detection of infrasound by the Atlantic cod. Journal of Experimental Biology 125:197-204.

Scandpower. 2001. Blowout frequency assessment of northstar. 27.83.01/R1. Prepared for BP Exploration (Alaska), Inc. Kjeller, Norway: Scandpower, 40 pp. plus appendices.

Schmutz, J. 2008. Reproductive demographics, use of marine habitats, and exposure to contaminants of red-throated loons breeding in Alaska. USGS Alaska Science Center, Anchorage, Alaska.

Schmutz, J. 2009. Information U.S. Geological Survey website on loons including telemetry studies accessed at http://alaska.usgs.gov/staff/staffbio.php?employeeid=187 on 03/27/09.

Schneider, W. and R. Bennett. 1979. Point Lay synopsis. pp. 107-119 *in*: Native livelihood and dependence, a study of land use and values through time. Rep. by North Slope Borough Contract Staff for U.S. Dep. Inter., Natl. Petrol. Reserve in Alaska, 105(c) Land Use Study, Anchorage, Alaska. 166 pp.

Schonberg, S.V., and K. H. Dunton. 2012. The distribution, abundance, and diversity of the benthic fauna of the northeastern Chukchi Sea. In: Chukchi Offshore Monitoring in Drilling Area (COMIDA): Chemical and Benthos (CAB) Final Report. Prepared for the Bureau of Ocean Energy Management. OCS Study BOEM 2012-012.

Schulberg, S., I. Show, and D. Van Schoik. 1989. Results of the 1987-1988 gray whale migration and landing craft air cushion interaction study program. U.S. Navy Contr. N62474-87-C-8669. Report from SRA Southwest Research Assoc., Cardiff, CA for the Naval Facilities Engineering Command, San Bruno, CA 45 pp.

Schwartz, C.C. 1997. Reproduction, natality and growth. pp. 141-171 *in*: A.W. Franzmann and C.C. Schwartz (eds.) Ecology and management of the North American moose. Smithsonian Institute Press, Washington, D.C.

Schwemmer, P., B. Mendel, N. Sonntag, V. Dierschke, and S. Garthe (2011). Effects of ship traffic on seabirds in offshore waters: implications for marine conservation and spatial planning. Ecol. Appl. 21: 1851–1860.

Scientific Research Association. 1988. Results of the 1986-1987 gray whale migration and landing craft air cushion interaction study program. U.S. Navy Contr. N62474-86-M-0942. Rep. from SRA Southwest Research Assoc., Cardiff, CA for the Naval Facilities Engineering Command, San Bruno, CA 31 pp.

Screen, J.A., I. Simmonds. 2010. The Central Role of Diminishing Sea Ice in Recent Arctic Temperature Amplification. *Nature*. Issue 464. Pgs. 1334-1337. Accepted March 12, 2010. doi:10.1038/nature09051

Sea Duck Joint Venture. 2003. Long-tailed duck (*Clangula hyemalis*). Sea Duck Information Series, Info Sheet# 10, October 2010. Sea Duck Joint Venture online at http://www.seaduckjv.org/.

Sea Duck Joint Venture. 2004a. King eider (*Somateria spectabilis*). Sea Duck Information Series, Info Sheet# 5, March 2004. Sea Duck Joint Venture online at http://www.seaduckjv.org/.

Sea Duck Joint Venture. 2004b. Common eider (*Somateria mollissima*). Sea Duck Information Series, Info Sheet# 5, March 2004. Sea Duck Joint Venture online at http://www.seaduckjv.org/.

Seaman, G. and J. Burns. 1980. Preliminary results of recent studies on belukhas in Alaskan waters. Unpublished Report by Alaska Department of Fish and Game, Fairbanks, AK. 31 pp.

Searing, G.F., E. Kyut, W.J. Richardson, and T.W. Barry. 1975. Seabirds of the southeastern Beaufort Sea: aircraft and group observations in 1972 and 1974. Beaufort Sea Technical Report 3B, Department of Environment, Victoria, British Columbia, Canada.

Shelden, K.E.W., D.P. DeMaster, D.J. Rugh, and A.M. Olson. 2001. Developing classification criteria under the U.S. Endangered Species Act: Bowhead whales as a case study. Conservation Biology 15(5):1300-1307.

Shell. 2008. Traditional and local knowledge overflight report, 2008 on-ice seismic exploration program, Beaufort Sea, Alaska. April 2008, report prepared by ASRC Energy Services, Anchorage, AK.

Shell. 2009. Exploration Plan, 2010 exploration drilling program Posey Blocks 6713, 6714, 6763, 6764, and 6912, Karo Blocks 6864 and 70-07, Burger, Crackerjack, and SW Shoebill Prospects, OCS Lease Sale, Chukchi Sea, Alaska, July 2009. Submitted to U.S. Department of Interior, Minerals Management Service, Alaska OCS Region by Shell Gulf of Mexico Inc., Anchorage, AK.

Shell. 2011. Revised Chukchi Sea exploration plan OCS Lease Sale 193, Chukchi Sea, Alaska, exploration drilling program Posey Area Blocks 6714, 6762, 6764, 6812, 6912, 6915, Appendix C. Incidental Harassment Authorization. Submitted to U.S. Department of Interior, Bureau of Ocean Energy Management, Regulation and Enforcement, Alaska OCS Region by Shell Gulf of Mexico Inc., Anchorage, AK.

Shell. 2011a. Revised Outer Continental Shelf lease exploration plan, Chukchi Sea, Alaska, Burger Prospect: Posey Area Blocks 6714, 6762, 6764, 6812, 6912, 6915, Chukchi Sea Lease Sale 193, May 2011. Submitted to U.S. Department of Interior, Bureau of Ocean Energy Management, Regulation and Enforcement, Alaska OCS Region by Shell Gulf of Mexico Inc., Anchorage, AK.

Shell. 2011b. Environmental impact analysis: Revised Chukchi Sea exploration plan OCS Lease Sale 193, Chukchi Sea, Alaska, Burger Prospect: Posey Area Blocks 6714, 6762, 6764, 6812, 6912, 6915. Submitted to U.S. Department of Interior, Bureau of Ocean Energy Management, Regulation and Enforcement, Alaska OCS Region by Shell Gulf of Mexico Inc., Anchorage, AK.

Shell 2013. Revised Outer Continental Shelf Lease Exploration Plan, Chukchi Sea Alaska. Burger Prospect: Posey Area Blocks 6714, 6762, 6764, 6812, 6912 and 6915; Chukchi Lease Sale 193, Revised November 2013.

Shell 2014a. Revised Outer Continental Shelf Lease Exploration Plan, Chukchi Sea, Alaska, Burger Prospect: Posey Area Blocks 6714, 6762, 6764, 6812, 6912, 6915, Chukchi Sea Lease Sale 193. Revised July August 2014.

Shell Global Solutions. 2009. Draft update: modeled drill mud impacts from an exploratory drilling campaign in the Chukchi Sea and Beaufort Sea, Alaska. Draft report prepared by Ian Voparil at Shell Global Solutions, Houston, Texas for Shell Exploration and Production, Anchorage, Alaska 68 pp.

Shepro, C.E., D.C. Maas, and D.G. Callaway. 2003. North Slope Borough 2003 economic profile and census report. Department of Planning and Community Services. IX. Barrow, Alaska.

Sherwood, K. 1998. Undiscovered oil and gas resources, Alaska federal offshore. OCS Monograph MMS 98-0054. USDOI Minerals Management Service, Alaska OCS Region, Anchorage. 381 pp. + app.

Sherwood, K., P. Johnson, J. Craig, S. Zerwick, R. Lothamer, D. Thurston, and S. Hurlbert. 2002. Structure and stratigraphy of the Hanna Trough. *in*: E. Miller, A. Grantz, and S. Klemperer (eds.), Tectonic evolution of the Bering Shelf-Chukchi Sea-Arctic margin and adjacent landmasses. Special Paper 360. The Geological Society of America, Boulder, Colorado. 387 p.

Shimada,K. R. Kamoshida, M. Itoh, S. Nishino, E. Carmack, F. McLaughlin, S. Zimmermann, A. Proshutinsky. 2006. Pacific Ocean Inflow: Influence on Catastrophic Reduction of Sea Ice Cover in the Arctic Ocean. *Geophysical Research Letters*, Vol. 33. L08605. DOI: 10.1029/2005GL025624. Published April 21, 2006.

Shirley, T.C. and S. Duesterloh. 2001. An experimental investigation of the role of zooplankton in the distribution of hydrocarbons. pp. 28-29 *in*: MBC Applied Environmental Sciences. 2001. Proceedings of the Eighth MMS Information Transfer Meeting. OCS Study MMS 2001-049. Prepared by MBC Applied Environmental Sciences, Costa Mesa, CA. Prepared for the U.S. Dept.

of the Interior, Minerals Management Service, Alaska OCS Region, Anchorage, AK. 61 pp. + attach.

Short, J., M.R. Lindeberg, P.M. Harris, J.M. Maselko, J.J. Pella, and S.SD. Rice. 2004. Estimate of oil persisting on the beaches of Prince William Sound 12 years after the Exxon Valdez oil spill. Environmental Science & Technology 38.1:19-25.

Short, J.W., J.M. Maselko, M.R. Lindeberg, P.M. Harris and S.SD. Rice. 2006. Vertical distribution and probability of encountering intertidal Exxon Valdez oil on shorelines of three embayments within Prince William Sound. Environmental Science & Technology 40:3723-3729.

Simpkins, M.A., L.M. Hiruki-Raring, G. Sheffield, J.M. Grebmeier, and J.L. Bengtson. 2003. Habitat selection by ice-associated pinnipeds near St. Lawrence Island, Alaska in March 2001. Polar Biology. 26:577-586.

Singleton, R., D. Bruden, L. Bulkow, G. Varney, and J. Butler. 2006. Decline in respiratory syncitial virus hospitalizations in a region with high hospitalization rates and prolonged season. Journal Pediatric Infectious Disease. 2512:1116-1122.

SLR Environmental Research Ltd. and D.F. Dickins Associates Ltd. 1987. Field research spills to investigate the physical and chemical fate of oil in pack ice. Report No. 062. Environmental Emergencies Technologies Division, Environment Canada, Ottawa, Ontario, Canada.

SLR International Corp. 2011. Point Lay Comprehensive Ambient Air and Meteorological Monitoring Program, Annual Data Summary for June 1, 2010 – May 31, 2011. Unpublished report by SLR Consulting, Inc. for Shell Offshore Inc., Anchorage, Alaska, Sep. 2011.

SLR International Corp. 2012a. 2011 Annual Data Report, Wainwright Ambient Air Quality and Meteorological Monitoring Program, Jan. 1 – Dec. 31, 2011. Unpublished report by SLR Consulting, Inc. for ConocoPhillips Alaska, Inc., Anchorage, Alaska, Feb. 2012.

SLR International Corp. 2012b. Quarterly Data Summary Wainwright Ambient Air Quality and Meteorological Monitoring Program: January 1, 2012 – March 31, 2012. Unpublished report prepared by SLR Int. Corp. for ConocoPhillips Alaska, Inc., Anchorage, Alaska.

SLR International Corp. 2012c. Quarterly Data Summary Wainwright Ambient Air Quality and Meteorological Monitoring Program: April 1, 2012 – June 30, 2012. Unpublished report prepared by SLR Int. Corp. for ConocoPhillips Alaska, Inc., Anchorage, Alaska.

SLR International Corp. 2013a. 2012 Annual Data Report Wainwright Ambient Air Quality and Meteorological Monitoring Program: Jan. 1, 2012 – Dec. 31, 2012. Unpublished report prepared by SLR Int. Corp. for ConocoPhillips Alaska, Inc., Anchorage, Alaska.

SLR International Corp. 2013b. 2012 Annual Data Report, Point Lay Comprehensive Ambient Air and Meteorological Monitoring Program, Jan. 1 – Dec. 31, 2012. Unpublished report by SLR Consulting, Inc. for Shell Gulf of Mexico Inc., Anchorage, Alaska, Feb. 2013.

SLR International Corp. 2014. 2013 Annual Data Report, Point Lay Comprehensive Ambient Air and Meteorological Monitoring Program, Jan. 1 – Dec. 31, 2013. Unpublished report by SLR Consulting, Inc. for Shell Gulf of Mexico Inc., Anchorage, Alaska, Feb. 2014.

Smith, J.P., M.G. Brandsma, and T.J. Nedwed. 2004. Field verification of the offshore operators committee (OOC) mud and produced water discharge model. Environmental Modeling & Software 19:739-749.

Smith, M.A. 2011. Place-based summary of the Arctic marine synthesis. Audubon Alaska, Anchorage, AK. Smith, T.G. 1980. Polar bear predation of ringed and bearded seals in the land-fast sea ice habitat. Canadian Journal of Zoology 58:2201-2209.Stirling, I. 1997. The importance of polynyas, ice edges, and leads to marine mammals and birds. Journal of Marine Systems 10:9-21.

Smith, T., M.O. Hammill, and G. Taugbol. 1991. A review of the development behavioural and physiological adaptations of the ringed seal, Phoca hispida, to life in the arctic winter. Arctic. 442:124-131

Smith, R.L., W.E. Barber, M. Vallarino, J. Gillispie, and A. Ritchie. 1997a. Population biology of the Staghorn Sculpin in the northeastern Chukchi Sea. pp. 133-139 *in*: J. Reynolds (ed.) Fish ecology in arctic North America. American Fisheries Society Symposium 19, Bethesda, Maryland.

Smith, R.L., M. Vallarino, E. Barbour, E. Fitzpatrick, and W.E. Barber. 1997b. Population biology of the Bering Flounder in the northeastern Chukchi Sea. Pages 127-132 in J. Reynolds, editor. Fish ecology in Arctic North America. American Fisheries Society Symposium 19, Bethesda, Maryland.

Smultea, M.A., M. Holst, W.R. Koski and S. Stoltz. 2004. Marine mammal monitoring during Lamont-Doherty earth observatory's seismic program in the Southeast Caribbean Sea and adjacent Atlantic Ocean, April-June 2004. LGL Rep. TA2822-26. Rep. from LGL Ltd., King City, ON, for Lamont-Doherty Earth Observatory of Columbia Univ., Palisades, NY, and Nat. Mar. Fish. Serv., Silver Spring, MD. 106 p.

Sound Enterprises and Associates, LLC. 2008. Chukchi village interview program. Unpublished report prepared by Sound Enterprises and Associates LLC, Bainbridge Island, WA for Shell Exploration and Production Company, Anchorage, Alaska.

Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene Jr., D. Kastak, D.K. 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. Special Issue of Aquatic Mammals 33(4):412-522.

Sowls, A., S. Hatch, and C. Lensink. 1978. Catalog of Alaskan seabird colonies. FWS/OBS-78/78. U.S. Fish and Wildlife Service, Anchorage, Alaska.

Springer, A.M. and D.G. Roseneau. 1978. Ecological studies of colonial seabirds at Cape Thompson and Cape Lisburne, Alaska. pp. 839-960 *in*: Environ. Assess. Alaskan Cont. Shelf. Annual Report Principal Investigators Volume 2. BLM/NOAA, OCSEAP, Boulder, CO.

Springer, A., E. Murphy, D. Roseneau, and M. Springer. 1982. Population status, reproductive ecology, and trophic relationships of seabirds in northwestern Alaska. Final Report by LGL Alaska Research Associates, Inc. for the Outer Continental Shelf Environmental Assessment Program, Research Unit 460, April 1982. 243 pp.

St. Aubin, D. 1988. Physiologic and toxicologic effects on pinnipeds. pp. 120-142 *in*: J. Geraci, J. and D. St. Aubin (eds.) Synthesis of effects of oil on marine mammals. OCS Study MMS 89-0049. Prepared by Battelle Memorial Institute for USDOI Minerals Management Service, Atlantic OCS Region.

St. Aubin, D.J. 1990. Physiologic and toxic effects on Pinnipeds. p. 103-127, In: J.R. Geraci and D.J. St. Aubin (eds.), Sea mammals and oil: confronting the risks, Academic Press, San Diego. 282 pp.

St. Aubin, D.J., R.H. Stinson, and J.R. Geraci. 1984. Aspects of the structure and composition of baleen and some effects of exposure to petroleum hydrocarbons. Canadian Journal of Zoology 622:193-198.

Starr, S.J., M.N. Kuwada, and L.L. Trasky. 1981. Recommendations for minimizing the impacts of hydrocarbon development on the fish, wildlife, and aquatic plant resources of the northern Bering Sea and Norton Sound. Habitat Division, Alaska Department of Fish and Game, Anchorage, AK 525pp.

Steele, M., W. Ermold, J. Zhang. 2008. Arctic Ocean Surface Warming Trends Over the Past 100 Years. *Geophysical Research Letters*. Vol. 35. L02614.

Stehn, R.A, C.P. Dau, B. Conant, and W.I. Butler. 1993. Decline of spectacled eiders nesting in western Alaska. Arctic. 46:264-277.

Steinacher, M., F. Joos, T.L. Frolicher, G.K. Plattner, and S.C. Doney. 2009. Imminent ocean acidification of the Arctic projected with the NCAR global coupled carbon-cycle climate model. Biogeosciences 6:515-533.

Stemp, R. 1985. Observation on the effects of seismic exploration on seabirds. pp. 217-233 *in*: G.D. Greene, F.R. Englehardt, and R.J. Paterson (eds.) Proceedings of the workshop on effects of explosives use in the marine environment, January 29 to 31, 1985. Technical Report No. 5. Halifax Energy, Mines and Resources Canada and Northern India Affairs Canada, Canada Oil and Gas Lands Administration, Environmental Branch, Ottawa.

Stephenson, R.O. 2003. *Units 25 and 26 Caribou Management Report*. pp. 252-267. *in*: C. Healy (ed.) Caribou management report of survey and inventory activities 1 July 2000 – 30 June 2002. Alaska Department of Fish and Game, Juneau, Alaska.

Stewart, B.S., W.E. Evans, and F.T. Awbrey. 1982. Effects of man-made water-borne noise on the behaviour of beluga whales, *Delphinapterus leucas*, in Bristol Bay, Alaska. HSWRI Technical Report 82-145. Report to the US National Oceanic and Atmospheric Administration, Juneau, Alaska by Gybbs/Sea World Research Institute, San Diego, California. 29pp.

Stirling, I. 1997. The importance of polynyas, ice edges, and leads to marine mammals and birds. Journal of Marine Systems 10:9-21.

Stirling, I. 2002. Polar bears and seals in the eastern Beaufort Sea and Amundsen Gulf: A synthesis of population trends and ecological relationships over three decades. Arctic 55:59-76.USFWS. 2002a. Birds of conservation concern 2002. U.S. Fish and Wildlife Service, Division of Migratory Bird Management. Arlington, VA.

Stoker S.W. 1981. Benthic invertebrate macrofauna of the eastern Bering/Chukchi continental shelf. pp. 1069-1090 *in*: D.W. Hood and J.A. Calder (eds). The eastern Bering Sea shelf: oceanography and resources. Volume 2. University of Washington Press, Seattle.

Stoker, S. 1983. Subsistence harvest estimates and faunal potential at whaling villages in northwestern Alaska. Appendix A *in*: Subsistence study of Alaska Eskimo whaling villages. USDOI Minerals Management Service, Washington, D.C.

Stone, C.J. 2003. The effects of seismic activity on marine mammals in UK waters 1998-2000. JNCC Report 323. Joint Nature Conservation Committee, Aberdeen, Scotland. 43 p.

Stott, P.A., G.S. Jones, and J.F.B. Mitchell. 2003. Do models underestimate the solar contribution in recent climate change? Journal of Climate 16:4079-4093.

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, Vol. 38, L02502, DOI:10.1029/2010GL045662.

Stroeve, J., M. Serreze, S. Drobot, S. Gearheard, M. Holland, J. Maslanik, W. Meier, and T. Scambos. 2008. Arctic sea ice extent plummets in 2007. EOS, Transactions, American Geophysical Union 89(2):13–14.

Stroeve, J.C., M.C. 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:L04501. doi:10.1029/2004GL021810.

Suydam, R. S. 2000. King Eider (*Somateria spectabilis*). *in*: A. Poole an F. Gill (eds .)The birds of North America, No. 491. The Birds of North America, Inc., Philadephia, PA.

Suydam R.S., L.F. Lowry, K.J. Frost, G.M. O'Corry-Crowe, and D. Pikok, Jr. 2001b. Satellite tracking of eastern Chukchi Sea beluga whales into the Arctic Ocean. Arctic 543:237-243.

Suydam, R.S. and J.C. George. 2004. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos 1974-2004. Paper SC/56/BRG12. International Whaling Commission, Cambridge, UK.

Suydam, R.S. and J.C. George. 1992. Recent sightings of harbor porpoises, *Phocoena phocoena* , near Point Barrow, Alaska. Canadian Field-Naturalist 1604:489-492.

Suydam, R.S. and J.C. George. 2012. Preliminary analysis of subsistence harvest data concerning bowhead whales (*Balaena mysticetus*) taken by Alaskan Native, 1974 to 2011. Paper SC/64/AWMP8. International Whaling Commission, Cambridge, UK.

Suydam, R.S., J.C. George, P.B. Nader, and T.F. Albert. 1995. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos, 1994. Paper SC/47/AS12. International Whaling Commission, Cambridge, UK.

Suydam, R.S., J.C. George, T.M. O’Hara, and T.F. Albert. 1996. Efficiency of the subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaska Eskimos, 1973 to 1995, and observations on the 1995 subsistence harvest, Paper SC/48/AS14 submitted to the Scientific Committee of the International Whaling Commission, Commission, Cambridge, UK.

Suydam, R.S., J.C. George, T.M. O'Hara, and T.F. Albert. 1997. Efficiency of the subsistence harvest of bowhead whales by Alaskan Eskimos, 1973 to 1996 with observations on the 1995, 1996, and 1997 subsistence harvests. Paper SC/49/AS21. International Whaling Commission, Cambridge, UK.

Suydam, R.S., D.L. Dickson, J.B. Fadley, and L.T. Quakenbush. 2000. Population declines of king and common eiders of the Beaufort Sea. Condor 102:219-222.

Suydam, R.S., J. George, T.M. O'Hara, and G. Sheffield. 2001. Subsistence harvest of bowhead whales by Alaska Eskimos during 2000. Paper SC/53/BRG10. International Whaling Commission, Cambridge, UK.

Suydam, R.S., T.M. O'Hara , J.C. George, V.M. Woshner, and G. Sheffield. 2002. Subsistence harvest of bowhead whales by Alaska Eskimos during 2001. Paper SC/54/BRG20. International Whaling Commission, Cambridge, UK.

Suydam, R.S., J.C. George, T.M. O'Hara, and G. Sheffield. 2003. Subsistence harvest of bowhead whales by Alaska Eskimos during 2002. Paper SC/55/BRG5. International Whaling Commission, Cambridge, UK.

Suydam, R.S., J.C. George, T.M. O'Hara, C. Hanns, and G. Sheffield. 2004. Subsistence harvest of bowhead whales (*Balaenus mysticetus*) by Alaskan Eskimos during 2003. Paper SC/56/BRG11. International Whaling Commission, Cambridge, UK.

Suydam, R.S., L.F. Lowry, and K.J. Frost. 2005a. Distribution and movements of beluga whales from the eastern Chukchi Sea stock during summer and early autumn. OCS Study MMS 2005-035 Final Report. USDOI Minerals Management Service, Alaska OCS Region, Anchorage, AK. 48 pp.

Suydam, R.S., J.C. George, T.M. O'Hara, C. Hanns, and G. Sheffield. 2005b. Subsistence harvest of bowhead whales (*Balaenus mysticetus*) by Alaskan Eskimos during 2004. Paper SC/57/BRG15. International Whaling Commission, Cambridge, UK.

Suydam, R.S., J.C. George, C. Hanns, and G. Sheffield. 2006. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2005. Paper SC/58/BRG21. International Whaling Commission, Cambridge, UK.

Suydam, R.S., J.C. George, C. Rosa, B. Person, C. Hanns, G. Sheffield, and J. Bacon. 2007. Subsistence harvest of bowhead whales (Balaena mysticetus) by Alaskan Eskimos during 2006. Paper SC/59/BRG4. International Whaling Commission, Cambridge, UK.

Suydam, R.S., J.C. George, C. Rosa, B. Person, C. Hanns, G. Sheffield, and J. Bacon. 2008. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2007. Paper SC/60/BRG10. International Whaling Commission, Cambridge, UK.

Suydam, R.S., J.C. George, C. Rosa, B. Person, C. Hanns, G. Sheffield, and J. Bacon. 2009. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2008. Paper SC/61/BRG6. International Whaling Commission, Cambridge, UK.

Suydam, R.S., J.C. George, C. Rosa, B. Person, C. Hanns, and G. Sheffield. 2010. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2009. Paper SC/62/BR18. International Whaling Commission, Cambridge, UK.

Suydam, R.S., J.C. George, C. Rosa, B. Person, C. Hanns, and G. Sheffield. 2011. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2010. Paper SC/62/BRG2. International Whaling Commission, Cambridge, UK.

Suydam, R.S., J.C. George, C. Rosa, B. Person, C. Hanns, and G. Sheffield. 2012. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2011. Paper SC/62/BR18. International Whaling Commission, Cambridge, UK.

Suydam, R.S., J.C. George, B. Person, C. Hanns, R. Stimmelmayr, L. Pierce, and G. Sheffield. 2013. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2012. Paper SC/65a/BRG19 submitted to the International Whaling Commission, Cambridge, UK.

Swartz, L.G. 1966. Sea cliff birds. pp. 611-678 In: N.J. Wilimovsky and J.N. Wolfe (eds.), Environment of Cape Thompson Region, Alaska. U.S. Atomic Energy Commission, Oak Ridge, Tennessee.

Swartz, S., B. Taylor, and D. Rugh. 2006. Gray whale *Eschrichtius robustus* population and stock identity. Mammal Review 36(1):66-84.

Tarpley, R.J., R.F. Sis, T.F. Albert, L.M. Dalton, and J.C. George. 1987. Observations on the anatomy of the stomach and duodenum of the bowhead whale *Balaena mysticetus*. The American Journal of Anatomy 180:295-322.

Tavolga, W.N., A.N. Popper, and R.R. Fay. 1981. Hearing and sound communication in fishes. Springer-Verlag, New York. 608 pp.

Taylor, E.J. 1993. Molt and energetics of Pacific Black Brant (*Branta bernicla nigricans*) on the Arctic Coastal Plain, Alaska. Ph.D. Thesis, Texas A&M University, College Station, Texas. 285 pp.

Taylor, R.J. 1981. Shoreline vegetation of the arctic Alaskan coast. Arctic 34:37-42.

Teal, J. and R. Howarth. 1984. Oil spill studies: A review of ecological effects. Environmental Management 81:27-44.

TERA. 1996. Distribution and abundance of spectacled eiders in the vicinity of the Prudhoe Bay, Alaska. Report prepared by Troy Ecological Research Associates, Anchorage, Alaska for BP Exploration (Alaska) Inc., Anchorage, Alaska.

Terhune, J.M. 1981. Influence of loud vessel noises on marine mammal hearing and vocal communication. In The Question of Sound from Icebreaker Operations. Proceedings of a Workshop. N.M. Peterson, ed. Toronto, Ontario, Canada: Arctic Pilot Project, Petro-Canada.

The Cornell Lab of Ornithology. 2010. Passive acoustic monitoring of marine mammals in the Chukchi Sea 9 September – 14 October 2008.

Thedinga, J.F., S.W. Johnson, A.D. Neff, C.A. Hoffman, J.M. Maselko. 2012. Nearshore fish assemblages of the Northeastern Chukchi Sea, Alaska. Alaska Fisheries Science Center and U.S. Army Corps of Engineers.

Thomas, Arlene. 2008. Personal communication. Stakeholder Relations Department Manager, ASRC, Energy Services.

Thomas, M.L.H. 1978. Comparison of Oiled and Unoiled Intertidal Communities in Chedabucto Bay, Nova Scotia. Journal of Fisheries Research Board of Canada, Vol. 35, pp. 707-716.

Thomas, T.A., W.R. Koski, D.S. Ireland, D.W. Funk, M. Laurinolli and A.M. Macrander. 2009. Pacific walrus movements and use of terrestrial haul-out sites along the Alaskan Chukchi Sea coast in 2007. Poster, Society for Marine Mammalogy annual meeting, Quebec City, Quebec.

Thomas, T., W.R. Koski and D.S. Ireland. 2010. Chukchi Sea nearshore aerial surveys. Chapter 4 *in*: Funk, D.W, D.S. Ireland, R. Rodrigues, and W.R. Koski (eds.). 2010. Joint Monitoring Program in the Chukchi and Beaufort seas, open-water seasons, 2006–2008. LGL Alaska Report P1050-3, Report from LGL Alaska Research Associates, Inc., LGL Ltd., Greeneridge Sciences, Inc., and JASCO Research, Ltd., for Shell Offshore, Inc. and Other Industry Contributors, and National Marine Fisheries Service, U.S. Fish and Wildlife Service. 499 pp. + app.

Thompson, D., M. Sjöberg, E.B. Bryant, P. Lovell and A. Bjørge. 1998. Behavioural and physiological responses of harbour (*Phoca vitulina*) and grey (*Halichoerus grypus*) seals to seismic surveys. p. 134 *in*: World Marine Mammal Science Conference. Abstract Volume. Monaco. 160 p.

Thomson, D. and R. Davis. 2001. Review of the potential effects of seismic exploration on marine animals in the Beaufort Sea. LGL Project TA 2582-2 Report prepared by LGL Limited, King City, Ontario for ISR Oceans Program Coordinator, Fisheries and Oceans Canada, Yellowknife, NWT. 81 pp.

Thorsteinson, L.K, L.E. Jarvela, and D.A. Hale. 1991. Arctic fish habitat use investigations: Nearshore studies in the Alaskan Beaufort Sea, summer 1990. Annual Report. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Services, Anchorage, AK. 166 pp.

Thurston, D. and L. Theiss. 1987. Geologic report for the Chukchi Sea planning area, Alaska; regional geology, petroleum geology, environmental geology. OCS Report MMS 87-0046. USDOI Minerals Management Service, Alaska OCS Region, Anchorage 192 pp.

Tornberg, L., E. Thielk, R. Nakatani, R. Miller, and S. Hillman. 1980. Toxicity of drilling fluids to marine organisms in the Beaufort Sea, Alaska. pp. 997-1016 *in*: Proceedings of Symposium, Research on Environmental Fate and Effects of Drilling Fluids and Cuttings, Volume I. January 21-24, 1980, Lake Buena Vista, Florida. American Petroleum Institute, Washington, DC.

Travis, R. 1984. Suicide and economic development among the Inupiat Eskimo. White Cloud Journal of American Indian Mental Health 3(3):14-21.

Treacy, S.D. 2002. Aerial surveys of endangered whales in the Beaufort Sea, fall 2000. OCS Study MMS 2002-014. USDOI Minerals Management Service, Alaska OCS Region, Anchorage, AK.

Trefry, J.H., and R.P. Trocine. 2009. Chemical assessment in Camden Bay (Sivulliq Prospect and Hammerhead drill site), Beaufort Sea, Alaska. Final Report prepared by Florida Institute of Technology, Melbourne, Florida for Shell Exploration & Production Co., Anchorage, AK. 95 pp.

Trefry, J.H., R.P. Trocine, and L.W. Cooper. 2012. Distribution and Provenance of Trace Metals in Recent Sediments of the Northeastern Chukchi Sea, *in*: Chukchi Sea Offshore Monitoring in Drilling Area (COMIDA): Chemical and Benthos (CAB) Final Report. Bureau of Ocean Energy Management, Department of the Interior. OCS Study BOEM 2012-012.

Troy, D.M. 2000. Shorebirds. pp. 277-303 *in*: J.C. Truett and S.R. Johnson (eds.) The natural history of an arctic oilfield: Development and the biota. Academic Press, San Diego, CA.

Troy, D.M. 2003. Molt migration of spectacled eiders in the Beaufort Sea region. Report prepared by Troy Ecological Research Associates, Anchorage, Alaska, for British Petroleum Exploration-Alaska, Inc. Anchorage, Alaska. 17 pp.

Tyack, P., M. Johnson, and P. Miller. 2003. Tracking responses of sperm whales to experimental exposures of airguns. p. 115-120 *in*: A.E. Jochens and D.C. Biggs (eds.) Sperm whale seismic study in the Gulf of Mexico/Annual Report: Year 1. OCS Study MMS 2003-069. Rep. from Texas A&M Univ., College Station for USDOI Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA.

UMIAQ. 2012. 2011 Subsistence advisor program, North Slope, Alaska. Report prepared by UMIAQ, Anchorage, AK for Shell Exploration and Production, Anchorage, AK.

UMIAQ. 2013. 2012 Subsistence advisor program, North Slope, Alaska. Report prepared by UMIAQ, Anchorage, AK for Shell Exploration and Production, Anchorage, AK.

UMIAQ. 2014. 2012 Subsistence advisor program, North Slope, Alaska. Report prepared by UMIAQ, Anchorage, AK for Shell Exploration and Production Company, Anchorage, AK.

UNEP. 2006. Vital arctic graphics: People and global heritage on our last wild shores.

University of Arkansas. 2007. Alaskan Whaling Villages. http://www.uark.edu/misc/jcdixon/Historic_Whaling/Villages/Main_Map.htm (Accessed June 21, 2007).

University of Arkansas. 2008. Alaskan Whaling Villages. http://www.uark.edu/misc/jcdixon/Historic_Whaling/Villages/Main_Map.htm accessed November 2008).

USACE. 1998. Beaufort Sea oil and gas development/ Northstar Project. Draft Environmental Impact Statement. Appendix B. Anchorage, AK: U.S. Army Corps of Engineers, 7 Vols.

USACE. 2000a. Ouzinke Harbor trip report, Steller's eider Survey No. 1 and 2. Unpublished memorandum for the Record. CEPOA-EN-CW-ER. Alaska District, Anchorage.

USACE. 2000b. Sand Point trip report, Steller's eider Survey No. 1, 2, and 3. Unpublished memorandum for the Record. CEPOA-EN-CW-ER. Alaska District, Anchorage.

USACE. 2000c. Unalaska trip report, Steller's eider Survey No. 1 of 4. Unpublished memorandum for the Record. CEPOA-EN-CW-ER. Alaska District, Anchorage.

USACE. 2000d. Biological Assessment of Steller's eider *Polysticta stelleri* (Pallas) for Harbor Construction at Sand Point, Alaska. Unpublished memorandum for the Record. CEPOA-EN-CW-PF. Alaska District, Anchorage.

USACE. 2013. Draft Results Available for First Year of the Alaska Deep-Draft Arctic Port System Study. Press Release, 1/31/2013, http://www.poa.usace.army.mil/Media/NewsReleases/tabid/3349/Article/9725/draft-results-available-for-first-year-of-alaska-deep-draft-arctic-port-system.aspx (accessed March 5, 2013).

USACE. 2015. Public Notice. Draft Integrated Feasibility Report and Environmental Assessment, and Draft Finding of No Significant Impact. Alaska Deep-Draft Arctic Port System Study, Nome, Alaska. Identification No. ER-15-02. February 20, 2015. http://www.poa.usace.army.mil/Portals/34/docs/civilworks/arcticdeepdraft/PNDraftIntegratedFeasRptandEAandDraftFONSIAlaskaDeepDraftArcticPortsSystemStudy.pdf (accessed March 29, 2015).

U.S. Census Bureau. 2008. American FactFinder. https://www.census.gov/population/projections/data/national/2008.html. Accessed July 22, 2008.

U.S. Census Bureau. 2010. American Fact Finder. http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml. Accessed March 2013.

USCG. 2008a. The emerging Arctic. A new maritime frontier. United States Coast Guard Arctic Overview. Last modified 4/15/2008.

USCG. 2008b. USCG Icebreaker Science Operations. http://www.icefloe.net (accessed May 15, 2008).

USCG. 2008c. USCG Icebreaker Science Operations. Ship-time Request Procedures. http://www.icefloe.net. Accessed May 15, 2008.

USCG. 2008d. USCGC Polar Sea (WACG-11

USCG. 2008f. Press Release: Coast Guard Cutter Healy to Deploy. Office of Public Affairs. USCG Thirteenth District. May 5, 2008.

USCG. 2011. USCG D17 Arctic Brief. www.uscg.mil/d17/Arctic%20Overview%20Feb2011.pdf (accessed March 5, 2013).

USCG. 2012a. Environmental Assessment Arctic Shield 2012 Alaska. U.S. Coast Guard District Seventeen. Juneau.

USCG. 2012b. USCGC Polar Sea (WAGB 11). http://www.uscg.mil/pacarea/cgcpolarsea/default.asp (accessed February 27, 2013).

USCG. 2012c. Coast Guard Cutter Healy to Begin First of Three Arctic Missions for 2012. Alaska Native News. http://www.uscgnews.com/go/doc/4007/1515287/Coast-Guard-cutter-Healy-to-begin-first-of-three-Arctic-missions-for-2012 (accessed February 27, 2013).

USCG. 2012d. Arctic West Summer (AWS) 2012. http://www.uscg.mil/pacarea/cgcHealy/aws12/ (accessed February 27, 2013).

USCG. 2013. Coast Guard Heavy Polar Icebreaker Project Taking Shape. Press Release February 28, 2013. http://www.uscg.mil/hq/cg9/newsroom/updates/icebreaker022813.asp (accessed March 1, 2013).

USFWS. 1996. Spectacled eider recovery plan. U.S. Fish and Wildlife Service, Anchorage, AK.

USFWS. 2000. Beringian Seabird Colony Catalog. Computer Database. U.S. Fish and Wildlife Service, Migratory Bird Management. Anchorage, AK.

USFWS. 2001. Endangered and threatened wildlife and plants; Final Determination of Critical Habitat for the spectacled eider; Final Rule. 50 CFR Part 17. U.S. Fish and Wildlife Service, Washington DC.

USFWS. 2002. Spectacled eider recovery plan. U.S. Fish and Wildlife Service, Anchorage, Alaska. Accessed March 12, 2013 at http://alaska.fws.gov/fisheries/endangered/pdf/Steller's%20Eider%20Recovery%20Plan.pdf

USFWS. 2002b. Spectacled eider fact sheet. U.S. Fish and Wildlife Service, Anchorage, AK. October 2002.

USFWS. 2002c. Steller's eider recovery plan. U.S. Fish and Wildlife Service, Fairbanks, AK.

USFWS. 2005. Final Biological Opinion (01-12-2005) U.S. Fish and Wildlife Service's (Service's) final biological opinion (BO) based on our review of the Bureau of Land Management's (BLM's) biological assessment covering the proposed Amendment to the Integrated Activity Plan/Environmental Impact Statement (IAP/EIS) for the Northeast National Petroleum Reserve-Alaska (NE NPR-A). United States Fish and Wildlife Service, Fairbanks, AK 71 p.

USFWS. 2006a. Draft study plan for estimating the size of the Pacific walrus population. U.S. Fish and Wildlife Service, Marine Mammals Management, Alaska Science Center; U.S. Geological Survey; GiproRybFlot, Research and Engineering Institute for the Development and Operation of Fisheries; ChukotTINRO, Pacific Research Institute of Fisheries and Oceanography. 43 pp.

USFWS. 2006b. Alaska Seabird Information Series: Kittlitz's Murrelet, Brachyramphus brevirostris. U.S. Department of Interior. U.S. Fish and Wildlife Service. Anchorage, AK. Accessed online on August 25, 2014 at http://www.fws.gov/alaska/mbsp/mbm/seabirds/pdf/kimu.pdf.

USFWS. 2007. Biological opinion Chukchi Sea planning area oil and gas lease sale 193 and associated seismic surveys and exploratory drilling. U.S. Fish and Wildlife Service, Alaska

USFWS. 2008a. Shorebirds: sanderling. U.S. Fish and Wildlife Service, Migratory Bird Management, Alaska Region updated September 14, 2008 accessed online at http://alaska.fws.gov/mbsp/mbm/shorebirds/species/Sanderling.htm.

USFWS. 2008b. Programmatic biological opinion for polar bear (*Ursus maritimus*) on Beaufort Sea incidental take regulations. June 2008. U. S. Fish and Wildlife Service, Fairbanks, AK.

USFWS. 2008c. Programmatic biological opinion for polar bear (Ursus maritimus) on Chukchi Sea Incidental Take Regulations. June 2008. U. S. Fish and Wildlife Service, Fairbanks, AK. 74 pp.

USFWS. 2008d. Endangered and threatened wildlife and plants; determination of threatened status for the polar bear (Ursus maritimus) throughout its range. Fed. Regist. 73 (95, 15 May.):28212–28303.

USFWS. 2009. Tagging database. Marking, Tagging and Reporting Program (MTRP). (Retrieved May 2009).

USFWS. 2009a. Alaska Maritime National Wildlife Refuge. Chukchi Sea. http://www.fws.gov/refuge/alaska_maritime/ (accessed May 10, 2009).

USFWS. 2009b. Species assessment and listing priority assignment form: Kittlit's murrelet. U.S. Fish and Wildlife Service, Anchorage, AK at https://absilcc.org/science/Plans/Kittlitz's%20Murrelet%20Candidate%20Listing%20Package%20USFWS.pdf.

USFWS. 2009c. Final biological opinion for Beaufort and Chukchi Sea program area lease sales and associated seismic surveys and exploratory drilling. September 2009. U. S. Fish and Wildlife Service, Fairbanks, AK. 168 pp

USFWS. 2010a. Pacific walrus (Odobenus rosmarus divergens): Alaska stock. Final stock assessment report. USFWS. 2010b. Polar bear (Ursus maritimus): Chukchi/Bering Seas stock. Final stock assessment report. Available at http://alaska.fws.gov/fisheries/mmm/stock/final_cbs_polar_bear_sar.pdf.

USFWS. 2010c. Polar bear (Ursus maritimus): Southern Beaufort Sea stock. Final stock assessment report. Available at http://alaska.fws.gov/fisheries/mmm/stock/final_sbs_polar_bear_sar.pdf.

USFWS. 2010d. Candidate assessment Kittlitz's murrelet: U.S. Fish and Wildlife Service Species Assessment and listing priority assessment form. Dated May 2010. U.S. Fish and Wildlife Service, Anchorage Field Office, Anchorage, AK. 46 pp.

USFWS. 2011a. Programmatic biological opinion for polar bears (*Ursus maritimus*), polar bear critical habitat, and conference opinion for the Pacific walrus (*Odobenus rosmarus divergens*) on Beaufort Sea incidental take regulations. U.S. Fish and Wildlife Service, Fairbanks, AK. 59 pp. + app.

USFWS 2011b. USFWS Threatened and Endangered Species–Spectacled Eider (Somateria fischeri) Fact Sheet.

USFWS. 2012. Biological Opinion and Conference Opinion for Oil and Gas Activities in the Beaufort and Chukchi Sea Planning Areas on Polar Bears (*Ursus Maritimus*), Polar Bear Critical Habitat, Spectacled Eiders (Somateria fischeri), Spectacled Eider Critical Habitat, Steller's Eiders (Polysticta stelleri), Kittlitz's Murrelets (Brachyramphus brevirostris), and Yellow-billed Loons (Gavia adamsii). Prepared by U.S. Fish and Wildlife Service. May 8, 2012. Fairbanks, AK.

USFWS. 2013a. Final Environmental Assessment: Final rule to authorize the incidental take of small numbers of Pacific walruses (*Odobenus rosmarus divergens*) and polar bears (Ursus maritimus) during oil and gas industry exploration activities in the Chukchi Sea. U.S. Fish and Wildlife Service, Anchorage, AK. 182 p.

USFWS. 2013b. Biological Opinion for Polar Bears and Conference Opinion for Pacific Walrus on the Chukchi Sea Incidental Take Regulations. U.S. Department of Interior. U.S. Fish and Wildlife Service. Fairbanks, AK. May 20, 2013.

USFWS. 2014a. USFWS Guidance for Preparing a Biological Assessment. U.S. Department of Interior. U.S. Fish and Wildlife Service. *Accessed online on* August 24, 2014 *at* http://www.fws.gov/midwest/endangered/section7/ba_guide.html.

USFWS. 2014b. Biological Opinion for the USFWS Region 7 Polar Bear and Pacific Walrus Deterrence Program. U.S. Department of Interior. U.S. Fish and Wildlife Service. January 13, 2014.

USGS. 2008. Wandering wildlife satellite and radio telemetry tracking wildlife across the Arctic: long tailed duck. Viewed online at http://alaska.usgs.gov/science/biology/wandering_wildlife/.

USGS. 2009. Wandering wildlife satellite and radio telemetry tracking wildlife across the Arctic: common eider. Viewed online at http://alaska.usgs.gov/science/biology/wandering_wildlife/.

Valkenburg, P. 1999. Caribou. ADF&G Wildlife Notebook Series. Juneau, AK.

Van Parijs, S.M. and C. Clark. 2006. Long-term mating tactics in an aquatic-mating pinniped, the bearded seal, Erignathus barbatus. Animal Behavior 72:1269-1277.

Van Vliet, G.B. and M. McAllister. 1994. Kittlitz's murrelet: the species most impacted by direct mortality from the Exxon Valdez oil spill? Pacific Seabirds 21:5-6.

Vermeer, K. and R. Vermeer. 1975. Oil threat to birds on the Canadian west coast. Canadian Field-Naturalist 89:278-298.

Verna, D. 2014. Risk of ballast-borne marine invasive species to coastal Alaska. Masters Thesis. Alaska Pacific University, Anchorage, Alaska.

Von Ziegesar, O., E. Miller, and M.E. Dahlheim. 1994. Impacts on humpback whales in Prince William Sound. pp. 173-191 *in*: T.R. Loughlin (ed.) Marine mammals and the Exxon Valdez. Academic Press, Inc., San Diego, CA.

Walsh, J.E. 2008. Climate of the arctic marine environment. Ecological Applications 18 Supplement pp. S3-S22.

Ward, J.G. and E. Pessah. 1986. Marine mammal observations in the Beaufort Sea, 1985 season, with a discussion of bowhead whales sightings, 1976-1985. Dome/Canmar Tech. Rep. Dome Petrol. Ltd., Calgary, Alb 54 p.

Ward, D. and R. Stehn. 1989. Response of brant and other geese to aircraft disturbances at Izemek Lagoon, Alaska. OSC Study 90-0046, report prepared by U.S. Fish and Wildlife Service, Alaska for USDOI Minerals Management Service, Alaska OCS Region, Anchorage, Alaska.

Wardle, C.S., T.J. Carter, G.G. Urquhart, A.D.F. Johnstone, A.M. Ziolkowski, G. Hampson and D. Mackie. 2001. Effects of seismic air guns on marine fish. Continental Shelf Research 21:1005-27.

Warner, G. and D. Hannay. 2009. Acoustic modeling of underwater noise from the Frontier Discoverer in the Chukchi and Beaufort seas. Version 1.0. Technical report for Shell Exploration and Production Company by JASCO Applied Sciences.

Wartzok, D., W. Watkins, B. Wursig, and C. Malme. 1989. Movements and behavior of bowhead whales in response to repeated exposures to noises associated with industrial activities in the Beaufort Sea. Report by Purdue University, Fort Wayne, Indiana, for Amoco Production Company, Anchorage, AK. 228 pp.

Watanabe, Y., C. Lydersen, K. Sato, Y. Naito, N. Miyazaki, and K. M. Kovacs. 2009. Diving behavior and swimming style of nursing bearded seal pups. Marine Ecology Progress Series 380:287-294.

Watkins, W.A. 1986. Whale reactions to human activities in Cape Cod waters. Mar. Mamm. Sci. 2(4):251-262.

Watson, G. and G. Divoky. 1972. Pelagic bird and mammal observations in the Eastern Chukchi Sea, Early Fall 1970. in An Ecological Survey in the Eastern Chukchi Sea, September-October 1970. U.S. Coast Guard Oceanographic Report 50.

Webb, C., and N. Kempf. 1998. The impact of shallow-water seismic in sensitive areas. Society of Petroleum Engineers Technical Paper SPE 46722. Caracas, Venezuela.

Weber J, C.J. Halsall, D.C.G. Muir, C. Teixeira, D.A. Burniston, W.M.J. Strachan, et al. 2006. Endosulfan and gamma-HCH in the Arctic: an assessment of surface seawater concentrations and air–sea exchange. Environmental Science and Technology 40(24):7570–6.

Weilgart, L.S. 2007. The impacts of anthropogenic ocean noise on cetaceans and implications for management. Canadian Journal of Zoology 85:1091-1116.

Weingartner, T. and S. Danielson. 2010. Physical oceanographic measurements in the Klondike and Burger survey area of the Chukchi Sea: 2008 and 2009. Final Report prepared by Institute of Marine Science, University of Alaska, Fairbanks for ConocoPhillips, Inc., Shell Exploration & Production Company, and Statoil, Inc., Anchorage, AK. 50 pp.

Weingartner, T., S. Danielson, L. Dobbins, and R. Potter 2011. Physical oceanographic measurements in the Klondike and Burger survey area of the Chukchi Sea: 2008-210. Prepared for ConocoPhillips, Inc., Shell Exploration & Production Company, and Statoil, Inc., Anchorage, AK. by Institute of Marine Science, University of Alaska, Fairbanks 89 pp.

Weingartner, T., S. Danielson, L. Dobbins, and R. Potter 2013. Physical oceanographic measurements in the northeastern Chukchi Sea: 2012. Prepared for ConocoPhillips, Inc., Shell Exploration & Production Company, and Statoil, Inc., Anchorage, AK. by Institute of Marine Science, University of Alaska, Fairbanks 63 pp.

Weingartner, T., S. Danielson, L. Dobbins, and R. Potter 2014. Physical Oceanographic Measurements in the Northeastern Chukchi Sea: 2013. Prepared for ConocoPhillips, Inc., Shell Exploration & Production Company, and Statoil, Inc., Anchorage, AK. by Institute of Marine Science, University of Alaska, Fairbanks 59 pp.

Weller, D.W., A.M. Burdin, B. Wursig, B.L. Taylor, and R.L. Brownell, Jr. 2002. The western gray whale: A review of past exploitation, current status and potential threats. Journal of Cetacean Research and Management 4(1):7-12.

Werner, I, I. Johanna, and H. Schunemann. 2007. Sea-ice algae in arctic pack ice during late winter. Polar Biology 30(11):1493-1504.

Wernham, Aaron. 2007. Inupiat health and proposed Alaskan oil development: Results of the first Integrated Health Impact Assessment/ Environmental Impact Statement for Proposed Oil Development on Alaska's North Slope. EcoHealth 4:500–513.

West, F. H. (1996). The Study of Beringia. In F. H. West, American Beginnings: The Prehistory and Palaeoecology of Beringia (pp. 1-10). Chicago: University of Chicago Press.

Whitten, K.R. and R.D. Cameron. 1985. Distribution of caribou calving in relation to the Prudhoe Bay oilfield. *in*: A.M Martell and D.E. Russell (eds.) Proceedings of the 1st North American Caribou Workshop, 28-29 Sept. 1983, Whitehorse, Yukon. Canadian Wildlife Services, Ottawa, Canada.

WHOI. 2009. Study links swings in North Atlantic oscillation variability to climate warming. New Release January 13, 2009.

Wiese, K. 1996. Sensory capacities of Euphausiids in the context of schooling. Marine and Freshwater Behavior and Physiology 28:183–194.

Wilber, P. 1992. Case studies of the thin-layer disposal of dredged material – Fowl River, Alabama. In: Environmental Effects of Dredging, Vol. D-92-5. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

Wilcox, W.J., II. and C.F. Cahill. 2003. Regional haze trends in Alaska: Implications for protected class I visibility areas. EM Dec. 2003:34-39.

Williamson, F.S.L., M.C. Thompson, and J.Q. Hines. 1966. Avifaunal investigations. Chapter 18 pp. 437-480 *in*: N. Wilimovsky and J. Wolfe (eds.) Environment of the Cape Thompson Region, Alaska. U.S. Atomic Energy Commission, Division of Technical Information, Washington D.C. 1,250 pp.

Wilson, B. and L.M. Dill. 2002. Pacific herring respond to simulated odontocete echolocation calls. Canadian Journal of Fisheries and Aquatic Science 59:542-553.

Wolotira, R.J. Jr., T.M. Sample, and M. Morin, Jr. 1977. Demersal fish and shellfish resources of Norton Sound, the southeastern Chukchi Sea, and adjacent waters in the baseline year 1976. Northwest and Alaska Fisheries Center, Processed Report.

Wong, C.K. 1996. Effects of diazinon on the demographic parameters of Moina macrocopa. Water, Air and Soil Pollution 393:393-399.

Woodby, C.A. and G.J. Divoky. 1982. Spring migration of eiders and other waterfowl and Point Barrow, Alaska. Arctic 35(3):403-410.

Woodby, D.A. and D.B. Botkin. 1993. Stock sizes prior to commercial whaling. pp. 387-407 in: J.J. Burns, J.J. Montague, and C.J. Cowles (eds.). The bowhead whale. Society Marine Mammals Spec. Publ. No. 2.

Woodgate, R.A., K. Aagaard, and T.J.O. Weingartner. 2005. A year in the physical oceanography of the Chukchi Sea: Moored measurements from autumn 1990-1991. Deep Sea Research Publishing. December.

World Bird Guide. 2009. Accessed May 10, 2009. http://avibase.bsc-eoc.org/avibase.jsp?lang=EN&pg=home.

WRCC (Western Region Climate Center). 2014. Barrow WSO Airport, Alaska: National Climatic Data Center (NCDCC) Monthly Normals for 1961-1990, 1971-2000, and 1981-2010. Available at http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ak0546

Würsig, B. 1990. Cetaceans and oil: Ecologic perspectives. pp. 129-65 *in*: J. Geraci and D. St Aubin (eds.) Sea mammals and oil: confronting the risks. Academic Press, Inc., San Diego.

Wyllie-Echeverria, T., W.E. Barber, and W. Wyllie-Echeverria. 1997. Water masses and transport of young of the year into the northeastern Chukchi Sea. American Fisheries Society Symposium 19:60-67.

Wynne, K. 1992. Guide to marine mammals of Alaska. Marine Advisory Bulletin 44. Alaska Sea Grant College Program, University of Alaska, Fairbanks. 75 pp.

Yazvenko, S.B., T.L. McDonald, S.A. Blokhin, S.R. Johnson, H.R. Melton, M.W. Newcomer, R. Nielson, P.W. Wainwright. 2007. Feeding of western gray whales during a seismic survey near Sakhalin Island, Russia. Environmental Monitoring and Assessment 134:93-106.

Yesner, D. R. and G. Pearson. (2002). "Microblades and Migrations: Ethnic and Economic Models in the Peopling of the Americas." *Archaeological Papers of the American Association.* 12:133-161.

Yoder, J.A. 2002. Declaration of James A. Yoder in opposition to plaintiff's motion for temporary restraining order, 28 October 2002. Civ. No. 02-05065-JL. U.S. District Court, Northern District of California, San Francisco Division.

Young, D.D., T.R McCabe, R. Ambrose, G.W. Garner, G.J. Weiler, HV. Reynolds, M.S. Udevitz, D.J. Reed, and B. Griffith. 2002. Predators. pp. 51-53 in D. C. Douglas, P. E. Reynolds, and E. B. Rhode (eds.) Arctic Refuge Coastal Plain Terrestrial Wildlife Research Summaries. Biological Science Report USGS/BRD/BSR-2002-0001. U.S. Geological Survey, Biological Resources Division.

Yu, Y., G.A. Maykut, and D.A. Rothrick. 2004. Changes in the thickness distribution of Arctic sea ice between 1958-1970 and 1993-1997. Journal of Geophysical Research. Vol. 109:C08004. doi:10.1029/2003JC001982.

Zachos, J.C., U. Röhl, S.A. Schellenberg, A. Sluijs, D.A. Hodell, D.C. Kelly, E. Thomas, M. Nicolo, I. Raffi, L.J. Lourens, H. McCarren, and D. Kroon. 2005. Rapid acidification of the ocean during the Paleocene-Eocene thermal maximum. Science 308(5728):1611 – 1615.

Zeh, J.E. and A.E. Punt. 2005. Updated 1978-2001 abundance estimates and their correlations for the Bering-Chukchi-Beaufort Seas stock of bowhead whales. Journal of Cetacean Research and Management 7(2):169-175.

Zeh, J.E., A.E. Raftery, and A.A. Schaffner. 1995. Revised estimates of bowhead population size and rate of increase. Unpublished report SC/47/AS/10. International Whaling Commission, Cambridge, UK. 26 pp.

Zwiers, F.W., and X. Zhang. 2003. Towards regional climate change detection. Journal of Climate. 16:793-797.