OCS EIS/EA
MMS 2003-008

Exploration Activities in the Eastern Sale Area: Eastern Planning Area, Gulf of Mexico OCS

Programmatic Environmental Assessment

U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Region

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PREFACE

This programmatic environmental assessment (PEA) on exploration activites is a reference document designed to streamline processing of the environmental reviews required to evaluate industry exploration plans in the Eastern Planning Area as defined herein. This PEA is intended to consider the areawide environmental resources and impacts from exploratory drilling and well completion or abandonment in this area. Subsequent site-specific EA's that are prepared to evaluate specific industry proposals in a leased block will be tiered from this PEA and other relevant National Environmental Policy Act documents. Preparation of this PEA is consistent with recommendations in the President's 2001 National Energy Policy to review and streamline the permitting process for exploration projects important to fulfilling the Nation's energy needs.

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ABBREVIATIONS AND ACRONYMS

AAC	Air Armaments Center
AFB	Air Force Base
ac	acre
AIRS	Aeromatic Information Retrieval System
A&M	Agriculture and Machinists
APD	Application for Permit to Drill
API	American Petroleum Institute
AVHRR	Advanced Very High Resolution Radiometer
BACT	best available control technology
Bbbl	billion barrels
bbl	barrel(s)
BOE	barrel of oil equivalent
BBSAP	Big Bend Seagrass Aquatic Preserve
BBOE	billion barrel of oil equivalent
bcf	billion cubic feet
BML	below mudline
BO	Biological Opinion
BOD	biochemical oxygen demand
BOP	blowout preventer
B.P.	before present
CAA	Clean Air Act of 1970
CEI	Coastal Environments, Inc.
CEQ	Council on Environmental Quality
CER	categorical exclusion review
c.f.	compare; see
CFR	Code of Federal Regulations
cm	centimeter
CO	carbon monoxide
COE	Corps of Engineers (U.S. Army)
COF	covered offshore facilities
CPA	Central Planning Area
CSA	Continental Shelf Associates
CWA	Clean Water Act
CZM	Coastal Zone Management
CZMA	Coastal Zone Management Act
dB	decibels
DGD	dual gradient drilling
DOCD	Development Operations Coordination Document
DOD	Department of Defense (U.S.)
DOI	Department of the Interior (U.S.) (also: USDOI)
DOT	Department of Transportation (U.S.)
DP	dynamically positioned
DWOP	Deepwater Operations Plan
EA	environmental assessment
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
e.g.	for example
EIS	environmental impact statement
EP	Exploration Plan
EPA	Eastern Planning Area
ERG	Energy Resources Group
ESA	Endangered Species Act of 1973
et al.	and others
et seq.	and the following
EWTA	Eglin Water Test Area
FAA	Federal Aviation Administration
FDEP	Florida Department of Environmental Protection
FKNMS	Florida Keys National Marine Sanctuary
FMC	Fishery Management Council
FMG	Florida Middle Ground
FMP	Fishery Management Plan
FR	*Federal Register*
ft	feet
FWS	Fish and Wildlife Service
g	gram
GMAQS	Gulf of Mexico Air Quality Study
GMFMC	Gulf of Mexico Fishery Management Council
GOM	Gulf of Mexico
GS	Geological Survey (also: USGS)
GSMFC	Gulf States Marine Fisheries Commission
GulfCet	Gulf of Mexico Cetacean Program
Ha	hectare
HCl	hydrochloric acid
Hz	hertz
H_2S	hydrogen sulfide
IAGC	International Association of Geophysical Contractors
i.e.	specifically
IMPLAN	Impact Analysis for Planning
in	inch
ITM	Information Transfer Meeting
ITOPF	International Tanker Owners Pollution Federation
kg	kilogram
km	kilometer
LATEX	Texas-Louisiana Shelf Circulation and Transport Process Program
lb	pound
LCE	Loop Current Eddy
m	meter
MAFLA	Mississippi, Alabama, and Florida
MAMES	Mississippi-Alabama Marine Ecosystem Study

MARPOL	International Convention for the Prevention of Pollution from Ships
MD	measured depth
mi	statute miles
mm	millimeter
MMbbl	million barrels
MMC	Marine Mammal Commission
MMPA	Marine Mammal Protection Act of 1972
MMS	Minerals Management Service
MODU	mobile offshore drilling unit
MSL	mean sea level
Mya	million years ago
NA	not applicable
NAAQS	National Ambient Air Quality Standards
NEGOM	Northeastern Gulf of Mexico Chemical Oceanography and Hydrography Study
NEPA	National Environmental Policy Act
NERBC	New England River Basins Commission
NMFS	National Marine Fisheries Service
nmi	nautical miles
NOAA	National Oceanic and Atmospheric Administration
NORM	naturally occurring radioactive material
NOSAC	National Offshore Safety Advisory Committee
NO_x	nitrogen oxides
NO_2	nitrogen oxide
NPDES	National Pollutant and Discharge Elimination System
NPS	National Park Service
NRC	National Research Council
NTL	Notice to Lessees and Operators
OBF (OBM)	oil-based drilling fluids (or mud)
OCD	Offshore and Coastal Dispersion model
OCS	Outer Continental Shelf
OCSLA	Outer Continental Shelf Lands Act
ODD	Ocean Disposal Database
ONR	Office of Naval Research
OPA	Oil Pollution Act of 1990 (also: OPA 90)
OSFR	oil-spill financial responsibility
OSRA	Oil Spill Risk Analysis
OSRP	oil-spill response plan
PEA	programmatic environmental assessment
P.L.	Public Law
PAH	polynuclear aromatic hydrocarbon
PM_{10}	particulate matter smaller than 10 microns
ppg	pounds per gallon
ppb	parts per billion
ppm	parts per million
ppt	parts per thousand
PSD	Prevention of Significant Deterioration
RCRA	Resource Conservation and Recovery Act
ROV	remotely operated vehicle
SAIC	Science Application International Corporation
SBF (SBM)	synthetic-based drilling fluid (or mud)
SEA	site-specific environmental assessment
SEAMAP	Southeastern Area Monitoring and Assessment Program
SEFSC	Southeast Fisheries Science Center
SOLAS	Safety of Life at Sea
SOV	spill occurrence variable
SO_x	sulfur oxides
sp.	species (undifferentiated)
spp.	multiple species (undifferentiated)
SUSIO	State University System of Florida Institute of Oceanography
SWAMP	Sperm Whale Acoustic and Monitoring Program
SWF	shallow water flow
SWSS	Sperm Whale Seismic Study
TBT	tributyltin
TD	total depth
TF	spill time frame
TRW	topographic Rossby wave
TSP	total suspended particulate matter
TV	time variable
UCSUSA	Union of Concerned Scientists (U.S.A)
U.S.A.	United States of America (also: U.S.)
USCG	U.S. Coast Guard
USCOE	U.S. Corp of Engineers
USDOA	U.S. Department of the Army
USDOC	U.S. Department of Commerce
USDOI	U.S. Department of the Interior (also: DOI)
USDOT	U.S. Department of Transportation
USEPA	U.S. Environmental Protection Agency
USGS	United States Geological Survey (also: GS)
VOC	volatile organic compounds
WBF (WBM)	water-based drilling fluids (or mud)
WPA	Western Planning Area

INTRODUCTION

Under the Outer Continental Shelf Lands Act (OCSLA), as amended, the Department of the Interior (DOI) is required to manage the leasing, exploration, development, and production of oil and gas resources on the Federal OCS. The Secretary of the Interior oversees the OCS oil and gas program and the Minerals Management Service (MMS) is the agency charged with this oversight. The Secretary is required to balance orderly resource development with protection of the human, marine, and coastal environments while ensuring that the U.S. public receives an equitable return for resources discovered and produced on public lands.

This programmatic environmental assessment (PEA) evaluates exploratory drilling and well completion or abandonment in a 256-block tract of the Eastern Planning Area (EPA), known as the EPA sale area (Figure 1-1). It encompasses about 1.5 million ac offshore Alabama in the westernmost part of the EPA in water depths ranging from 1,550 to 3,000 m (5,085 to 9,840 ft); this is the same area offered for lease on December 5, 2001, for Sale 181.

The Lease Sale 181 proposed action was evaluated in an environmental assessment (EA) as a Revised Proposal (USDOI, MMS, 2001b), after publication of the Final Environmental Impact Statement (EIS) (USDOI, MMS, 2001a). The area offered for lease in Sale 181 was reduced in size 75 percent from the area considered for leasing in the Final EIS. The EPA sale area is the same area proposed for lease sales 189 and 197 in 2003 and 2005, respectively (USDOI, MMS, 2002c).

Exploratory drilling and well testing or abandonment comprises a subset of OCS Program activities that have been evaluated to varying degrees in several recent NEPA documents. Among these are the Final EIS for Destin Dome Unit 56 (USDOI, MMS, 1999), the Final EIS for Floating Production, Storage, and Offloading Systems (USDOI, MMS, 2001e), and the EA for deepwater operations and activites (USDOI, MMS, 2000). The NEPA analyses that are most relevant to exploratory drilling in the EPA sale area and from which this PEA explicitly tiers, however, are contained in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a) and the EPA Multisale Draft EIS (USDOI, MMS, 2002c).

1. PURPOSE AND NEED FOR EXPLORATORY DRILLING

1.1. PURPOSE

The purpose of exploratory drilling is to evaluate the hydrocarbon potential in the 256-block EPA sale area. Under the Outer Continental Shelf Lands Act (OCSLA), as amended, the Department of the Interior (DOI) is required to manage the leasing, exploration, development, and production of oil and gas resources on the Federal OCS. The Secretary of the Interior oversees the OCS oil and gas program and the Minerals Management Service (MMS) is the agency charged with this oversight. The Secretary is required to balance orderly resource development with protection of the human, marine, and coastal environments while ensuring that the U.S. public receives an equitable return for resources discovered and produced on public lands.

1.2. NEED

The need for exploratory activities is as follows:

- leaseholders have a legal right to pursue exploration for hydrocarbon resources,
- commercial quantities of hydrocarbons resources may be encountered,
- leaseholders are obligated via lease terms to diligently develop the resources, and
- failure to develop resources could lead to the loss of sunk costs for acquiring the lease and maintaining access to it for the full lease term of 10 years.

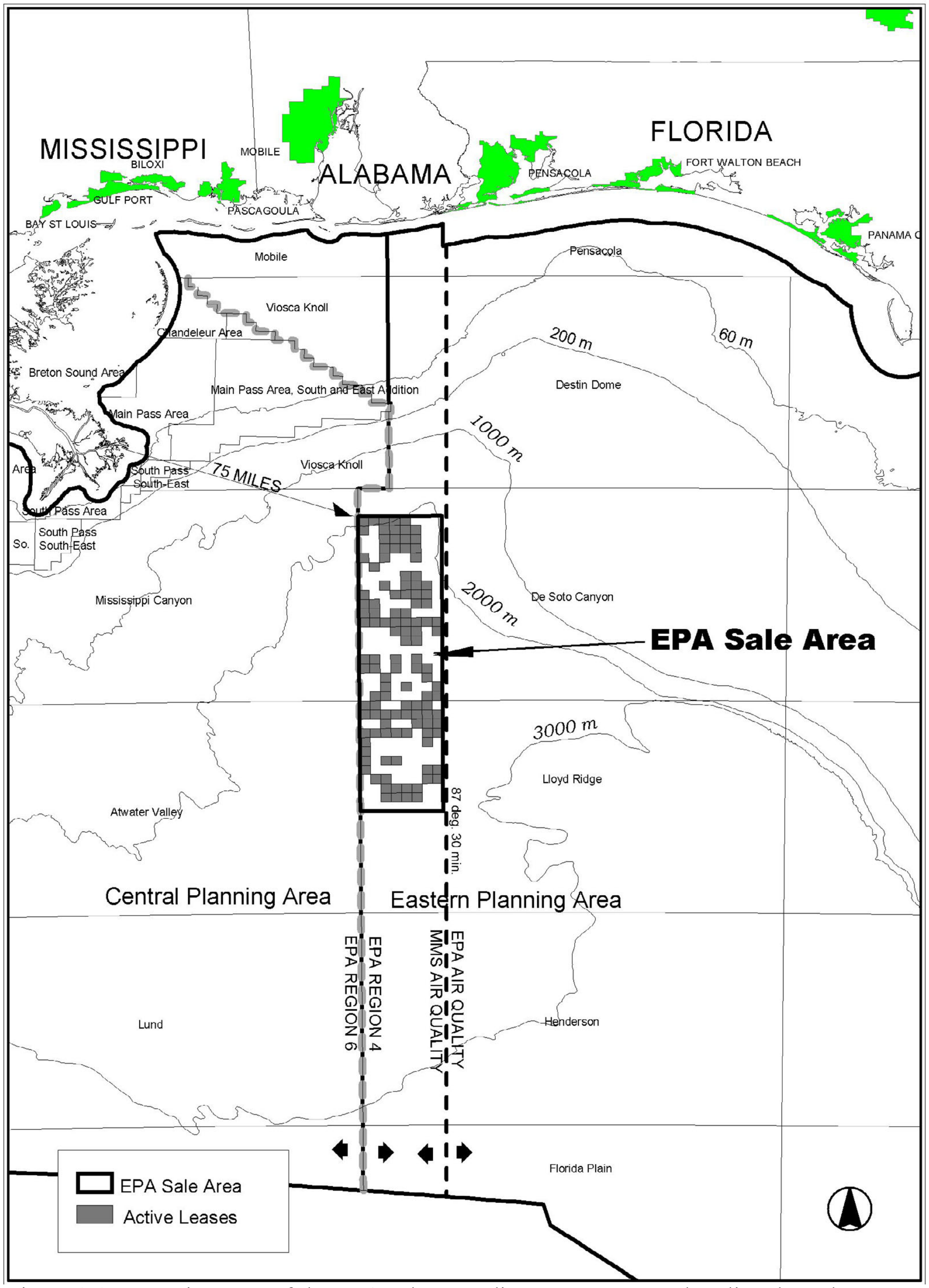

Figure 1-1. Location map of the EPA sale area, distance to nearest shoreline, leased acreage within EPA sale area, relationship to Central and Eastern Planning Areas, and jurisdictional boundaries for USEPA Region 4 and Region 6 (for NPDES permits) and between MMS and USEPA (for air quality).

Exploration, discovery, and production of hydrocarbon resources help satisfy the Nation's need for energy supplies. The oil and gas industry expects to evaluate the economic potential of the leases they acquire. Exploratory drilling is necessary to evaluate leases and realize an economic value from them. Value is realized either by establishing the presence or absence of an economic hydrocarbon resource or by the scientific data collected from the formations that are penetrated.

1.3. Scope of Environmental Assessment

The MMS's approval of exploratory drilling on the OCS is considered a Federal action requiring a National Environmental Policy Act (NEPA) review. Exploratory drilling is one phase of OCS operations that was evaluated in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a). This PEA will assist in preparing the required NEPA review of industry Exploration Plans (EP) by providing a reference document for areawide resources and impacts. A SEA will examine an operator's unique exploration program and will provide the NEPA decisionmaking document.

This PEA does not address development drilling activities approved under a Development Operations Coordination Document (DOCD).

1.4. Federal Regulatory Framework

The MMS is responsible for managing, regulating, and monitoring oil and natural gas exploration, development, and production operations on the OCS to promote orderly development of mineral resources and to prevent harm or damage to, or waste of, any natural resource, any life or property, or the marine, coastal, or human environment. Exploration activities and operations on the OCS must comply with Federal, State, and local laws and regulations. Several Federal regulations establish specific consultation and coordination processes with Federal, State, and local agencies. The MMS regulatory framework is intended to ensure that exploratory drilling is conducted in a technically safe and environmentally sound manner. The applicable laws and regulations are briefly summarized below. Additional information can be found in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a) or the Final EIS for the 2003-2007 Central and Western Gulf of Mexico lease sales (USDOI, MMS, 2002a).

1.4.1. Outer Continental Shelf Lands Act

The Outer Continental Lands Act (OCSLA) established Federal jurisdiction over submerged lands on the OCS seaward of State boundaries. The Act provides guidelines for implementing an OCS oil and gas exploration and development program. In addition, the OCSLA provides a statutory foundation for coordination with the affected States and, to a more limited extent, local governments. At each step of the procedures that lead to lease issuance, participation from the affected States and other interested parties is encouraged and sought.

1.4.2. National Environmental Policy Act

The NEPA requires that all Federal agencies use a systematic, interdisciplinary approach to protect the natural and human environment. An interdisciplinary approach will ensure the integrated use of the natural and social sciences in any planning and decisionmaking that may have an impact upon the environment. In 1979, the Council on Environmental Quality (CEQ) established uniform guidelines for implementing the procedural provisions of NEPA.

1.4.3. The Marine Mammal Protection Act

The Marine Mammal Protection Act (MMPA) established a moratorium on the taking of marine mammals in waters under U.S. jurisdiction. The MMPA defines "take" to mean "to harass, harm, shoot, wound, trap, hunt, capture, or kill, or attempt to engage in any such conduct (including actions that induce stress, adversely impact critical habitat, or result in adverse secondary or cumulative impacts)."

1.4.4. The Endangered Species Act

The Endangered Species Act (ESA) establishes a national policy designed to protect and conserve threatened and endangered species and the ecosystems upon which they depend. The ESA is administered by the Fish and Wildlife Service (FWS) and National Marine Fisheries Service (also known as NOAA Fisheries). Section 7 of the ESA governs interagency cooperation and consultation. Under Section 7, MMS formally consults with NOAA Fisheries and FWS to ensure that activities on the OCS under MMS jurisdiction do not jeopardize the continued existence of threatened or endangered species and/or result in adverse modification or destruction of their critical habitat.

1.4.5. The Clean Air Act

The Clean Air Act (CAA) delineates jurisdiction of air quality between the U.S. Environmental Protection Agency (USEPA) and the DOI. For OCS operations in the Gulf of Mexico (GOM), operations east of 87.5^{o} W. longitude are subject to USEPA air quality regulations and operations west of 87.5^{o} W. longitude are subject to MMS air quality regulations. In the OCS areas under MMS jurisdiction the regulations at 30 CFR 250 apply. The CAA amendments of 1990 established the Prevention of Significant Deterioration (PSD) program. Under the PSD program, Class I Areas receive the most protection. Any new large permanent source of emissions is required to receive a review by the permitting agency, and the permitting agency must consult with the appropriate Federal land manager prior to granting approval of the proposed activities.

1.4.6. The Clean Water Act

The Clean Water Act (CWA) establishes the basic structure for regulating discharges of pollutants to waters of the U.S. Under the CWA, it is unlawful for any person to discharge any pollutant from a point source into navigable waters without a National Pollution Discharge Elimination System (NPDES) permit. All waste streams generated from offshore oil and gas activities are regulated by the USEPA, primarily by general NPDES permits. Under Sections 301 and 304 of the CWA, USEPA issues technology-based effluent guidelines that establish discharge standards based on treatment technologies that are available and economically achievable. The most recent effluent guidelines for the oil and gas extraction point-source category were published in 1993 (58 FR 12454). Within the GOM, USEPA Region 4 has jurisdiction over the eastern portion of the Gulf, including all of the EPA and the northeast part of the Central Planning Area (CPA). The USEPA's Region 6 has jurisdiction over the majority of the CPA and all of the Western Planning Area (WPA). Each region has promulgated general permits for discharges that incorporate the 1993 effluent guidelines as a minimum. In some instances, a site-specific permit is required. The USEPA published new guidelines for the discharge of synthetic-based drilling fluids (SBF) on January 22, 2001 (66 FR 6850). The Region 4 general permit was issued in October 1998 (63 FR 55718), was modified in March 2001 (66 FR 14988), and expires on October 31, 2003. Region 4 has not revised the general permit to incorporate new guidelines for SBF and other nonaqueous-based drilling fluids.

1.4.7. The Oil Pollution Act

The Oil Pollution Act of 1990 (OPA 90) expanded Federal spill-response authority, increased penalties for spills, established U.S. Coast Guard (USCG) prepositioned oil-spill response equipment sites, required vessel and facility response plans, and provided for interagency contingency plans. The Act also established USCG oil-spill district response groups (including equipment and personnel). The OPA 90 provides that parties responsible for offshore facilities demonstrate, establish, and maintain oil-spill financial responsibility (OSFR) for those facilities. The MMS is responsible for OSFR certification. The minimum amount of OSFR is $35 million for covered offshore facilities (COF's) located on the OCS and $10 million for COF's located in State waters. A COF is any structure and all of its components, equipment, pipeline, or device (other than a vessel, a pipeline, or deepwater port licensed under the Deepwater Port Act of 1974) used for exploratory drilling or production of oil, or for the transportation of oil from such facilities. The USCG regulates the oil-spill financial responsibility program for vessels. A mobile offshore drilling unit (MODU) is classified as a vessel. A well drilled from a MODU, however, is classified as an offshore facility under this rule.

1.4.8. Coastal Zone Management Act

The Coastal Zone Management Act (CZMA) established a national coastal management program to comprehensively manage and balance competing uses of and impacts to any coastal use or resource. The national coastal management program is implemented by individual State coastal management programs in partnership with the Federal Government. For a summary of the coastal zone management plans of the Gulf Coast States, see Appendix A of the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a). The CZMA's Federal consistency requirement requires that direct Federal activities (e.g., OCS lease sales) be consistent to the maximum extent practicable with the enforceable policies of a State's coastal management program. The Federal consistency requirement also requires that other federally approved activities (e.g., activities requiring Federal permits, such as OCS EP's) be fully consistent with a State's federally approved coastal management program.

1.5. EXISTING MITIGATION MEASURES

The MMS has established regulations and operating procedures to ensure that proposed operations are orderly, safe, and pollution-free, specifically including reducing the risk of oil-spill occurrence and mitigating impacts should an oil spill occur. The MMS considers the best mitigation of environmental impacts to be risk management and avoidance of accidental events. The goal of the established MMS review and approval processes and the MMS inspection program is to minimize adverse impacts from routine operations and to reduce the potential for accidental impacts. Proposed operations must meet or exceed the safety standards set by MMS. Site-specific and project-specific mitigation measures can be identified and become requirements at any stage of review or operations. Regulations for oil, gas, and sulphur lease operations on the OCS are specified in 30 CFR 250. Regulations for geological and geophysical exploration operations on the OCS are specified in 30 CFR 251.

Mitigating measures have been proposed, identified, evaluated, or developed through previous MMS lease sale NEPA review and consultation processes. Many of these mitigating measures have been adopted and incorporated into regulations and/or guidelines governing OCS exploration, development, and production activities. All OCS plans go through MMS review and approval to ensure compliance with established laws and regulations. Each EP and DOCD, as well as every pipeline application, goes through proposal specific technical, safety, and NEPA environmental reviews. Mitigating measures must be incorporated and documented in plans submitted to MMS. Additional project-specific mitigation may be applied as conditions of plan approval. Operational compliance is enforced through the MMS onsite inspection program. The MMS has the authority to monitor and enforce these conditions, and under 30 CFR 250 Subpart N, may seek remedies and penalties from any operator that fails to comply with the conditions of permit approvals, including stipulations and other mitigation measures.

Mitigating measures are a standard part of the OCS Program that will apply to any activities resulting from approval of an operator's EP; for example, the requirements of the Notices to Lessees (NTL) discussed in Chapter 2. Avoidance of impacts to sensitive environmental resources could entail site-area reduction, relocation, or reconfiguration of anchoring patterns.

The MMS's responsibilities under OPA 90 include spill prevention in Federal and State offshore waters, review and approval of oil-spill response plans (OSRP's), inspection of oil-spill containment and cleanup equipment, and ensuring oil-spill financial responsibility. The regulation at 30 CFR 254.2 requires that an OSRP must be submitted and approved before an operator can use a facility, or the operator must certify in writing to MMS that it is capable of responding to a "worst-case" spill or the substantial threat of such a spill.

Some MMS-identified mitigating measures are incorporated into OCS operations through cooperative agreements or efforts with industry and various State and Federal agencies. These include regulations on minimum helicopter altitudes to prevent disturbance of wildlife, labeling operational supplies to track possible sources of debris loss, and semiannual beach cleanup events to survey trash categories.

The MMS also controls or mitigates potential environmental or safety problems associated with a specific proposal by enforcement of the use of the best available and safest technology on offshore facilities, by enforcement of the MMS offshore inspection program, and by applying conditions to plan and permit approval. To assure that OCS oil and gas exploration are conducted in a safe and pollution free manner, OCS operations approved by MMS are required to use the best available and safest technology.

The MMS's rules, lease stipulations, and applicable regulatory mechanisms will be effective in mitigating possible cumulative adverse effects of OCS oil and gas activities. These requirements include oil-spill response planning, use of blowout preventors, use of best available and safest technology, and compliance with NPDES permits and standards. The MMS also conducts onsite inspections to assure regulatory compliance and confirm safety and pollution prevention requirements.

1.6. EXPLORATION PLANS

An EP must be submitted to MMS for review and decision before any exploration activities, except for preliminary activities, can begin on a lease. The EP describes (1) exploration activities, (2) a proposed schedule, (3) drilling rig and support vessels, (4) the proposed drilling program and well-testing operations, (5) environmental monitoring plans, and (6) other relevant information. Guidelines and requirements for submitting an EP are addressed in 30 CFR 250.203 and further explained in NTL 2002-G08 (effective August 2002). Supporting environmental information, archaeological reports, biological reports (monitoring and/or live-bottom survey), and other environmental data determined necessary must be submitted with an OCS EP. This information provides the basis for an analysis of both offshore and onshore impacts that may occur as a result of the activities. The MMS may require additional specific supporting information to aid in the evaluation of the potential environmental impacts of the proposed activities.

After receiving an EP, MMS performs geological, geophysical, and environmental reviews. The EP is reviewed by a multidisciplinary team including geologists, geophysicists, biologists, archaeologists, air quality specialists, and oil-spill specialists. The MMS evaluates the proposed exploration activities in relation to potential seafloor or drilling hazards (including existing pipelines); archaeological resources; endangered species; sensitive biological features; water quality; air quality; oil-spill response; other uses (e.g., military operations) of the OCS; and compliance with applicable laws and regulations.

In the EPA sale area, DOI departmental guidelines call for a site-specific environmental assessment (SEA) to be prepared for each EP. As part of the review process, all intial and supplemental EP's and supporting information are sent to the affected State(s) for their determination of consistency with approved CZM programs. For revisions to a previously approved EP, a case-by-case decision is made on whether the EP should be sent to the State(s) for additional review.

Based on the MMS reviews of the EP, the findings of the EA, and other applicable MMS studies and NEPA documents, the OCS plan is approved or disapproved by MMS, or modification of the plan is required. Although very few OCS plans are ultimately disapproved, many must be amended prior to approval to fully comply with MMS operating regulations and requirements, to address reviewing agencies' concerns, or to avoid potential hazards or impacts to environmental resources.

After the EP is approved, the operator is required to submit and obtain approval for an Application for Permit to Drill (APD) for each individual well prior to actually conducting drilling operations. The APD, which includes additional technical details not usually provided in the EP, must be in accordance with the activities approved under the EP.

1.6.1. Permits and Applications

After EP approval, the operator submits applications for specific activities to MMS for approval. These include applications for drilling, well-test flaring, and abandonment of wells.

1.6.1.1. Application for Permit to Drill

Requirements for drilling wells can be found at 30 CFR 250 Subpart D. Prior to conducting drilling operations, the operator is required to submit and obtain approval for an APD. The APD requires detailed information to support the technical and safety reviews done by MMS to determine if the lessee's proposed operation is in compliance with regulations and engineering standards. The planned well casing points, drilling muds, safety systems, drilling operations, and well-testing procedures are reviewed by MMS engineers. Lessees are required to take precautions with their drilling mud programs to keep all wells under control at all times. The lessee must use the best available and safest technology to enhance the evaluation of abnormal pressure conditions and to minimize the potential for uncontrolled well flow.

1.6.1.2. National Pollutant Discharge Elimination System

Operations in the EPA sale area are under USEPA Region 4 jurisdiction for discharges. Any discharges in the area would occur under general permit GMG 280000 as promulgated on October 26, 1998 (63 FR 55718). These regulations were discussed in more detail in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a; pages I-8, I-9, IV-26 through IV-29, IV-164, IV-165, and the response to API-37 on page V-121) and are in effect until October 31, 2003.

Under the current general permit, overboard discharge of SBF or cuttings while drilling with SBF are not permitted. On January 22, 2001, USEPA promulgated guidelines (66 FR 6850) on limitations for the potential discharge of SBF cuttings. On March 14, 2001 (66 FR 14988), USEPA Region 4 modified the requirements for discharges of produced water in their NPDES permit by including a series of tables for calculating the critical dilution criteria and removing the requirement to use the CORMIX model for proposed discharges. The modified permit also added effluent limitations for miscellaneous discharges of chemically treated seawater and freshwater. Operators may apply for individual permits, which could result in the granting of permission to discharge cuttings according to the recent guidelines.

1.6.1.3. Well-Test Flaring

During well-testing operations, natural gas may be burned or vented from a specially designed boom. The MMS heavily regulates flaring and does not allow flaring or venting of natural gas on an extended basis. With approval from MMS, the regulations do provide for some limited volume, short-duration (typically 2-14 days) flaring or venting conducted as part of testing operations to provide sufficient reservoir data for the operator to evaluate a reservoir or development options, and in emergency situations.

1.6.1.4. Well Abandonment

The MMS regulations at 30 CFR 250.702 address the requirements for temporary and permanent abandonment of a well on the OCS. A temporary abandonment includes the isolation of any hydrocarbon-bearing zones in the open wellbore, plugging of perforated intervals, and setting a surface plug. All plugs must be tested in accordance with the regulations. Permanent abandonment includes these and extra plugging requirements plus cutting and retrieving the casing at least 15 ft below the mudline, and removal of all wellhead superstructure, casing stubs, and debris from the sea floor.

If a well is temporarily abandoned, the operator must provide MMS with an annual report summarizing plans to permanently abandon the well or to bring the well into production.

1.6.2. Personnel Training and Education

To ensure that offshore oil and gas operations are carried out in a manner that emphasizes operational safety and minimizes the risk of environmental damage, MMS established training requirements (30 CFR 250 Subpart O). The mandatory Drilling Well-Control Training Program was instituted by MMS in 1979. In 1983, the mandatory Safety Device Training Program was established to ensure that personnel involved in installing, inspecting, testing, and maintaining safety devices are qualified. As a preventive measure, all offshore personnel must be trained to operate oil-spill cleanup equipment, or the lessee must retain a trained contractor(s) to operate the equipment for them. The MMS offers numerous technical seminars to ensure that personnel are capable of performing their duties and are incorporating the most up-to-date safety procedures and technology in the petroleum industry.

2. EXPLORATION ACTIVITIES AND ALTERNATIVES

2.1. EXPLORATION ACTIVITIES

Industry operators submit exploration plans (EP) to MMS for valid leases in the 256-block EPA sale area (Figure 2-1). Lessees have the option to submit EP's for all blocks leased during Lease Sale 181, and all blocks leased previously and subsequently in this area. The affected environment, impact-producing factors, and environmental impacts evaluated in this PEA are those that result as a consequence of carrying out the exploratory drilling, well abandonment, or well completion activity defined in EP's.

The potential impacts that accompany exploratory drilling in this area of the Gulf encompass only one part of the total spectrum of OCS Program activity that was considered in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a) and that is being considered in the EPA Multisale Draft EIS for lease sales in this area in 2003 and 2005 (USDOI, MMS, 2002c).

The EPA sale area encompasses about 1.5 million ac located 160-320 km (100-200 mi) offshore Alabama and is nowhere less than 120 km (75 mi) southeast of the Mississippi River Delta. Water depths range from 1,550 to 3,000 m (5,085-9,840 ft). The MMS estimates that 15-115 million barrels of oil and 225-750 billion cubic feet of gas could be discovered and produced in the EPA sale area.

The terms "exploration activity" and "exploratory drilling" used in this PEA are generally synonymous. Both refer to the suite of operations required for postlease exploratory drilling and well completion or abandonment.

2.2. Alternatives

Alternatives, including a no action alternative, that would limit or restrict the option for operators to submit EP's for valid leases in the EPA sale area are not considered in this PEA. Issuance of an OCS lease gives the lessee the right to submit EP's for MMS evaluation and decision.

2.3. OCS Program Scenario

The life of exploration activity in the EPA sale area is not expected to exceed 40 years (2003-2043) (see the EPA Multisale Draft EIS (USDOI, MMS, 2002c)). This PEA uses the same scenario duration, which is based on averages for the time required for exploration, development, production, and abandonment of leases in the GOM. In that span 38-73 exploration and delineation wells are projected to be drilled in the EPA sale area. Activity projections become increasingly uncertain as the length of time increases and the number of influencing variables, or unknown variables, enter the equation. The projections used to develop Gulfwide OCS Program scenarios are based on resource and reserve estimates presented in the *2000 Assessment of Conventionally Recoverable Hydrocarbon Resources of the Gulf of Mexico and Atlantic Outer Continental Shelf as of January 1, 1999* (Lore et al., 2001), current industry information, and historical trends.

2.4. Significant Issues

The major issues analyzed in this PEA are those that apply to exploration activities. They are a subset of those issues or concerns identified and analyzed during the EIS scoping process and public comment on the Draft EIS for Lease Sale 181 (USDOI, MMS, 2000b). To solicit comments on proposed lease sales, MMS conducts scoping in accordance with the CEQ's implementing regulations. Scoping provides those with an interest in the OCS Program an early opportunity for input on the identification of the alternatives, issues, and mitigation measures addressed in the lease sale EIS's. The MMS also conducts early coordination with appropriate Federal and State agencies and other concerned parties to discuss alternatives, issues, and mitigation measures.

The environmental analyses in this PEA are addressed in terms of the potential impact from exploratory drilling and well-completion or abandonment activities on the following physical, biological, and socioeconomic resources: (1) air quality, (2) water and sediment quality, (3) coastal resources, (4) deepwater benthic resources, (5) marine mammals, (6) sea turtles, (7) coastal and marine birds, (8) fish and fisheries, (9) commercial fishing, (10) recreational resources, (11) archaeological resources, and (12) human and socioeconomic resources.

2.5. Mitigation Measures

Measures to mitigate potential impacts are an integral part of the OCS Program. These measures are implemented through lease stipulations, operating regulations, NTL's, and project-specific requirements or approval conditions. Mitigating measures address concerns such as endangered and threatened species, geologic and manmade hazards, military warning and ordnance disposal areas, air quality, oil-spill response planning, chemosynthetic communities, operations in H_2S-prone areas, and shunting of drill effluents in the vicinity of biologically sensitive resources.

The MMS issues NTL's to provide clarification, description, or interpretation of a regulation; to provide guidelines on the implementation of a special lease stipulation or regional requirement; or to transmit administrative information. Copies of the NTL's are available through the MMS Public Information Office by calling 1-800-200-GULF or from the MMS website at http://www.mms.gov.

Conditions of approval are mechanisms to control or mitigate potential safety or environmental problems associated with proposed operations. Conditions of approval are based on MMS technical and environmental evaluations of the proposed operations. Comments from Federal and State agencies (as applicable) are also considered in establishing conditions. Conditions may be applied to any OCS plan, permit, right-of-use of easement, or pipeline right-of-way grant.

2.5.1. Lease Stipulations

Three mitigation measures to help reduce potential conflicts between military and OCS oil and gas activities are included in the proposed action in the form of lease stipulations. Mitigation measures in the form of stipulations are added to the lease terms and are therefore enforceable as part of the lease. The three stipulations were evaluated in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a), are incorporated by reference, and are summarized below.

The mitigation measures included in the proposed action were developed as a result of scoping efforts over a number of years for the continuing OCS Program in the GOM and from specific consultation and coordination with the Department of Defense (DOD) for Lease Sale 181. It is expected that these measures will serve to eliminate dangerous conflicts between oil and gas operations and military operations in the EPA of the GOM, thus allowing both of these activities of great importance to the national interest to take place without risk to either. Continued close coordination between MMS and DOD may result in improvements in the wording and implementation of these stipulations.

2.5.1.1. Military Warning Areas Stipulation — Hold and Save Harmless, Electromagnetic Emissions, and Operational Restrictions ("standard" Eastern Gulf of Mexico military stipulation)

A standard military warning area stipulation has been applied to all blocks leased in military areas in the GOM since 1977. This stipulation for the EPA is applied to all blocks leased within a warning or water test area (Figure 2-1). The stipulation was applied to blocks in warning areas in past lease sales in the EPA and is considered by the DOI and DOD to be an effective method of mitigating potential multiple-use conflicts. The text of the stipulation is provided on page II-25 of the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a).

2.5.1.2. Evacuation Stipulation for the Eglin Water Test Areas

This stipulation, restricting oil and gas activities in the Eglin Water Test Areas (EWTA) (Figure 2-1), was developed in close coordination with Air Armament Center (AAC) personnel at Eglin Air Force Base (AFB) in Florida. The stipulation is designed to prevent space-use conflicts between oil and gas industry and DOD operations in the Eastern Gulf. Air Force operations staged from Eglin AFB and Tyndall AFB in Florida make extensive use of the airspace over the Eastern Gulf. These uses include equipment and weapons testing, which results in debris of varying size that fall into the Gulf. Shipping is warned of such tests and is cleared from the Gulf, and commercial and private air traffic is routed away from the testing areas. In addition, mishaps can occur during routine training missions, resulting in debris hitting the water. Falling debris can range in size and weigh from several kilograms to several tons. The text of the stipulation is provided on pages II-27 and II-28 of the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a). This stipulation would be applied to any lease on the following blocks:

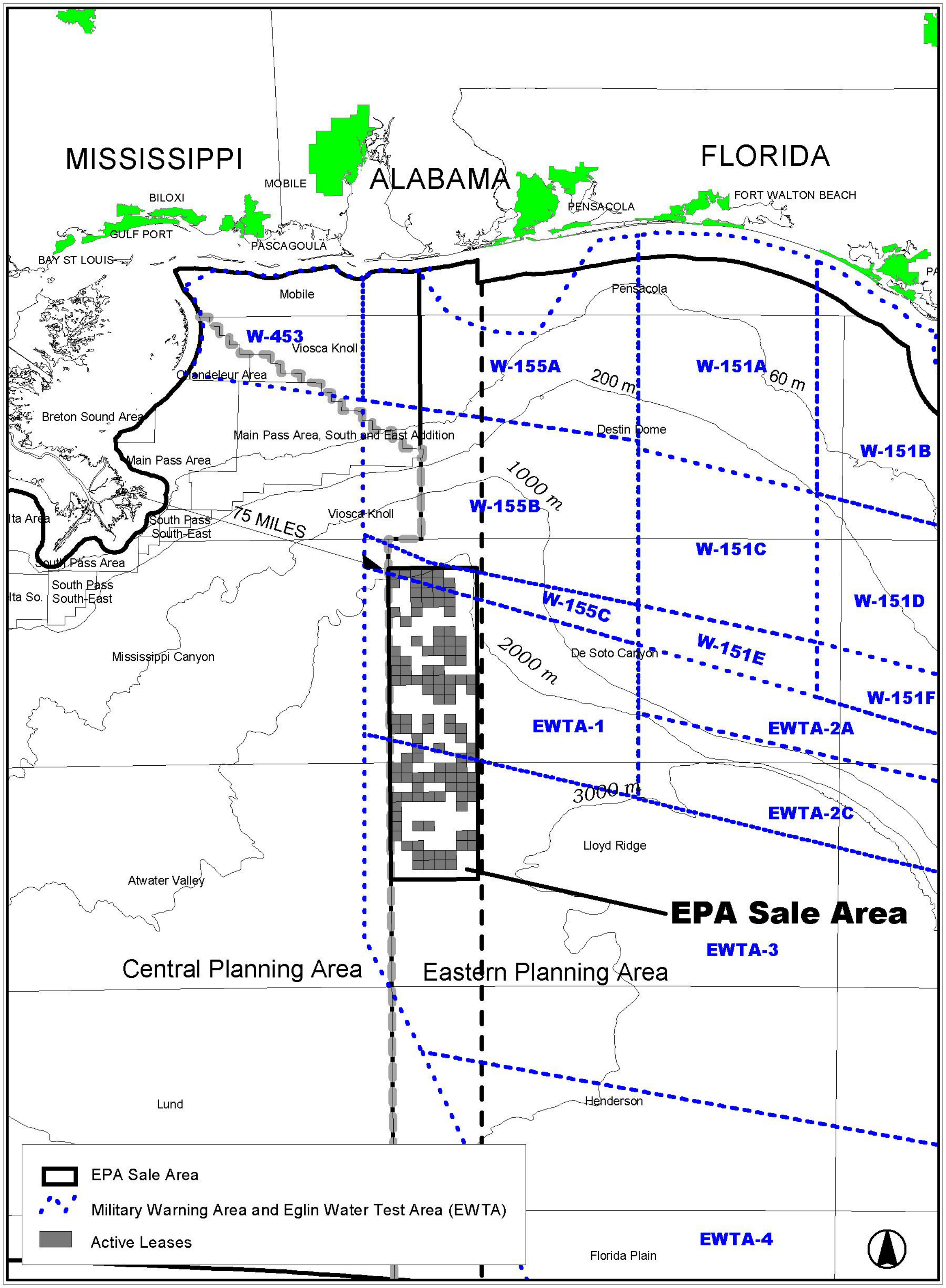

Figure 2-1. Military Warning Areas in the EPA sale area.

DeSoto Canyon	Lloyd Ridge
241-243, 285-288,	21-25, 65-69,
329-333, 373-377,	109-113, 153-157,
417-421, 461-465,	197-201, 241-245,
505-509, 549-553,	285-289, 329-333,
593-597, 637-641,	373-377, 417-421,
681-685, 725-729,	461-465, 505-509
769-773, 813-817,	
857-861, 901-905,	
945-949, 989-993	

2.5.1.3. Coordination and Consultation Stipulation for Exploration Activities in the Eglin Water Test Areas

This stipulation, requiring close coordination between DOD and MMS for oil and gas activities in the Eglin Water Test Areas (Figure 2-1), was developed by MMS and AAC personnel at Eglin AFB in Florida. This stipulation would be applied to any lease resulting from Sale 181 on the same blocks as listed above for the Evacuation Stipulation for the Eglin Water Test Areas. The text of the stipulation is provided on pages II-28 and II-29 of the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a).

2.5.2. Notices to Lessees's and Operators

2.5.2.1. NTL 2000-G20 — Deepwater Chemosynthetic Communities

The Deepwater Chemosynthetic Communities NTL 2000-G20 is designed to protect these unusual biological assemblages discovered in the GOM 18 years ago. There are no known chemosynthetic communities within the EPA sale area; however, they may exist. Features or areas that could support high-density chemosynthetic communities include hydrocarbon-charged sediments associated with surface faulting, acoustic void zones associated with surface faulting, anomalous mounds or knolls, and gas or oil seeps. Damage to these communities could result from oil and gas activities that disturb the seafloor in the immediate vicinity of these communities. Such activities include, but are not limited to, drilling, anchoring, emplacing seafloor templates, discharging muds and cuttings, and installing pipelines.

The OCS applications or plans submitted for pipelines or for exploration or development activities in all areas deeper than 400 m go through a review by biologists to determine whether there are potential chemosynthetic communities located near the proposed impacting activities. Operators are required to maintain the following separation distances from features or areas that could support high-density chemosynthetic communities:

- at least 457 m (1,500 ft) from each proposed mud and cuttings discharge location; and
- at least 76 m (250 ft) from the location of all other proposed seafloor disturbances (including those caused by anchors, anchor chains, wire ropes, seafloor template installation, and pipeline construction).

2.5.2.2. NTL 2002-G08—Information Requirements for Exploration Plans and Development Operations Coordination Documents

NTL 2002-G08 was approved August 29, 2002. This NTL provides interim guidance on preparing the EP's required by 30 CFR 250, Subpart B, while MMS drafts revised Subpart B regulations (see Chapter 1.5, Exploration Plans).

2.6. SUMMARY OF IMPACTS FROM EXPLORATION ACTIVITIES

The affected environment, impact-producing factors, and potential impacts that would apply to exploration activities are summarized below.

Coastal Resources: No significant direct impacts to sensitive coastal resources are expected from exploratory drilling, and well completion or abandonment in the EPA sale area. Because this area is remote from sensitive coastal resources, no impacts are expected to sensitive barrier beaches, wetlands, seagrasses, soft-bottom benthic communities. No impacts are expected to any sensitive habitats or ecosystems for; fish, fisheries, or essential fish habitat; sea turtles; coastal and marine birds; or marine mammals. No impacts are expected to protected species, such as beach mice, and Gulf sturgeon. No impacts are expected to air or water quality; to existing human, socioeconomic, or demographic patterns; land use trends or patterns; or equities of environmental justice. Any oil spilled as a result of exploratory drilling and well completion is expected to degrade and disperse before contact with sensitive coastal environments.

Offshore Resources: No significant direct impacts to sensitive offshore resources are expected from exploration activities in the EPA sale area. No significant impacts to the ecological function or biological productivity of offshore resources are expected. The significant offshore environmental resources evaluated for impacts in this PEA are (1) marine mammals, (2) sea turtles, (3) fish and essential fish habitat, (4) commercial fisheries, (5) recreational fisheries, (6) marine birds, (7) soft-bottom benthic communities, (8) chemosynthetic communities, (9) water quality, (10) air quality, and (11) human, socioeconomic, and archaeological resources. No lethal effects or long-term adverse impacts to the size or productivity of population stocks are expected for any marine mammal or sea turtle species in the northern or eastern GOM. No significant impacts are expected on fishes or essential fish habitat. Any effect on commercial or recreational fishing will be indistinguishable from variations attributable to natural causes. No impacts to the size and productivity of marine bird populations are expected. No impacts on the ecological function or biological productivity are expected for widespread, low-density benthic communities or chemosynthetic communities that may be discovered. Discharges from routine exploratory drilling operations and accidental oil spills will contribute less than 1 percent to any long-term, regional offshore water quality degradation. No degradation to air quality in offshore or coastal habitats is expected. No impacts to archaeological resources are expected due to existing mitigation measures. No impacts are expected to protected species in sensitive offshore habitats because of mitigation measures currently in place.

Any oil spilled as a result of exploratory drilling and well completion or abandonment, or the vessel support for these activities, is expected to be small in volume (1-10 bbl), but occurrences may be numerous over the life of exploration activity in the EPA sale area. The slicks from such a spill would be expected to persist on the water surface for a period of hours to days, depending on weather conditions, but degrade and disburse before impacting sensitive offshore environments.

3. DESCRIPTION OF THE AFFECTED ENVIRONMENT

3.1. INTRODUCTION

Chapter 3 describes the environmental resources in and around the EPA sale area that could be potentially affected by exploration activities. The individual elements presented in this chapter include physical resources such as air and water quality and biological resources such as sea turtles. The descriptions present environmental resources as they are now, thus providing baseline information for the analyses in Chapter 4 that examine these resources as potentially impacted by exploratory drilling in the EPA sale area.

The resources described below are sensitive components of the environment in this region. These resources were identified for analysis during public scoping, discussions with the affected State agencies, and coordination with other Federal agencies during preparation of the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a). Where appropriate, discussions in the Final EIS for Lease Sale 181 are summarized or incorporated by reference. The physical and biological resources of the affected environment for this PEA include the following:

Air Quality
Archaeological Resources
Barrier Islands and Dunes
Beach Mice
Chemosynthetic Communities
Coastal and Marine Birds
Commercial Fishing
Deepwater Benthic Resources
Fisheries
Marine Mammals
Sea Turtles
Socioeconomic and Human Resources
Recreational Fishing and Tourism
Water and Sediment Quality
Wetlands and Seagrass Communities

3.2. PHYSICAL RESOURCES

Descriptions of the following components of the physical environment are contained in Appendix A: (1) geologic and geographic setting; (2) physical oceanography; and (3) meteorological conditions.

3.2.1. Air Quality

Ambient air quality of a region is a function of population size, distribution, and activities in relationship to economic development, transportation, and energy policies. Meteorological conditions and topography may confine, disperse, or distribute air pollutants. Assessments of air quality depend on multiple variables such as the quantity of emissions, dispersion rates, distances from receptors, and local meteorology. Because of the variable nature of these independent factors, ambient air quality is a dynamic process.

The (CAA) established the National Ambient Air Quality Standards (NAAQS) to protect public health. The 1990 Amendments to the CAA established classification designations based on the seriousness of the regional air quality problem. When measured concentrations of regulated pollutants exceed standards published by NAAQS, an area may be designated as a nonattainment area for the regulated pollutant. The number of exceedances and the concentrations determine the nonattainment classification of an area. There are five classifications of nonattainment status: marginal, moderate, serious, severe, and extreme. The Federal OCS waters are unclassified. Unclassified areas may either be nonattainment or attainment but cannot be classified due to lack of data. The areas west of 87.5° W. longitude fall under the MMS's jurisdiction for enforcement of the CAA. The areas east of this line fall under USEPA Region 4 jurisdiction. The current NAAQS (40 CFR 50.12 and 62 FR 138 (*Federal Register*, 1997a and b)) are shown in Table 3-1. Figure 3-1 presents the air quality status in the Gulf Coast as of August 2001.

Measurements of pollutant concentrations in Louisiana are presented in the *Air Quality Data Annual Report, 1996* (Louisiana Dept. of Environmental Quality, 1996). Louisiana is considered to be in attainment of the NAAQS for CO, SO_2, NO_2, and PM_{10} (also see USEPA, 2001). As of August 2001, six Louisiana coastal zone parishes have been tentatively designated nonattainment for ozone: Iberville, Ascension, Lafourche, East Baton Rouge, West Baton Rouge, and Livingston (USEPA, 2001). Ozone measurements between 1989 and 1997 show that the number of days exceeding national standards are declining (Louisiana Dept. of Environmental Quality, written communication, 1997).

There are three coastal counties in Mississippi. None of the coastal counties are designated as nonattainment for ozone.

Air quality data for PM_{10}, NO_2, and O_3 in Alabama were obtained from the Alabama Department of Environmental Management for the year 1993 and from the USEPA website for the years 1995-2001. The data shows that the coastal counties of Mobile and Baldwin are in attainment of the NAAQS for all criteria pollutants.

The State of Florida has no nonattainment areas in its coastal counties (USEPA, 2001). The USEPA AIRS data (USEPA's Aerometric Information Retrieval System (AIRS)) are available through the year 2001. Relative to onshore air quality in Escambia County, the EPA AIRS was accessed for ambient air monitoring data of SO_2, O_3, and PM_{10} for the years 1995 through 2001. During the 1995-1997 period, the following exceedances of applicable standards were recorded: no measurements of SO_2 (the number of measurements is referred to the number of stations with exceedances); three measurements of O_3 (one in 1995 and two in 1996); and no measurements of PM_{10}. If the proposed, new, 8-hr O_3 standard is imposed using the 1996-1998 data, Escambia County would be in violation. Indeed, during the 1998 summer season, there were a number of ozone alerts and additional O_3 exceedances in 1998 and 2000.

Table 3-1

National Ambient Air Quality Standards

Pollutant	Averaging Period	Primary Standards[a]	Secondary Standards[b]
Ozone	1-hour [c]	0.12 ppm (235 μg/m^3)	Same as Primary
	8-hour [d e]	0.08 ppm (157 μg/m^3)	Same as Primary
Sulphur Dioxide	Annual	0.03 ppm (80 μg/m^3)	NA
	24-hour	0.14 ppm (365 μg/m^3)	NA
	3-hour [c]	NA	1,300 μg/m^3
Carbon Monoxide	8-hour [c]	9.0 ppm (10 mg/m^3)	NA
	1-hour [c]	35 ppm (40 mg/m^3)	NA
Nitrogen Dioxide	Annual	0.053 ppm (100 μg/m^3)	Same as Primary
Suspended Particulate Matter (PM_{10})	Annual	50 μg/m^3	Same as Primary
	24-hour	150 μg/m^3 [f]	Same as Primary
$PM_{2.5}$[d]	Annual	15 μg/m^3 [g]	Same as Primary
	24-hour	65 μg/m^3 [h]	Same as Primary
Lead	Calendar Quarter	1.5 μg/m^3	Same as Primary

[a] The levels of air quality necessary, with an adequate margin of safety to protect the public health.
[b] The levels of air quality necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant.
[c] Not to be exceeded more than once a year.
[d] New standard effective 9/16/97, but as of 8/01 has not yet been fully implemented because of pending court action.
[e] Three-year average of the annual fourth-highest daily maximum 8- hour average for each monitor.
[f] Based on the 99th percentile of 24-hour PM_{10} concentration at each monitor.
[g] Based on 3-year average of annual arithmetic mean concentrations.
[h] Based on 3-year average of 98th percentile of 24-hour concentrations.

Note: mg/m^3 = milligrams per cubic meter = 1,000 μg/m^{-3}.
μg/m^3 = micrograms per cubic meter.

Source: 40 CFR 50, 1997.

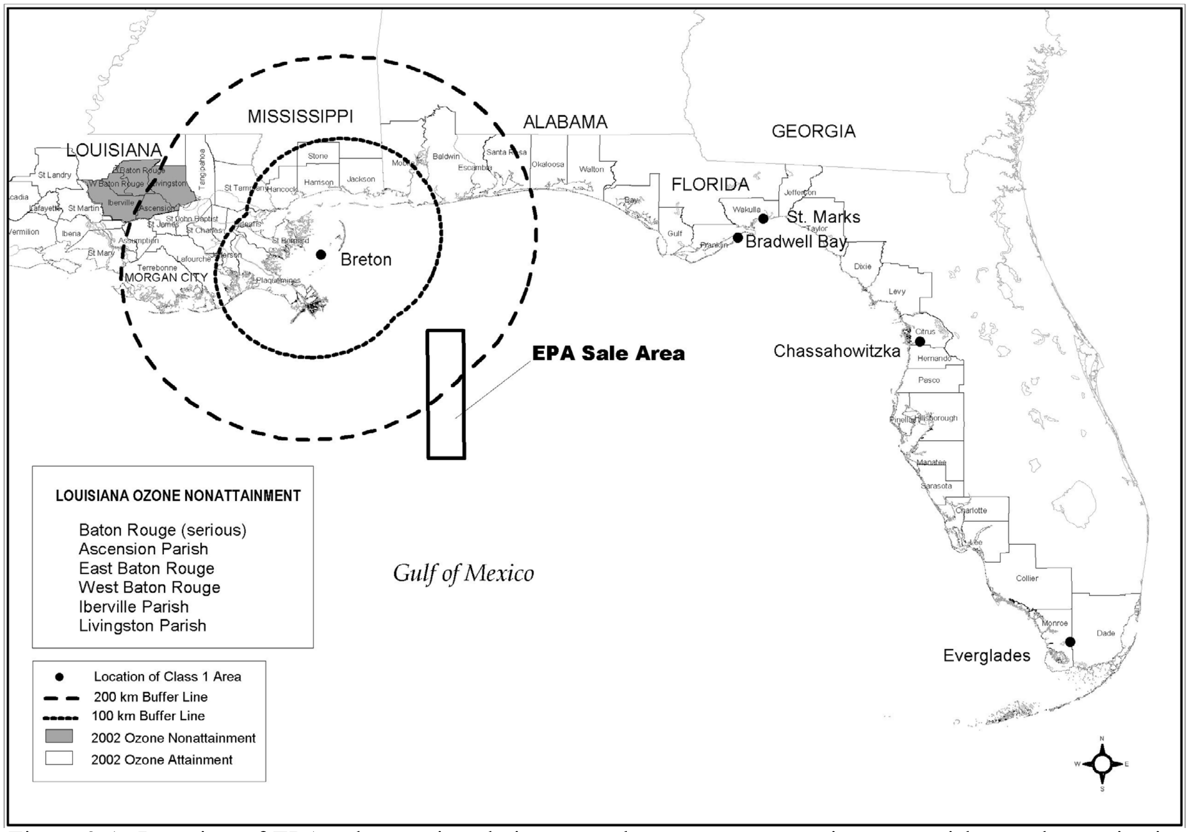

Figure 3-1. Location of EPA sale area in relation to onshore ozone nonattainment parishes and counties in Louisiana, Mississippi, Alabama and Florida, and proximity to prevention of significant deterioration Class I air quality areas; Breton National Wilderness Area, offshore Mississippi, and Saint Marks, Bradwell Bay and Chassahowitzka areas in Florida.

While Florida's ambient air quality standards are at least as stringent as the national standards, the State standards for sulfur dioxide are stricter than the national standards. Florida has an annual standard of 60 $\mu g/m^3$, a 24-hr standard of 260 $\mu g/m^3$, and a 3-hr standard of 1,300 $\mu g/m^3$. According to the Florida Air Quality Report for 1996 (Florida Dept. of Environmental Protection et al., 1997), sulfur dioxide concentrations are generally well within both State and National ambient air quality standards throughout the State.

The Federal OCS waters attainment status is unclassified. Unclassified areas may be either attainment or nonattainment but cannot be classified due to the lack of representative air quality data in these areas.

The Breton National Wildlife Refuge and National Wilderness Area off the Mississippi coast is designated as Prevention of Significant Deterioration (PSD) Class I air quality area. The EPA sale area is between 120 and 250 km (75-155 mi) from the Breton National Wilderness Area. Class I Areas are afforded the greatest degree of air quality protection and are protected by stringent air quality standards that allow for very little deterioration of their air quality. The PSD maximum allowable pollutant increase for Class I Areas are as follows: 2.5 $\mu g/m^3$ annual increment for NO_2; 25 $\mu g/m^3$ 3-hr increment, 5 $\mu g/m^3$ 24-hr increment, and 2 $\mu g/m^3$ annual increment for SO_2; and 8 $\mu g/m^3$ 24-hr increment and 5 $\mu g/m^3$ annual increment for PM_{10}. The FWS is responsible for protecting wildlife, vegetation, visibility, and other sensitive resources in this Class I Area. The FWS has expressed concern that the NO_2 and SO_2 increments for the Breton National Wilderness Area have been consumed.

3.2.2. Water Quality

For the purposes of this PEA, water quality is the ability of a waterbody to maintain the ecosystems it supports or influences. Evaluation of water quality is done by direct measurement of factors that are considered important to the health of an ecosystem. The primary factors influencing coastal and marine water quality are temperature, salinity, oxygen, nutrients, and turbidity or suspended load. Pathogens and pH are also important coastal water quality factors. In addition, trace constituents such as metals and organic compounds can affect water quality. The effects of these influencing factors can be localized or widespread. Water quality on the Federal OCS is regulated by the USEPA.

3.2.2.1. Coastal Waters

The Mississippi River drains about one-third of the contiguous U.S. In addition to being a major freshwater source, the Mississippi River is the hydrological boundary between the western Louisiana coastal zone and the estuaries of Mississippi, Alabama, and Florida. Lower salinity water from the Louisiana coast, including the Mississippi plume, are transported to the upper Texas coast by a westerly nearshore current. This fresher water varies substantially in salinity, depending on inflow from rivers. Salinity can vary between 27 and 36 parts per thousand (ppt) (Orlando et al., 1993). The only major estuarine system in Louisiana east of the Mississippi River is the Lake Pontchartrain, Lake Borgne, and Chandeleur Sound complex. Due to lower freshwater inflow, the Florida coast exhibits little seasonal variation in salinity. Summer-to-winter salinities range from 35.8 to 36.0 ppt. More detailed discussion can be found in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a; Section III.B.2.a).

Estuaries represent a transition zone between freshwater rivers and the higher salinity waters offshore. These bodies of water are influenced by freshwater and sediment influx from rivers and the tidal actions of the oceans. Due to their proximity to land and associated population centers, the water quality of estuaries is particularly affected by anthropogenic (manmade) sources of pollutants. This includes permitted discharges, spills, nonpoint-source runoff, and atmospheric deposition of pollutants (USEPA, 1999a).

There are general east to west trends in selected attributes of water quality in Gulf Coast estuaries. This trend is associated with changes in regional geology, general geomorphology, sediment loading, and freshwater inflow. The primary variables that influence the chemistry and fate of various pollutants and other important water quality attributes are (1) water temperature, (2) total dissolved solids (a measure of salinity), (3) pH (acidity or hydrogen ion content), (4) oxygen, (5) nutrients, and (6) suspended solids (turbidity). Changes to the ecosystem that involve these parameters may result in the local or widespread destruction of a specific species, species habitat, mass mortality, or the support of undesirable or exotic species.

There are nutrient, oxygen, and water salinity/density gradients in most estuaries, depending on their submarine geomorphology, depth, freshwater input, tidal flushing, and season of the year. Higher salinity water is usually associated with the deeper portions of the estuary that open into the open Gulf. Higher salinity water forms a denser "salt wedge" that moves up the estuary with tidal action. The mean tidal range along the upper Gulf Coast is on the order of 0.5 m. Near large energetic outlets the tidal excursion can be large and may approach 15 km. Density gradients can form effective transport mechanisms for planktonic organisms and dissolved and particulate matter. The salinity of water and associated water quality variables can influence the behavior of various pollutants by affecting the solubility of various compounds. An estuary's salinity structure and temperature regime are determined primarily by hydrodynamic mechanisms (tides, interaction with nearshore currents, seasonal trends local meterology, water depth, and freshwater inflow).

3.2.2.2. Marine Waters

Marine water, as defined in this programmatic PEA, includes only Federal OCS waters. The marine waters, within the area of interest, can be divided into three regions: the continental shelf west of the Mississippi River, the continental shelf east of the Mississippi River, and deep water (>1,000 m or 3,280 ft). The EPA sale area is entirely within deep water. While the various parameters measured to evaluate water quality do vary in marine waters, one parameter, pH, does not. The buffering capacity of the marine system is controlled by carbonate and bicarbonate, which maintains the pH at 8.2.

3.2.2.2.1. Continental Shelf West of the Mississippi River

Water quality on the Louisiana continental shelf is influenced by the influx of water, sediment, and contaminants from the Mississippi and Atchafalaya Rivers (Murray, 1998). In the *Texas-Louisiana Shelf*

Circulation and Transport Process Study (LATEX A; Nowlin et al., 1998), samples were collected over a three-year period during May, August, and November. Surface temperatures were influenced by the atmospheric temperature and ranged from 20° to 30°C, while bottom temperatures were from 16° to 28°C, decreasing with increasing depth. Salinity was as high as 36.6 ppt, but there is a freshening near the coast to <30 ppt due to the influence of rivers and run-off. During summer months, a turbid, low salinity surface layer of water from the Mississippi and Atchafalaya Rivers spreads out over the shelf. This results in a stratified water column. Nitrate, phosphate, and silicate concentrations were primarily influenced by input from the rivers. A bottom nepheloid layer composed of suspended clay material from the underlying sediment is also generally present on the shelf

Surface oxygen concentrations were saturated during the fall and winter months and near saturation for the other seasons. Hypoxia, defined as oxygen concentrations less than 2 ml/l O_2, was observed in bottom waters during the summer months.

The zone of hypoxia on the Louisiana-Texas shelf is one of the largest areas experiencing such conditions in the world's coastal waters and occurs 80-160 km (50-100 mi) to the west and north of the EPA sale area. The oxygen-depleted bottom waters occur seasonally and are affected by the timing of the Mississippi and Atchafalaya River discharges carrying nutrients to the surface waters (LATEX B; Murray, 1998).

3.2.2.2.2. Continental Shelf East of the Mississippi River

Water quality on the continental shelf from the Mississippi River Delta to Tampa Bay is influenced by river discharge and run-off from the coast and eddies from the Loop Current. The Mississippi River accounts for 72 percent of the total discharge into the Mississippi, Alabama, and Florida (MAFLA) area (SUSIO, 1975). The Loop Current intrudes in irregular intervals onto the shelf, and the water column can transition from well mixed to highly stratified very rapidly. Discharges from the Mississippi River can be easily entrained in the Loop Current.

A three-year, large-scale marine environmental baseline study conducted from 1974 to 1977 in the Eastern GOM resulted in an overview of the MAFLA OCS environment to 200 m (SUSIO, 1977; Dames and Moore, 1979). The study focused on selected parameters that might be influenced by oil and gas development. Samples were collected over several seasons from both the water column and sediments. Analysis of water, sediments, and biota for hydrocarbons indicated that the MAFLA area is pristine with some influence of anthropogenic and petrogenic hydrocarbons from river sources. Analysis of nine trace metals (barium, cadmium, chromium, copper, iron, lead, nickel, vanadium, and zinc) also indicated no contamination. Information about water quality on the shelf from DeSoto Canyon to Tarpon Springs and from the coast to 200-m water depth was summarized by SAIC (1997). Several small rivers and the Loop Current are the primary influences on water quality in this region. The Loop Current flushes the area with clear, low nutrient water.

The shelf region of the Mississippi River Delta to DeSoto Canyon, bounded by the 20-m and 200-m isobaths, was studied during winter and summer months in 1987 and 1988 as part of the Mississippi-Alabama Marine Ecosystem Study (MAMES) (Brooks, 1991). Generally, the water temperature is influenced by the season, with colder temperatures and the breakdown of the thermocline in winter months and the formation of stratified waters in the summer. Salinity throughout the region was greater than 30 ppt with surface waters being slightly fresher than deeper water. The outflow of the Mississippi River generally extends 75 km (45 mi) to the east (Vittor and Associates, Inc., 1985) except under extreme high flow. A bottom nepheloid layer and surface lenses of suspended particulates that originate from river outflow are also observed along the shelf. The water clarity is higher towards Florida, where the influence of the Mississippi River outflow is rarely observed. Hypoxia is rarely observed on the Mississippi-Alabama shelf, although low dissolved oxygen values of 2.93-2.99 mg/l were observed during the MAMES cruises (Brooks, 1991). Nutrients in the region are generally low with both nitrate and phosphate levels less than 1.0 µm except in the summer where some surface nitrate values exceeded 1.0 µm in the winter.

At present, information is being collected from the Mississippi River Delta to Tampa Bay in water depths from 10 to 1,000 m as part of the Northeastern Gulf of Mexico Chemical Oceanography and Hydrography Study (NEGOM) (Jochens and Nowlin, 1999). Nutrients exhibit classical marine patterns with depletion in the photic zone and enhancement at depth. Concentrations of particles and nutrients are higher near river input. Dissolved oxygen in surface water is at equilibrium in surface water and depleted at depth. There is no evidence of hypoxic (<2 ml/l O_2) conditions at the bottom; however, there is an oxygen minimum zone between 200 m and 600 m where the oxygen level decreases below 3 ml/l O_2 and impinges on the seafloor. At 1,000 m the oxygen concentration begins to increase to the 5 ml/l O_2 average of the offshore deepwater.

Harmful algal blooms or red tides are common occurrences in the GOM and can affect water quality by the toxins exuded from two dinoflagellate species (Darnell, 1992). The blooms of algae can cause massive fish kills, neurotoxic shellfish poisoning, and irritate human respiratory systems. The first written account of an algal bloom was described in 1844 (Jones et al., 1973). During the spring and summer of 1998, an unusual occurrence of mass mortalities of fishes and invertebrates was observed (Collard and Lugo-Fernández, 1999). The unusual conditions of upwelling and large river influx created a stratified water column with high nutrient concentrations at the surface. A dense algal bloom developed as a result of the increased nutrients that subsequently died off and sank to the bottom. The degradation of the increased organic matter used the oxygen near the bottom and created a hypoxic situation that distressed or killed both fish and invertebrates. This event was considered a response to climatic conditions associated with *El Niño*.

3.2.2.2.3. Deep Water

The EPA sale area is entirely within deepwater. The water at depths greater than 1,400 m is relatively homogeneous with respect to temperature, salinity, and oxygen. Temperature ranges from 4.0° to 4.5°C, salinity from 34.963 to 34.976 ppt, and oxygen from 4.58 to 5.61 ml/l O_2 (Nowlin, 1972). Most of this data was collected during a very comprehensive survey of the GOM conducted by Texas A&M University in the winter months of 1962. Subsequent studies have made similar observations (Pequegnat, 1983; Gallaway et al., 1988; Jochens, et al. 2002). Of importance, as pointed out by Pequegnat (1983), is the flushing time of the GOM. Oxygen in deepwater must come from the surface and be mixed by some mechanism. Deep oceanic circulation patterns begin at the poles where cooler and denser water sinks and is circulated in large oceanic gyres. The linkage between oceanic circulation and conditions at a specific site in the EPA sale area is not known. If the replenishment of the water occurs over a long period of time, the addition of discharges from oil and gas activities could lead low oxygen, and potentially hypoxic conditions in the deepwater OCS. The mechanism for maintaining the constant oxygen levels in deep waters of the GOM is unknown.

Limited analyses of trace metals and hydrocarbons for the water column and sediments exist (Trefry, 1981; Gallaway et al., 1988). Hydrocarbon seeps are extensive throughout the continental slope and contribute hydrocarbons to the surface sediments and water column, especially in the Central Gulf (Sassen et al., 1993). In addition to hydrocarbon seeps, other fluids leak from the underlying sediments into the bottom water along the slope. These fluids have been identified to have three origins: (1) seawater trapped during the settling of sediments; (2) dissolution of underlying salt diapirs; and (3) deep-seated formation waters (Fu and Aharon, 1998). The first two fluids are the source of authigenic carbonate deposits while the third is rich in barium and is the source of barite deposits.

3.2.3. Bottom Sediment Quality

The Mississippi-Alabama shelf is strongly influenced by fine sediments discharged from the Mississippi River. The West Florida Shelf has very little sediment input and is characterized by primarily high-carbonate sands offshore and quartz sands nearshore. Sediment quality is defined by the ability of the sediment to support the marine life that resides in and on the seafloor.

Bottom sediments on the Mississippi-Alabama shelf were analyzed for high-molecular-weight hydrocarbons and heavy metals during the MAMES cruises (Brooks, 1991). The high-molecular-weight hydrocarbons can come from natural petroleum seepage or biogenic gases from organic decomposition, as well as input from manmade sources. In the case of the Mississippi-Alabama shelf, the primary source of petroleum hydrocarbons and terrestrial plant material is the Mississippi River. Higher levels of hydrocarbons were observed in the late spring, which coincides with increased river influx. The sediments, however, are moved and redeposited later in the year as evidenced by low hydrocarbon values in winter months. None of the 14 metals measured by MAMES were at concentrations above natural background levels.

3.3. BIOLOGICAL RESOURCES

3.3.1. Coastal Resources

3.3.1.1. Barrier Islands and Dunes

The GOM shoreline from the Mexican border to Florida is about 1,500 km (932 mi) long. These shorelines are typically composed of sandy beaches that are divided into several interrelated environments. Generally, beaches consist of the following:

- a shoreface — underwater seaward slope from the low tidal waterline;
- a foreshore — exposed, usually nonvegated slope from the ocean to the beach berm crest; and
- a back shore — typically found between the beach berm-crest and dune area, sparsely vegetated. The berm-crest and backshore may occasionally be absent due to storm activity.

The dune zone of a barrier landform can consist of a single low dune ridge, several parallel dune ridges, or a number of curving dune lines that may be stabilized by vegetation. These elongated, narrow landforms are composed of wind-blown sand and other unconsolidated, predominantly coarse sediments.

Sand dunes and shorelines conform to environmental conditions found at its site. These conditions usually include waves, currents, wind, and human activities. Ocean wave intensities around the GOM are generally low to moderate; however, when GOM waters are elevated by storms, waves are generally larger and can overwash lower coastal barriers, creating overwash fans or terraces behind and between the dunes. Over time, opportunistic plants will reestablish on these flat sand terraces, followed by the usual vegetative succession for this area. Along more stable barriers, where overwash is rare, the vegetative succession in areas behind the dunes is generally complete. Vegetation in these areas of broad flats or coastal strands consists of scrubby woody vegetation, marshes, and maritime forests. Saline and freshwater ponds may be found among the dunes and on the landward flats. Landward, these flats may grade into wetlands and intertidal mud flats that fringe the shore of lagoons, islands, and embayments. In areas where no bay or lagoon separates barrier landforms from the mainland, the barrier vegetation grades into scrub or forest habitat of the mainland.

Accumulation and movement of sediments that make up barrier landforms are often described in terms of regressive and transgressive sequences. Although transgressive landforms dominate around the Gulf, both transgressive and regressive barriers occur there. A regressive sequence deposits terrestrial sediments over marine deposits, as a delta builds land into the sea. Regressive barriers have high and broad dune profiles. These thick accumulations of sand may form parallel ridges.

A transgressive sequence moves the shore landward, allowing marine deposits to overstep terrestrial sediments. Transgressive coastal landforms around the Gulf have low profiles and are characterized by (1) narrow widths; (2) low, sparsely vegetated, and discontinuous dunes; and (3) numerous, closely spaced, active washover channels. Landward movement or erosion of a barrier shoreline may be caused by any combination of subsidence, sea-level rise, storms, channels, or be accentuated by manmade structures such as groins, seawalls, and jetties. Movement of barrier systems is not a steady process because the passage rates and intensities of cold fronts and tropical storms, as well as intensities of seasons, are not constant (Williams et al., 1992).

Coastal retreat, the result of transgression, does not occur at a steady rate because it is largely driven by storms occurring with the passage of cold fronts, which vary in their frequency and intensity (Williams et al., 1992). Storm winds can elevate Gulf waters so that they overwash barriers and dunes, creating overwash fans or terraces behind and between the dunes. With time, these terraces will be vegetated by opportunistic species.

Mississippi River Delta Complex

Most barrier shorelines of the Mississippi River Delta in Louisiana are transgressive and trace the seaward remains of a series of five abandoned delta lobes. The Mississippi River is channelized through the sixth lobe, the Belize Delta, more commonly known as the Birdfoot Delta. Channelization isolated the river from most of this sixth delta, except near distributary channel mouths. At the Birdfoot Delta, a small fraction of the river's sediment load is contributed to longshore currents for building and maintaining barrier shores. Because the continental shelf is very narrow offshore of the Birdfoot Delta, the bulk of river sediments are deposited directly into deepwater, where they cannot be reworked and contribute to the longshore drift. Most of southeastern Louisiana's barrier beaches are composed of medium to coarse sand.

The shoreface of the Mississippi River Delta complex generally slopes gently seaward at angles higher than that found off the Chenier Plain, which reduces wave energy at the shorelines. Mud flats are exposed during very low tidal events. The steepest shoreface of the delta is found at the Caminada-Moreau Coast, where the greatest rates of erosion occur. From this site longshore current splits into east and west components, which removes sand from the area (Wolfe et al., 1988; Wetherell, 1992; Holder and Lugo-Fernandez, 1993).

Regressive shorelines occur in Louisiana's deltaic region. The diversion of the Red River and about 30 percent of the Mississippi River to the Atchafalaya River has allowed transport of large volumes of sediment into shallow Atchafalya Bay. There, inland deltas are forming at the mouths of that river and Wax Lake Outlet. Recent satellite photography of these deltas reveal that dredge-disposal islands were constructed off Point au Fer in very shallow water (3-5 ft) at the mouth of Atchafalaya Bay. These islands and surrounding shallows are the foundations for a future barrier shoreline in this area, if the Atchafalaya River Delta continues to build seaward as expected.

Most dune zones of the Mississippi River Delta contain low, single-line dune ridges that may be sparsely to heavily vegetated. Generally in this area, the vegetation on a dune ridge gets denser as the time between storms lengthens. The dune zone of the Chandeleur Islands is larger and more complex. Boyd and Penland (1988) reported that elevations of the Chandeleur Islands ranged between less than 1 and 8 m MSL (above mean sea level). Since then, the hurricanes of the 1990's greatly lowered these elevations, which are slowly recovering. In 1997 the Chandeleur Islands contained about 1,930 ha (4,769 ac) of land, most of which was beach and dune complex (USDOI, GS, 1998).

Boyd and Penland (1988) reported that 52 percent of the Caminada-Moreau Coast had a vegetated, dune ridge of less than 1 m MSL and that the elevation of the remaining length ranges up to 3 m MSL. The mean water-level threshold for overwashing 75 percent of that beach is 1.42 m MSL. They estimated that this threshold is achieved about 15 times a year, on average. Mean water elevations exceeding 2.5 m MSL occur once every 2 years (Richie and Penland, 1985).

Boyd and Penland (1988) estimated that storms raise mean water levels 1.73-2.03 m MSL 10-30 times per year. Under those conditions, the following would be over washed: (1) 67 percent of Timbalier Island; (2) 100 percent of Isles Dernieres and the Barataria Bay Barriers (excluding Grand Isle); and (3) 100, 89, and 64 percent of the southern, central, and northern portions of the Chandeleur Islands, respectively.

Shell Key is an emerged barrier feature that varies greatly from the others around the Mississippi Delta. It is located south of Marsh Island, Louisiana, at the mouth of Atchafalaya Bay, and is composed almost entirely of oyster-shell fragments. It is found amid extensive shell reefs, which are part of the Shell Keys National Wildlife Refuge. This dynamic, minimally vegetated island fluctuates in size with passing storms. In 1992 and 1999, Hurricane Andrew and Hurricane Francis reduced the island to little more than a shoal that largely submerges under storm tides. The shallow, submerged shell reefs around Shell Key also serve as barrier features. Located on the other side of the bay's mouth and to the southeast, the Point au Fer Shell Reefs were commercially dredged for shells, and no longer exist (USDOI, FWS, 2001; Schales and Soileau, personal communication, 2001).

Mississippi and Alabama

The Dog Keys define the Mississippi Sound of Mississippi and Alabama. Mississippi has about 54.6 km (34 mi) of barrier beaches on these islands (USDOI, FWS, 1999). Dauphin Island represents about another 12 km (7.5 mi). This relatively young group of islands was formed 3,000-4,000 years ago as a result of shoal-bar accretion (Otvos, 1979). Wide passes with deep channels separate them. Shoals are typically adjacent to these barriers. Generally, these islands are regressive and stable in size as they migrate westward in response to the predominantly westward-moving longshore currents.

These islands generally have high beach ridges and prominent sand dunes. Although overwash channels do not commonly occur, the islands may be overwashed during strong storms. The islands are well vegetated among and behind the dunes and around ponds. Southern maritime climax forests of pine and palmetto are found behind some of their dune fields.

Dauphin Island, Alabama, is the exception to the above description. It is essentially a low-profile transgressive barrier island, except for a small, eroding, Pleistocene core at its eastern end. The western end is a Holocene spit that is characterized by small dunes and many washover fans, exposed marsh deposits, and tree stumps exposed in the surf zone.

Pelican Island, Alabama, is a vegetated sand shoal, located Gulfward of Dauphin Island. Southeasterly of that island is Sand Island, which is little more than a shoal. These barrier islands are parts of Mobile Bay's ebb-tidal delta. As such, they continually change shape under storm and tidal influences. The sand from these islands and shoals generally moves northwesterly into the longshore drift, nourishing beaches down drift. These sediments may also move landward during flood tides (Hummell, 1990).

The Gulf Shores region of Alabama extends from Mobile Point eastward to the Florida boundary, a distance of about 50 km (31 mi) (Smith, 1984). It has the widest beaches and largest dune system among the barrier beaches in the GOM.

Florida

A 67-km (42-mi) line of barrier islands extends north from the mouth of Tampa Bay. These islands are generally low and flat, without conspicuous dunes. Their foundations are mostly limestone about 12 ft below sea level. Historically, the longshore drift may have diverged at Indian Rocks, Florida, creating a southerly drift south of that site and a northerly drift north of it, building Anclote Keys, the northern most islands in this system. Records indicate that the net sediment drift at the passes between all of these islands is southerly and that the offshore tidal range in the vicinity of these islands is between 76 and 88 cm (30-34.6 in).

North of Anclote Keys, lies the very low energy seas of the Big Bend Coast region (Kwon, 1969), an area very different from the sandy coast around the rest of the Gulf. The Big Bend Coast stretches about 300 km (186 mi) between the Ochlockonee River, on the western boundary of Wakulla County, and the Anclote Keys of Pasco County, Florida. This shoreline and its associated continental shelf has a very low slope seaward which helps lower wave energy and modifies the waves to a wide profile and low average breaker height. The area also has a low tidal range. Together, these circumstances generally cause less sediment movement.

The foundation of this area is largely constructed of Eocene limestone that is either exposed to weathering and dissolution, or thinly covered with peaty sediment. Hence, the coast is very irregular with numerous tidal creeks, embayments, and small islands. This situation allows development of oyster bioherms in lower salinities. These bioherms extend several kilometers offshore, creating depositional basins with distinct sedimentary processes. Where the oyster bioherms have largely died, they have been severely eroded, contributing sediments to the area.

The Big Bend Coast has very limited sediment influx because the Suwanee River and other large streams that carry sediment into this region drain a watershed composed of limestone.

3.3.1.2. Wetlands

Wetland habitats found along the Western, Central, and Eastern GOM coasts include (1) fresh, intermediate, brackish, and saline marshes; (2) mud and sand flats; and (3) forested wetlands of mangrove swamps, cypress-tupelo swamps, and bottomland hardwoods. Coastal wetland habitats occur as bands around waterways and as broad expanses. Saline and brackish habitats support sharply delineated, segregated stands of single plant species. Fresh and very low salinity environments support more diverse and mixed communities of plants. The plant species that occur in greatest abundance vary greatly around the GOM. According to the USDOI (Dahl, 1990; Henfer et al., 1994), during the mid-1980's, 4.4 percent of Texas (3,083,860 ha or 7,620,400 ac), 28 percent of Louisiana (3,557,520 ha or 8,790,800 ac), 14 percent of Mississippi (17,678,730 ha or 43,685,000 ac) and 8 percent of Alabama (1,073,655 ha or 2,653,000 ac) were considered wetlands. These States' wetland areas decreased by 1.6-5.6 percent during the previous decade. Additionally, the coastal counties of Florida contain about 994,950 ha (2,448,725 ac) of wetlands. Reviewers of this document are referred to ecological characterization and inventory studies conducted by the FWS, the Texas Bureau of Economic Geology, and other agencies and researchers (Gosselink et al., 1979; Gosselink, 1984; Smith, 1984; Fisher et al., 1972 and 1973; Brown et al., 1976 and 1977; Stout et al., 1981).

The importance of coastal wetlands to the coastal environment has been well documented. Wetlands are characterized by high organic productivity and they are very efficient at nutrient recycling. Wetlands rely on overbank deposition of sediments from rivers in flood stage. Floods deposit layers of sediment, raising ground and waterbottom elevations to a level that supports emergent and other wetland vegetation. Wetlands provide habitat for a great number and wide diversity of invertebrates, fish, reptiles, birds, and mammals. The high detritus production and habitat diversity have rendered wetlands as particularly important nursery grounds for many fish and shellfish juveniles, which in turn support a thriving fishing industry. Louisiana's coastal wetlands support more than two-thirds of the wintering waterfowl population of the Mississippi Flyway, including 20-25 percent of North America's puddle duck population. Louisiana's coastal region also supports the largest animal fur harvest in North America (Olds, 1984).

Mississippi River Delta Complex

Over the past 6,000 years, the Mississippi River Delta Complex has formed a plain composed of a series of six overlapping delta lobes that built seaward onto the continental shelf. Wetlands on this delta plain are the most extensive habitat.

Sparse stands of black mangrove are found in the highest salinity areas of the Barataria and Terrebonne Basins. Extensive salt and brackish marshes are found throughout the southern half of the plain and east of the Mississippi River. Further inland, extensive intermediate and freshwater marshes are found. East of the Mississippi River and south of Lake Pontchartrain, Louisiana, very few intermediate and freshwater wetlands existed until the Caernarvon Freshwater Diversion was intermittently put into action in 1993. In freshwater areas, cypress-tupelo swamps are found flanking the natural levees and in areas that are impounded by dredged materials, levees, or roads. Bottomland hardwoods are found on the numerous natural levees and in drained levee areas.

Except for leveed areas and the delta and basin of the Atchafalaya River, all of these deltas are generally experiencing succession towards wetter terrestrial and deeper water habitats. This is due to delta abandonment and human actions, which have caused erosion of lowland environments. Most of these wetlands are built upon highly organic soils, which are easily eroded, compacted, and oxidized.

Two active deltas are found in this area. The more active is in Atchafalaya Bay, at the mouths of the Atchafalaya River and its distributary, Wax-Lake Outlet. Because the Red River and about 30 percent of the Mississippi River have been diverted to the Atchafalaya River, large volumes of sediment are being delivered to that shallow bay. As a result, extensive freshwater marshes, swamps, and bottomland hardwoods are found in this river basin; relatively few estuarine marshes are found there.

The less active of the two deltas occurs at the mouth of the Mississippi River, which is referred to as the Belize or Birdfoot Delta. The Mississippi River has been channelized throughout most of this delta, greatly reducing overbank flow and the volume of sediment available to build up the delta and contribute to longshore currents. A few manmade diversions have been installed that are designed to deliver water rather than sediments to this delta.

The 1990 estimates of coastal Louisiana wetland acreage, projected acreage losses by 2050, and the influence of legislation designed to decrease or remediate wetland loss (Breaux Act) in a nine-basin area based on the U.S. Dept. of the Army, Corps of Engineers (COE) database are described below:

Basin	Acres of Marsh in 1990	Acres of Marsh Lost by 2050 without Restoration	Acres of Marsh Preserved by the Breaux Act and Diversions	Net Acres of Marsh Lost by 2050 at Current Restoration Levels	Acres of Swamp in 1990	Acres of Swamp Lost by 2050 at Current Restoration Levels
Ponchartrain	253,000	50,330	4,720	45,610	213,570	105,100
Breton Sound	171,100	44,480	17,900	26,580	0	0
Mississippi Delta	64,100	24,730	18,340	6,390	0	0
Barataria	423,500	134,990	42,420	92,570	146,360	80,000
Terrebonne	488,800	145,250	5,170	140,080	152,400	46,700
Atchafalaya	48,800	(30,030)*	8,080	(38,110)*	12,600	0
Teche/ Vermilion	234,300	32,160	3,360	28,800	18,390	0
Mermentau	441,000	61,710	2,600	59,110	370	0
Calcasieu/ Sabine	317,100	50,840	12,440	38,400	170	0

*Source: Louisiana Coastal Wetlands Conservation and Restoration Task Force, 1993.

Direct causes of Louisiana wetland loss may be attributed to the following activities: (1) dredging and stream channelization for navigation channels and pipeline canals; (2) filling for dredged material and other solid-waste disposal; (3) roads and highways; (4) industrial expansion; and (5) accidental discharge of pollutants into wetlands. Indirect causes of wetland loss may be attributed to the following: (1) sediment diversion by dams, deep channels, and other structures; (2) hydrologic alterations by canals; (3) dredged-material disposal banks, roads, and other structures; and (4) subsidence due to extraction of groundwater, oil, gas, sulfur, and other minerals.

Mississippi and Alabama

Estuarine marshes around Mississippi Sound and associated bays occur in discontinuous bands. The most extensive wetland areas in Mississippi occur in the eastern Pearl River delta near the western border of the State and in the Pascagoula River delta area near the eastern border of the State. Mississippi's wetlands seem to be more stable than those in Louisiana and Alabama, perhaps reflecting the more stable substrate, more active and less disrupted sedimentation patterns in wetland areas, and the occurrence of only minor canal dredging and development.

Alabama has approximately 118,000 ac of coastal wetlands, of which approximately 75,000 ac are forested, 4,400 ac are freshwater marsh, and 35,400 ac are estuarine marsh (Wallace, 1996). Most coastal wetlands in Alabama occur on the Mobile River delta or along the northern Mississippi Sound.

Florida

The coastal counties of Florida contain about 994,950 ha (2,448,725 ac) of wetlands. Hardwood swamps represent the largest percentage (32.5%) of those wetlands. These hardwood swamps are largely associated with river deltas in Pensacola, Choctawatchee, and St. Andrews Bays. Estuarine wetlands, such as marsh and mangroves, represent 7.4 percent of that total (Florida Game and Freshwater Fish Commission, 1996).

Florida's saltmarshes form along the margins of many north Florida estuaries. Gulf Coast salt marshes occur along low energy shorelines, at the mouth of rivers, and in bays, bayous, and sounds. The Panhandle region west of Apalachicola Bay consists mainly of estuaries with few salt marshes. From Apalachicola Bay south to Tampa Bay, however, salt marshes are the main form of coastal vegetation. The coastal area known as "Big Bend" has the greatest salt marsh acreage in Florida, extending from Apalachicola Bay to Cedar Key. Florida's dominant salt marsh species include the following: black needle rush (*Juncus roemerianus*)—the grayish rush occurring along higher marsh areas; saltmeadow cord grass (*Spartina patens*), growing in areas that are periodically inundated; smooth cord grass (*Spartina alterniflora*), found in the lowest areas that are most frequently inundated; and sawgrass

(*Cladium jamaicense*), which is actually a freshwater plant that sometimes grows along the upper edges of salt marshes.

South of Cedar Key, salt marshes begin to be replaced by mangroves as the predominant intertidal plants. As one of Florida's true native coastal marsh plants, mangroves thrive in salty environments because they are able to obtain freshwater from saltwater. Some species of mangrove secrete excess salt through their leaves; others block absorption of salt at their roots.

Florida's estimated 189,800 ha (469,000 ac) of mangrove forests contribute to the overall health of the State's southern coastal zone. This ecosystem traps and cycles various organic materials, chemical elements, and important nutrients. Mangrove roots act not only as physical traps but provide attachment surfaces for various marine organisms. Many of these attached organisms filter water through their bodies and, in turn, trap and cycle nutrients. Mangroves stabilize shorelines with their specialized root systems that act to (1) filter water and trap sediment, (2) maintain water quality and clarity, and (3) reduce erosion.

The relationship between mangroves and their associated marine life is significant. Mangroves provide protected nursery areas for fishes, crustaceans, and shellfish. They also provide food for a multitude of marine species such as snook, snapper, tarpon, jack, sheepshead, red drum, oyster, and shrimp. Many of Florida's important recreational and commercial fisheries depend on healthy mangrove forests. Many animals find shelter either in the roots or branches of mangroves. Mangrove branches act as rookeries by providing nesting areas for various coastal birds such as brown pelicans and roseate spoonbills.

Of the three mangrove species found in Florida, the red mangrove (*Rhizophora mangle*) is probably the most well known. It typically grows along the water's edge and has a system of "prop-roots." The black mangrove (*Avicennia germinans*) usually occupies slightly higher elevations upland from the red mangrove. The black mangrove can be identified by numerous finger-like projections, called pneumatophores, that protrude from the soil around the tree's trunk. The white mangrove (*Laguncularia racemosa*) usually occupies the highest elevations farther upland than either the red or black mangroves. Unlike its red or black counterparts, the white mangrove has no visible aerial root systems. In all three species, seeds sprout while still on the trees and drop into the soft bottom around the base of the trees or are transported by currents and tides to other suitable locations.

3.3.1.3. Seagrass Communities

Seagrass meadows are among the most common coastal ecosystems and are extremely valuable because of their diverse habitatas within the coastal landscape. Seagrasses play a fundamental role by providing complex structure in both water column (leaves and fronds) and sediments (roots and rhizomes). They also increase bottom area as a result of leaf surfaces allowing complex epiphytic communities (animals that live on leaves and fronds) to develop. Dense meadows may consist of more than 4,000 plants per square meter with an associated increase in bottom area of 15-20 times (McRoy and Helfferich, 1977). Biologically, seagrasses provide nursery areas, refuge, and rich foraging grounds for a variety of estuarine fish and invertebrates, including a number of commercially and recreationally important species. Seagrasses also play a major role in nutrient cycling within the water column and sediments, and the associated detritus is an important source of organic material to adjacent coastal and nearshore ecosystems.

Three million hectares (7,413,100 ac) of submerged seagrass beds are estimated to exist in exposed, shallow coastal waters of the northern Gulf. An additional 166,000 ha (410,190 ac) are found in protected natural embayments and are not considered exposed to OCS impacts. Approximately 98.5 percent of all coastal seagrasses in the northern Gulf are located within the EPA, off coastal Florida; Texas and Louisiana contain approximately 0.5 percent; and Mississippi and Alabama have the remaining 1 percent of known seagrass meadows.

Louisiana, Mississippi, and Alabama

The turbid waters and soft, highly organic sediments of Louisiana's estuaries and offshore areas limit widespread distribution of seagrass beds that prefer higher salinities. Consequently, only a few areas in offshore Louisiana, mostly in Chandeleur Sound, support seagrass beds and associated fauna. In coastal Mississippi during 1973, about 8,100 ha (20,015 ac) of seagrass beds were reported. In 1985, about 1,800 ha (4,447 ac) of seagrass beds were associated with the State's barrier islands. Stout et al. (1981) reported

1,105 ha (2,730 ac) of submerged vegetation beds in the coastal zone of Alabama. A few beds are found along the shores on Mobile Bay and in the rivers and wetlands that feed into the bay.

Florida

There are an estimated 809,370 ha (2,000,000 ac) of seagrass in Florida waters of the Gulf and Florida Bay (over 1,000,000 ac in Florida Bay alone). Approximately 362,520 ha (895,110 ac) of these seagrass beds are located within Florida's coastal waters (Sargent at al., 1995). Earlier, Wolfe et al. (1988) reviewed previous studies and reported that about 15,250 ha (37,683 ac) of submerged vegetation beds were reported for the higher-salinity regions of estuaries in the Florida Panhandle between Pensacola and Alligator Harbor. Some seagrass beds in the Big Bend area of Florida extend into Federal waters, which begin 16.7 km (10.3 mi) offshore, and some beds extend to about 26 km (16.1 mi) offshore (Sargent et al., 1995). Wave energy in the vicinity is relatively low due to the shallow and gently sloping nature of the sea bottom.

The general decline of inshore and nearshore submerged vegetation, particularly seagrasses, in this region has been attributed to increases of both coastal development and accompanying turbidity and contaminants. Dredge-and-fill projects seem to have the greatest adverse impacts upon submerged vegetation (SAIC, 1997; Sargent et al., 1995; Wolfe et al., 1988).

The distribution of seagrass beds in coastal waters of the Western, Central, and Eastern GOM have diminished during recent decades. Primary factors considered responsible include dredging, dredged material disposal, trawling, water quality degradation, hurricanes, a combination of flood protection levees that have directed freshwater away from wetlands, saltwater intrusion and flooding from subsidence that moved growing conditions closer inland, and infrequent freshwater diversions from the Mississippi River into coastal areas during flood stage, as well as the increased coastal development in Florida and other aesthetically desirable Gulf Coast locations.

3.3.1.4. Beach Mice and Salt Marsh Vole

Hall (1981) recognizes 16 subspecies of field mouse (*Peromyscus polionotus*), 8 of which are collectively known as beach mice. The Alabama, Choctawhatchee, St. Andrew, and Perdido Key beach mice and the Florida salt marsh vole are designated as protected species under the Endangered Species Act of 1973. These mice occupy restricted habitat behind coastal foredunes of Florida and Alabama (Ehrhart, 1978; USDOI, FWS, 1987). Documented beach mouse occurrences are on the Fort Morgan Peninsula, in Gulf State Park (Perdido Key Unit); along Gulf Islands National Seashore, in Topsail Park; and on Shell Island. The Florida salt marsh vole occupies only a single tidal marsh, located on Waccasassa Bay, Florida, about 90 mi north of Tampa, Florida. Fossil voles indicate an ancient-wide distribution over salt marshes in what is now the continental shelf that was drowned by rising sea levels. Portions of these areas have been designated as critical habitat.

Beach mice populations have fallen to levels approaching extinction. For example, in the late 1980's, estimates of total remaining beach mice were less than 900 for the Alabama beach mouse subspecies; about 500 for the Choctawhatchee beach mouse subspecies; and about 80 for the Perdido Key beach mouse subspecies. Continued monitoring of populations of all subspecies along the Gulf Coast between 1985 and the present indicates that approximately 52 km (32.3 mi) of coastal dune habitat are now occupied by the four listed subspecies (1/3 of historic range). Beach mice were listed because of the loss of coastal habitat caused by human development. The reduced distribution and numbers of beach mice have continued because of multiple habitat threats over their entire range (coastal development and associated human activities, military activities, coastal erosion, and hurricane effects). Additional discussion can be found in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a; Section III.C.7).

3.3.2. Deepwater Benthic Resources

The EPA sale area encompasses a range of habitats and water depths that would exclude the continental shelf. Deepwater benthic habitats shallower than the 1,000-m (3,280-ft) isobath would exclude the entire EPA sale area. "Deepwater" refers to water depths greater than 1,000 m (3,280 ft). Water depth in the EPA sale extends to the upper limits of the abyssal zone, which is generally deeper than 3,000 m (9,850 ft).

Contrary to a widely perceived view that little is known about the deepwater environment in the northern and eastern Gulf, numerous studies have been performed in the deep GOM including some sampling inside the EPA (USDOI, MMS, 2001a) that date back to the mid-1960's. Pequegnat (1983) reported a total of 14 stations sampled within this area ranging in depth from 788 to 3,092 m (2,580-10,150 ft). Biological sampling was conducted at these stations between 1962 and 1969 using trawls, benthic skimmers, and camera lowering. The other major MMS study conducted throughout the northern GOM continental slope between 1983 and 1986 (Gallaway et al., 1988) included six stations located within the originally proposed area for Lease Sale 181 (out of the total of 60). Sampling for this study was multidisciplinary, ranging from box cores for sediment community biology and chemistry to trawling and photography for larger benthic animal forms (megafauna). All of the sample stations mentioned above are listed and shown in the Final EIS (USDOI, MMS, 2001a; Table III-4 and Figure III-5).

3.3.2.1. Chemosynthetic Communities

No chemosynthetic communities have been documented in the EPA sale area. The nearest documented community is approximately 25 mi (40 km) to the north-northwest of the northwest corner of the EPA sale area (USDOI, MMS, 2001a; Figure III-6). Chemosynthetic communities are discussed here because they have been identified in adjacent waters and because their occurrence in the EPA sale area is possible.

Chemosynthetic communities are remarkable in that they use a carbon source independent of photosynthesis and the sun-dependent photosynthetic food chain that supports all other life on earth. Although the process of chemosynthesis is entirely microbial, chemosynthetic bacteria and their primary production can support thriving assemblages of higher organisms through symbiosis. The fauna include tube worms, mussels, and rarely, vesicomyid clams. The occurrence of chemosynthetic organisms dependent on hydrocarbon seepage has been documented in water depths as shallow as 290 m (very small and unsubstantial; Roberts et al., 1990) and as deep as 2,200 m (MacDonald, 1992). This depth range specifically places chemosynthetic communities in the deepwater region of the GOM.

Four general chemosynthetic community types have been described by MacDonald et al. (1990). These are communities dominated by Vestimentiferan tubeworms (*Lamellibrachia* c.f. *barhami* and *Escarpia* n.sp. (taxonomy under investigation)), mytilid mussels (Seep Mytilid Ia, Ib, and III, and others), vesicomyid clams (*Vesicomya cordata* and *Calyptogena ponderosa*), and infaunal lucinid or thyasirid clams (*Lucinoma* sp. or *Thyasira* sp.). These faunal groups tend to display distinctive characteristics in terms of how they aggregate, the size of aggregations, the geological and chemical properties of the habitats in which they occur and, to some degree, the heterotrophic fauna that occur with them. Many of the species found at cold seep communities in the Gulf are new to science and remain undescribed. As an example, at least six different species of seep mussels have been collected, but none are yet described.

Individual lamellibranchid tube worms, the longer of two taxa found at seeps (the other is *Escarpi*-like sp.), can reach lengths of 3 m and live hundreds of years (Fisher et al., 1997). Growth rates determined from recovered marked tube worms have been variable, ranging from no growth of 13 individuals measured one year to a maximum growth of 20 mm per year in a Lamellibrachia individual. Average growth rate was 2.5 mm/yr for the escarpid-like tubeworms and 7.1 mm/yr for lamellibrachids. These are slower growth rates than their hydrothermal vent relatives, but lamellibrachs in the GOM can reach lengths that are 2-3 times that of the largest known hydrothermal vent species. Individuals of *Lamellibrachia* sp. in excess of 3 m have been collected on several occasions, representing probable ages in excess of 400 years (Fisher, 1995). Vestimentiferan tube-worm spawning is not seasonal and recruitment is episodic.

Growth rates for methanotrophic mussels at cold seep sites have recently been reported (Fisher, 1995). General growth rates were found to be relatively high. Adult mussel growth rates were similar to mussels from a littoral environment at similar temperatures. Fisher also found that juvenile mussels at hydrocarbon seeps initially grow rapidly, but the growth rate drops markedly in adults; they grow to reproductive size very quickly. Both individuals and communities appear to be very long lived. These methane-dependent mussels (Type Ia) have strict chemical requirements that tie them to areas of the most active seepage in the GOM. As a result of their rapid growth rates, mussel recolonization of a disturbed seep site could occur relatively rapidly. There is some early evidence that mussels also have some requirement of a hard substrate and could increase in numbers if suitable substrate is increased on the seafloor (Fisher, 1995).

Unlike mussel beds, chemosynthetic clam beds may persist as a visual surface phenomenon for an extended period without input of new living individuals due to low dissolution rates and low sedimentation rates. Most clam beds investigated by Powell (1995) were inactive. Living individuals were rarely encountered. Powell reported that over a 50-year time span, local extinctions and recolonizations should be gradual and exceedingly rare.

Extensive mats of free-living bacteria are also evident at hydrocarbon seep sites. These bacteria may compete with the major fauna for sulfide and methane sources and may also contribute substantially to overall production (MacDonald, 1998). The white "nonpigmented" mats were found to be an autotrophic sulfur bacteria *Beggiatoa sp.*, and the orange mats possessed an unidentified nonautotrophic metabolism (MacDonald, 1998). Autotrophic bacteria are able to manufacture nutrients from the environment.

Through taphonomic studies (death assemblages of shells) and interpretation of seep assemblage composition from cores, Powell (1995) reported that, overall, seep communities were persistent over periods of 500-1,000 years. Some sites retained optimal habitat over geological time scales. Powell reported evidence of mussel and clam communities persisting in the same sites for 500-4,000 years. Powell also found that both the composition of species and trophic tiering of hydrocarbon seep communities tend to be fairly constant across time, with temporal variations only in numerical abundance. He found few cases in which the community type changed (from mussel to clam communities, for example) or had disappeared completely. Faunal succession was not observed. Surprisingly, when recovery occurred after a past destructive event, the same chemosynthetic species reoccupied a site. There was little evidence of catastrophic burial events, but two instances were found in mussel communities in Green Canyon Block 234. The most notable observation reported by Powell (1995) was the nearly perpetual uniqueness of each chemosynthetic community site.

There is a clear relationship between known hydrocarbon discoveries at great depth on the Gulf slope and chemosynthetic communities, hydrocarbon seepage, and authigenic minerals including carbonates at the seafloor (Sassen et al., 1993; Roberts, in press). While the hydrocarbon reservoirs are broad areas several kilometers beneath the Gulf, chemosynthetic communities occur in isolated areas or thin veneers of sediment only a few meters thick. Hydrocarbon fluids and gasses from seeps tend to be diffused through the overlying sediment, so the corresponding hydrocarbon seep communities tend to be larger (a few hundred meters wide) than chemosynthetic communities found around the hydrothermal vents of the eastern Pacific (MacDonald, 1992). There are large differences in the concentrations of hydrocarbons at seep sites, and recent discoveries have determined that the flow rate and stability of seeps appear to have substantial influence on the conditions that allow high-density communities to become established. A wide spectrum of seepage or venting rates have been identified ranging from rapid venting resulting in mud volcanoes, generally unsuitable for community development, to slow seepage resulting in carbonate precipitation, which also inhibits substantial community development (Roberts and Carney, 1997; Roberts, in preparation). Intermediate seepage rates, typically associated with the presence of gas hydrates, appear to be correlated with most of the known high-density chemosynthetic community types (Roberts, in press).

The nearest known chemosynthetic community to the EPA sale area is located in Viosca Knoll Block 826 in water depths between 430 and 475 m approximately 25 mi (40 km) to the north-northwest of the northwestern corner of the EPA sale area. A large area of Viosca Knoll Block 826 (and parts of Viosca Knoll Blocks 825 and 870) have been well documented by ROV surveys performed in 1990 and reported by Oceaneering International, Inc. (1990) and Oceaneering and LGL (1991). Numerous areas of all three major types of chemosynthetic communities exist in the Viosca Knoll Block 826 including tubeworms, clams, and mussels. There are also substantial colonies of the deep-sea coral, *Lophelia*, attached to areas of carbonate outcroppings, presumably resulting from biogenic precipitation of hydrocarbon gas seeps in the past.

By extrapolating and using basic knowledge of geology of salt diapirism in the area, a relatively small part of the EPA sale area possesses the conditions to support high-density chemosynthetic communities. This area would consist of approximately 50 blocks with water depths between 500 and 2,000 m (1,650-6,550 ft). This area is possibly an extension of the geological structure seen in the Viosca Knoll area where the easternmost chemosynthetic community complex has been recognized.

Further descriptions of chemosynthetic communities, their distribution, stability and biologic elements may be found in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a; pages III-34 through III-41).

3.3.2.2. Other Benthic Communities

Chemosynthetic communities inhabit a tiny fraction of the available bottom area in the northern GOM. The vast areas of deepwater sea bottom that remain are coverd by hemipelagic clay and silt. In contrast to early theories of the deep sea, animal diversity, particularly the smaller forms living in bottom sediments, rivals that of the richest terrestrial environments such as rain forests. Other types of communities include the full spectrum of living organisms also found on the continental shelf or other areas of the marine environment. Major groups include bacteria and other microbenthos, meiofauna (0.063-0.3 mm) (organisms capable of living between sand grains), macrofauna (greater than 0.3 mm), and megafauna (larger organisms such as crabs, sea pens, crinoids, demersal fish). All of these groups are represented throughout the entire Gulf — from the continental shelf to the deepest abyss at about 3,850 m (12,630 ft). Enhanced densities of these heterotrophic communities (organisms that derive nourishment from organic substances) have been reported in association with chemosynthetic communities (Carney, 1993). Some of these heterotrophic communities found at and near seep sites are mixtures of species unique to seeps and those that are a normal component from the surrounding environment.

There are also rare examples of deepwater communities that would not be considered typical of the deep GOM continental slope. One example is represented by what was reported as a deepwater coral reef by Moore and Bullis (1960). In an area measuring 300 m (980 ft) in length and more than 37 km (23 mi) from the nearest known chemosynthetic community (Viosca Knoll Block 907), a trawl collected more than 136 kg (300 lb) of the scleractinian coral *Lophelia prolifera* from a depth of 421-512 m (1,380-1,679 ft). This type of unusual and unexpected community may exist in many other areas of the deep GOM.

Pequegnat (1983) first described qualitatively the numerous hypotheses of depth zonation patterns and aspects of faunal differences between the eastern and western GOM. The first major quantitative deepwater benthos study in the GOM was that of LGL Ecological Research Associates Inc. (Gallaway et al., 1988) as part of the MMS Northern Gulf of Mexico Continental Slope Study. This multiyear project is certainly the most comprehensive of all previous research in the GOM deep sea. Gallaway et al. (1988) reported that after their study, it was possible to predict with a reasonable degree of certainty the basic composition of the faunal communities on the northern GOM slope between 300 and 2,500 m water depth and between 85° and 94° W. longitude. This is approximately 75 percent of the northern Gulf slope area. There was a reasonable degree of agreement between the faunal distribution results of the LGL study (Gallaway et al., 1988) and Pequegnat (1983). Because the deep Gulf has only recently been investigated in any systematic way, a large number of species obtained during the LGL/MMS study were new to science.

Numerous stations from these two studies were located within the boundaries of the proposed action for Lease Sale 181 (USDOI, MMS, 2001a). Brief descriptions of each major group of benthic biological resources – bacteria, meiofauna, macrofauna, and megafauna – can be found in the Final EIS for Lease Sale 181 and the Final EIS for the 2003-2007 Central and Western Gulf Lease Sales (USDOI, MMS, 2002a).

3.3.3. Marine Mammals

Twenty-eight cetacean (whales and dolphins) and one sirenian (manatee) species have confirmed occurrences in the northern GOM (Table 3-2). Cetaceans are divided into two major suborders: Mysticeti (baleen whales) and Odontoceti (toothed whales). Of the seven baleen whale species occurring in the Gulf, five are listed as endangered or threatened. Of the 21 toothed whale species occurring in the Gulf, only the sperm whale is listed as endangered. The only member of the Order Sirenia found in the Gulf is the endangered West Indian manatee. During 1991-1994, MMS funded the first phase of the Gulf of Mexico Cetacean Program (GulfCet), which was jointly conducted by the Texas Institute of Oceanography, Texas A&M University, and NOAA Fisheries. GulfCet I consisted of aerial and shipboard surveys to determine the seasonal and geographic distribution of cetaceans along the continental slope in the north-central and western Gulf (Davis and Fargion, 1996; Davis et al., 1998). Additionally, acoustic recordings of shelf-edge and deepwater species were made. The GulfCet I study showed that several poorly known species are moderately common (beaked whales, pygmy and dwarf sperm whales, melon-headed whale, and Fraser's and Clymene dolphins). The GulfCet II Study (surveys conducted 1996-1997), administered by the U.S. Geological Survey, Biological Resources Division, continued work on patterns of distribution and abundance of Gulf cetaceans and identified possible associations between cetacean high-use habitats and the ocean environment (Davis et al., 2000). The Sperm Whale Acoustic and Monitoring Program (SWAMP) studies were conducted under an interagency agreement with the NOAA Fisheries during the summers of 2000 and 2001. An expanded sperm whale study, the Sperm Whale Seimic Study (SWSS), in conjunction with Texas Agriculture and Machinists

(A&M) Research Foundation, the Office of Naval Research (ONR) and the International Association of Geophysical Contractors (IAGC), completed the first field season in 2002.

Table 3-2

Marine Mammals of the Gulf of Mexico

Order Cetacea	Common Name
Suborder Mysticeti (baleen whales)	
Family Balaenidae	
Eubalaena glacialis	northern right whale*
Family Balaenopteridae	
Balaenoptera musculus	blue whale*
Balaenoptera physalus	fin whale*
Balaenoptera borealis	sei whale*
Balaenoptera edeni	Bryde's whale
Balaenoptera acutorostrata	minke whale
Megaptera novaeangliae	humpback whale*
Suborder Odontoceti (toothed whales)	
Family Physeteridae	
Physeter macrocephalus	sperm whale*
Kogia breviceps	pygmy sperm whale
Kogia simus	dwarf sperm whale
Family Ziphiidae	
Mesoplodon bidens	Sowerby's beaked whale
Mesoplodon densirostris	Blainville's beaked whale
Mesoplodon europaeus	Gervais' beaked whale
Ziphius cavirostris	Cuvier's beaked whale
Family Delphinidae	
Orcinus orca	killer whale
Pseudorca crassidens	false killer whale
Feresa attenuate	pygmy killer whale
Globicephala macrorhynchus	short-finned pilot whale
Grampus griseus	Risso's dolphin
Peponocephala electra	melon-headed whale
Tursiops truncates	Atlantic bottlenose dolphin
Steno bredanensis	rough-toothed dolphin
Stenella coeruleoalba	striped dolphin
Stenella attenuate	pantropical spotted dolphin
Stenella clymene	Clymene dolphin
Stenella frontalis	Atlantic spotted dolphin
Stenella longirostris	spinner dolphin
Lagenodelphis hosei	Fraser's dolphin
Order Sirenia	
Family Trichechidae	
Trichechus manatus	West Indian manatee*

* = endangered.

Source: Davis and Fargion, 1996.

Cetacean distribution in the Gulf is influenced by both bottom depth and by the presence of mesoscale hydrographic features (cold-core and warm-core rings and confluences). The GulfCet studies showed that cetaceans were concentrated along the upper continental slope in water depth from 200-1,000 m (650-3,280 ft) and sighted less often over the abyssal regions in water depths >2,000 m (6,560 ft). Cetaceans are observed frequently on the upper continental slope and tend to be associated with upwelling events, cyclones and the confluence between cyclone-anticyclone pairs. These hydrographic features concentrate zooplankton and micronekton biomass, and indicate richer concentrations of cetacean prey. Since cyclones in the northern Gulf are dynamic and usually associated with westward moving cyclone-anticyclone pairs, cetacean distribution will be dynamic. Bottlenose dolphins, Atlantic spotted dolphins, and possibly Bryde's whale, that typically occur on the continental shelf or along the shelf break, are outside of the major influences of eddies. Another preferential area for foraging is the area south of the mouth of the Mississippi River, which is a deepwater environment with locally enhanced primary and secondary productivity. It should be noted that for any given area in the offshore GOM, a characterization of marine mammals known to occur in that area is as much a function of survey effort as actual animal occurrences.

3.3.3.1. Nonendangered and Nonthreatened Species

Baleen Whales

Bryde's Whale

The Bryde's whale is the second smallest of the balaenopterid whales; it is found in tropical and warm temperate waters (Cummings, 1985). The Bryde's whale feeds upon small pelagic fishes and cephalopods. There are more records of Bryde's whale than of any other baleen whale species in the GOM. It is likely that the Gulf represents at least a portion of the range of a dispersed, resident population of Bryde's whale (Jefferson and Schiro, 1997). Bryde's whales in the Gulf, with few exceptions, have been sighted along a narrow corridor near the 100-m isobath (Davis and Fargion, 1996; Davis et al., 2000). Most sightings have been made in the DeSoto Canyon region and off western Florida, though there have been some in the west-central portion of the northeastern Gulf. Group sizes range from one to seven animals. Abundance estimates are 29 and 25 from ship and aerial surveys of the EPA slope, respectively, and 22 for the oceanic northern Gulf (Davis et al., 2000)

Minke Whale

The minke whale is the smallest of the rorquals. This species feeds on zooplankton and fish (Stewart and Leatherwood, 1985). The minke whale is widely distributed in tropical, temperate, and polar waters. At least three geographically isolated populations are recognized: North Pacific, North Atlantic, and Southern Hemisphere. The North Atlantic population migrates southward during winter months to the Florida Keys and the Caribbean Sea. Although there are 10 reliable records of minke whales in the GOM, all are strandings (Jefferson and Schiro, 1997). Most records from the Gulf have come from the Florida Keys, although strandings in western and northern Florida, Louisiana, and Texas have been reported (Jefferson and Schiro, 1997). These records may represent strays from low-latitude breeding grounds elsewhere in the western North Atlantic (Mitchell, 1991).

Toothed Whales

Kogia

Kogia (pygmy and dwarf sperm whales) are medium-sized toothed whales that feed on cephalopods and, less often, on deep-sea fishes and shrimps (Caldwell and Caldwell, 1989). Little is known of *Kogia* life history. A recent study of *Kogia* in South Africa has determined that these two species have a much earlier sexual maturity and shorter lifespan than other similarly sized toothed whales (Plön and Bernard, 1999). Dwarf and pygmy sperm whales are typically found in deeper waters (the continental shelf edge and beyond) and have small group sizes (2-10 individuals). *Kogia* has been found throughout the range of water depths and topographies in the Gulf (Mullin et al., 1991; Davis et al., 1998; Davis et al., 2000). The GulfCet I study found these animals in waters with a mean bottom depth of 929 m (Davis et al., 1998). Although *Kogia* have been sighted on the continental shelf at water depths less than 200 m (650 ft), there is no evidence that they are regular inhabitants of continental shelf waters. Data suggests that *Kogia* may associate with frontal regions along the shelf break and upper continental slope, areas with high epipelagic zooplankton biomass (Baumgartner, 1995). During the GulfCet II study, *Kogia* were widely distributed in the oceanic northern Gulf, including slope waters of the EPA. *Kogia* frequently strand on the coastline of the Gulf, more often in the eastern Gulf (Jefferson and Schiro, 1997). In a recent study using hematological and stable-isotope data, Barros et al. (1998) speculated that dwarf sperm whales have a more pelagic distribution than pygmy sperm whales and/or dive deeper during feeding bouts.

Dwarf and pygmy sperm whales are difficult to distinguish from one another, and sightings of either species are often categorized as *Kogia sp*. The difficulty in sighting pygmy and dwarf sperm whales is exacerbated by their avoidance reaction towards ships, and change in behavior towards approaching survey aircraft (Würsig et al., 1998). Combined estimated abundances are 66 and 188 from ship and aerial surveys of the EPA slope, respectively, and 733 for the oceanic northern Gulf (Davis et al., 2000).

Beaked Whales

There are four species of beaked whales known to occur in the Gulf, including Cuvier's beaked whale and three members of the genus *Mesoplodon* (Gervais', Blainville's, and Sowerby's beaked whales). Morphological similarities among species in the genus *Mesoplodon* make identification of free-ranging animals difficult. Life history data on these species are extremely limited. Observed group sizes of beaked whales are small (1-4 individuals) (Mullin et al., 1991; Davis and Fargion, 1996; Davis et al., 2000). In general, beaked whales are broadly distributed in waters over the lower slope and abyssal areas, with a bottom depth greater than 1,000 m in the oceanic northern Gulf (Davis et al., 1998; Davis et al., 2000). An analysis of stomach contents from captured and stranded individuals suggest that they are deep-diving animals, feeding predominantly on mesopelagic fish and squid or deepwater benthic invertebrates (Heyning, 1989; Mead, 1989). Abundance estimates are 0 and 59 from ship and aerial surveys of the EPA slope, respectively, and 150 for the oceanic northern Gulf (Davis et al., 2000). These estimates may also include an unknown number of Cuvier's beaked whales. Abundance estimates are 0 and 22 from ship and aerial surveys of the EPA slope, respectively, and 159 for the oceanic northern Gulf (Davis et al., 2000). The abundance of Gervais', Blainville's, or Sowerby's beaked whale cannot be estimated due to difficulty of species identification at sea.

The Cuvier's beaked whale is the most cosmopolitan of all the beaked whales (Heyning, 1989) and is probably the most common beaked whale in the Gulf (Jefferson and Schiro, 1997). The Gervais' beaked whale is probably the most common mesoplodont in the northern Gulf, as suggested by stranding records (Jefferson and Schiro, 1997). There are only three confirmed records of Blainville's beaked whale, plus one questionable record (Jefferson and Schiro, 1997). Additionally, one beaked whale sighted during GulfCet II was determined to be a Blainville's beaked whale (Davis et al., 2000). Sowerby's beaked whale is represented in the Gulf by only a single record, a stranding in Florida; this record is considered extralimital since this species normally occurs much farther north in the North Atlantic (Jefferson and Schiro, 1997).

Dolphins

All remaining species of nonendangered whales and dolphins found in the Gulf are members of the family Delphinidae. Most delphinids, with the exception of the bottlenose dolphin and the Atlantic spotted dolphin, inhabit deeper waters of the Gulf.

Bottlenose Dolphins

Bottlenose dolphins are the most common delphinid in the nearshore waters and outer edge of the continental shelf in the Gulf. There appears to be two ecotypes of bottlenose dolphins, a coastal form and an offshore form (Hersh and Duffield, 1990; Mead and Potter, 1990). The coastal or inshore stock(s) is genetically isolated from the offshore stock (Curry and Smith, 1997). Genetic data also support the concept of relatively discrete bay, sound, and estuary stocks (Waring et al., 1999). In the GOM, bottlenose dolphins appear to have an almost bimodal distribution: shallow water (16-67 m) and a shelf break (about 250 m) region. These regions may represent the individual depth preferences of the coastal and offshore forms (Baumgartner, 1995).

Little is known of the behavior or ranging patterns of offshore bottlenose dolphins. Recently, two bottlenose dolphins that had stranded in Florida were fitted with satellite transmitters; these animals exhibited much more mobility than has been previously documented for this species (Wells et al., 1999a). One dolphin was stranded in northwestern Florida and was released in the GOM off central-west Florida. This dolphin moved around Florida northward to off Cape Hatteras, North Carolina, linking two regions previously considered to be used by different continental shelf stocks. The second dolphin stranded off the Atlantic coast of Florida and moved into waters more than 5,000 m (16,400 ft) deep, much deeper than the previously held concept of bottlenose dolphin movements. This dolphin also traveled well outside of U.S. waters, which suggests the need for a different management approach than for dolphins remaining within U.S. waters. These records expand the range and known habitat for the bottlenose offshore stock inhabiting the waters off the southeastern U.S., and underscore the difficulties of defining pelagic stocks. Abundance estimates are 1,056 and 1,824 from ship and aerial surveys, respectively, of the shelf in the EPA (Davis et al., 2000). Abundance estimates are 1,025 and 3,959 from ship and aerial surveys, respectively, of the EPA slope, and 3,040 for the oceanic northern Gulf. Abundance estimates for various Gulf bays, sounds, and estuaries are found listed in Waring et al. (1999). Bottlenose dolphins are opportunistic feeders, taking a wide variety of fishes, cephalopods, and shrimp (Wells and Scott, 1999).

Atlantic Spotted Dolphin

The Atlantic spotted dolphin is the only species, other than the bottlenose dolphin, that commonly occurs over the continental shelf in the Gulf, typically inhabiting waters within the 250-m isobath (Mullin et al., 1991 and 1994a; Davis et al., 1998; Davis et al., 2000). This species appears to prefer shelf waters with a gently sloping bottom, although it may also occur along the shelf break and upper continental slope (Davis et al., 1998). Mills and Rademacher (1996) found the principal depth range of the Atlantic spotted dolphin to be much shallower at 15-100 m water depth. Griffin and Griffin (1999) found Atlantic spotted dolphins on the eastern Gulf continental shelf in waters greater than 20 m (30 km from the coast). A satellite-tagged Atlantic spotted dolphin was found to prefer shallow water habitat and make short dives (Davis et al., 1996). Atlantic spotted dolphins are sighted more frequently in areas east of the Mississippi River (Mills and Rademacher, 1996). Perrin et al. (1994a) relate accounts of brief aggregations of smaller groups of Atlantic spotted dolphins (forming a larger group) on the coast of northern Florida. Abundance estimates are 1,827 and 1,096 from ship and aerial surveys, respectively, of the EPA shelf (Davis et al., 2000). Abundance estimates are 1,055 and 1,800 from ship and aerial surveys, respectively, of the EPA slope, and 528 for the oceanic northern Gulf (Davis et al., 2000). This species feeds on small cephalopods, fish, and benthic invertebrates (Perrin et al., 1994a), and has been seen feeding in a coordinated manner on clupeid fishes in the northern Gulf (Fertl and Würsig, 1995).

Risso's Dolphin

The Risso's dolphin is an offshore, deepwater species that is distributed worldwide in tropical and warm temperate waters (Kruse et al., 1999). Risso's dolphins in the northern Gulf have been frequently sighted along the shelf edge, along the upper slope, and most commonly, over or near the 200-m water depth contour just south of the Mississippi River in recent years (Würsig et al., 2000). There is a strong correlation between Risso's dolphin distribution and the steeper portions of the upper continental slope, which correlates with the distribution of their chief food source, cephalopds (Baumgartner, 1997; Davis et al., 2000). Risso's dolphins have been sighted in continental shelf waters less than 200 m (Mullin et al., 1994a; Davis et al., 1998). Abundance estimates are 679 and 1,317 individuals from ship and aerial surveys, respectively, of the EPA slope and 3,040 individuals for the oceanic northern Gulf (Davis et al., 2000).

Melon-headed Whale

Melon-headed whales occur in tropical and subtropical waters throughout the world (Perryman et al., 1994). Melon-headed whales are known to feed on squid and small fish. The first two records of occurrence in the Gulf of this species are recent strandings, one in Texas in 1990, and the other in Louisiana in 1991 (Barron and Jefferson, 1993). GulfCet surveys have made many sightings of melon-headed whales, suggesting that this species is a regular inhabitant of the GOM (e.g., Mullin et al., 1994b). Most melon-headed whale sightings have been in deepwaters, well beyond the edge of the continental shelf (Mullin et al., 1994b; Davis and Fargion, 1996). Melon-headed whales have been sighted almost exclusively west of the Mississippi River (Mullin and Hansen, 1999). The abundance for the oceanic northern Gulf is estimated to be 1,734 individuals (Davis et al., 2000).

Pygmy Killer Whale

Pygmy killer whales occur in tropical and subtropical waters throughout the world (Ross and Leatherwood, 1994). This species eats mostly fish and squid, and occasionally attack other dolphins. Pygmy killer whales do not appear to be common in the Gulf; most records are of strandings (Jefferson and Schiro, 1997). Abundance estimates are 0 and 218 from ship and aerial surveys, respectively, of the EPA slope and 175 for the oceanic northern Gulf (Davis et al., 2000). Pygmy killer whales in the Gulf are generally found in water depths of 500-1,000 m (Davis and Fargion, 1996).

Killer Whale

Killer whales are found in all oceans and seas (Dahlheim and Heyning, 1999). Most killer whale sightings in the northern Gulf have been in offshore waters greater than 200 m deep, although there are other sightings from over the continental shelf (Davis and Fargion, 1996). Killer whales are found almost exclusively in a broad area of the north-central Gulf (Mullin and Hansen, 1999). There was a sighting in May 1998 of killer whales in DeSoto Canyon (Ortega, personal communication, 1998). Abundance estimates were 0 for both ship and aerial surveys for the EPA slope and 68 for the oceanic northern Gulf (Davis et al., 2000). Thirty-two individual killer whales have been photoidentified so far in the Gulf; some individuals have a wide temporal and spatial distribution (some with a linear distance of more than 1,100 km) (O'Sullivan and Mullin, 1997). It is not known whether killer whales in the Gulf stay within the confines of the Gulf or range more widely (Würsig et al., 2000). Worldwide, killer whales feed on fishes, elasmobranchs, cephalopods, seabirds, sea turtles, and other marine mammals. An attack by killer whales on a group of pantropical spotted dolphins was observed during one of the GulfCet surveys (O'Sullivan and Mullin, 1997).

Pantropical Spotted Dolphin

The pantropical spotted dolphin is distributed in tropical and subtropical waters worldwide (Perrin and Hohn, 1994). The pantropical spotted dolphin is the most common cetacean in the oceanic northern Gulf (Mullin et al., 1994a; Davis and Fargion, 1996; Davis et al., 2000). Pantropical spotted dolphins are typically found in waters deeper than 1,200 m (Mullin et al., 1994a; Davis et al., 1998), over the lower slope, and in abyssal areas (Davis et al., 2000), but they also have been sighted on the continental shelf (Mullin et al., 1994a). Baumgartner (1995) did not find that pantropical spotted dolphins had a preference for any one habitat. He suggested that this species might be able to use prey species in each distinct habitat (e.g., within the Loop Current, inside a cold-core eddy, or along the continental slope). This ability very well may contribute to this species' success and abundance in the northern Gulf. Abundance estimates are 7,432 and 13,649 from ship and aerial surveys, respectively, of the EPA slope and 46,625 for the oceanic northern Gulf (Davis et al., 2000). Pantropical spotted dolphins prey on epipelagic fish and squid.

Clymene Dolphin

The Clymene dolphin is a deepwater species endemic to tropical and subtropical waters of the Atlantic (Perrin and Mead, 1994). The rarity of Clymene dolphin records for the Gulf in the past was probably a result of this species' recently clarified taxonomic status and the tendency for observers to confuse it with other species (Jefferson and Schiro, 1997). The Clymene dolphin represents a significant component of the northern GOM cetacean population (Mullin et al., 1994c). Clymene dolphins are found widely distributed in the western and the northeastern Gulf slope waters (Davis et al., 2000). Clymene dolphins have been sighted in water depths from 612 to 1,979 m (2,000-6,500 ft) (Davis et al., 1998). The Clymene dolphin was shown to have a relationship with the depth of the 15°C isotherm, demonstrating a preference for waters where this isotherm shoals (most probably relating to productivity) (Baumgartner, 1995). Abundance estimates are 0 and 2,292 from ship and aerial surveys, respectively, of the EPA slope and 10,093 for the oceanic northern Gulf (Davis et al., 2000). Knowledge of feeding habits of this species is limited to stomach contents (small fish and squid) of two individuals and one observation of coordinated feeding on schooling fish in the northern Gulf (Perrin et al., 1981; Fertl et al., 1997, respectively).

Striped Dolphin

Striped dolphins occur in tropical and subtropical oceanic waters (Perrin et al., 1994b). Sightings in the Gulf occur primarily over the deeper waters off the continental shelf; striped dolphins have been sighted in waters with a bottom depth ranging from 570 to 1,997 m (1,870-6,550 ft) (Davis et al., 1998). Distribution of the striped dolphin was shown to have a relationship with the depth of the 15°C isotherm, demonstrating a preference for waters where this isotherm shoals (most probably relating to productivity) (Baumgartner, 1995). Abundance estimates are 416 and 2,198 from ship and aerial surveys, respectively, of the EPA slope and 4,381 for the oceanic northern Gulf (Davis et al., 2000). Striped dolphins feed primarily on small, mid-water squid and fish (especially lanternfish).

Spinner Dolphin

Spinner dolphins occur worldwide in tropical oceanic waters (Perrin and Gilpatrick, 1994). Sightings of spinner dolphins in the northern Gulf occur primarily over the deeper waters off the continental shelf with a bottom depth range of 526-1,776 m (1,725-5,825 ft) (Davis et al., 1998). Although sample sizes are small, most spinner dolphin sightings are east of the Mississippi River (Mullin and Hansen, 1999). Distribution of the spinner dolphin was shown to have a relationship with the depth of the 15°C isotherm, demonstrating a preference for waters where this isotherm shoals (most probably relating to productivity) (Baumgartner, 1995). Abundance estimates were 5,319 and 8,670 from ship and aerial surveys, respectively, of the EPA slope and 11,251 for the oceanic northern Gulf (Davis et al., 2000). Spinner dolphins feed on mid-water fish and squid.

Rough-toothed Dolphin

Rough-toothed dolphins are found in tropical to warm temperate waters globally (Miyazaki and Perrin, 1994). Sightings in the Gulf of this species occur primarily over the deeper waters (950-1,100 m) off the continental shelf (Mullin et al., 1994a; Davis et al., 1998). Most of the rough-toothed dolphin sightings have been west of the Mississippi River (Mullin and Hansen, 1999). A mass stranding of 62 rough-toothed dolphins occurred near Cape San Blas, Florida, on December 14, 1997. Four of the stranded dolphins were rehabilitated and released; three carried satellite-linked transmitters (Wells et al., 1999b). Water depth at tracking locations of these individuals averaged 195 m (640 ft). Data from the tracked individuals, plus additional sightings at Santa Rosa Beach on December 28-29, 1998 (Rhinehart et al., 1999) suggest a regular occurrence of this species in the northern Gulf, which was undocumented. Abundance estimates are 16 and 165 from ship and aerial surveys, respectively, of the EPA slope and 453 for the oceanic northern Gulf (Davis et al., 2000). This species feeds on cephalopods and fish.

Fraser's Dolphin

This is a tropical species (Perrin et al., 1994c), with few records from the Atlantic Ocean (Leatherwood et al., 1993). This species was previously known to the Gulf from only a mass stranding in the Florida Keys in 1981 (Hersh and Odell, 1986). GulfCet ship-based surveys led to sightings of two large herds (greater than 100 individuals) and first-time recordings of sounds produced by these animals (Leatherwood et al., 1993). The sightings in the northwestern part of the Gulf were in waters around 1,000 m (3,280 ft) deep (Davis and Fargion, 1996). From 1992 to 1996, there were at least three strandings in Florida and Texas (Würsig et al., 2000). The abundance for the EPA slope was estimated to be 942 (Davis et al., 2000). Fraser's dolphins feed on mid-water fish, squid, and crustaceans.

Short-finned Pilot Whale

Short-finned pilot whales are found in warm temperate to tropical waters of the world, generally in deep offshore areas (Bernard and Reilly, 1999). Based on historical records (mostly strandings), the short-finned pilot whale would be considered one of the most common offshore cetaceans in the Gulf (Jefferson and Schiro, 1997). However, the short-finned pilot whale has only occasionally been sighted during recent surveys in the northern Gulf. One potential explanation for the preponderance of pilot whales in the older records were misidentifications of other "blackfish" (e.g., false killer, killer, pygmy killer, and melon-headed whales) (Jefferson and Schiro, 1997). Short-finned pilot whales have been sighted almost exclusively west of the Mississippi River (Mullin and Hansen, 1999). There was one sighting of short-finned pilot whales in the EPA slope during GulfCet II, in the extreme western part of the study area (Davis et al., 2000). Short-finned pilot whales occur in the deeper slope waters with a mean bottom depth of 863 m (2,830 ft) (Davis et al., 1998). Abundance estimates are 0 and 160 from ship and aerial surveys, respectively, of the EPA slope and 1,471 for the oceanic northern Gulf (Davis et al., 2000). Squids are the predominant prey, with fish being taken occasionally.

False Killer Whale

False killer whales are found in deep offshore waters in tropical to warm temperate zones (Odell and McClune, 1999). Most sightings have been made in oceanic waters greater than 200 m deep, although there have been sightings from over the continental shelf (Davis and Fargion, 1996). Although sample sizes are small, most false killer whale sightings have been east of the Mississippi River (Mullin and Hansen, 1999). Abundance estimates are 311 and 150 from ship and aerial surveys, respectively, of the EPA slope and 817 for the oceanic northern Gulf (Davis et al., 2000). False killer whales primarily eat fish and cephalopods, but they have been known to attack other toothed whales.

3.3.3.2. Endangered and Threatened Species

There are five baleen (northern right, blue, fin, sei, and humpback) whale species, one toothed (sperm) whale species, and one sirenian (West Indian manatee) occurring in the GOM that are endangered. The sperm whale is common in the Gulf, while the baleen whales are considered uncommon.

Northern Right Whale

The northern right whale is one of the world's most endangered whales. It has a massive head that can be up to one-third of its body length (Jefferson et al., 1993). Right whales forage primarily on subsurface concentrations of calanoid copepods by skim feeding with their mouths agape (Watkins and Schevill, 1976). Northern right whales range from wintering and calving grounds in coastal waters of the southeastern U.S. to summer feeding, nursery, and mating grounds in New England waters and northward to the Bay of Fundy and the Scotian Shelf. Five major habitats or congregation areas have been identified for the western North Atlantic right whale: (1) southeastern U.S. coastal waters; (2) Great South Channel; (3) Cape Cod Bay; (4) Bay of Fundy; and (5) the Scotian Shelf. The distribution of approximately 85 percent of the winter population and 33 percent of the summer population is unknown. During the winter, a portion of the population moves from the summer foraging grounds to the calving/breeding grounds off Florida, Georgia, and South Carolina. Calves are produced off the coast of the southeastern U.S.

The coastal nature and slow swimming speed of the northern right whale makes it especially vulnerable to human activities (USDOC, NMFS, 1991). Based on a census of individual whales identified using photo-identification techniques, the western North Atlantic population size was estimated to be 295 individuals in 1992 (Waring et al., 1999). Confirmed historical records of northern right whales in the GOM consist of a single stranding in Texas (Schmidly et al., 1972) and a sighting off Sarasota County, Florida (Moore and Clark, 1963; Schmidly, 1981). The northern right whale is not a normal inhabitant of the GOM; existing records probably represent extralimital strays from the wintering grounds of this species off the southeastern U.S. from Georgia to northeastern Florida (Jefferson and Schiro, 1997).

Blue Whale

The blue whale is the largest animal known. Like all rorquals, the blue whale is slender and streamlined. The blue whale feeds almost exclusively on zooplankton via a combination of gulping and lunge-feeding in areas of heavy prey concentration (Yochem and Leatherwood, 1985). The blue whale occurs in all major oceans of the world; some blue whales are resident, some are migratory (Jefferson et al., 1993; USDOC, NMFS, 1998a). Those that migrate move poleward to feeding grounds in spring and summer, after wintering in subtropical and tropical waters (Yochem and Leatherwood, 1985). Records of the blue whale in the Gulf consist of two strandings on the Texas coast (Lowery, 1974). There appears to be little justification for considering the blue whale to be a regular inhabitant of the GOM (Jefferson and Schiro, 1997).

Fin Whale

The fin whale is the second largest rorqual. The fin whale has unusual head coloration; it is markedly asymmetric with the right lower jaw being largely white in contrast to the rest of the head, which is dark. Fin whales are active lunge feeders, taking small invertebrates, schooling fishes, and squid (Jefferson et al., 1993). Fin whales have a worldwide distribution and are most commonly sighted where deepwater approaches the coast (Jefferson et al., 1993). The fin whale makes regular seasonal migrations between temperate waters, where it mates and calves, and the more polar feeding grounds occupied in the summer months. Sightings in the Gulf have typically been made in deeper waters, more commonly in the north-central area (Mullin et al., 1991). There are seven reliable reports of fin whales in the Gulf, indicating that fin whales are not abundant in the GOM (Jefferson and Schiro, 1997). It is possible that the Gulf represents a portion of the range of a low latitude western Atlantic population; however, it is more likely that fin whales are extralimital to this area (Jefferson and Schiro, 1997).

Sei Whale

The sei whale is a medium-sized rorqual. Sei whales skim copepods and other small prey types, rather than lunging and gulping like other rorquals (Gambell, 1985). Sei whales are open ocean whales, not often seen close to shore (Jefferson et al., 1993). They occur from the tropics to polar zones, but are more restricted to mid-latitude temperate zones than are other rorquals (Jefferson et al., 1993). The sei whale is represented in the Gulf by only four reliable records (Jefferson and Schiro, 1997). One stranding was reported for the Florida Panhandle (Jefferson and Schiro, 1997). This species should be considered most likely to be of accidental occurrence in the Gulf, although it is worth noting that three of the four reliable records were from strandings in eastern Louisiana (Jefferson and Schiro, 1997).

Humpback Whale

The humpback whale is more robust in body than other balaenopterids. They have rounded heads and extremely long flippers that are often all or partly white. They occur in all oceans, feeding in higher latitudes during spring, summer, and autumn, and migrating to a winter range over shallow tropical banks, where they calve and presumably mate (Jefferson et al., 1993). Humpbacks are adaptable lunge feeders, using a variety of techniques to help concentrate krill and small schooling fish for easier feeding (Winn and Reichley, 1985). During summer, there are at least five geographically distinct humpback whale feeding aggregations occurring between latitudes 42° N. and 78° N. latitude; the western North Atlantic stock is considered to include all humpback whales (an estimated 5,450 individuals) from these five feeding areas. Humpback whales from all feeding areas migrate to the Caribbean in winter, where courtship, breeding, and calving occur, although some animals have been reported in the feeding regions during winter. There have been occasional reports of humpback whales in the northern Gulf in Florida waters: a confirmed sighting of a humpback whale in 1980 in the coastal waters off Pensacola (Weller et al., 1996); two questionable records of humpback whale sightings from 1952 and 1957 off the coast of Alabama (Weller et al., 1996); a stranding east of Destin, Florida, in mid-April 1998 (Mullin, personal communication, 1998); and a confirmed sighting of six humpback whales in May 1998 in DeSoto Canyon (Ortega, personal communication, 1998). It seems likely that some humpbacks stray into the GOM during the breeding season on their return migration northward. The time of the year (winter and spring) and the small size of the animals involved suggest that these sightings are inexperienced yearlings on their first return migration (Weller et al., 1996).

Sperm Whale

The sperm whale is the largest toothed whale. Large mesopelagic squid are the primary diet of sperm whales; other cephalopods, demersal fishes, and occasionally benthic invertebrates may also be eaten (Rice, 1989; Clarke, 1996). Sperm whales are distributed from the tropics to the pack-ice edges in both hemispheres, although generally only large males venture to the extreme northern and southern portions of their range (Jefferson et al., 1993). As a group, sperm whales seem to prefer certain areas within each major ocean basin, which historically have been termed "grounds" (Rice, 1989). As deep divers, sperm whales tend to inhabit oceanic waters, but they do come close to shore where submarine canyons or other physical features bring deepwater near the coast (Jefferson et al., 1993).

The sperm whale is the most abundant large cetacean in the GOM; it has been sighted on most surveys conducted in deeper waters (Fritts et al., 1983; Mullin et al., 1991; Davis and Fargion, 1996). Abundance estimates are 57 and 37 from ship and aerial surveys of the EPA slope, respectively, and 387 for the oceanic northern Gulf (Davis et al., 2000). Sperm whales are found primarily in deepwaters beyond the edge of the continental shelf, frequently along the lower slope (1,000-2,000 m water depth), although there are a few records from over the shelf (Collum and Fritts, 1985; Mullin et al., 1994a; Jefferson and Schiro, 1997). Sperm whales in the Gulf occur in waters with a mean bottom depth of 1,105 m (3,625 ft) (Davis et al., 1998).

Mesoscale patterns in the biological and physical environment are important in regulating sperm whale habitat usage (Griffin, 1999). Baumgartner (1995) noted that sperm whales avoided warm features characterized by a depressed 15°C isotherm and warm water at 100-m water depth; the highest sighting rates occurred in a cooler watermass characterized by intermediate to cool temperatures at 100 m and a moderately shallow 15°C isotherm. Sperm whales were found in waters with the steepest sea surface temperature gradient; sperm whales may forage along the thermal fronts associated with eddies (Davis et al., 1998). The GulfCet II study found that most sperm whales were concentrated along the slope in or near cyclones (Davis et al., 2000). Congregations of sperm whales are commonly seen off the shelf edge in the vicinity of the Mississippi River Delta (Mullin et al., 1994a; Davis and Fargion, 1996; Davis et al., 2000). Low-salinity, nutrient-rich water from the Mississippi River, which may contribute to enhanced primary and secondary productivity in the north-central Gulf, may explain the year-round presence of sperm whales south of the delta. Sperm whales have also been sighted with some regularity in the DeSoto Canyon in the northeastern Gulf. These observations have included very large male sperm whales. It is likely that there is a resident population of sperm whales in the Gulf (Jefferson and Schiro, 1997), consisting of females, calves, and immature whales (Davis and Fargion, 1996; Weller et al., 2000). Sperm whales in the Gulf are currently considered to be a separate stock from those in the Atlantic and Caribbean (Waring et al., 1997).

3.3.3.3. Cetacean Distribution within Offshore Waters of the Northern GOM

Factors influencing the spatial and temporal distribution and abundance of cetaceans may be environmental, biotic, or anthropogenic. Environmental factors encompass physiochemical, climatological, or geomorphological parameters. Biotic factors include the distribution and abundance of prey, inter- and intra-specific competition, reproduction, natural mortality, catastrophic events (e.g., die offs), and predation (Davis et al., 1998). Anthropogenic factors include historical hunting pressure (on some populations or species), pollution, habitat loss and degradation, vessel traffic, recreational and commercial fishing, oil and gas development and production, seismic exploration, and other manmade sources of noise in the sea.

Within the northern Gulf, many of the environmental and biotic factors influencing the distribution of cetaceans are affected by various hydrological circulation patterns. River discharge, wind stress, and the Loop Current generally drive these patterns. The major river system in this area is the Mississippi-Atchafalaya. Most of the river discharge into the northern Gulf is transported west and along the coast. Circulation on the continental shelf is largely wind-driven, with localized effects from freshwater (i.e., riverine) discharge. Beyond the shelf, the Loop Current in the eastern Gulf chiefly drives mesoscale circulation. Meanders of the Loop Current create warm-core anticyclonic eddies (anticyclones) once or twice annually that migrate westward. The anticyclones in turn spawn cold-core cyclonic eddies (cyclones). Together, anticyclones and cyclones govern the circulation of the continental slope in the central and western Gulf. The Loop Current and anticyclones are dynamic features that transport large quantities of high-salinity, nutrient-poor water across the near-surface waters of the northern Gulf. Cyclones, in contrast, contain high concentrations of nutrients and stimulate localized production. The combination of added nutrients into the northern Gulf from river outflow and mesoscale circulation features enhances productivity, and consequently the abundance of various species of fishes and cephalopods that cetaceans prey upon in the northern Gulf. The dynamics of these oceanographic features in turn affect the spatial and temporal distribution of prey species and ultimately influence cetacean diversity, abundance, and distribution (Mullin et al., 1994b; Davis et al., 2000).

Studies conducted during the GulfCet I program demonstrated a correlation of cetacean distribution patterns with certain geomorphic features such as seafloor depth or topographic relief. These studies suggested that seafloor depth was the most important variable in habitat partitioning among cetacean species in the northern Gulf (Baumgartner, 1995; Davis et al., 1998). For example, GulfCet I surveys, along with other surveys (such as the subsequent GulfCet II program) and opportunistic sightings of cetaceans within the U.S. GOM, found that only the Atlantic spotted dolphin and the coastal form of the bottlenose dolphin were common inhabitants of the continental shelf. The remaining species of cetaceans known to regularly occur in the Gulf (with possible exception of the Bryde's whale) were sighted on the continental slope (Mullin et al., 1994b; Jefferson, 1995; Davis et al., 1998 and 2000). During the GulfCet II program, the most commonly sighted cetaceans on the continental slope were bottlenose dolphins (pelagic form), pantropical spotted dolphins, Risso's dolphins, and dwarf/pygmy sperm whales. The most abundant species on the slope were pantropical spotted and spinner dolphins. Sperm whales sighted during GulfCet II surveys were found almost entirely in the north-central and northeastern Gulf, and near the 1,000-m (3,280-ft) isobath on the continental slope (Davis et al., 2000).

An objective of the GulfCet II program was to correlate a number of environmental parameters such as selected hydrographic features with cetacean sighting data in an effort to characterize cetacean habitats in the GOM (Davis et al., 2000). From GulfCet II surveys, sightings of cetaceans along the slope were concentrated in cyclones where production (in this case, measured chlorophyll concentration) was elevated; increased primary production within these cyclonic features enhances secondary production, including preferred prey items. Sightings of these oceanic species, however, were much less frequent in water depths greater than 2,000 m (6,562 ft) and in anticyclones. Sperm whales tended to occur along the mid-to-lower slope, near the mouth of the Mississippi River and, in some areas, in cyclones and zones of confluence between cyclones and anticyclones. From these data, it was suggested that the greater densities of cetaceans sighted along the continental slope, rather than abyssal areas, of the northern Gulf, probably result from localized conditions of enhanced productivity, especially along the upper slope, and as a result of the collisions of mesoscale eddies with the continental margin (Davis et al., 2000).

In the north-central Gulf, the relatively narrow continental shelf south of the Mississippi River Delta may be an additional factor affecting cetacean distribution, especially in the case of sperm whales (Davis et al., 2000). Outflow from the Mississippi River mouth transports large volumes of low salinity, nutrient-rich water southward across the continental shelf and over the slope. River outflow may also be entrained within the confluence of a cyclone-anticyclone eddy pair and transported beyond the continental slope. In either case, this input of nutrient-rich water leads to a localized deepwater environment with enhanced productivity and may explain the presence of a resident population of sperm whales within 50 km (31 mi) of the Mississippi River Delta in the vicinity of the Mississippi Canyon.

Temporal variability in the distribution of cetaceans in the northern GOM may also be dependent upon the extent of river discharge and the presence and dynamic nature of mesoscale hydrographic features such as cyclones. Consequently, the distribution of cetacean species will change in response to the movement of prey species associated with these hydrographic features. GulfCet I and II survey data determined that most cetacean species routinely or commonly sighted in the northern Gulf apparently occur in these waters throughout the year. However, seasonal abundance of certain species or species assemblages in slope waters may vary at least regionally (Baumgartner, 1995; Davis et al., 1998 and 2000).

3.3.3.4. West Indian Manatee

The West Indian manatee (*Trichechus manatus*) is the only sirenian known to occur in tropical and subtropical coastal waters of the southeastern U.S., GOM, Caribbean Sea, and the Atlantic coast of northern and northeastern South America (Reeves et al., 1992; Jefferson et al., 1993; O'Shea et al., 1995). There are two subspecies of the West Indian manatee: the Florida manatee *(T. m. latirostris*), which ranges from the northern GOM to Virginia; and the Antillean manatee *(T. m. manatus*), which ranges from northern Mexico to eastern Brazil, including the islands of the Caribbean Sea.

During warmer months, manatees are common along the west coast of Florida from the Everglades National Park northward to the Suwannee River in northwestern Florida and less common farther westward. In winter, the population moves southward to warmer waters. The winter range is restricted to smaller areas at the southern tip of Florida and to waters near localized warm-water sources, such as power plant outfalls and natural springs in west-central Florida. Crystal River, in Citrus County, is typically the northern limit of the manatee's winter range on the Gulf Coast. There are thirteen winter-aggregation sites on the Florida west coast for manatees (USDOI, FWS, 2001). The number of manatees, and probably the proportion of the manatee population, using localized warm-water refuges have increased appreciably (MMC, 1999). It is not known to what extent the increasing use of refuges in the Tampa Bay area is due to manatee population growth and/or redistribution of the manatees formerly wintering in southern Florida. Manatees are uncommon along the Florida Panhandle and are infrequently found (strandings and sightings) as far west as Louisiana and Texas (Powell and Rathbun, 1984; Rathbun et al., 1990; Schiro et al., 1998). Several sightings of two different animals were documented in the bays of the Texas Coastal Bend region (centered at Corpus Christi, Texas) during September and November 2001 (Beaver, personal communication, 2001).

Aerial surveys to estimate manatee populations are conducted during colder months when manatees aggregate at warm-water refuges in Florida. There are approximately 1,300 manatees on the Gulf Coast of Florida (Ackerman, personal communication, 1999). One manatee that died in Louisiana waters was determined to be from Tampa Bay, Florida. The manatees occasionally appearing in south Texas waters might be strays from Mexico rather than Florida (Powell and Rathbun, 1984). Manatees found in east Texas probably come from Florida.

Two important aspects of manatee physiology influence their behavior and distribution: nutrition and metabolism. Manatees are herbivores that feed opportunistically on a wide variety of submerged, floating, and emergent vegetation (USDOI, FWS, 2001b). Distribution of the manatee is limited to low-energy, inshore habitats supporting the growth of seagrasses (Hartman, 1979). Manatees have an unusually low metabolic rate and a high thermal conductance that leads to energetic stresses in winters, which are remedied by migration to warmer areas and aggregating in warm water refuges (Hartman, 1979; O'Shea et al., 1995; Deutsch et al., 1999). Manatees primarily use open coastal (shallow nearshore) areas, estuaries, and are also found far up freshwater tributaries. Shallow grass beds with access to deep channels are preferred feeding areas in coastal and riverine habitats (USDOI, FWS, 2001b). Manatees often use secluded canals, creeks, embayments, and lagoons, particularly near the mouths of coastal rivers and sloughs, for feeding, resting, mating, and calving (USDOI, FWS, 2001b). Natural and artificial freshwater areas are sought by manatees in estuarine and brackish areas (USDOI, FWS, 2001b) for drinking. Florida manatees can exist for some time without freshwater, but it is believed that they must have access to freshwater periodically to survive (Reynolds and Odell, 1991). It is important that adequate freshwater sources be a component of manatee conservation strategies. Manatee protection has focused on protecting essential manatee habitats (seagrass beds have declined in most parts of Florida), as well as reducing direct causes of mortality, injury, and disturbance caused by people.

Notwithstanding their association with coastal areas, a manatee was documented far offshore at several OCS work barges where it was grazing on algae growing on the vessel's sides and bottom (Valade, written communication, 2001). Multiple sightings of this animal occurred in October 2001 in water exceeding 1,500 m (5,000 ft) in depth in Mississippi Canyon Block 85, 130 mi east-southeast of Venice, Louisiana, and adjacent to the EPA sale area.

3.3.4. Sea Turtles

Endangered and Threatened Species

Five species of sea turtle are found in the waters of the GOM: Kemp's ridley, loggerhead, green, leatherback, and hawksbill. All are protected under the ESA; and all except the loggerhead turtle (threatened) are listed as endangered. Sea turtles spend nearly all of their lives in the water. Females must emerge periodically from the ocean to nest on beaches. Sea turtles are long-lived, slow-reproducing animals. It is generally believed that all sea turtle species spend the first few years of their lives in pelagic waters, occurring in driftlines and convergence zones (in sargassum rafts) where they find refuge and food in items that accumulate in surface circulation features (Carr, 1986 and 1987). Genetic analysis of sea turtles has revealed in recent years that discrete, non-interbreeding stocks of sea turtles make up "worldwide extensive ranges" of the various species.

Adult turtles in the Gulf are apparently less abundant in the deeper waters of the Gulf than they are in waters less than 27-50 m (80-160 ft) deep (NRC, 1990). More sea turtles are sighted in the northeastern Gulf than in the northwestern Gulf (Thompson, 1988). Sea turtle abundance in the Gulf appears to increase dramatically east of Mobile Bay (Davis et al., 2000). Factors such as water depth, bottom sediments, and prey availability may account for this. In the offshore Gulf, sea turtle distribution has been linked to zones of convergence.

Green

The green turtle (*Chelonia mydas*) is the largest hard-shelled sea turtle and commonly reaches 150 kg (330 lb) (USDOC, NMFS, 1990). The green turtle has a global distribution in tropical and subtropical waters.

Green turtles primarily occur in coastal waters, where they forage on seagrasses, algae, and associated organisms (Carr and Caldwell, 1956; Hendrickson, 1980). Some green turtles may move through a series of "developmental" feeding habitats as they grow (Hirth, 1997). Small pelagic sea turtles are omnivorous. Adult green turtles in the Caribbean and GOM are herbivores, feeding primarily on seagrasses and, to a lesser extent, on algae and sponges. Areas that are known as important feeding areas for green turtles in Florida include the Indian River, Florida Bay, Homosassa River, Crystal River, and Cedar Key (USDOC, NMFS, 1990). Green turtles in the Western Gulf are primarily restricted to the lower Texas coast where seagrass meadows and algae-laden jetties provide them developmental habitat, especially during warmer months (Landry and Costa, 1999).

Leatherback

The leatherback (*Dermochelys coriacea*) is the largest of the sea turtles and commonly reaches 200-700 kg (440-1,540 lb) (USDOC, NMFS, 1992). Leatherbacks have unique deep-diving abilities (Eckert et al., 1986), a specialized jellyfish diet (Brongersma, 1972), and unique physiological properties that distinguish them from other sea turtles (Lutcavage et al., 1990; Paladino et al., 1990). This species is the most pelagic and most wide-ranging of sea turtles, undertaking extensive migrations following depth contours for hundreds, even thousands, of kilometers (Morreale et al., 1996; Hughes et al., 1998).

The leatherback's distribution is not entirely oceanic. It is commonly found in relatively shallow continental shelf waters along the U.S. Atlantic Coast (Hoffman and Fritts, 1982; Knowlton and Weigle, 1989; Shoop and Kenney, 1992) and northern GOM (Leary, 1957; Fritts et al., 1983; Lohoefener et al. 1988, 1990; Collard, 1990; Davis et al., 2000). Based on a summary of several studies, Davis and Fargion (1996) concluded that primary habitat of the leatherback in the northwestern Gulf is oceanic (>200 m). In contrast, the overall densities of leatherbacks in the Eastern Gulf on the shelf and on the slope were similar (Davis et al., 2000). It has been suggested that the region from Mississippi Canyon east to DeSoto Canyon appears to be an important habitat for leatherbacks (Davis and Fargion, 1996). The majority of sightings of leatherbacks during the GulfCet surveys occurred just north of DeSoto Canyon (Davis and Fargion, 1996; Davis et al., 2000). The nearly disjunct summer and winter distributions of leatherback sightings on the slope in the Eastern Gulf during GulfCet II indicate that specific areas may be important to this species either seasonally or for short periods of time. These specific locations are most probably correlated with oceanographic conditions and resulting concentrations of prey. Large numbers of leatherbacks in waters off the northeast U.S. have been associated with concentrations of jellyfish (Shoop and Kenney, 1992). Other clusterings of leatherback sightings have been reported for the northern Gulf: 8 leatherbacks were sighted on one day in DeSoto Canyon (Davis and Fargion, 1996), 11 during one day just south of the Mississippi River Delta, and 14 during another day in DeSoto Canyon (Lohoefener et al., 1990).

Hawksbill

The hawksbill sea turtle (*Eretmochelys imbricate*) is a medium-sized sea turtle that can reach up to 80 kg (176 lb) (Hildebrand, 1982) (USDOC, NMFS, 1993). The hawksbill occurs in tropical and subtropical seas of the Atlantic, Pacific, and Indian Oceans. The species is widely distributed in the Caribbean Sea and western Atlantic Ocean. In the continental U.S., the species is recorded from all the Gulf States and from along the eastern seaboard as far north as Massachusetts, with the exception of Connecticut; however, sightings north of Florida are rare (USDOC, NMFS, 1993). Stranded hawksbills have been reported in Texas (Hildebrand, 1982; Amos, 1989) and in Louisiana (Koike, 1996); these tend to be either hatchlings or yearlings. They have been reported accidentally caught in a purse seine net offshore of Louisiana (Rester and Condrey, 1996). Texas and Florida are the only states where hawksbills are sighted with any regularity (USDOC, NMFS, 1993).

Kemp's Ridley

The Kemp's ridley (*Lepidochelys kempi*) is the smallest sea turtle and the most imperiled, generally weighing less than 45 kg (100 lb). The GOM's population of nesting females has dwindled from an estimated 47,000 in 1947 to a current nesting population of approximately 1,500 females (Byles et al., 1996). The population crash that occurred between 1947 and the early 1970's may have been the result of both intensive annual harvest of the eggs and mortality of juveniles and adults in trawl fisheries (NRC, 1990). The recovery of the species has been forestalled primarily by incidental mortality in commercial shrimping, preventing adequate recruitment into the breeding population (USDOI, FWS 1992; USDOC, NMFS, 1992).

There is little prolonged utilization of offshore habitats by this species. Hatchlings appear to disperse offshore and are sometimes found in sargassum mats (Collard and Ogren, 1990). Two juvenile Kemp's ridleys were found drifting in sargassum: one was found 4.6 km (25 nmi) south of Mobile, Alabama; the other 2.5 nmi off Horseshoe and Pepperfish Keys on the north-central Gulf Coast of Florida (Manzella et al., 1991). In the pelagic stage, the turtle is dependent on currents, fronts, and gyres to determine their distribution. In the Gulf, Kemp's ridleys inhabit nearshore areas, being most abundant in coastal waters from Texas to west Florida (Ogren, 1989; Marquez, 1990 and 1994; Rudloe et al., 1991). Kemp's ridleys display strong seasonal fidelity to tidal passes and adjacent beachfront environs of the northern Gulf (Landry and Costa, 1999).

Loggerhead

The loggerhead sea turtle (*Caretta caretta*), reaching 110 kg (250 lb), is the most common sea turtle species in the northern Gulf (e.g., Fritts et al., 1983; Fuller and Tappan, 1986; Rosman et al., 1987; Lohoefener et al., 1990) and the most abundant species of sea turtle occurring in U.S. waters. The loggerhead occurs throughout the inner continental shelf from Florida through Cape Cod, Massachusetts.

Juvenile and subadult loggerheads are omnivorous, foraging on pelagic crabs, molluscs, jellyfish, and vegetation captured at or near the surface (Dodd, 1988; Plotkin et al., 1993). Adult loggerheads are generalist carnivores that forage on nearshore benthic invertebrates (Dodd, 1988). The banks off the central Louisiana coast and near the Mississippi Delta are also important sea turtle feeding areas (Hildebrand, 1982).

Aerial surveys indicate that loggerheads are largely distributed in water depths less than 100 m (Shoop et al., 1981; Fritts et al., 1983). Loggerheads were sighted throughout the northern Gulf continental shelf, near the 100-m isobath (>100 m), during GulfCet aerial surveys (Davis et al., 2000) and also in deepwater (>1,000 m). Loggerhead abundance in slope waters of the eastern Gulf increased appreciably during winter (Davis et al., 2000). It is not clear why adult loggerheads would occur in oceanic waters, unless they were traveling between foraging sites in distant and separate areas on the continental shelf or seeking warmer waters during winter (Davis et al., 2000). Loggerheads have been found to be abundant in Florida waters (Fritts and Reynolds, 1981; Fritts et al., 1983; Davis et al., 2000). Census dives made near artificial reefs and a sunken offshore platform near Panama City, Florida, noted 17 sightings of sea turtles; all turtles sighted were loggerheads (Rosman et al., 1987). In the Central Gulf, loggerheads are very abundant just offshore of Breton and Chandeleur Islands (Lohoefener et al., 1990).

3.3.5. Coastal and Marine Birds

The analysis in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a; Figure III-7) provides an analysis of the proportion of the shoreline in the EPA sale area that functions as bird habitat and as nesting area. This analysis included the aquatic birds that could be contacted by an oil spill associated with exploratory drilling in the area offered for lease in Sale 181. Analysis of impacts of spilled oil from OCS Program activities was aided by quantifying coastal bird distributions and abundances within shoreline segments between the state of Mississippi and Sarasota Bay, Florida (USDOI, MMS, 2001a; Figure III-7) and proportions of usage by each major class of nonendangered and nonthreatened bird (diving, passerine, pelagic, raptor, shorebird, wading bird, waterfowl and gulls and their allies) and by individual endangered or threatened birds or species of concern (piping plover, snowy plover, bald eagle, and brown pelican). Next, proportions of coastal usage by each type of bird were estimated for each of the segments. Ranges from the segment with highest proportion to the segment with lowest proportion were listed for each type of bird in Table III-7 of the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a). Habitat and nesting data for the Louisiana coastline are not yet available.

3.3.5.1. Nonendangered and Nonthreatened Species

The offshore waters, coastal beaches, and contiguous wetlands of the northeastern GOM are populated by both resident and migratory species of coastal and marine birds. This analysis assumes five major groups in the area of concern: seabirds, shorebirds, marsh and wading birds, waterfowl, and raptors. Many species are mostly pelagic and, therefore, are rarely sighted nearshore. Fidelity to nesting sites varies from year to year along the Gulf Coast (Martin and Lester, 1991). Birds may abandon sites along the northern Gulf Coast because of altered habitat and excessive human disturbance.

Seabirds

Seabirds are a diverse group of birds that spend much of their lives on or over saltwater (Table 3-3). Species diversity and overall abundance is highest in the spring and summer and lowest in the fall and winter. Four ecological categories of seabirds have been documented in the deepwater areas of the Gulf: summer migrants (e.g., shearwaters, storm petrels and boobies), summer residents that breed in the Gulf (e.g., sooty, least, and sandwich tern, and frigate birds), winter residents (e.g., gannets, gulls, and jaegers), and permanent resident species (e.g., laughing gulls and royal and bridled terns) (Hess and Ribic, 2000; USDOI, MMS, 2001a) Collectively, they live far from land most of the year, roosting on the water surface, except at breeding time when they return to nesting areas along coastlines (Terres, 1991). Seabirds typically aggregate in social groups called colonies; the degree of colony formation varies between species (Parnell et al., 1988). They also tend to associate with various oceanic conditions including specific sea-surface temperatures, salinities, areas of high planktonic productivity, or current activity. Seabirds obtain their food from the sea with a variety of behaviors including piracy, scavenging, dipping, plunging, and surface seizing.

Table 3-3

Common Seabirds of the Northern Gulf of Mexico

Common Name	Scientific Name	Occurrence*	Feeding Behavior and Diet
Wilson's storm-petrel	*Oceanites oceanicus*	Summer resident	Picks crustaceans, fish, and squid from the sea surface
Magnificent frigatebird	*Fregata magnificens*	Summer resident	Dives to pluck jellyfish, fish, and crustaceans from the sea surface
Northern gannet	*Morus bassanus*	Wintering resident	Fish and squid
Masked booby	*Sula dactylatra*	Wintering resident	Plunge dives for flying fishes and small squid
Brown booby	*Sula leucogaster*	Wintering resident	Prefers to perch; comes ashore at night to roost
Cory’s shearwater	*Calonectris diomedea*	Summer resident	Feeds at the water surface at night on crustaceans and large squid
Greater shearwater	*Puffinus gravis*	Summer resident	Dives to catch fish
Adubon shearwater	*Puffinus lherminieri*	Summer resident	Dives to catch fish, squid, and other organisms

*All major seabirds are distributed Gulfwide.

Shorebirds

Shorebirds are those members of the order Charadriiformes generally restricted to coastline margins (beaches, mudflats, etc.). Gulf of Mexico shorebirds comprise five taxonomic families — Jacanidae (jacanas), Haematopodidae (oystercatchers), Recurvirostridae (stilts and avocets), Charadriidae (plovers), and Scolopacidae (sandpipers, snipes, and allies) (Hayman et al., 1986). An important characteristic of almost all shorebird species is their strongly developed migratory behavior, with some shorebirds migrating from nesting places in the far north to the southern part of South America (Terres, 1991). Both spring and fall migrations take place in a series of "hops" to staging areas where birds spend time feeding heavily to store up fat for the sustained flight to the next staging area; many coastal habitats along the GOM are critical for such purposes. Along the Gulf Coast, observers have recorded 44 species of shorebirds. Six species nest in the area; the remaining species are wintering residents and/or "staging" transients (Pashley, 1991). Although variations occur between species, most shorebirds begin breeding at 1-2 years of age and generally lay 3-4 eggs per year. They feed on a variety of marine and freshwater invertebrates and fish, and small amounts of plant life.

Marsh and Wading Birds

Wading birds have long legs that allow them to forage by wading into shallow water, while they use their usually long necks and long bills to probe under water or to make long swift strokes to seize fish, frogs, aquatic insects, crustaceans, and other prey (Terres, 1991) (Table 3-4). These families have representatives in the northern Gulf: Ardeidae (herons, bitterns, and egrets), Ciconiidae (storks), Threskiornithidae (ibises and spoonbills), Gruidae (crane), and Rallidae (rails, moorhens, gallinules, and coots).

"Wading birds" is a collective term referring to birds that have adapted to living in marshes and shallow water. Seventeen species of wading birds in the Order Ciconiiformes currently nest in the U.S., and all except the wood stork nest in the northern Gulf coastal region (Martin, 1991). Louisiana supports the majority of nesting wading birds. Great egrets are the most widespread nesting species in the Gulf region; they often occupy urban canals (Martin, 1991). Members of the Rallidae family are elusive marsh birds, rarely seen within the low vegetation of fresh and saline marshes, swamps, and rice fields (Bent, 1926; National Geographic Society, 1983; Ripley and Beehler, 1985).

Waterfowl

Waterfowl belong to the taxonomic order Anseriformes and include swans, geese, and ducks. A total of 27 species are regularly reported along the north-central and western Gulf Coast (Table 3-5). Among these are 1 swan, 4 geese, 7 surface-feeding (dabbling) ducks and teal, 4 diving ducks (pochards), and 11 others (including the wood duck, wistling duck, sea ducks, ruddy duck, and mergansers) (Clapp et al., 1982; National Geographic Society, 1983; Madge and Burn, 1988). Many species usually migrate from wintering grounds along the Gulf Coast to summer nesting grounds in the northern U.S. Waterfowl migration pathways have traditionally been divided into four parallel north-south paths, or "flyways," across the North American continent. The Gulf Coast serves as the southern terminus of the Mississippi (Louisiana, Mississippi, and Alabama) flyway. Waterfowl are social and have a diverse array of feeding adaptations related to their habitat (Johnsgard, 1975).

Raptors

The American peregrine falcon was removed from the endangered species list on August 20, 1999. Although the final determination to delist removes the American peregrine falcon from ESA protection, the species is still protected under the Migratory Bird Treaty Act. The FWS will continue to monitor the falcon's status for 13 years to ensure that recovery is established.

Diving Birds

There are three main groups of diving birds, respectively: cormorants and anhingas, loons, and grebes (Table 3-6). Of the two pelican species in North America, only the brown pelican is listed as endangered.

Table 3-4

Common Marsh or Wading Birds in the Northern Gulf of Mexico

Common Name	Scientific Name	Occurrence*	Feeding Behavior and Diet
American bittern	*Botaurus lentiginosus*	*	Amphibians, small fish, small snakes, crayfish, small rodents, and water bugs
Least bittern	*Ixobrychus exilus*	Summer resident	NA
Great blue heron	*Ardea herodias*	*	Various aquatic animals
Great egret	*Casmerodias albus*	*	Fish, frogs, snakes, crayfish, and large insects
Snowy egret	*Egretta thula*	*	Arthropods, fish
Little blue heron	*Egretta caerulea*	*	Small vertebrates, crustaceans, and large insects
Tricolored heron	*Egretta tricolor*	*	NA
Reddish egret	*Egretta rufescens*	Pan-Gulf except for central and eastern FL Panhandle	NA
Cattle egret	*Bulbulcus ibis*	*	NA
Green-backed heron	*Butorides striatus*	Permanent resident in central LA and eastward; summer resident, TX and western LA	NA
Black-crowned night heron	*Nycticorax nicticorax*	*	NA
Yellow-crowned night heron	*Nyctanassa biolacea*	Permanent resident TX, eastern LA, MS, AL, and eastern FL Panhandle	Aquatic organisms, especially crustaceans
White ibis	*Eudocimus albus*	*	NA
Glossy ibis	*Plegadis falconellus*	*	Snakes, crayfish, and crabs
White-faced ibis	*Plegadis chini*	Permanent resident in TX and western and central LA; Summer resident in eastern LA	NA
Roseate spoonbill	*Ajaia ajaja*	Permanent resident; summer resident in LA	NA

*All wading birds are permanent residents Gulfwide unless otherwise indicated.
NA = Not available.

Table 3-5

Common Waterfowl in the Northern Gulf of Mexico

Common Name	Scientific Name	Occurrence*	Feeding Behavior and Diet
Wood duck	*Aix sponsa*	Year-round	Dabbler; eats plants, invertebrates, tadpoles, and salamanders
Canvasback duck	*Aythya valisineria*	Year-round	Diver; feeds on molluscs and aquatic plants
Redhead duck	*Aythya americana*	*	Diver; mostly herbivorous
Ring-necked duck	*Aythya collaris*	*	Diver
Fulvous whistling duck	*Dendrocygna bicolor*	Nests in TX, LA	Feeds nocturnally on plant seeds on shore
Lesser scaup	*Aythya affinis*	High abundance	Diver; feeds on plants and animals
Greater scaup	*Aythya maarila*	*	Feeds on plants, insects, and invertebrates in nesting season; diet at sea in winter is mostly molluscs and plants
Black scoter	*Melanitta nigra*	Low abundance	Diver; feeds mostly on molluscs
White-winged scoter	*Melanitta fusca*	TX, LA, AL; low abundance	Diver; feeds mostly on shellfish
Surf scoter	*Melanitta perspicilla*	Low abundance	Diver; feeds mostly on molluscs and crustaceans
Common goldeneye	*Bucephala clangula*	*	Diver; needs on molluscs, crustaceans, insects, and aquatic plants
Bufflehead	*Bucephala albeola*	*	Diver; in fresh water, eats aquatic adult and larval insects, snails, small fish, and aquatic plant seeds; in salt water, eats crustaceans, shellfish, and snails
Common merganser	*Mergus merganser*	*	Diver; feeds on molluscs, crustaceans, aquatic insects, and some plants
Red-breasted merganser	*Mergus serrator*	*	Eats mostly fish
Hooded merganser	*Lophodytes cucullatus*	*	Diver; thin serrated bill is adapted to taking fish; also feeds on crustaceans, aquatic insects, other animals, and plants
Tundra swan	*Cygnus columbianus*	Winters on Atlantic Coast, minor presence in Gulf	NA
Greater white-fronted goose	*Answer albifrons*	TX, LA, AL	Feeds on plants and insects
Snow goose	*Chen caerulescens*	TX, LA, MS, AL	Dabbler, grazer, herbivore
Canada goose	*Branta canadensis*	*	Dabbler; herbivore
Brant goose	*Branta bernicla*	FL	Herbivore
Mallard duck	*Anas platyrhynchos*	*	Dabbler; usually a herbivore; female supplements diet with invertebrate protein source when producing eggs
Mottled duck	*Anas fulvigula*	TX, LA year-round	Dabbler; invertebrates and some plant material
American widgeon duck	*Anas americana*	*	Dabbler; may feed on widgeon grass (*Ruppia maritima*)
Northern pintail duck	*Anas acuta*	Abundant in TX	Dabbler mostly herbivorous
Northern shoveler duck	*Anas clypeata*	*	Dabbler; strains food through combs of teeth that are found inside the bill on each side
Blue-winged teal duck	*Anas discors*	*	Dabbler; mostly hebivorous
Cinnamon teal duck	*Anas cyanoptera*	TX, west LA	Dabbler; eats invertebrates, plant seeds, and algae; sometimes skims water surface with bill
Gadwall duck	*Anas strepera*	*	Dabbler; mostly herbivorous
Ruddy duck	*Oxyura jamaicensis*	*	Diver; mostly herbivorous

*All waterfowl are wintering residents Gulf-wide unless otherwise indicated.
NA = Not available.

Table 3-6

Common Diving Birds in the Northern Gulf of Mexico

Common Name	Scientific Name	Occurrence*	Feeding Behavior and Diet
Common loon	*Gavia immer*	Wintering resident	Dives from surface for fish, arthropods, snails, leeches, frogs, and salamanders
Horned grebe	*Podiceps auritus*	Wintering resident	Fish and some arthropods
Eared grebe	*Podiceps nigricollis*	TX, LA, MS, AL	Arthropods
Pied-billed grebe	*Podilymbus podiceps*	Permanent resident	Arthropods, small fish
Anhinga	*Anhinga anhinga*	Permanent resident	Swims underwater for fish, frogs, snakes, and leeches
Olivaceous cormorant	*Phalacrocorax olivaceus*	*	NA
Double-crested cormorant	*Phylacrocorax auritus*	Permanent resident	NA

*All of these diving birds are distributed Gulfwide except where otherwise indicated.
NA = Not available.

3.3.5.2. Endangered and Threatened Species

The following coastal and marine bird species that inhabit or frequent the northern GOM coastal areas are recognized by FWS as either endangered or threatened: piping plover, southeastern snowy plover, least tern, bald eagle, and brown pelican. The southeastern snowy plover is a species of concern to the State of Florida.

Piping Plover

The piping plover (*Charadrius melodus*) is a migratory shorebird that is native to North America. It breeds on the northern Great Plains (especially in open flats along the Missouri River), in the Great Lakes, and along the Atlantic Coast (Newfoundland to North Carolina). It winters on the Atlantic and Gulf Coasts from North Carolina to Mexico and in the Bahamas West Indies. Hypothetically, plovers may have a preferred prey base and/or the substrate coloration provides protection from aerial predators due to camouflage by color matching in specific wintering habitat. Such areas include coastal sand flats and mud flats in proximity to large inlets or passes, which may attract the largest concentrations of piping plovers (Nicholls and Baldassarre, 1990). Similarly, nesting habitat in the north includes open flats. This species remains in a precarious state given its low population numbers, sparse distribution, and continued threats to habitat throughout its range.

On July 6, 2000, the FWS proposed critical habitat for the wintering population of piping plover in 146 areas along approximately 2,700 mi of the coast of North Carolina, South Carolina, Georgia, Florida, Alabama, Louisiana, and Texas. Critical habitat identifies specific areas that are essential to the conservation of a listed species and that may require special management consideration or protection. The primary constituent needs for the piping plover are those habitat components that are essential for the primary biological needs of foraging, sheltering, and roosting.

Southeastern Snowy Plover

The following account of the southeastern snowy plover (*Charadrius alexandrius tenuirostris*) is taken from Gore and Chase (1989). In the area of the proposed action, the species nests on coastal sand beaches and interior flats. Observed nest sites in the Florida Panhandle ranged from the Florida-Alabama border eastward beyond Little St. George. Southward within the area of the proposed action, nesting is scattered in Pasco County and also in Hillsborough County in the Tampa Bay area. At some locations more than 1.5 breeding pairs per kilometer were counted. Most nests are near the front dune and close to vegetation. High nest counts occur in restricted coastline areas controlled by Eglin Air Force Base because vehicle and human traffic is not permitted.

Least Tern

The least tern is not considered federally endangered or threatened within 50 mi of the Gulf (Patrick, personal communication, 1997). Only the interior nesting colonies are endangered.

Bald Eagle

In July 1995, the FWS reclassified the bald eagle from endangered to threatened in the lower 48 states (*Federal Register*, 1995b). The bald eagle (*Haliaeetus leucocephalus*) is the only species of sea eagle that regularly occurs on the North American continent (USDOI, FWS, 1984). Its range extends from central Alaska and Canada to northern Mexico. The bulk of the bald eagle's diet is fish, though bald eagles will opportunistically take birds, reptiles, and mammals (USDOI, FWS, 1984). The general tendency is for winter breeding in the South with a progressive shift toward spring breeding in northern locations. In the Southeast, nesting begins in early September; egg laying begins as early as late October and peaks in late December. The historical nesting range of the bald eagle within the southeastern U.S. included the entire coastal plain and shores of major rivers and lakes. There are certain general elements that seem to be consistent among nest site selection. These include (1) the proximity of water (usually within ½ mi) and a clear flight path to a close point on the water, (2) the largest living tree in a span, and (3) an open view of the surrounding area. The proximity of good perching trees may also be a factor in site selection. Bald eagles may not use an otherwise suitable site if there is excessive human activity in the area. The current range is limited, with most breeding pairs occurring in peninsular Florida and Louisiana, and some in South Carolina, Alabama, and east Texas. Sporadic breeding takes place in the rest of the southeastern states. A total of 120 nests have been found in Louisiana, but only 3 nests occurred within 5 mi of the coast (Patrick, personal communication, 1997).

Brown Pelican

The brown pelican remains endangered (*Federal Register*, 1985) in Louisiana and Mississippi, where it inhabits the coastal areas. It is not Federally listed in Florida, rather it is a State species of special concern. The brown pelican (*Pelicanus occidentalis*) is one of two pelican species in North America. It feeds entirely upon fishes captured by plunge diving in coastal waters. Organochlorine pesticide pollution apparently contributed to the endangerment of the brown pelican. In recent years, there has been a marked increase in brown pelican populations along its entire former range. The population of brown pelicans and their habitat in Alabama, Florida, Georgia, North and South Carolina, and points northward along the Atlantic Coast were removed from the endangered species list in 1985.

The Louisiana Department of Wildlife and Fisheries submitted a request to the FWS in March 1994 to officially remove the brown pelican from the endangered species list in Louisiana (Louisiana Dept. of Wildlife and Fisheries, 1994). Ten thousand nests and an estimated 25,000 adults were found in Louisiana (Patrick, personal communication, 1997).

3.3.6. Fisheries

3.3.6.1. Fish Resources

Ichthyoplankton

Most fishes inhabiting the GOM, whether benthic or pelagic as adults, have pelagic larval stages. Wide-ranging epipelagic species such as skipjack tuna (*Euthynnus pelamis*), sailfish (*Istiophorus platypterus*), and Atlantic swordfish (*Xiphias gladius*) were collected only in water depths exceeding 150 m (492 ft). Species such as Atlantic croaker, spot, and Gulf menhaden migrate to the outer shelf during winter months to spawn. Consequently, larvae of these species are often numerically dominant during winter months. Larvae of families such as anchovies (Engraulidae), searobins (Triglidae), tonguefishes (Cygnoglossidae), and pufferfishes (Tetradontidae) were collected during all months.

For various lengths of time (10-100 days depending on the species), the pelagic eggs and larvae of these and other deepwater species become part of the planktonic community. Variability in survival and transport of pelagic larval stages is thought to be an important determinant of future year-class strength in adult populations of fishes and invertebrates (Underwood and Fairweather, 1989; Doherty and Fowler, 1994). For this reason, larval fishes and the physical and biological factors that influence their distribution and abundance have received increasing attention from marine ecologists. In general, the distribution of fish larvae depends on spawning behavior of adults, hydrographic structure at a variety of scales, duration of the pelagic period, behavior of larvae, and larval mortality and growth (Leis, 1991).

Richards (1990) estimates that there are 200 families with more than 1,700 species whose early life stages may occur in the GOM. In addition to the resident fauna, many eggs, larvae, and juveniles may be advected into the Gulf from the Caribbean Sea via the Loop Current. In their study of the Loop Current front, Richards et al. (1993) identified 237 taxa representing 100 families. They considered this a remarkable family-level diversity when compared with previous surveys made in the GOM and other oceans. The diversity was attributed to a mix of fauna from tropical and warm temperate oceanic, mesopelagic, and coastal demersal and pelagic species. The larval sampling surveys by Houde et al. (1979) yielded over 200 taxa from 91 families in the Eastern GOM. Ditty et al. (1988) summarized information from over 80 ichthyoplankton studies from the northern GOM (north of 26ºN. latitude) and reported 200 coastal and oceanic fishes from 61 families. Preliminary Southeastern Area Monitoring and Assessment Program (SEAMAP) cruises collected 137 genera and species from 91 families (Sherman et al., 1983). The most abundant families collected in the Eastern Gulf by Houde et al. (1979) were clupeids (herrings), gobiids (gobies), bregmacerotids (codlets), carangids (jacks), synodontids (lizardfishes), myctophids (lanternfishes), serranids (seabasses), ophidiids (cusk eels), and labrids (wrasses). These families contributed 64 percent of the total taxa collected by Houde et al. (1979). Sherman et al. (1983) compared the rank order of the 21 most abundant families overall and by quadrant (northeast, northwest, southeast, southwest) taken during early SEAMAP cruises (see Table III-8 of Final EIS for Lease Sale 181; USDOI, MMS, 2001a).

Two of the most important hydrographic features within or close to the EPA sale area are the Mississippi River discharge plume and the Loop Current. A series of investigations have shown that ichthyoplankton aggregate at the frontal zone of the Mississippi River discharge plume (Govoni et al., 1989; Grimes and Finucane, 1991; Govoni and Grimes, 1992). Grimes and Finucane (1991) sampled larval fishes, chlorophyll *a*, and zooplankton along transects traversing the discharge plume. They found that when comparing catches of ichthyoplankton among shelf, frontal, and plume samples that frontal samples contained a higher average number of fish larvae than either plume or shelf waters.

Richards et al. (1989 and 1993) examined the distribution of larval fishes along eight transects across the Loop Current boundary, as defined from satellite imagery of sea surface temperature. Most of the samples were off the continental shelf in water depths exceeding 200 m (656 ft). Although 100 fish families were identified, only 25 families were relatively common (represented by >0.5 individuals/sample). Of these, the lanternfishes were most abundant. A cluster analysis of the 25 most-abundant families resolved three assemblages: oceanic, shelf, and frontal. The oceanic assemblage consisted of mesopelagic families such as hachetfishes (sternoptichyids), lanternfishes (myctophids), and bristlemouths (gonostomatids). The shelf group was subdivided into three groups including demersal taxa (e.g., sciaenids and bothids) and coastal pelagic taxa (e.g., carangids and scombrids) and widely dispersing reef species (e.g., labrids, scarids, and scorpaenids). The frontal group consisted of both oceanic and shelf taxa. These studies suggest that water temperature is a major influence on the structure of larval fish assemblages (Richards et al., 1993).

Lyczkowski-Shultz (1999) summarizes observations on the kinds and abundance of fish larvae collected in the vicinity of the DeSoto Canyon. The data suggest that the DeSoto Canyon area is a significant incubator for fish larvae. Further discussion of DeSoto Canyon ichthyoplankton is in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a; pages III-78 through III-80).

Fish Groups

The GOM supports a great diversity of fish resources that are related to variable ecological factors, including salinity, primary productivity, and bottom type and water depth. These factors differ widely across the GOM and between the inshore and offshore waters. Characteristic fish resources are associated with the various environments and are not randomly distributed. High densities of fish resources are associated with particular habitat types. Approximately 46 percent of the southeastern U.S. wetlands and estuaries important to fish resources are located within the GOM (Mager and Ruebsamen, 1988). Consequently, estuary-dependent species of finfish, reefish, demersals, and shellfish dominate the fisheries of the central and north-central Gulf, particularly in the water depths of the continental shelf (<200 m).

This PEA focuses on exploratory drilling and well testing in the EPA sale area, a deepwater setting between 1,600 and 2,800 m (5,250-9,840 ft) deep. Open ocean and pelagic fishes, and migrants occur throughout the area in this habitat. Although most finfishes, reef fishes, demersals, and shellfish inhabit estuarine, nearshore, and shallow shelf habitats for at least part of their lifecycles, open ocean fish groups are most likely to come into contact with exploration activities. A more detailed discussion of fish groups in the EPA can be found in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a) or the EPA Multisale Draft EIS (USDOI, MMS, 2002c).

3.3.6.2. Essential Fish Habitat

Essential Fish Habitat Program in the Gulf of Mexico

An essential fish habitat (EFH) is defined as those waters and substrate necessary to fish for spawning, breeding, feeding, and growth to maturity. Due to the wide variation of habitat requirements for all life history stages, EFH for the GOM includes all estuarine and marine waters and substrates from the shoreline to the seaward limit of the Exclusive Economic Zone (EEZ).

The Magnuson-Stevens Fishery Conservation and Management Act of 1976, as amended through 1998, places requirements on any Federal agency with respect to EFH, and requires the development of management plans for all managed fish species. The Gulf of Mexico Fisheries Management Council (GMFMC) currently maintains Fishery Management Plans (FMP) for a variety of bay and estuarine species that spend a large part of their life cycles in these nearshore environments. Occurrence of these managed species, along with major adult prey species and relationships with estuary and bay systems in the Eastern GOM, is outlined in Table III-14 of the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a). Detailed presentations of species abundance, life histories, and habitat associations for all life history stages are presented in the generic Amendment for Essential Fish Habitat (GMFMC, 1998).

3.3.6.3. Managed Species

The GMFMC currently describes FMP's for the following species with the potential to occur in the EPA sale area: red grouper (*Epinephelus morio*), gag grouper (*Mycteroperca microlepis*), scamp grouper (*Mycteroperca phenax*), red snapper *(Lutjanus campechanus*), gray snapper (*Lutjanus griseus*), yellowtail snapper (*Ocyurus chrysurus*), lane snapper (*Lujanus syngagris*), gray triggerfish (*Balistes capriscus*), greater amberjack (*Seriola dumerili*), lesser amberjack (*Seriola fasciata*), king mackerel (*Scomberomorus cavalla*), Spanish mackerel (*Scomberomorus maculates),* cobia (*Rachycentron canadum*), dolphin fish (*Coryphaena hippurus*), stone crab (*Menippe spp*.), and spiny lobster (*Panulirus spp*.). None of the stocks managed by the GMFMC are endangered or threatened.

Occurrence of these managed species, along with major adult prey species and relationships with estuary and bay systems in the eastern GOM is outlined in Table 3-7. Detailed presentations of species abundance, life histories, and habitat associations for all life history stages are presented in the generic Amendment for Essential Fish Habitat by the GMFMC (1998).

ratory species that are likely to be encountered in the EPA sale area would include, tuna (Scombridae), billfish (Istiophoridae), swordfish (Xiphiidae), and sharks (Squaliformes). These groups are under the direct management of NOAA Fisheries and are not included as Fishery Management Council managed species. The EFH areas for these highly migratory species are described in separate FMP's, including the FMP for Atlantic tunas, swordfish, and sharks (USDOC, NMFS, 1998b) and the Atlantic billfish FMP Amendment 1 (USDOC, NMFS, 1998a). These separately managed species include bluefin tuna (*Thunnus thynnus*), skipjack tuna (*Euthynnus pelamis*), yellowfin tuna (*Thunnus albacares*), swordfish (*Xiphias gladius*), a suite of 32 shark species (Squaliformes), billfish (Istiophoridae), blue marlin (*Makaira nigricans*), white marlin (*Tetrapturus albidus*), sailfish (*Istiophorus platypterus*), and swordfish. The 12 species in Table 3-6 are common species determined to have at least one life history stage occurring in or near the EPA sale area. Due to the water depth of the final EPA sale area, migratory species, including tunas, swordfish, billfish, and sharks, are the only managed fish species occurring in the area.

Table 3-7
Gulf of Mexico Essential Fish Habitat Assessment
(species under Gulf of Mexico Fishery Management Plans
with the potential to occur in EPA sale area)

Species	Presence in the Eastern Planning Area	Bay and Estuary Relationships	Adult Prey Species
Invertebrates			
stone crab	Uncommon; would only occur on artificial reef structure.	Nursery area	opportunistic carnivore
spiny lobster	Likely recruited to structures, not present on bottom.	None noted	mollusks and arthropods
Fish (in taxonomic order)			
gag grouper	Possible recruitment, only on artificial reef structure.	seagrass beds, Nursery nearshore	primarily fish
red grouper	Adult present year-round to north of the EPA sale area area but would occur only on artificial reef.	None noted	primarily fish
scamp grouper	Would occur only on artificial reef, likely recruited.`	None noted	primarily fish
cobia	Could occur in open water but not likely this far offshore; may be attracted to structures.	Nursery nearshore	primarily crustaceans and some fish
lesser amberjack	Occurs around platforms but presence highly unlikely in open water.	None noted	cephalopods
greater amberjack	Occurs around platforms but presence highly unlikely in open water.	None noted	variety fish, crustaceans, and cephalopods
dolphin fish	Adult present year-round, not associated with platforms.	None noted	pelagic fish
lane, gray, and red snapper	Would occur only on artificial reef, recruitment possible but not likely in deepwater.	Nursery nearshore	fish, crustaceans, mollusks, algae
yellowtail snapper	May occur in the EPA sale area and be recruited to platforms.	None noted	benthic fish and crustaceans
king mackerel	Adults present year-round closer to shore; spawning may extend into the EPA sale area. Not associated with platforms.	None noted	mostly fish, anchovies, and herrings
Spanish mackerel	Uncommon; may extend into the EPA sale area. Not associated with platforms.	Nursery nearshore	mostly fish, anchovies, and herrings
gray triggerfish	Would occur only at artificial reefs.	None noted	mostly bivalves and barnacles; also polychaetes and echinoderms

As described by NOAA Fisheries documents (USDOC, NMFS, 1998a and b), the current status of the scientific knowledge of these species is such that habitat preferences are largely unknown or are difficult to determine. As in the case with shark species, it is difficult to define the habitat of sharks of this temperate zone in the GOM because most species are highly migratory, using diverse habitats in apparently nonspecific or poorly understood ways. Temperature is a primary factor affecting the distribution of sharks, and their movement in coastal waters is usually correlated with unpredictable seasonal changes in water temperature. The occurrence of fish species managed by NOAA Fisheries, along with major prey species, is outlined in Table 3-8. Some of these highly migratory species occur offshore beyond the 200-m isobath, and many, such as billfishes, are associated with upwelling areas where canyons cause changes in current flow (upwelling) and create areas of higher productivity.

Table 3-8

Gulf of Mexico Essential Fish Habitat Assessment
(highly migratory species managed by NOAA Fisheries in the EPA sale area)

Species	Presence In or Near the EPA sale area	Known Prey Species
Billfish		
blue marlin	Juvenile/subadult and adults occur in area beyond 100-m contour	Adults: fish at surface, and deepwater: scombrids, cephalopods
white marlin	Juvenile/subadult and adults occur in area beyond 50-m contour	Juveniles: fish. Adults: squid and fish
sailfish	Juvenile/subadult only occurs in area	Pelagic schooling fish and squids
Swordfish	Spawning and eggs/larvae and adults occur in area	Larvae: zooplankton, fish larvae Juveniles: fish, squid, pelagic crustaceans Adults: pelagic fish, squid, demersal fish
Tunas		
bluefin tuna	Spawning and eggs/larvae occur in area no juvenile/subadult or adult noted	Juveniles: crustacea, larval, and small fish
skipjack tuna	Spawning and eggs/larvae occur in area no juvenile/subadult or adult noted	Larvae: small fish
yellowfin tuna	Spawning and eggs/larvae, subadult, and adult occurs in area	Larvae: small fish Juveniles: fish Adults: crustacea and fish
Sharks		
dusky	No life stage occurrence noted, but area designated as research area	None noted (unknown)
silky	Neonate/early juvenile only noted but adult attraction to platforms common in deepwater areas.	None noted (unknown)
tiger	Neonate/early juvenile, late juvenile, subadult, and adult occurs to north of area shallower than 200 m. Presence possible in area.	None noted (unknown)
Atlantic sharpnose	Adults only in area	None noted (unknown)
longfin mako	Neonate/early juvenile, juvenile/ subadult and adults occur in area.	None noted (unknown)

Pelagics

Pelagic fishes occur throughout the water column from the beach to the open ocean. Water-column structure (temperature, salinity, and turbidity) is the only partitioning of this vast habitat. On a broad scale, pelagic fishes recognize different watermasses based upon physical and biological characteristics. Two of these three pelagic ecological groups would be encountered in the area of the proposed action:

- coastal pelagic species;
- oceanic pelagic species; and
- mesopelagic species.

Coastal Pelagics

Coastal pelagic species occur in waters from the shoreline to the shelf edge and would not be extant in the EPA sale area. The shelf edge is usually delineated at the 200-m isobath; therefore, the coastal pelagic species group would not be a pelagic fish group potentially subject to impacts from the proposed action. Oceanic pelagic species occur mainly in open waters offshore from the shelf break (>200 m); however, some species venture onto the shelf with watermass (e.g., Loop Current) intrusions. Mesopelagic fishes occur below the oceanic species group (deeper) in the open ocean, usually at depths of 200-1,000 m (656-1,280 ft) depending upon absolute water depth. Oceanic and mesopelagic species would be the pelagic species groups most likely to come into contact with exploration activities in the EPA sale area.

Information on the distribution and abundance of oceanic pelagic species comes from commercial longline catches and recreational fishing surveys. In addition, NOAA Fisheries has conducted routine surveys of the GOM billfishery since 1970 (Pristas et al., 1992). Mesopelagic species are not harvested commercially but have been collected in special, discrete-depth nets that provide some quantitative data on relative abundance (Bakus et al., 1977; Hopkins and Lancraft, 1984; Hopkins and Baird, 1985; Gartner et al., 1987).

Recently, additional restrictions have been placed on the harvest of some sharks, which may be temporary migrants or might spend some of their life cycles in oceanic pelagic or mesopelagic habitats. Effective July 1, 2000, it is prohibited to retain, possess, sell, or purchase the following sharks: white, basking, sand tiger, bigeye sand tiger, dusky, bignose, Galapagos, night, Caribbean reef, narrowtooth, Caribbean sharpnose, smalltail, Atlantic angel, longfin, mako, bigeye thresher, sevengill, sixgill, and bigeye sixgill.

Oceanic Pelagics

Common oceanic pelagic species include tunas, marlins, sailfish, swordfish, dolphins, wahoo, and mako sharks. In addition to these large predatory species, there are halfbeaks, flyingfishes, and driftfishes (Stromateidae). Lesser-known oceanic pelagics include opah, snake mackerels (Gempylidae), ribbonfishes (Trachipteridae), and escolar.

Oceanic pelagic species occur throughout the GOM, especially at or beyond the shelf edge. Oceanic pelagics are reportedly associated with mesoscale hydrographic features such as fronts, eddies, and discontinuities. Fishermen contend that yellowfin tuna aggregate near sea-surface temperature boundaries or frontal zones; however, Power and May (1991) found no correlation between longline catches of yellowfin tuna and sea-surface temperature (defined from satellite imagery) in the GOM. The occurrence of bluefin tuna larvae in the GOM associated with the Loop Current boundary and the Mississippi River discharge plume is evidence that these species spawn in the GOM (Richards et al., 1989). Many of the oceanic fishes associate with drifting *Sargassum*, which provides forage areas and/or nursery refugia.

Mesopelagics

Mesopelagic fish assemblages in the GOM are numerically dominated by myctophids (lanternfishes), with gonostomatids (bristlemouths) and sternoptychids (hachetfishes) common but less abundant in collections. These fishes make extensive vertical migrations during the night from mesopelagic depths (200-1,000 m or 656-3,280 ft) to feed in higher, food rich layers of the water column (Hopkins and Baird, 1985). Mesopelagic fishes are important ecologically because they transfer substantial amounts of energy between mesopelagic and epipelagic zones over each diurnal cycle.

Mesopelagic fish assemblages have been studied in the Eastern GOM by Bakus et al. (1977), Hopkins and Lancraft (1984), and Gartner et al. (1987). Hopkins and Lancraft (1984) collected 143 mesopelagic fishes from the Eastern GOM during 12 cruises from 1970 to 1977. Most of their collections were made near 27° N. latitude, 86° W. longitude. Lanternfishes were most common in the catches made by Bakus et al. (1977) and Hopkins and Lancraft (1984). Bakus et al. (1977) analyzed lanternfish distribution in the western Atlantic Ocean and recognized the GOM as a distinct zoogeographic province. Species with tropical and subtropical affinities were most prevalent in the GOM lanternfish assemblage. This was particularly true for the Eastern Gulf, where Loop Current effects on species distribution were most pronounced. Gartner et al. (1987) collected 17 genera and 49 species of lanternfish in trawls fished at discrete depths from stations in the southern, central, and eastern Gulf. The most abundant species in decreasing order of importance were *Ceratoscopleus warmingii*, *Notolychus valdiviae*, *Lepidophanes guentheri*, *Lampanyctus alatus*, *Diaphus dumerili*, *Benthosema suborbitale*, and *Myctophum affine*. Gartner et al. (1987) sampled three stations near the region, including one near DeSoto Canyon (87° 01' W. longitude, 29° 01' N. latitude). Forty-two of the 49 lanternfish species collected from all stations were taken from the northeastern stations. The most abundant species were similar to those for the entire Eastern Gulf, with the exception of *Diaphus mollis*, which ranked among the seven most abundant species. Ichthyoplankton collections from oceanic waters yielded high numbers of mesopelagic larvae as compared with larvae of other species (Richards et al., 1989). Lanternfishes of the Eastern Gulf generally spawn year-round, with peak activity in spring and summer (Gartner, 1993). Darnell and Kleypas (1987) reported some lanternfishes in trawl collections from near the rim of DeSoto Canyon.

3.3.6.4. Gulf Sturgeon

The Gulf sturgeon (*Acipenser oxyrinchus desotoi*) is the only listed threatened fish species in the GOM. Gulf sturgeons are bottom suction feeders that have ventrally located, highly extrusible mouths. Fishes that forage by taste are opportunistic feeders because smell is much more discriminating than taste. Another adaptation of sturgeon to major rivers and offshore waters is mobility (an adaptation to the large habitat scale). The decline of the Gulf sturgeon is believed to be due to overfishing and habitat destruction, primarily the damming of coastal rivers and the degradation of water quality (Barkuloo, 1988).

A subspecies of the Atlantic sturgeon, the Gulf sturgeon is anadromous (ascend rivers to breed), with immature and mature fish participating in freshwater migrations. Gill netting and biotelemetry have shown that subadults and adults spend 8-9 months each year in rivers and 3-4 of the coolest months in estuaries or Gulf waters. Sturgeon less than about two years old live in riverine and estuarine habitats throughout the year (Clugston, 1991). According to Wooley and Crateau (1985), Gulf sturgeon occurred in most major river systems from the Mississippi River to the Suwannee River, Florida, and marine waters of the Central and Eastern GOM south to Florida Bay. Gulf sturgeon population sizes are largely unknown throughout the species' range, but estimates have been completed recently for the Suwannee, Apalachicola, and West Pearl Rivers, and the first year of a 3-year study has been completed on the Choctawhatchee River. Surveys have not been conducted yet on the remaining river systems that historically contained Gulf sturgeon. Gulf sturgeon historically spawned in major rivers of Alabama, Mississippi, and the Florida northern Gulf Coast. Until recently only two spawning sites were known, both in the Suwannee River in Florida. Eggs have now been discovered in six locations within the Choctawhatchee River system in Florida and Alabama (Fox and Hightower, 1998). In spring, large subadults and adults that migrate from the estuaries or the Gulf into major river passes feed primarily on lancelets, brachiopods, amphipods, polychaetes, and globular molluscs. Small sturgeon that remain in river passes during spring feed on amphipods, shrimp, isopods, oligochaetes, and aquatic insect larvae (Clugston, 1991). During the riverine stage, adults cease feeding, undergo gonadal maturation, and migrate upstream to spawn. Spawning occurs over coarse deep substrate.

Gulf sturgeon in the rivers and estuaries are interrupted when migrating by capture with gill nets suspended from floats in the rivers and river mouths. Nets with mesh wide enough not to close the very large opercula are used. Migration to the sea is recorded in fall when the fish, represented by signals from sonar tags, disappear from river mouths and estuaries. Until recently, no capture or tracking was feasible in the open Gulf just when the fish migrated into it because cold fronts come every 2-3 days, with up to 9-ft seas. Conditions are dangerous for the size of vessel required. Results of tracking by popup tag use, however, are starting to come in and show extensive movement parallel with the shore, form one estuary to the next. Recent cooperative research between the University of South Florida and the USGS Biological Resources Division is beginning to provide acoustic tag location data for Gulf sturgeon after they leave inhabited rivers. Relocations and active tracking of individual fish moving in a 3-12 mi area off inhabited rivers have been documented (Sulak, personal communication, 2002). Researchers suspect that in January and February many sturgeon move beyond the 12 miles documented to date and that tagged fish either move away from the nearshore areas along the coast or they disperse into deeper offshore waters.

The FWS is proposing critical habitat for the Gulf sturgeon which will include 14 geographic areas among rivers emptying into the Gulf of Mexico that encompass 1,589 river miles and 2,333 sq/mi of estuarine and marine habitat.

3.3.6.5. Smalltooth Sawfish

In November 1999, National Marine Fisheries Service (also known as NOAA Fisheries) received a petition from the Center for Marine Conservation requesting that the smalltooth sawfish (*Pristis pectinata*) be listed as endangered under the ESA. NOAA Fisheries completed a status review for the smalltooth sawfish in December 2000 and published a proposed rule to list the U.S. population of this species as endangered on April 16, 2001. The following information is excerpted from the NOAA Fisheries' Office of Protected Resources website (USDOC, NMFS, 2002) and the status review prepared by NOAA Fisheries. The December 2000 status review is also available at the cited website.

Sawfish, like sharks, skates and rays, belong to a class of fish called elasmobranchs, possessing skeletons made of cartilage. Sawfish are actually modified rays with a shark-like body, and gill slits on their ventral side. Sawfish get their name from their "saws"; long, flat snouts edged with a row of paired teeth used for slashing or rooting. Their diet includes mostly fish but also some crustaceans.

The smalltooth sawfish is one of two species of sawfishes that inhabit U.S. waters. The smalltooth sawfish commonly reaches 18 ft (5.5 m) in length and may grow to 25 ft (7 m). Little is known about the life history of these cartilagineous fish, but they may live 25-30 years and mature after about 10 years. Like many elasmobranchs, the smalltooth sawfish is ovoviviparous, meaning the mother holds the eggs internally until the young are ready to be born, usually in litters of 15-20 pups.

In the U.S., the smalltooth sawfish is generally an inhabitant of inshore bars, mangrove edges, and seagrass beds, but may be occasionally found in deeper neritic waters. The smalltooth sawfish was said to be commonly found in shallow water throughout the northern GOM, especially near river mouths and in large bays and was common in peninsular Florida (Walls, 1975). Historical records indicate that the smalltooth sawfish have been found in the lower reaches of the Mississippi and St. Johns Rivers and the Indian River lagoon system. Individuals have also historically been reported to migrate northward along the Atlantic seaboard in the warmer months. Estimating from the latitudinal limits within which they are year-round residents and from the summer-winter temperatures of the Carolinian waters that they visit during the warmer half of the year, the lower thermal limit to their normal range is probably about 16º-18ºC.

Bigelow and Schroeder (1953) report that sawfish in general subsist chiefly on whatever small schooling fish may be abundant locally, such as mullets and the smaller members of the herring family. Bigelow and Schroeder also reported that they feed to some extent on crustaceans and other bottom dwelling inhabitants. The smalltooth sawfish is noted as often being seen "stirring the mud with its saw" to locate its prey. Bigelow and Schroeder noted the smalltooth sawfish has been reported to attack schools of small fishes by slashing sideways with its saw and then eating the wounded fish.

The smalltooth sawfish in the northern and western GOM have become rare in the last 30 years. Expansion of commercial fishing and an increase in scientific research fishing in the GOM in the 1950's and 1960's produced many records of smalltooth sawfish, primarily from the northwestern Gulf in Texas, Louisiana, Mississippi, and Alabama. Sawfish catches have historically been reasonably common in Texas, Louisiana, and Mississippi. Reports of captures have dropped dramatically and the trend of decline in the region is apparent. Louisiana, an area of historical localized abundance, has experienced a marked decline in sawfish landings and landings per unit effort (Simpfendorfer, 2000). The lack of smalltooth sawfish records since 1984 from the area west of peninsular Florida is a clear indication of decline of the species abundance in the northwestern Gulf. Peninsular Florida has been the U.S. region with the largest numbers of capture records of smalltooth sawfish and apparently is the only area that historically hosted the species year round. Although no longer common, smalltooth sawfish were once characteristic and prominent elements of the inshore Florida fish fauna. NOAA Fisheries does not have information supporting that there is a population in Mexico. Quantitative data are not available to conduct a formal stock assessment for smalltooth sawfish.

3.3.7. Areas of Special Biological Concern

Five areas of special biological concern are considered in this PEA. These habitats are the Florida Keys National Marine Sanctuary (FKNMS), Florida Middle Ground (FMG), and two new restricted fisheries areas, Steamboat Lumps and Madison/Swanson Special Management Areas. Figure III-4 in the Final EIS for Lease Sale 181 shows the locations of FMG on the eastern Florida continental shelf (USDOI, MMS, 2001a).

The FKNMS contains significant coral reef habitats but the sanctuary lies more than 345 mi (555 km) from the proposed action. Corals within the FKNMS occur at shallow depths from the low tide level to about 60 m (200 ft).

The FMG is located closer to the EPA sale area but is still at a considerable distance (207 mi or 333 km). This live-bottom habitat is one of the larger and more significant features on the west Florida Shelf and includes live coral growth. However, it is not a coral reef and has been described as a "degradational environment" from observations of abundant reef rubble and very few living reef-building organisms. The shallowest point of the FMG is 23 m.

The Madison and Swanson, and Steamboat Lumps Special Management Areas (USDOI, MMS, 2001a; Figure III-4) have been closed to all fishing except for highly migratory species since June 1, 2000. These special areas have been designated to protect gag (grouper) spawning aggregations from fishing activities.

The Big Bend Seagrass Aquatic Preserve lies in a 10-mi-wide belt along the coastline and shoreface of western Florida, south of the Apalachicola Delta. The preserve is located along all or parts of Wakullasi, Jefferson, Taylor, Dixie, and Levy Counties, about 300 mi (482 km) east-northeast from the EPA sale area. The preserve has the characteristics of other seagrass habitats described in Chapter 3.3.1.3, Seagrass Communities.

Other Commercial Uses and Dredge Disposal

The MMS is not aware of any other existing or planned commercial uses in the EPA sale area. There are no ocean dumping areas for dredged material that have been selected for use or permitted by the USEPA or USCOE in the entire EPA sale area. Dredged material disposal sites generally occur close to the boundaries between OCS and State waters of Louisiana, Mississippi, and Alabama. The nearest dredged material disposal locations are near the Mississippi River Delta distributary system, approximately 75 mi (120 km) northwest of the northwest corner of the EPA sale area (USDOA, COE, 2002).

3.4. SOCIOECONOMIC RESOURCES

3.4.1. Commerical Fisheries

The GOM provides nearly 21 percent of the commercial fish landings in the continental U.S. on an annual basis. The most recent, complete information on landings and value of fisheries for the U.S. was compiled by NOAA Fisheries for 2001. During 2001 commercial landings of all fisheries in the Gulf totaled nearly 1.6 billion pounds and were valued at over $804 million (USDOC, NMFS, 2002a). Total landings for the various fisheries can be found on the NOAA Fisheries website (USDOC, NMFS, 2002a).

The EPA sale area is a pelagic, or open-ocean environment. This habitat, therefore, accounts for a small part of the productivity in the Gulf's commercial fisheries. Fisheries that are active beyond the continental shelf (>200 m) would be extant in the EPA sale area. Certain deepwater reef fishes such as snowy, yellowedge, and warsaw groupers are fished exclusively in waters off the shelf break (>200 m); however, the shallowest portion of the sale area is deeper than the habitat range for all these grouper species.

Continental Shelf Associates (1997) completed a study that characterized recreational and commercial fishing east of the Mississippi Delta. The following material and conclusions concerning commercial fishing in this region from 1983 to 1993 are taken from this study. Oceanic pelagic fishes were not landed in high quantities relative to other finfish groups during 1983-1993; however, they were very valuable, ranking second to reef fishes in average dollar value of landings. The most important species, yellowfin tuna and swordfish, were caught primarily by surface longline in oceanic waters offshore of the shelf break. Bay County and to a lesser extent Santa Rosa County were the only counties reporting sizeable proportions of oceanic pelagic fishes in their landings. Because these fisheries operate in the open Gulf, catches responsible for specific State landings could have been made in waters outside of the region. The demand for oceanic pelagic fishes accelerated very rapidly over the 1983-1986 period and leveled off over the remainder of the study period remaining rather static in terms of catch, price, and dockside value from 1987 to 1993.

The remaining group of finfishes landed by commercial fishers in the northeastern Gulf: the demersal fishes (bottom dwellers), reef fishes, coastal pelagics, and baitfish; are taken exclusively from estuarine, nearshore, or shelf waters, over natural or artificial bottoms. Important finfish groups landed at ports in Alabama and along Florida's northwest coast include snapper, porgies, mullet, baitfish, jacks, triggerfish, grouper, tuna, and other pelagics. None of these species groups or habitats occur in the EPA sale area.

Many commercial species harvested from Federal waters of the GOM are considered to be at or near an overfished condition. Continued fishing at the present levels may result in rapid declines in commercial landings and eventual failure of certain fisheries. Commercial landings of traditional fisheries in shallower OCS waters, such as red snapper, vermilion snapper, spiny lobster, jewfish grouper, and mackerel, have declined over the past decade despite substantial increases in fishing effort. Commercial landings of recent fisheries, such as shark, black drum, and tuna, have increased exponentially over the past five years, and those fisheries are thought to be in need of conservation (Angelovic, written communication, 1989; Grimes et al., 1992; USDOC, NMFS, 1997). The number of species considered to be overfished will likely continue to rise under new, more stringent requirements of the Magnuson-Stevens Fisheries Management and Conservation Act (USDOI, MMS, 2001a; Section I.D.6.). Stresses on specific commercial fisheries are discussed in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a; Section III.D.1.) and in the EPA Multisale Draft EIS (USDOI, MMS, 2002c; pages 4-92 through 4-94).

On November 1, 2000, NOAA Fisheries put into effect a new regulation to reduce bycatch and bycatch mortality in the pelagic longline fishery. Two rectangular areas in the GOM (one of which lies over a portion of the DeSoto Canyon area) are closed year-round to pelagic longline fishing. These closed areas cover 32,800 mi^2 (84,950 km^2) (Figure 3-2). This region has been identified by NOAA Fisheries as a swordfish nursery area, and where there has historically been a low ratio of swordfish kept to the number of undersized swordfish discarded, which over the period of 1993-1998 has averaged less than one swordfish kept to one swordfish discarded. The area closure is expected to produce approximately a 4 percent reduction in Gulf and Atlantic undersized swordfish bycatch. The DeSoto Canyon area coordinates are as follows:

Upper Area

North boundary	30° N. latitude
South boundary	28° N. latitude
East boundary	86° W. longitude
West boundary	88° W. longitude

Lower Area

North boundary	28° N. latitude
South boundary	26° N. latitude
East boundary	84° W. longitude
West boundary	86° W. longitude

The upper closure area encompasses 160 of the 256 total blocks making up the sale area. Surface longline fishing would be prohibited in these lease blocks.

Compared with the development of deepwater fisheries by other countries, the U.S. has developed only a few of its deep-sea resources. Upper ocean trolling, mixed-depth long lining, deep bottom trawling, and deep bottom longlining are practiced on a limited basis in deepwater areas of the eastern GOM. Deepwater fishing includes commercial efforts and charterboats for hire. The equipment and practice of deepwater fishing are substantial in terms of size, weight, time, and expense.

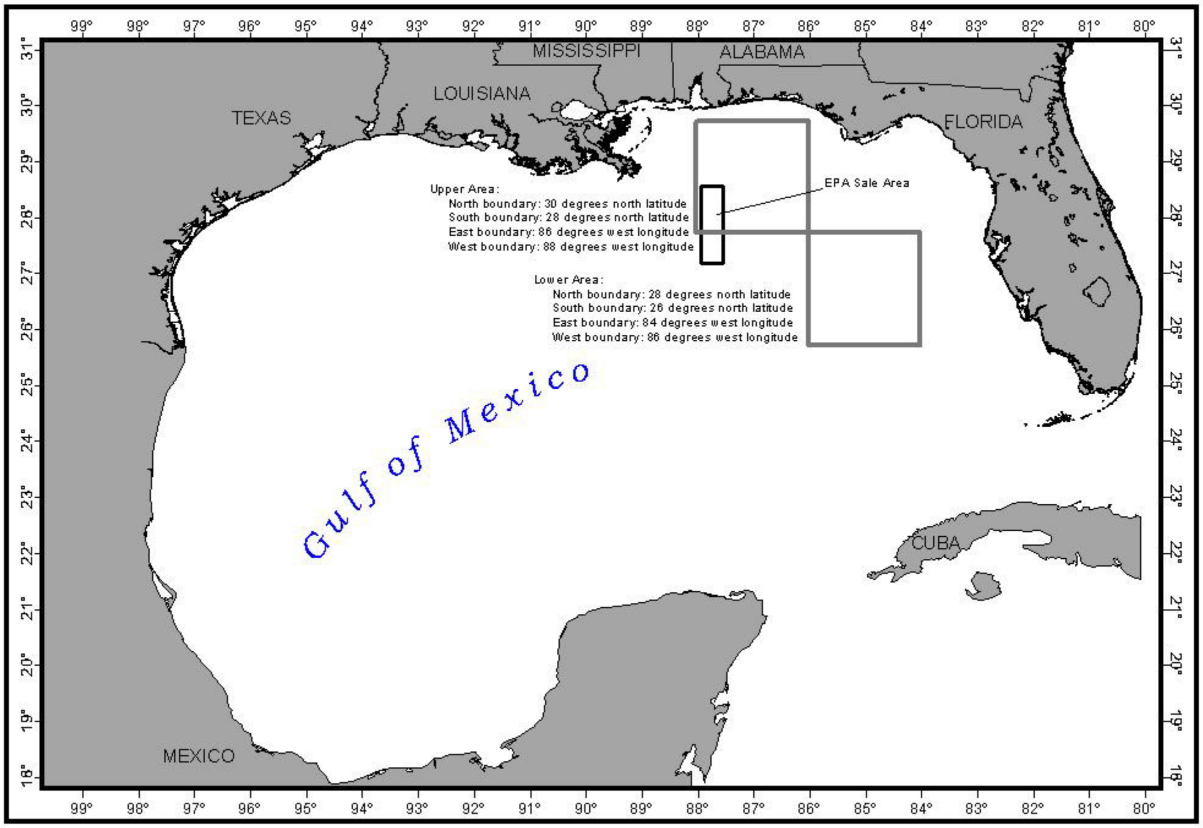

Figure 3-2. Areas of banned longline fishing and their relationship with the EPA sale area, Eastern Gulf of Mexico.

3.4.2. Recreational Fisheries

Marine recreational fishing along Florida's west coast and coastal Alabama is very popular with both residents and tourists, and is economically important to both coastal states. The latest information from the NOAA Fisheries Marine Recreational Fisheries Statistics Survey (USDOC, NMFS, 2001) indicates there were almost 2 million resident participants in GOM saltwater fishing from Louisiana to Florida and a similar number of out-of-state (tourist) fishermen that fished from the west coast of Florida and coastal Alabama in 1999. Of these resident and tourist fishermen from Louisiana to Florida, an estimated 1.7 million offshore fishing trips occurred in the OCS (>10 mi off Florida's west coast and >3 mi off Alabama, Louisiana, and Mississippi) during 1999 (USDOC, NMFS, 2001). The greatest number of fish caught and landed from this offshore zone included dolphins, grunts, jacks, porgies, groupers, snappers, and mackerels. Likewise, a significant amount of effort is expended by a specialized group of big game or billfish fishermen seeking primarily tuna, marlin, and wahoo focused in deep offshore waters from south of the Mississippi Delta to the DeSoto Canyon off northwest Florida.

Because the EPA sale area lies nowhere <75 mi (120 km) from the nearest state (Louisiana), and everywhere >100 mi (160 km) from the coastline of Florida, only a very small population of fishermen departing from northwest Florida to coastal Alabama are likely to be impacted by exploratory drilling. Almost all offshore recreational fishing is currently confined within 100 mi of shore and almost all of the EPA sale area lies 100-200 mi from shore. Very few fishing trips go beyond the 200-m isobath in the DeSoto Canyon OCS area, or 100 mi from shore.

3.4.3. Recreational Resources

The northern GOM coastal zone is one of the major recreational regions of the U.S., particularly formarine fishing and beach activities. Gulf Coast shorelines offer a diversity of natural and developed landscapes and seascapes. Major recreational resources include coastal beaches, barrier islands, estuarine bays and sounds, river deltas, and tidal marshes. Other resources include publicly owned and administered areas, such as national seashores, parks, beaches, and wildlife lands, as well as designated preservation areas, such as historic and natural sites and landmarks, wilderness areas, wildlife sanctuaries, and scenic rivers. Gulf Coast residents and tourists from throughout the nation, as well as from foreign countries, use these resources extensively and intensively for recreational activity. Commercial and private recreational facilities and establishments, such as resorts, marinas, amusement parks, and ornamental gardens, also serve as primary-interest areas. Bird watching, or public enjoyment of locating, identifying, and observing coastal and marine birds, is a recreational activity of growing interest and importance all along the Gulf Coast.

More than 25 years ago Congress set aside outstanding examples of Gulf coastal beach and barrier island ecosystems to be managed by the National Park Service for the preservation, enjoyment, and understanding of their inherent natural, cultural, and recreational values. One such park, Gulf Islands National Seashore, accounts for approximately 65 km (40 mi) of exposed Gulf beachfront in Mississippi and Florida and accommodates over 1 million recreational visits a year. In addition to beaches, Gulf Islands National Seashore harbors historic forts, shipwrecks, wetlands, lagoons and estuaries, seagrasses, fish and wildlife, and archeological sites. In 1978, approximately 728 ha (1,800 ac) on Horn and Petit Bois Islands, part of Gulf Islands National Seashore in Mississippi, were designated by Congress as components of the National Wilderness System.

Tourism is one of Florida's largest industries, generating over $30 billion in taxable spending each year since the mid-1990's. Over 40 million domestic and international travelers visit the State annually, and over 7 million of these visitors come to the Florida Panhandle to enjoy warm sunshine, white sand beaches, and tranquil natural scenery (Chiles, written communication, 1995). Other public destination sites attract fishermen and travelers interested in undeveloped natural environments, i.e., ecotourism. These sites include Santa Rosa Island and Perdido Key (Gulf Islands National Seashore), Gulf State Park and fishing pier, Orange Beach charter boats, Bon Secour National Wildlife Refuge, Forts Morgan and Gains, Big Lagoon State Recreation Area, and Grayton Beach and St. Andrews State Parks. Tourists and travelers are also attracted to the sites, sounds, shopping, and dining associated with developed GOM coastal and marine areas. Although there is recreational use of the Gulf Coast year round, the primary season is during the spring and summer. Spending for food, beverages, and lodging along Baldwin County beaches was estimated by Alabama's Gulf Coast Convention and Visitors Bureau at approximately $300 million in 1995 (*Mobile Register*, 1996). Foster and Associates, Inc. (1996) documented major increases in sales and lodging tax revenues in both Baldwin and Mobile counties in recent years, indicating the critical importance and effect of tourism on coastal Alabama. Other coastal trends charted by Foster and Associates, Inc. (1996), such as population growth and the increase in pleasure boat registrations, also indicate a corresponding growth in resident recreational demand associated with many of the same resources (beaches and water resources) of interest to the tourist. Both the Alabama and the Florida Panhandle coastal areas, exhibit strong growing economies closely tied to abundant and attractive natural resources.

Marine recreational fishing in the Gulf from Louisiana to Florida is a major industry important to these states' cultures and economies. The marine recreational fishing industry in the Gulf accounts for nearly a billion dollars in sales (equipment, transportation, food, lodging, insurance, and services) and accounts for thousands of jobs. The Gulf States from Louisiana to Florida account for about 1.6 million registered motorboats with almost 4 million anglers making more than 16 million saltwater fishing trips in 1998 (USDOC, NMFS, 1999). Many of these trips are taken from Florida and Alabama, accounting for over 800 charter boats. Only a small number of charter trips venture into deep offshore waters of the OCS (Table 3-9). Snapper, grouper, and dolphin fish are some of the more popular fish sought and caught more frequently in offshore waters. Billfish, tuna, and to some extent snapper, grouper and dolphin fish are sought by recreational fishermen in the more-distant deep offshore waters. A more detailed analysis of trends in marine recreational fishing between 1983 and 1993 in the vicinity of the Florida Panhandle can be found in a special report funded by the MMS and USGS (CSA, 1997a).

Table 3-9

Marine Recreational Fishermen and Fishing Trips

	Number of Fishermen	Total All Fishing Trips	Number of Offshore Fishing Trips	Federal EEZ Fishing Trips[1]
West Florida	2,962,980	12,234,580	5,399,161	1,094,976
Alabama	257,161	968,485	639,800	204,607
Mississippi	174,523	827,536	173,597	151,409
Louisiana	581,207	2,672,764	440,528	73,808
Total	3,975,871	16,703,365	6,653,086	1,524,800

[1] Federal Exclusive Economic Zone: >3 mi off Louisiana, Mississippi, and Alabama; and >10 mi off northwest Florida.
Source: USDOC, NMFS, 1999.

3.4.4. Archaeological Resources

Archaeological resource means any material remains of human life or activities that are at least 50 years of age and that are of archaeological interest (30 CFR 250.105(5)). Archaeological interest means capable of providing scientific or humanistic understanding of past human behavior, cultural adaptation, and related topics through the application of scientific or scholarly techniques. The Archaeological Resources Regulation (30 CFR 250.194) provides specific authority to each MMS Regional Director to require archaeological resource surveys, analyses, and reports. Surveys are required prior to any exploration or development activities on leases within high-probability areas (NTL 2002-G01, *Archaeological Resource Surveys and Reports*, effective in March 15, 2002).

3.4.4.1. Prehistoric

Available geologic evidence suggests that sea level in the northern GOM was at least 90 m, and possibly as much as 130 m, lower than present sea level, and that the low sea-stand occurred during the period 20,000-17,000 years before present (B.P.) (Nelson and Bray, 1970). Sea level in the northern Gulf reached its present stand around 3,500 years B.P. (Coastal Environments, Inc., 1986).

Aten (1983) indicates that early man entered the Gulf area around 12,000 B.P. According to the relative sea level curves for the Gulf prepared by CEI (1977 and 1982), at 12,000 B.P. the continental shelf out to the present water depth of about 45-60 m would have been exposed as dry land suited for human habitation with the potential for prehistoric sites. Because of inherent uncertainties in both the depth of sea level and the entry date of prehistoric man into North America, MMS adopted the 12,000 years B.P. and the 60-m (200 ft) water depth as the seaward extant of the prehistoric archaeological high-probability area.

The water depth in the EPA sale area ranges from 1,550 to 3,000 m (5,085 to 9,840 ft). Based on the current acceptable seaward extent of the prehistoric archaeological high-probability area, the extreme depth precludes the existence of any prehistoric archaeological resources within these lease areas.

3.4.4.2. Historic

With the exception of the Ship Shoal Lighthouse structure, known historic resources on the Eastern Gulf of Mexico OCS consist of historic shipwrecks. A historic shipwreck is defined as a submerged or buried vessel, at least 50 years old, that has sunk, stranded, or wrecked and is presently lying on or embedded in the seafloor. This includes vessels (except abandoned hulks) that exist intact or as scattered components on or in the seafloor. A 1977 MMS archaeological resources baseline study for the northern GOM concluded that two-thirds of the total number of shipwrecks in the northern Gulf lie within 1.5 km of shore and most of the remainder lie between 1.5 and 10 km of the coast (CEI, 1977). A subsequent MMS study published in 1989 found that changes in the late 19th and early 20th century sailing routes increased the frequency of shipwrecks in the open sea in the Eastern Gulf to nearly double that of the Western and Central Gulf (Garrison et al., 1989). The highest observed frequency of shipwrecks occurred within areas of intense marine traffic, such as the approaches and entrances to seaports and the mouths of navigable rivers and straits.

Reviews by Garrison (et al., 1989) and Pearson et al. (2002) list three possible shipwrecks that fall within the EPA sale area (Table 3-10). The Garrison et al. and Pearson et al. shipwreck databases should not be considered exhaustive lists of shipwrecks, but they are the most extensive to date. Regular reporting of shipwrecks did not occur until late in the 19th century, and losses of several classes of vessels, such as small coastal fishing boats, were largely unreported in official records.

Table 3-10

Historic Shipwrecks within the EPA Sale Area
(DeSoto Canyon and Lloyd Ridge)

Vessel Name	Date of Wreck	Lease Area
Marion N. Cobb	1925	DeSoto Canyon
Ontario	1942	DeSoto Canyon
Speedwell	1920	Lloyd Ridge

Wrecks occurring in deeper water would have a moderate to high preservation potential as can be seen by the copper-sheathed wreck recently found in Mississippi Canyon Block 74. In the deepwater, temperature at the seafloor is extremely cold, which slows the oxidation of ferrous metals and helps to preserve wood features. The cold water would also eliminate the wood eating shipworm *Terredo navalis* (Anuskiewicz, 1989; page 90).

Aside from acts of war, hurricanes cause the greatest number of wrecks in the Gulf. Shipwrecks occurring in shallow water nearer to shore are more likely to have been reworked and scattered by subsequent storms than those wrecks occurring at greater depths or in deepwater OCS. For example, the wreckage of the 19th century steamer *New York,* which was destroyed in a hurricane in 1846, lies in 16 m of water and has been documented by MMS (Irion and Anuskiewicz, 1999) as scattered over the ocean floor in a swath over 1,500 ft long. Historic research indicates that shipwrecks occur less frequently in Federal OCS waters. These wrecks, however, are likely to be better preserved, less disturbed, and, therefore, more likely to be eligible for nomination to the National Register of Historic Places than are wrecks in shallower State waters.

3.4.5. Human Resources and Land Use

The EPA sale area is everywhere greater than 160 km (100 mi) from the coastlines of Florida, Alabama, and Mississippi. The EPA sale area is no nearer to Louisiana (terminal edges of the Mississippi River Delta) than 75 mi (120 km). The MMS has conducted economic modeling of impacts by subdividing the U.S. coastline into a series of subareas encompassing 12 counties in the Florida Panhandle, 21 parishes in Louisiana, 4 counties in Mississippi, 2 counties in Alabama, and 24 counties in Texas (USDOI, MMS, 2001a; Figure IV-I). This larger area represents the industrial and service markets for activities potentially affected by, or that have a role in the support of, exploratory drilling in the EPA sale area.

A geographic area comprising 10 counties along the Gulf coastline extending from Jackson County, Mississippi, and Franklin County, Florida, are areas where the economies and residents are most likely to be influenced by exploratory drilling in the EPA sale area. The 10 counties in Mississippi, Alabama, and Florida span some 480 km (300 mi) of Gulf coastline and occupy slightly more than 9,200 mi^2 of territory. In addition, there are currently onshore support bases at Bayou Casotte next to Pascagoula in Jackson County, Mississippi, and Theodore in Mobile County, Alabama. If petroleum extraction becomes a prominent feature of the Eastern Gulf, then it is possible that the ports of Pensacola in Escambia County, Florida, and Panama City in Bay County, Florida, could also become part of the servicing network.

According to an article in the *Mobile Register's Business Quarterly*, there are current and historical ties among those who live and work in coastal Mississippi, south Alabama, and northwest Florida. Shipbuilding, timber, fishing, agriculture, and sea trade were the lifeblood of the region in 1783 when the British left. Today, those same resources and activities are present with the added attractions of tourism beaches, hotels, and gambling (Casey, 1997; page 9). Over the past five years, there has been a substantial increase in cross-cutting economic ties, joint ventures, and regional marketing, as well as multi-county meetings for purposes of forging mutual cooperation and strategies. Population densities calculated from 1995 estimates range from 23 persons/mi^2 in Franklin County, Florida, to 174 persons/mi^2 in Okaloosa County, Florida. The highest densities are 315 persons/mi^2 in Mobile County, Alabama, and 410 persons/mi^2 in Escambia County, Florida. These ranges are shown graphically in Figure III-10 of the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a).

3.4.5.1. Demographics

3.4.5.1.1. Population

The combined population of the 10 counties was 1.1 million in 1980, 1.26 million in 1990, and 1.47 million in 2000. The rate of growth during the decade between 1980 and 1990 reached 14 percent. The rate increased to almost 17 percent between 1990 and 2000, Santa Rosa County in Florida, part of metropolitan Pensacola, had the highest rate of population growth — 44 percent from 1990 to 2000. Baldwin County, Alabama, included in the Mobile Metropolitan Statistical Area, had a 43 percent increase in population.

There is notable variation between the counties in the number of people and in racial diversity. Within the 10-county area, African-Americans constituted nearly 20 percent, or about 240,000 of the total people counted in 1990. Persons claiming American Indian heritage were 0.7 percent of the 1990 population for the 10-county area, less than 1 percent of the total. Individuals identifying themselves as Hispanic numbered 18,560 in 1990, or 1.2 percent of the total count for the region as a whole. This information is compiled from two sources: (1) USDOC, Bureau of Economic Analysis (1997); and (2) three datasets from a private company, Equifax National Decision Systems (1997).

Projections of population changes over the next 20 years show a continuation of recent trends, i.e., Baldwin and Santa Rosa Counties remain on their meteoric rise, while the remaining counties show a steady but modest increase in the numbers of local residents. A more detailed discussion of demographics and population for the 10 counties can be found in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a) and the EPA Multisale Draft EIS (USDOI, MMS, 2002c).

3.4.5.1.2. Median Age

Median age is one indicator of how young or old a given group of people is and of the vitality of local social and economic institutions. The urban counties of Jackson in Mississippi, Mobile in Alabama, and Escambia and Bay in Florida show a diverse grouping of ages, from those in their early twenties to those in their sixties. This age spread is typical of metropolitan centers where there are a variety of jobs and activities for local residents.

Along the coastline, the median age is older than the rest of the county tracts, which reflects the importance of tourism and retirement to this portion of the GOM. Both industries require money and leisure time of the consumer, and both reflect an older age group with disposable income and the time to spend it away from their usual residences.

3.4.5.1.3. Educational Levels

Of those potentially educated in the 10-county area (i.e., aged 25 and over), 37 percent (or 295,169 persons) had at least a high-school diploma. Out of this basically educated group, about 45 percent had advanced beyond high school, i.e., college or graduate degrees. In general, this is not a highly educated population, meaning that professional, paraprofessional, and technical jobs have been neither numerous nor important to local economic activities.

3.4.5.2. Economic Factors

Table III-22 in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a) and discussions therein summarizes the per capita sources of money in each of the 10 counties.

3.4.5.2.1. Current Oil and Gas Industry Activity

The Gulf of Mexico OCS Region has one of the highest concentrations of oil and gas activity in the world. The offshore oil and gas industry has experienced dramatic changes over the last two decades What began in the early-1980s as a boom period for industry ended as a vast retrenchment between the mid-1980's and early 1990's as oversupply caused commodity prices and rig utilization rates to crash. In the period between 1995 and 1997, industry activity in the Gulf was generally expanding. The industry experienced a brief downturn in 1999 due to oversupply and a short crash in commodity prices, followed by gradual improvement beginning in the second half of 2000. Activity from 2001 to 2002 has been stable to slightly declining.

The number of drilling rigs utilized (for unspecified rig types) in the GOM on December 13, 2002, is 135, up from 120 at the same time in 2001 (Rigzone, 2002). Current crude oil and natural gas prices are substantially above the economically viable threshold for drilling in the GOM (varies by company, but approximately $18-22 bbl). As of December 13, 2002, light sweet crude listed for $27.2 bbl on the New York Mercantile Exchange, while Henry Hub Natural Gas listed at $4.45 per million British thermal units (OILNERGY, 2002).

Currently the major oil companies are focusing on the largest prospects in the deepwater OCS. Without a well-developed, deepwater pipeline infrastructure, smaller prospects (<100 million bbl) or those with borderline economics are deferred or temporarily abandoned once drilled. Medium-sized prospects (>100 and <300 million bbl) become economic only with higher commodity prices (Rike, 2000). Hydrocarbons from small to medium, marginally economic prospects will probably be extracted using subsurface production systems with pipeline tie-backs to existing or modified surface transfer structures that feed oil and gas into existing pipelines, or floating production, storage, and offloading systems (USDOI, MMS, 2001e). The lag time between discovery of economically marginal deepwater discoveries and construction of the pipeline networks needed for production could be several years.

Some companies have taken advantage of lower drilling rates and have increased their drilling in the GOM. Concurrently, technological innovations (such as 3-D seismic, slim-hole drilling, and hydraulic rigs) are decreasing the cost of extraction and stimulating the development of large or mega prospects that are still considered economic even at oil commodity prices from $18-$22 bbl. Piloted directional or remote drilling (the drill bit is piloted with the benefit of integrated 3-D seismic data) and equipment placement and control with ROV's have further opened the way for deepwater exploration and development. Access to technological advancements has allowed the independents to decrease their finding costs comparable to the majors and to pursue deepwater opportunities.

3.4.5.2.2. Activity by Major Industrial Sector

The 10-county coastal region proximate to the EPA sale area contains a variety of businesses, most of which exploit the primary resources of timber, salt, sand, gravel, clay, oil, natural gas, and seafood. Key industries include international trade, shipbuilding, extraction of oil and natural gas, commercial fishing, wood and paper products, chemical manufacturing, health care, tourism, and military installations.

Some of the largest private employers are Ingalls Shipbuilding and Singing River Hospital, both of which are in the City of Pascagoula in Jackson County, Mississippi; Mobile Infirmary Medical Center in Mobile, Alabama; and Baptist Health Care hospitals in Pensacola, Escambia County, Florida. Each of these has over 2,000 employees.

In the public sector, the military is a visible and important presence throughout the 10-county region. From west to east, military installations include Naval Station Pascagoula, Naval Air Station Pensacola, Eglin Air Force Base, Hurlburt Field (also part of the Air Force), and Tyndall Air Force Base. Stennis Space Center in Hancock County, Mississippi, is an installation of the National Aeronautics and Space Administration that specializes in rocket propulsion testing. Stennis also coordinates research programs on sea truthing of phytoplankton, sediment, or other sea constituents. Stennis employs 4,600 people in these and other research programs conducted by Federal, State, academic, and private organizations.

To add to the economic diversity of the area, there are four commercial seaports: Pascagoula in Jackson County; Mobile in Mobile County; Pensacola in Escambia County; and Panama City in Bay County. Principal exports from these ports are forest products, chemicals, petroleum products, coal fertilizer, frozen poultry, and other foods. Chief imports are iron ore, petroleum products, forest products, and fruit.

Industrial activities related to oil and gas exploration and extraction on the OCS are limited to onshore service bases in Jackson and Mobile Counties, a gas processing plant in Mobile County, and a refinery in Pascagoula.

3.4.5.2.3. *Employment/Labor Force Participation*

Petroleum-related employment is less than 1 percent for all of the 10 counties in the proximate area. The Final EIS for Lease Sale 181 (USDOI, MMS, 2001a) or the EPA Multisale Draft EIS (USDOI, MMS, 2002c) contains more detailed discussions of labor force participation in the 10 counties. Tables in the Final EIS for Lease Sale 181 (Tables III-24, III-25, III-26, and III-27) show population and employment trends for the 10-counties.

For analysis purposes, MMS divided the larger impact area encompassing the parishes and counties bordering the northern GOM coastline into subareas in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a; Figure IV-1). The objectives were to allocate expenditures from the offshore oil and gas industry to the representative onshore subarea where the dollars were spent (USDOI, MMS, 2001a; Table III-23 and Section IV). Most of the probable changes in population, labor, and employment resulting from exploratory drilling in the EPA sale area would occur in the 21 parishes in Louisiana and the 6 counties in Mississippi/Alabama where the oil and gas industry is best established in this region. Some of the likely changes in population, labor, and employment resulting from exploration activities in the EPA sale area would occur to a lesser extent in the 24 Texas counties because their location is more inconvenient for work in the EPA sale area. Still; much of the oil and gas industry is headquartered in Houston, Texas and some supporting industries are only located in Texas, for example liquid injection facilities for normal oil-field wastes. Changes in economic factors (in minor service and support industries) would occur to a much lesser extent in the 12 counties of the Florida Panhandle given the lack of offshore leasing in most of the EPA and Florida's attitude towards oil and gas development off of state shorelines.

3.4.5.3. Infrastructure, Land Use, and Ports

The Gulf of Mexico OCS Region has one of the highest concentrations of oil and gas activity in the world. As of June 2000, there were almost 3,000 producing structures Gulfwide, with 129 of these located east of the Mississippi River Delta. To date, only exploration activities have taken place off the shores of the State of Florida.

The high level of offshore oil and gas activity in the GOM is accompanied by an extensive development of onshore service and support facilities. The major types of onshore infrastructure include gas processing plants, navigation channels, oil refineries, pipelines and pipeline landfalls, pipecoating and storage yards, platform fabrication yards, separation facilities, service bases, terminals, and other industry-related installations such as landfills and disposal sites for drilling and production wastes. In the 10-county area, only Bayou Casotte/Pascagoula in Mississippi, and Dauphin Island, Mobile, and Theodore in Alabama (Figure 3-3) have any existing onshore servicing facilities, however, these bases are more commercially oriented rather than focused on oil and gas industry support. Other potential service base ports in support of exploratory drilling in the EPA sale area are Leeville, Morgan City, Port Fourchon, Venice, and Grand Isle, Louisiana (Figure 3-3). Potential onshore activities resulting from exploratory drilling could involve a variety of materials, people, and money. One such activity could be the expansion or abandonment of existing waste disposal sites.

Pascagoula, in Jackson County, Mississippi, (Figure 3-3) has a strong industrial base, as represented by Ingalls Shipyard (the largest manufacturing employer in the 10-county area) and Chevron's Pascagoula Refinery. Neighboring Mobile County in Alabama is also heavily industrialized. Major manufacturers in Mobile include three paper mills, a German-owned chemical plant, and two large shipbuilding and repair yards. There are several oil- and gas-related businesses, including Mobil's MaryAnn/823 plant, established in 1990, and Shell's Yellowhammer plant, founded in 1989; both of these plants process natural gas (Harris InfoSource, 1998).

Exploratory drilling in the EPA sale area is expected to impact only those ports that currently have facilities needed for use by the oil and gas industry as offshore service bases. A service base is a community of businesses that load, store, and supply equipment, supplies, and personnel needed at offshore work sites. Although a service base may primarily serve the OCS planning area and subarea in which it is located, it may also provide services for the other OCS planning areas and subareas. Based on

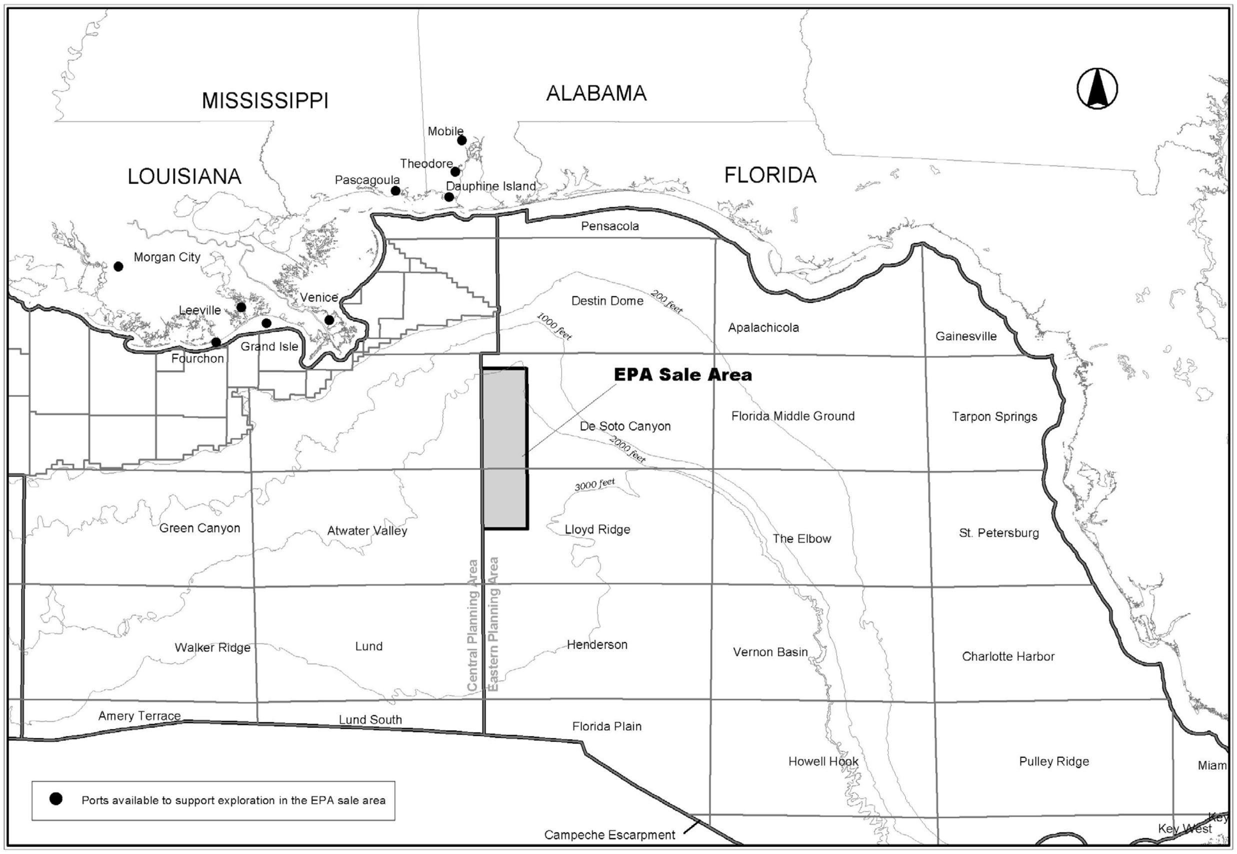

Figure 3-3. Shore bases with facilities suitable to support exploration drilling in the EPA sale area.

MMS's database of OCS Initial Plan Well and Structure Sites, an analysis was conducted for the EPA and the area proposed for Lease Sale 181 (USDOI, MMS, 2001a) to define expected primary service bases. Nine ports in Alabama, Mississippi, and Louisiana were statistically determined as expected service bases: Dauphin Island, Mobile, and Theodore, Alabama; Pascagoula, Mississippi; and Grand Isle, Leeville, Morgan City, Port Fourchon, and Venice, Louisiana (Figure 3-3). Four of the nine current service base ports, i.e., Mobile, Theodore, Morgan City, and Pascagoula, are commercially oriented. The other five ports are a combination of local recreation and offshore service activity. Ports in the Florida Panhandle region at Pensacola, Destin, or Panama City are oriented toward recreation or fishing.

As OCS operations have progressively moved into deeper waters, larger vessels with deeper drafts have been phased into service, mainly for their greater range of travel, greater speed of travel, and larger carrying capacity. Service bases with the greatest appeal for deepwater activity have several common characteristics: strong and reliable transportation system; adequate depth and width of navigation channels; adequate port facilities; existing petroleum industry support infrastructure; location central to OCS deepwater activities; adequate worker population within commuting distance; and insightful strong leadership. Typically, deeper draft service vessels require channels with depths of 6-8 m. Of the nine current service bases, Mobile, Theodore, Venice, and Pascagoula have controlling depths 4 m greater than the maximum requirement, while Morgan City and Port Fourchon have the minimum requirement of 6 m.

3.4.5.4. Environmental Justice

There are no environmental justice issues in the actual offshore Gulf of Mexico OCS planning areas; however, environmental justice concerns are related to nearshore and onshore activities that result from OCS activity, including exploratory drilling in the EPA sale area. These concerns are addressed in two categories, those related to routine operations and those related to nonroutine events (accidents). Concerns related to routine operations center on increases in onshore activity (such as employment, migration, commuter traffic, and truck traffic) and on additions to or expansions of the infrastructure supporting this activity (such as fabrication yards, supply ports, and onshore disposal sites for offshore waste). Concerns related to nonroutine events focus on oil spills.

The OCS Program in the GOM is large and has been ongoing for more than 50 years. During this period, substantial leasing has occurred off Texas, Louisiana, Mississippi, and Alabama. Much infrastructure is located in coastal Louisiana, less in coastal Texas, and less still in Mississippi's Jackson County and Alabama's Mobile County. While many fabrication and supply facilities are concentrated around coastal ports, downstream processing is concentrated more in industrial corridors farther inland. The MMS expects that these same areas will support petroleum extraction in the eastern Gulf. Ports in the panhandle currently are not equipped to support hydrocarbon exploration or production activities, and the citizenry and political leadership continue their vocal opposition to such activities.

Population distribution in the counties that border the GOM show that areas exceeding 50 percent minority are appropriate areas for an environmental justice focus. Most of these concentrations occur in both large urban areas such as Houston and Beaumont in Texas; Lafayette, Baton Rouge, and New Orleans in Louisiana; and Mobile in Alabama as well as in smaller coastal urban areas like Corpus Christi and Galveston in Texas; Morgan City in Louisiana; and Gulfport, Biloxi, and Pascagoula in Mississippi. Large, rural, agricultural, predominantly minority census tracts are found in Texas, Louisiana, and Alabama. The Louisiana census tracts around Morgan City and along the Mississippi River below New Orleans are areas of mixed industry and agriculture. Coastal areas are sparsely inhabited in both census tracts. These pockets of minority populations do not match the distribution of the offshore oil industry and its supporting infrastructure. Instead, they are the product of urbanization and of the historical role African Americans had in southern agriculture.

The Final EIS for Lease Sale 181 (USDOI, MMS, 2001a) shows census tracts that have >50 percent low-income households. The CEQ (1997) guidance for defining low-income areas is less explicit than it is for minority areas. The MMS selected the 50-percent level as comparable to the minority definition. In almost every case, these census tracts are neighborhoods in large or coastal urban areas listed above. Except in south Texas, all low-income census tracts are also minority census tracts. Again, like the concentrations of minority population, these pockets of poverty are a product of urbanization and southern agriculture.

4. SCENARIO AND ENVIRONMENTAL CONSEQUENCES

This chapter describes the infrastructure, activities, and disturbances associated with projected exploratory drilling in the EPA sale area. A scenario is developed to provide a framework for the analysis of potential impacts to the biological, physical, and socioeconomic resources of the GOM (Chapter 4.3). The scenario is a hypothetical framework of assumptions based on projected number of OCS exploration wells to be drilled in the EPA sale area. The projections for exploration wells in the EPA sale area are based on resource and reserves estimates as presented in the *2000 Assessment of Conventionally Recoverable Hydrocarbon Resources of the Gulf of Mexico and Atlantic Outer Continental Shelf as of January 1, 1999* (Lore et al., 2001), current industry information, and historical trends. The scenario is only approximate since future factors such as the contemporary economic marketplace and evolving technologies are unknown. Notwithstanding these unpredictable factors, the scenario represents the best assumptions and estimates of a set of future conditions that are considered reasonably foreseeable and suitable for impact analyses.

Exploration, development, and production activities resulting from a lease sale in the EPA sale area are expected to take place over a 40-year period. Exploration activities in support of existing and future leases are projected to include drilling 38-73 exploration and delineation wells beginning as early as 2003. This PEA also analyzes the support activities of personnel and supply transport for potential impacts to both offshore and onshore resources in the EPA sale area.

4.1. EXPLORATION AND DELINEATION ACTIVITIES

Exploration activity involves prospecting for oil and natural gas (hydrocarbons). To form economically viable accumulations of oil and gas, four geological criteria must be met. First, a rock containing an enriched supply of organic material that is capable of forming oil and gas by the chemical and physical changes that occur during burial (the source rock) must be present. Second, a rock with pores and openings sufficient to hold and transmit oil or gas after it is generated (the reservoir, commonly sandstone) must be present. Third, the layers of rock must be structurally configured so as to capture a large accumulation of hydrocarbon resource (the trap). Fourth, the trapping structure and the reservoir rock must be overlain or configured so that the trap is sealed to prevent the escape of oil or gas (the seal).

Exploration begins as a prelease activity. An operator's team of geologists, geophysics, and engineers ("explorationists") conceptualize, evaluate available data, test hypotheses, and eventually present to management candidate prospects for OCS lease sales. Operators select those prospects on which they decide to bid by ranking them using proprietary methodologies input with geological and geophysical data and economic criteria. This evaluation determines a dollar amount the operator will bid for the lease.

When an operator successfully acquires an OCS lease, a period of postlease prospect maturation begins. Maturation refers to a suite of concurrent activities whereby data and analyses are assembled to a state of completeness or sophistication that permits management to decide on whether or not to invest in a drilling program. Matured prospects usually again undergo ranking using an operator's proprietary economic models, an internal risk evaluation team, or various types of decision trees.

The entire process is designed to increase the likelihood of an economically viable discovery. Even with the best technology for remotely exploring the subsurface, some exploration wells end up as dry holes or uneconomic discoveries. The stakes are especially high for exploratory drilling in deep water where costs can be $15-60 million per exploration well, a major investment for any operator who wants a discovered resource as an investment return. Over the last five years, the success rate for exploration wells in the GOM in water depths greater than 200 m is 30-40 percent (60-70% are dry holes). This high success rate can be attributed to improvements in seismic surveying and analysis technologies and to more conservative and focused exploratory drilling programs; a reflection of the high cost of deepwater operations.

4.1.1. Exploratory Drilling Activities

Operators drill exploration wells to evaluate the economic potential of their leases. If an exploration well does not encounter a reservoir rock or there are no hydrocarbons in a suitable reservoir rock, the well is called a dry hole. Dry holes are usually abandoned permanently without much delay. When an exploration well discovers hydrocarbon resources, it may not always be clear if an economic resource has been discovered. To determine if a discovery is economically viable, an operator can pursue a couple of options. One option might be to temporarily abandon the well to allow for additional analyses. Another option might be to drill a separate delineation well to test the size of the discovery. One type of delineation well is called a "sidetrack." A sidetrack shares the upper part of the wellbore with a previous well and extends outward at an angle to the original well so that different formations or bottom hole locations can be tested. The option to drill delineation wells or sidetracks is typically included in an operator's EP for a lease.

4.1.2. Exploration and Delineation Drilling Infrastructure

In the GOM, exploration and delineation wells are drilled with mobile offshore drilling units (MODU's). The type of MODU deployed at a site depends mainly on water depth. The term ultra-deepwater is frequently used in industry to refer to water depth exceeding 5,000 ft (1,525 ft). The EPA sale area lies in water depths from 1,600 to 3,000 m (4,925-9,850 ft). The MODU's capable of being deployed at these depths for exploration are (1) conventionally-moored semisubmersibles, (2) dynamically-positioned (DP) semisubmersibles, or (3) DP drillships (Figure 4-1). The upper water-depth limit for conventionally-moored semisubmersibles (anchored to the bottom with a chain catenary or tension mooring) is approximately 2,600 m (8,550 ft). Most of the EPA sale area, therefore, is within the capability of this class of MODU's, but not completely. In March 2002, Shell Exploration and Production set an ultra-deepwater world record in the GOM for water depth of a non-DP, conventionally-moored semisubmersible of 2,775 m (9,100 ft) for the depth of the deepest anchor (Offshore-Technology, 2002).

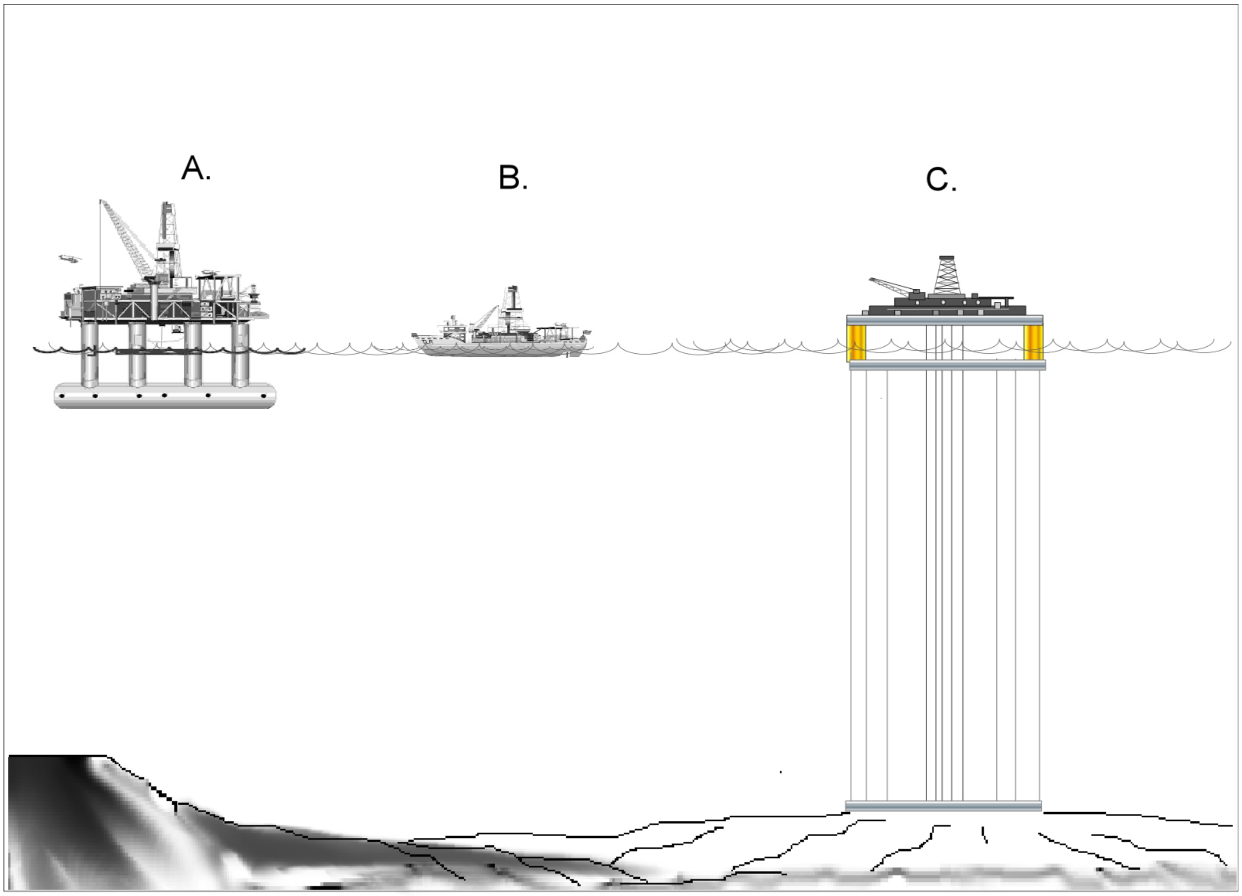

Figure 4-1. Mobile offshore drilling units suitable for the water depths in the EPA sale area.
A. dynamically-positioned semisubmersible,
B. dynamically-positioned drillship,
C. conventionally-moored semisubmersible.

The depth ranges for DP drillships and DP semisubmersibles overlap at all but the deepest water depths. The DP semisubmersibles can drill in water depths up to about 3,000 m. The DP semisubmersibles have the a depth range of operation of about 500 m greater than conventionally-moored semisubmersibles and the advantage that they do not disturb the bottom with anchors.

Drillships are designed to integrate a drill rig assembly and its support facilities into a floating hull. The practical ultra-deepwater drilling depth limits are currently about 3,100 m (10,200 ft). Because of their size, DP drillships are used in the deepest water (>3,000 m; >9,800 ft). Rigzone (2002) indicates that very few rigs have the capability to drill beyond 10,000 ft. Those that do are only DP drillships. Table 4-1 indicates the depth ranges used in this PEA for GOM MODU's.

Table 4-1

MODU Depth Capability

Drilling Rig Type	Water-Depth Range
Conventionally-moored semisubmersible	>600 but <2,600 m
DP semisubmersible	>600 but <3,000 m
DP drillship	>600 to 3,100 m

The MMS reported in November 2001 that 47 drilling rigs were operating on the deepwater OCS (water deeper than 1,000 ft). In October 2002, the day rate for semisubmersible rigs was reported as \$86,000 to \$94,000 for 2nd and 3rd generation semisubmersibles (Rigzone, 2002). The Rigzone website categorizes semisubmersibles by 1st through 5th generation, but these generations are not correlated directly to water depth range or DP capability. In October 2002, the day rate for a DP drillship was reported as \$149,000 (Rigzone, 2002).

Based on a sampling of well durations in OCS areas, a deepwater exploration well in the EPA sale area would be expected to take about 42 days to reach total depth; however, the range can be from 30 to 100 days, depending on numerous variables. Time on station can increase when problems are encountered with the equipment, weather, or the geology.

Before the drilling of an exploration or delineation well is begun, or the well is "spudded," an analysis of the bottom conditions at the well site is required in an operator's EP. A shallow geohazards analysis characterizes the sea bottom for conditions that may threaten the stability of drill-rig anchors or pose complications for controlling pressures in the well bore. Among the bottom geohazards known in the deepwater environment are (1) high rates of sedimentation, (2) movement of underlying salt or shale masses, (3) faulting, (4) slope instability and sediment sliding, (5) hydrocarbon seeps, (6) gas hydrates, and (7) shallow overpressured channel sands (Campbell, 1999). Among these, the most significant appear to be shallow geopressured zones and shallow water-flow zones (SWF). The SWF zones are caused by stringers and pods of sandy sediment deposited in buried channels. These sandy zones are more permeable than the surrounding shale in which they are encased and can be intervals of anomalous formation pressure. These zones can cause well stability problems if penetrated during drilling because of unpredictable pressure changes that an operator's drilling mud program may not be prepared to accommodate. Such an event can precipitate a well blowout.

Figure 4-2 represents a generic well schematic for an exploration well in the EPA sale area. The generic well design was derived from actual well-casing programs from nearby projects in the Mississippi Canyon and DeSoto Canyon areas and from internal MMS data. A generic well configuration cannot capture all of the possible configurations that might impact the well design. Well design is influenced by (1) unique geologic conditions at a specific well location, (2) directional drilling requirements, (3) the need for potential sidetrack(s), or (4) company preferences. For exploration wells, contingencies (such as SWF zones in the formation) must also be considered in the casing program.

The drilling of a deepwater exploration well begins with setting the first of many segments of steel casing. Casing is steel tubing within which the drilling operation is conducted. Deeper casing sections are narrower than the shallower sections and each change in casing diameter is separated by a "shoe" (Figure 4-2). The drillstring (pipe and bit) drills the wellbore inside the casing. The first casing set at the sea bottom (or mudline) can be 30-40 in (75-100 cm) in diameter. The first string is typically 60-90 m (200-300 ft) long and is emplaced by "jetting" out the unconsolidated sediment with a water jet as the largest casing pipe is set in place or by drilling with treated sea water to lubricate the drill bit. Because shallow sediments are soft and unconsolidated, this casing interval is commonly drilled with treated seawater without a riser (a steel-jacketed tube that connects the well head to the drill rig and within which the drilling mud and cuttings circulate). Drilling mud is generally not used when a riser is not used, and the formation cuttings are discharged from the wellbore directly to the sea bottom. The first casing string is cemented to the formation by forcing cement downhole to squeeze up and around the outside of the pipe and the wall of the geologic formation. This seal is tested with a pressure test. The next casing

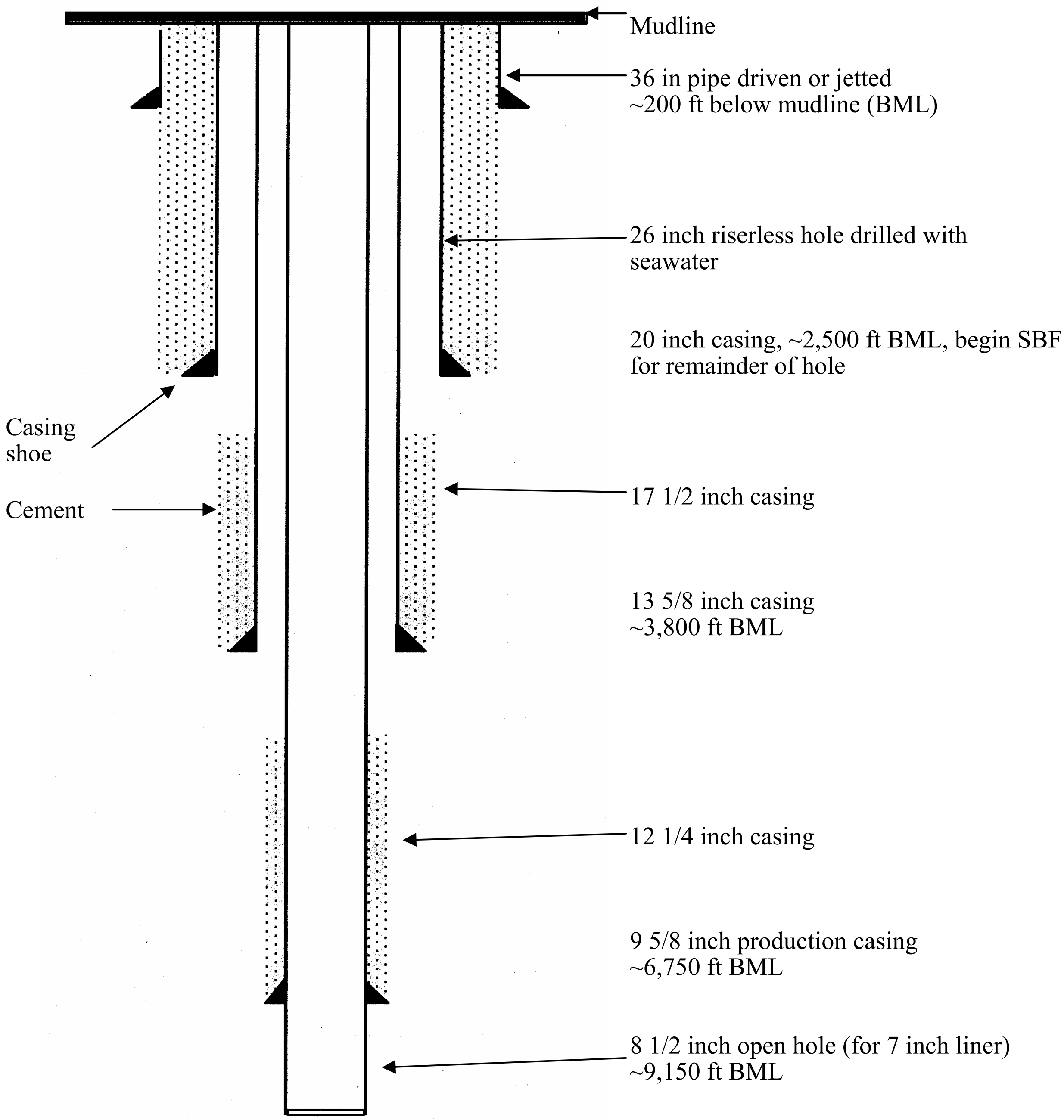

Figure 4-2. Well schematic for a typical exploration well expected in the EPA sale area (not every casing interval shown), composited from nearby industry developments projects in the Central Planning Area.

string is typically 26 in (91 cm) and may be set to a depth of about 488 m (1,600 ft). After the blowout preventer (BOP) is installed, commonly on the 20-in (51-cm) casing at the sea bottom, the riser is connected and circulation for drilling mud and cuttings between the well bit and the surface rig is established.

Next, a repetitive procedure takes place until the well reaches its planned total depth: (1) drill to the next casing point, (2) install the casing, (3) cement the casing, (4) test the seal, and (5) drill through the cement shoe and downhole until the next casing point is reached. The casing points are determined by downhole formation pressure that is predicted before drilling with seismic wave velocities. As the well deepens, extra lengths of pipe (each about 100-ft long) are screwed onto the drillstring at the surface to extend length to the cutting bit. The rig downtime needed to install extra lengths of drill pipe is referred to as "tripping" into or out of the hole. The bottom of a well is commonly uncased, prior to completion of the well.

The average depth of an exploration well in water depths greater than 200 m (656 ft) is 4,390 m or 14,400 ft. Assuming 1,600 m (5,250 ft) water depth, the wellbore depth would be 2,789 m or 9,150 ft below mudline (BML) (below the seafloor). The volume of cuttings in the upper sections of the well is greater than from deeper sections (Figure 4-2). Commonly, the upper portion of a deepwater well is drilled either with treated seawater or water-based fluid (WBF). For the generic example in Figure 4-2 it is assumed that the operator switches from WBF to SBF at 760 m (2,500 ft) BML (after the 51 cm (20 in) surface casing has been set). The SBF would be used until total depth (2,789 m or 9,150 ft BML) is reached. With the SBF, the rate of penetration may increase significantly compared to drilling rates with WBF at similar depths. It is also assumed that the operator will install the BOP on the 51-cm (20-in) casing.

Several factors may be constraints on the pace of exploratory drilling in the EPA sale area. The availability of rigs capable of drilling in deeper waters is currently one such constraint in the GOM. The GOM projects compete for resources with projects in other basins in the world where operators have active exploration programs and substantial interests. Also, during the mid- to late-1990's, operators in the Gulf acquired many more lease blocks than they are capable of drilling (USDOI, MMS, 2002b; Figure 4-2). In this active leasing environment, only the best prospects will eventually be drilled and many leased blocks will expire before they can be drilled, making them available in subsequent lease sales. Historical trends indicate that approximately 10 percent of deepwater leases are eventually drilled; only 5 percent of deepwater leases acquired between 1996 and 1997 have been drilled. The effect of a limited rig fleet qualified for deepwater drilling, alternative prospects throughout the world, operator's exploration budget limitations, and the availability of technical personnel qualified to work the latest equipment on new drill rigs will challenge operators to complete exploratory drilling within the 10-year period of their leases (USDOI, MMS; 2002a; page 107).

4.1.2.1. Emerging Technologies in Exploratory Drilling

Deepwater areas pose some unique concerns regarding well-control activities. Technological advancements in the oil and gas industry have not only improved the discovery and recovery of hydrocarbons on the OCS, but they have lessened impacts on the environment. For example, electronic safety systems, dual gradient drilling (DGD), horizontal wellbores and completions, and synthetic drilling fluids are technologies that have accomplished both goals. Electronic safety systems are used to monitor safety functions including shutdowns, alarms, and other critical devices. These systems are more reliable and accurate than previously used safety systems, allowing operators to respond more quickly to potential problems.

Extended-reach technology (specialized directional drilling) allows wells to be drilled as far as 6-8 km (4-5 mi) from a centralized surface location. The advantage to the environment from this technology comes from reducing the number of structures needed to develop a field. Horizontal drilling allows a wellbore to intersect more of the producing formation than is possible with conventionally drilled holes. This technology allows more reserves to be produced from a single wellbore. Ultimately, fewer wells may be drilled to recover equal quantities of hydrocarbons from a particular zone.

Dual gradient drilling (DGD) is perhaps the greatest single technological advancement for drilling in deepwater and ultra-deepwater environments. As drilling operations move into deeper waters, the hydrostatic pressure represented by the mud column in the riser introduces a major challenge for well control. In drilling young, rapidly subsiding depositional basins typical of the GOM, the margin between high-formation pore pressures and low-fracture resistance pressures require additional casing strings in both the upper part of the hole and in pressure transition zones. At issue is that slightly overweighted mud can be quickly lost to the formation because the difference in pressure between keeping the well and formation pressure in balance with the mud and fracing the formation is very small. With extra casing strings in the shallow part of the well, the bottom-hole casing size can be as small as 15-17 cm (6-6.75 in) – too narrow to permit horizontal or multilateral completions. The cost of an ultra-deepwater well (>5,000 ft water depth) can be $15-60 million or more, without certainty that objectives can be reached. The solution to the problem of narrow margins between formation pore pressure and fracture resistance is DGD.

Unlike conventional single gradient drilling technology, in which control of bottom-hole pressure is achieved with a mud column from the bottom of the well back to the rig, DGD achieves the same effect by using drilling mud from the hole bottom to the mudline, and seawater in the riser from the mudline to the surface rig floor – the result is a DGD system. Subsea pumps separate formation water or hydrocarbon from drilling fluid and cuttings and circulate it back to the surface in separate lines. Seawater replaces mud in the marine riser that connects the wellhead to the surface rig. The basic goal of DGD is to create a situation where the well perceives that only the weight of seawater exists above the mudline so that the formation below the mudline reacts as though the rig is sitting on the seafloor and the problem of hydrostatic pressure is eliminated. Not only does this method eliminate as many as four strings of casing, but it is possible to drill in almost any water depth and reach the well's objectives with a bottom-hole diameter of about 12 in. This diameter is large enough to permit 7-in production casing to be installed up to the mudline and provide for both horizontal and multilateral completions. Operators estimate that DGD systems can save $5-15 million on a deepwater well.

The industry drilled its first well in the Gulf using this technology in Green Canyon Block 136. A series of papers presented at the 2001 Society of Petroleum Engineers conference in New Orleans describe this joint industry project. The MMS prepared SEA's for the test well (USDOI, MMS, 2001c; 2001d) and determined that the potential environmental effects from the use of the DGD technology were comparable to, or better than, those expected from more conventional technology (see 30 CFR 250.141) (USDOI, MMS, 2001c).

The SBF were developed to combine the technical advantages of oil-based drilling fluids with the low persistence and toxicity of WBF. In a SBF, the liquid phase is a well-characterized synthetic organic compound added to brine and other ingredients. The SBF have had a significant effect on exploration and development operations. A recent Department of Energy publication (USDOE, 1999) cites results from a GOM operator study that concluded that SBF significantly outperformed WBF. Of eight wells drilled under comparable conditions to the same depth, the study found that the three wells drilled using SBF were completed in an average of 53 days at a cost of approximately $5.5 million. In comparison, the five wells drilled using WBF were completed in an average of 195 days at a cost of approximately $12.4 million. The environmental benefits from the use of SBF include reduced air emissions because of shorter drilling times and less waste because SBF are recycled (the cuttings are disposed).

The MMS requires that operators conduct their offshore operations in a safe manner. The MMS's operating regulations at 30 CFR 250 Subpart D provide guidance to operators for drilling activities. For example, operators are required by 30 CFR 250.400 to take necessary precautions to keep their wells under control at all times using the best available and safest drilling technology (NTL 99-G01).

4.1.2.2. Well Abandonment and Site Clearance

An exploration well generally refers to the first well drilled on a prospective structure to determine if a resource exists. When an exploration well discovers a hydrocarbon accumulation, the operator reaches a decision point. They must decide whether or not to complete the well immediately, delay completion with the rig on station, or temporarily abandon the well. An operator may temporarily abandon a well to collect more data to aid in decisions. Temporary abandonments occur to (1) allow detailed analyses, (2) drill additional delineation wells, (3) save the wellbore for a future sidetrack to a new geologic bottom hole location, or (4) wait on design or construction of special production equipment or facilities. The operator must meet specific plugging and sealing requirements to temporarily abandon a well (30 CFR 250.703). If a well is temporarily abandoned at the seafloor, an operator must provide MMS with annual reports summarizing plans to permanently abandon the well or to bring the well into production.

The decision to permanently abandon a well can come immediately in the case of a dry hole, after a well has been temporarily abandoned for a time, or at the conclusion of a long production history. If the operator decides not to put the well into production, the next step is permanent abandonment. Permanent abandonment operations are undertaken when a wellbore is of no further use to the operator (i.e., the well is a dry hole or the well's producible hydrocarbon resources have been depleted). During permanent abandonment operations, equipment is removed from the well, and specific intervals in the well that have zones of hydrocarbon are plugged with cement. There is one permanent abandonment operation per well. To carry out either temporary or permanent well abandonment operations, a workover rig remains on station for a period of 5-15 days.

4.1.3. Service Vessels

A service trip is a round trip between a service base and a drillsite. All trips are assumed to originate from existing service bases. Venice, Port Fourchon, and Morgan City, Louisiana, currently service most of the exploration activity in the northern GOM and would be expected to support exploration activity in the EPA sale area. Port Fourchon is one of the few Gulf ports that can accommodate the draft of fully laden deepwater vessels.

Service vessels used in support of deepwater exploratory drilling are primarily offshore supply vessels and crew boats. The supply vessels carry freshwater, fuel, cement, barite, liquid drilling fluids, tubular steel drillstrings, wireline logging services, equipment, food, and miscellaneous supplies, and sometimes personnel. Crew boats carry primarily personnel and sometimes needed supplies.

There is an average of 6-9 trips per week in support of exploratory drilling. Assuming an average of 6 weeks (42 days) onsite to drill an exploration well, this amounts to 36-54 service-vessel trips in support of each well. This amounts to approximately 1,300-3,900 vessel trips to support the projected 38-73 total number of exploration wells in the EPA sale area. Deepwater service vessels cruising at 12-14 kn (loaded) (16 mph) would reach sites in the EPA sale area in 10-18 hours, depending on the location with the EPA sale area. The nearest EPA sale area sites in deep water may be reached within 8 hours.

Compared to shelf-bound service vessels, deepwater service vessels have a number of improvements, among them, (1) better hull designs (increased efficiency and speed), (2) a passive computerized anti-roll system, (3) drier and safer working decks, (4) increased cargo capacity (water, cement, barite, drilling muds, etc.), (5) increased deck cargo capability, (6) increased cargo transfer rates to reduce the time alongside rig structures, (7) dual and independent propulsion systems, (8) true dynamic positioning system, (9) fuel and NO_x efficient engines, and (10) Safety of Life at Sea (SOLAS) capability (*WorkBoat*, 1998).

4.1.4. Helicopters

Helicopters are the primary mode of transporting personnel between shore bases and offshore drill rigs. Helicopters are routinely used for normal crew changes and at other times to transport management and special service people to offshore exploration sites. Normal offshore work schedules in deepwater activities involve two-week (or longer) cycles with crew changes on a weekly basis. Helicopters are expected to travel to exploration drill rigs in the EPA sale area at least once a week. Small parts needed for emergency repair or replacement, and miscellaneous supplies such as daily newspapers and mail are also routinely transported by helicopter.

Each helicopter makes an average of 3-10 round trips per week in support of exploratory drilling operations. Assuming 6 weeks on site to drill an exploration well, about 18-60 helicopter trips would be expected in support of each well. This amounts to about 684-4,380 round trips to support the estimated number of exploration wells in the EPA sale area. Helicopters cruising at 170 kn (loaded) (200 mph) may reach deepwater sites of the EPA sale area within <1.0 to 2.0 hours, depending on location.

The Federal Aviation Administration (FAA) regulates helicopter flight patterns. Because of noise concerns, FAA Circular 91-36C encourages pilots to maintain higher than minimum altitudes near noise-sensitive areas. Corporate policy (all helicopter companies) states that helicopters should maintain a minimum altitude of 700 ft while in transit offshore and 500 ft while working between platforms and drill rigs. When flying over land, the specified minimum altitude is 1,000 ft over unpopulated areas and coastlines and 2,000 ft over populated areas and sensitive areas including national parks, recreational seashores, and wildlife refuges. In addition, the guidelines and regulations promulgated by NOAA Fisheries require helicopter pilots to maintain 1,000 ft of airspace over marine mammals.

4.2. IMPACT-PRODUCING FACTORS

This chapter will provide a survey of the impact-producing factors involved in deepwater exploratory drilling operations in the EPA sale area.

4.2.1. Sea Bottom Disturbance

Conventionally-moored semisubmersibles, DP semisubmersibles, or DP drillships are the MODU's expected to be used in the water depths of the EPA sale area (1,500-3,000 m or 4,925-9,850 ft). Because DP MODU's do not anchor, they do not disturb the sea bottom except for the tiny area where the well bore penetrates the sea bottom. Semisubmersibles that are non-DP capable will disturb small areas of the sea bottom as a result of the proposed action. Disturbance of the sea bottom resuspends fine-grained bottom mud, causing a local increase in turbidity. Direct impact causes crushing and disturbance of the stratigraphy of sediments near anchor sites.

The disturbed sea-bottom footprint for each anchor of a conventionally-moored semisubmersible is 2.1 ha (5.2 ac). Semisubmersible MODU's commonly have eight anchors. If it is assumed that all exploratory drill rigs deployed in the EPA sale area are anchored and that each deployment drills five wells, then the range of area for potential disturbed sea bottom would be between 315 and 607 ac, or between 5 and 10 percent of the area of one OCS block. This area of sea bottom is very small out of a tract of 256 OCS blocks, which is equivalent to 1,474,000 ac. Many rig deployments for exploratory drilling would use DP drillships and DP semisubmersibles that do not require anchoring.

Regulations, lease stipulations, and existing mitigation measures protect sensitive resources, such as historical archaeological resources and chemosynthetic communities from potential impacts from bottom disturbance by requiring avoidance.

4.2.2. Space Use

The areas occupied by exploration rigs, service vessels, mooring buoys, and surrounding safety zones are unavailable to commercial fishermen. To drill an exploration well, drill rigs spend approximately 40-150 days on site, depending on drilling depth, the drilling program, and any mechanical difficulties that are encountered. The space occupied, including safety zones for service vessels, is approximately 3-15 ha (7-37 ac). Virtually all commercial trawl fishing in the GOM is performed in water depths less than 200 m (Louisiana Dept. of Wildlife and Fisheries, 1992). Longline fishing is performed in water depths greater than 100 m and usually beyond 300 m. The EPA sale area is entirely in water depths greater than 1,500 m (4,925 ft). Some longlining excursions may need to alter their planned pathways to accommodate a rig's presence.

4.2.3. Aesthetics

A drill rig or drillship is visible from shore at distances of 5-16 km (3-10 mi). On a clear night, lights on the top of drilling derricks could be visible to approximately 32 km (20 mi). The EPA sale area is nowhere less than 75 mi (120 km) from the shoreline of the nearest State (Louisiana); therefore, no MODU in the EPA sale area will be visible from shore.

4.2.4. Drilling Unit Operational Wastes and Discharges

The major operational wastes generated during offshore oil and gas exploration are drilling fluids and cuttings. Other significant wastes streams generated during exploratory drilling are formation water or hydrocarbons produced during well testing, fracturing and acidifying fluids, and well treatment or completion fluids. Minor wastes include sanitary and domestic wastes, desalination unit discharges, ballast water, storage displacement water, and other miscellaneous minor discharges. Each waste stream as it applies to exploratory drilling, will be discussed individually.

No wastes generated during oil and gas operations can be discharged overboard unless they meet the standards required within a USEPA National Pollutant and Discharge Elimination System (NPDES) permit. The EPA is under the jurisdiction of the USEPA, Region 4 Office. An NPDES general permit (GMG280000) has been issued by the USEPA Region 4 for the eastern portion of the GOM in water depths greater than 200 m (final permit published in the *Federal Register*, 66 FR 50, page 14998, March 14, 2001). This NPDES general permit applies to EPA sale area. Region 4 is requiring operators to include in their general permit technical information on the characteristics of the sea bottom within 1,000 m of the discharge point, including but not limited to, information regarding geohazards, topographical formations, live bottoms, and chemosynthetic communities. The USEPA will use this information to determine if an NPDES individual permit is required. The current NPDES general permit will expire on October 31, 2003, but the MMS expects that a general permit will be reissued with similar requirements.

Miscellaneous wastes likely to be generated on drill rigs include excess cement, uncontaminated seawater, desalinization unit water, and uncontaminated ballast waters. These waste types are regulated together by the USEPA under miscellaneous discharges and are discharged overboard if they meet the general NPDES permit requirements.

4.2.4.1. Drilling Muds and Cuttings

The discharges from drilling operations are drilling fluids (also known as drilling mud) and cuttings of the rocks penetrated by the drilling bit. Drilling fluids are used in rotary drilling to (1) remove cuttings from beneath the bit and bring them to the surface, (2) control well pressure, and (3) cool and lubricate the drillstring. Drilling fluid, either seawater or WBF and cuttings are discharged directly onto the sea bottom during initial well drilling before a riser is connected to the casing string to circulate and return mud and cuttings from the drill bit to the surface. In lieu of drilling the shallowest part of a wellbore may be jetted with pressurized water. Pre-riser casing installation typically involves 36-in (91-cm) casing that may be set to a depth of 300 ft (91 m) and 26 in (66 cm) casing that may be set to a depth of 1,600 ft (500 m). The volume of jetted or drilled cuttings from the pre-riser wellbore could total as much as 226 m^3 (1,422 bbl) (Halliburton Company, 1995) or more (see Chapter 4.2.4.1.1, Deepwater Well Construction and Well Volume, for a GOM example). Discharges from DGD operations are not expected to be greater than conventional drilling operations.

The composition of drilling fluids is complex. The bulk of the fluid fraction consists of clay minerals, barite, and a base fluid, which can be fresh or salt water, mineral or diesel oil, or any of a number of synthetic oils. Three categories of drilling fluids are used on the OCS: water based, oil based, and synthetic based. The WBF have been used for decades to aid drilling on the continental shelf. Occasionally, oil-based fluids (OBF) are used for directional drilling and in sections where problems arise from using WBF. Since 1992, use of SBF has increased, especially in deep water, because SBF performs better, is less toxic than OBF, and reduces drilling time and cost incurred from expensive drill rigs.

Numerous chemicals can be added to improve the performance of drilling mud. These additives can be potato starch, potassium chloride, corn starch, acrylamide, xantham gum, or polyanionic cellulose. The precise composition is dependent on the drilling situation and may vary during the drilling of the hole. Other chemicals may be added if circulation is lost or if the drilling bit or pipe becomes stuck. Walnut shells, mica, lime, and food grade emulsifiers may be useful additives under these conditions. The WBF may have diesel oil or mineral oil added to assist lubrication.

The mineral barite is a major constituent of drilling mud because of its high specific gravity. It makes the WBF heavy to control downhole pressure. Trace levels of heavy metals, such as mercury, cadmium, chromium, lead, and zinc are naturally associated with the barite mineral structure. The discharge of WBF and cuttings is allowed everywhere in the GOM under general NPDES permits, as long as the discharge meets the toxicity guidelines. The NPDES general permit allows for the discharge of WBF and cuttings that meet the criteria for mercury (<1 ppm), cadmium (<3 ppm), and toxicity <30,000 ppm. Elevations of all these metals except chromium were observed within 500 m of six drillsites in the GOM (Boothe and Presley, 1989). Trace amounts of mercury in barite is predominantly inorganic mercuric sulfate and mercuric sulfide (Trefrey, 1998). Mercury is a concern because it potentially bioaccumulates in aquatic organisms. Because barite is nearly insoluble in seawater, mercury and other trace metals are trapped in the barite mineral structure. Therefore, unless the mercuric sulfide in barite can be microbially methylated to methylmercury, this source of mercury remains inorganic and is relatively unavailable for uptake into the marine food web.

Concentrations of total mercury in uncontaminated estuarine and marine sediments generally are 0.2 μg/g dry weight or lower. Surface sediments collected 20-2,000 m away from four oil production platforms in northwestern GOM contained 0.044-0.12 μg/g total mercury. These amounts are essentially background concentrations for mercury in surficial sediments on the OCS of the GOM (Neff, 2002). The

NPDES limits reduce the addition of mercury to the OCS environment to quantities similar to the background concentration of mercury found in marine sediments throughout the GOM (Avanti Corporation, 1993a and b; USEPA, 1993a and b). On the other hand, elevated levels of methylmercury have been found in top predatory fish and marine mammals (USEPA, 1997). Research conducted by Neff et al. (1989) showed no uptake of mercury in winter flounder exposed to barite-amended sediments. Deposition of mercury from the atmosphere is believed to be the main source of anthropogenic mercury input into the marine environment. Mercury in barite originating from OCS activity has been suggested as a secondary source in the GOM.

The WBF that is discharged overboard can have no free oil as determined by the static sheen test. Oil and grease is limited to <42 mg/l daily and 29 mg/l monthly average. The WBF and cuttings would be discharged overboard at a rate not to exceed 1,000 bbl per hour. Occasionally, formation fluids containing hydrocarbon may be mixed with drilling fluid and cutting, but this discharge is subject to NPDES limits. Historically, on average, about 12 percent of the mud and 2 percent of the cuttings fail permit limits (USEPA, 1993a).

The physical dispersion of WBF discharges in the water column has been the subject of considerable study (e.g., NRC, 1983; Neff, 1981; Petrazzuolo, 1981; Ecomar, Inc., 1980; Engelhardt et al., 1989; Avanti Corporation, 1993a and b). Although not an issue in the deep water of the EPA sale area, discharges overboard are not permitted within 1,000 m of an area of biological concern. The turbidity plume created by the discharge of WBF and cuttings is greatly influenced by current direction and speed. In shallow OCS waters, elevated levels of petroleum hydrocarbons and metals contained in drilling fluids and cuttings could be measured in sediments as far out as 2,000-3,000 m downcurrent from the discharge outfall (Boothe and Presley, 1989; Neff, 1987; Erickson, et al, 1989). Generally, the plume rapidly disperses within 3,000 m of the discharge point (Avanti Corporation, 1993a). Actual drilling and associated discharges only occur about 50 percent of the time a drill rig is on-site. The rest of the time is used to change out equipment or "trip" into the hole. High-volume, bulk discharges (500-1,000 bbl/hr) last for periods of 20 minutes to 3 hours (Petrazzuolo, 1981; Avanti Corporation, 1993a) and take place once or twice during the drilling of a well, usually during the upper section of the well. Otherwise, the discharge volume decreases with increasing depth as the wellbore decreases in diameter.

Impacts to marine water and sediment quality from the overboard discharge of WBF and cuttings are dependent on water depth and current speed. Discharged fluid can contain trace metals and it increases turbidity in the water column. Discharged cuttings can alter sediment characteristics as the coarse cuttings settle to the bottom. In shallow-water settings, WBF are rapidly dispersed in the water column immediately after discharge and cuttings rapidly descend to the seafloor to carpet a relatively small area (Neff, 1987). The greatest effects to the benthos are within 100-200 m, primarily due to incidental burial and the increased coarsening of the sediment by cuttings.

Because of the toxic nature of OBF, discharge of both OBF and OBF cuttings overboard into the water is prohibited everywhere on the Gulf of Mexico OCS. All OBF fluids and associated cuttings must be retained and disposed onshore, leading to expensive handling and disposal costs. OBF's and cuttings do not readily disperse in the water column and reach the sediment as clumps. Severe impacts have been observed within 200 m of the drilling site with measurable impacts out to 1,000 m (Neff, 1987). The primary toxicants in OBF are light aromatics such as benzene, toluene, and xylene. The SBF are specialized, non-water soluble, manufactured drilling fluids that have been developed over the past 15 years, primarily in response to the toxic nature of OBF discharges. Now, SBF are more likely used for difficult drilling situations where WBF are deficient and where OBF might have been used previously, for example, when formation-swelling clays make borehole stability a problem. In deepwater, SBF are used throughout the GOM because they are more effective at higher well temperatures, reduce drilling problems such as hydrate formation, and shorten the drilling time to reduce costs. The SBF is rented by the operator and is returned to the mud vendor for recycling.

Region 4's general NPDES permit does not allow the discharge of SBF anywhere on the Gulf of Mexico OCS. All SBF cuttings must be retained and disposed onshore. On January 22, 2001 the USEPA promulgated new effluent guidelines to address overboard discharge of SBF and cuttings (66 CFR 6850). This guideline established technology-based effluent limitations for existing and new sources. Discharge of SBF-wetted cuttings wastes could be addressed with the reissuance of the USEPA Region 4 general permit in October 2003. USEPA Region 6 (CPA and WPA) has modified its general permit to reflect the recent guidelines. The USEPA Region 6 general permit has added several new monitoring requirements for discharge of SBF-wetted cuttings to prevent adverse environmental effects that includes (1) a sediment toxicity test, (2) a polycyclic aromatic hydrocarbon (PAH) analysis, and (3) an anaerobic biodegradation test (by gas generation). The USEPA Region 4 (EPA) has not modified the existing general NPDES permit but may do so for the October 2003 permit reissuance. The SBF-wetted cuttings have approximately 5-15 weight percent of SBF adhered on the cuttings (Neff et al., 2000). The USEPA established guidelines for retention of SBF on cuttings of 6.9 percent for internal olefins and 9.4 percent for vegetable esters (66 FR 6850). The use of large dryers on exploration drillrigs can achieve these levels, and less, of adhered SBF fluid on cuttings.

A recent literature review (Neff et al., 2000) discussed the current knowledge about the fate and effects of SBF discharges on the seabed. The SBF exhibit clumping tendencies and do not readily disperse in the water column. They settle very close to the discharge point and affect the local sediments. The SBF do not contain aromatic compounds and are not toxic. The primary affects on the benthos are smothering or burial, alteration of grain size, and addition of organic matter to the sediment, which can result in localized anoxia while the SBF degrades. Different formulations of SBF result in base fluids that degrade at different rates, thus affecting the magnitude of impact. Bioaccumulation tests also indicate that SBF and their degradation products should not bioaccumulate. The MMS is currently jointly funding a study of the spatial and temporal effects of discharged SBF and cuttings.

Deepwater Well Construction and Mud Volume

Figure 4-2 represents a generic well schematic for an exploration well in the EPA sale area. The shallower section of a well is drilled with a large diameter bit, and progressively smaller drilling bits and casing strings are used with increasing depth. Therefore, the volume of cuttings per casing interval (length of wellbore) in the upper sections of the well is greater than the volume generated in the deeper sections. Commonly, the upper portion of a deepwater well is drilled with treated seawater or WBF. For this generic example, it is assumed that the operator switches from WBF to SBF after the 51 cm (20 in) surface casing has been set (the 44.5-cm or 17.5-in hole) at 762 m (2,500 ft) BML. The SBF would be used until total depth (2,789 m or 9,150 ft BML) is reached. With the SBF, the rate of penetration may increase significantly compared to drilling rates with WBF at similar wellbore depths. It is also assumed that the operator will also install the blowout preventer on top of the 20-in casing string.

Under the current general NPDES permit in USEPA Region 4, discharges SBF or cuttings associated with SBF drilling are not permitted. The retention of adhered SBF on cuttings was measured from 54 wells drilled in the GOM – about 9.2 percent was internal olefins (USEPA, 1999b), a primary component in the SBF. In USEPA Region 6, which includes the CPA and WPA, the modified NPDES permit limits the amount of SBF adhered to cuttings discharged overboard to a maximum weighted mass ratio of 6.9 grams (g) internal olefin SBF/100 g wet weight drill cuttings or 9.4 g ester SBF/100 gram wet weight drill cuttings. The USEPA is suggesting the use of cutting dryers to reduce the adhered SBF.

Table 4-1 shows the calculated average volumes of fluids (muds) and cuttings discharged from a generic deepwater exploration well in the EPA sale area using treated seawater and/or WBF and SBF (Richardson and Trocquet, personal communication, 2002). The wellbore from the seafloor to about 2,500 ft may be drilled entirely using treated seawater. If wellbore stability problems are encountered, WBF may also be used in drilling to 2,500-ft depth BML. The drilling of a single deepwater exploration well in the EPA sale area is expected to result in the discharge of up to 230 bbl of WBF, 3,300 bbl of cuttings including the water and synthetic segments, and 100 bbl of SBF adhered to the cuttings (Table 4-2). Drilling of the projected 38-73 exploration and delineation wells in the EPA sale area would be expected to generate 8,700-18,000 bbl of WBF, 114,000-241,000 bbl of cuttings, and 3,800-7,300 bbl of SBF adhered to the cuttings during the period 2003-2043.

Table 4-2

Average Volumes of Muds and Cuttings Projected
for an Exploration Well in the EPA Sale Area
(assumes a total depth of 2,789 m or 9,150 ft below mudline measured depth)

Drilling Fluid	Average Range of Well Depth (BML, MD)	Volume of Mud Discharged (bbl)[1]	Volume of Cuttings Discharged (bbl)[2]
Treated seawater or WBF (pre-riser)	Seafloor to 762 m (2,500 ft)	229	2,291
SBF	762 m (2,500 ft) to 2,789 m (9,150 ft) TD	108	1,084

[1] Assumes 10% adherence factor
[2] Wellbore erosional factors are included in these estimates: 20-40% washout in upper portion of the wellbore (<762 m; <2,500 ft) (seawater or WBF) and 5-15% in the lower portion of the wellbore (>762 m; >2,500 ft) (SBF).

The discharge of muds and cuttings is expected to be the primary impact-producing factor associated with exploratory drilling in the EPA sale area. Table 4-2 gives estimated volumes of muds and cuttings that may be discharged from the drilling of an "average" well. Because OBF are used only under special circumstances and may be replaced with SBF in the future, estimates of the amount of OBF muds and cuttings are not possible. Cuttings from SBF may either be discharged overboard or onshore disposal will continue to be required, depending on the decisions of USEPA Region 4 in October 2003. The greatest potential impacts, therefore, would be to onshore disposal facilities.

4.2.4.2. Well Completion Fluids

Completion of exploration wells takes place in a continuum of formation processing that could convert an exploration well to a producing well. Completion activities take place after an operator has decided that enough resource is in place to perform a production test to determine flow characteristics as a further step in formation evaluation. If the exploration well is not completed, the operator either temporarily or permanently abandons the well (see Chapter 4.1.2.2, Well Abandonment and Site Clearance).

Well completion is the process of installing the downhole equipment to allow testing of the hydrocarbon-bearing formation. Completion includes setting and cementing casing, perforating the casing and cement, installing production tubing and packers, and gravel-packing the well. Well treatment refers to processes that enhance or stimulate the well to achieve stable flow rates.

Fracing (or fracturing) and acidizing, separately or together, are common well treatment and stimulation techniques used in the GOM. Fracing pressurizes the downhole environment and formations at specific intervals to open pore throats for better permeability. Sometimes propping agents are mixed with fracing fluids and foams (for example, glass microspheres) that act to prop open pore throats after downhole pressure returns to normal.

Acidizing with hydrochloric acid (HCl) and other acids is used to increase permeability by dissolving cementing agents. Hydrochloric acid is generally diluted with water to 3-15 percent HCl. Other acids such as hydrofluoric, acetic, and formic acid are also used. Acids dissolve limestone, calcareous cements of sandstone, and other deposits and are therefore altered during use. Because of the corrosive nature of acids, particularly when hot, corrosion inhibitors are added. Because the fluids are permanently altered, they cannot be recovered and recycled; however, these products may be diluted and discharged overboard.

Wells are drilled using a base fluid and a combination of other chemicals to aid in the drilling process. After a well is determined to be an economic discovery, the exploration well can transition to a production well. Fluids (drilling muds) present in the borehole can damage the geologic formation in the producing zone. Completion fluids are used to displace the drilling fluid, thus minimizing impacts on the permeability of productive zones, while still maintaining the characteristics of drilling fluid. Modified drilling fluids or "clear" fluids can be used for completion. "Clear" fluids consist of brines made from seawater mixed with calcium chloride, calcium bromide, and/or zinc bromide. These salts can be adjusted to increase or decrease the density of the brine. Additives, such as defoamers and corrosion inhibitors are used to reduce problems associated with the completion fluid. The recovered completion fluids are bought back by the chemical supplier and recycled for reuse. Each well completion is estimated to result in 150 bbl of completion fluids.

USEPA Region 4, under the NPDES general permit (GMG280000, 63 FR 55718), allows the discharge of well-treatment, completion, and workover fluids, but the discharge must meet the specified guidelines. The permit limits the use of treatment chemicals at or below the maximum manufacturer's recommended dose, or 500 mg/l, in addition to prohibiting the discharge of free oil.

Additives containing priority pollutants must be monitored, and records of the monthly discharge are kept. The primary discharges of well-treatment chemicals would occur with discharge of WBF and cuttings. Both must meet the general toxicity guidelines in the NPDES general permit. Some chemicals react with the formation and are lost, while others could be discharged in formation water as described below. Other chemicals could be retained and disposed along with formation solids or transported to shore with SBF. Chemicals are recycled when possible.

4.2.4.3. Hydrocarbons from Well Testing

When an oil or gas resource is discovered, it may or may not be an economic discovery. The operator usually conducts a well test to quantify the amount of resource in place as input to a decision whether or not to complete the well or produce the discovery. The well test consists of a varying period of temporary production to test formation porosity and permeability and the sustainability of flow rates. As exploratory drilling occurs in progressively deeper water, operators may consider using MODU's that have onboard hydrocarbon storage capabilities. This option may be exercised if a well requires extended flow testing, 1-2 weeks or longer, in order to fully evaluate potential producible zones. The liquid hydrocarbons resulting from an extended well test would be stored for later transport to shore for processing.

Operators may also consider barges or the use of shuttle tankers to transport liquid hydrocarbons to shore or to another storage facility. Some drillships have liquid hydrocarbon storage capabilities that range from 100,000 to 500,000 bbl. Any oil stored from an extended well test would be offloaded to a barge or shuttle tanker for transport to another facility or to shore. Weather and seas will place limits on offloading operations. Barging operations associated with extended well tests are expected to occur only once during the economic evaluation of a field. The offloading procedures are carried out under USCG regulations (33 CFR Subchapter O). If operators do not choose to store produced liquid hydrocarbons during the well test, they must request and receive approval from MMS to burn, or flare, hydrocarbons from well testing. Flaring of test gas can be approved in accordance with 30 CFR 250,1105, but no long-term flaring approvals are granted. The MMS has approved flaring of limited volume and duration to allow for well testing, well unloading, and other infrequent, short-term events. Flaring under ordinary circumstances is contrary to MMS's mission to conserve the Nation's nonrenewable natural resources.

4.2.4.4. Formation Water from Well Testing

Formation water (also called fossil or connate water) refers to the water naturally present in the formation. When formation water is produced with oil and gas, it is called produced water. Formation water is therefore analogous to produced water except formation water, for purposes of this PEA, is restricted to waters recovered as part of well testing undertaken during the exploration phase of postlease activity. Formation water would represent a small component of the waste stream during well testing, generally having the chemical characteristics of produced water. Formation waters or brines from a well test are a mixture of water and chemicals used to stimulate or treat the well and oil or gas. These waters can be high in total dissolved solids (salinity), total organic carbon, metals, and very low in dissolved oxygen. Because formation waters are intermingled with petroleum, they usually contain variable concentrations of dissolved and dispersed petroleum hydrocarbons. High concentrations of other soluble organic compounds have also been found, particularly phenols and carboxylic organic acids (Neff, 1997). High levels of toxic metals such as vanadium, copper, and arsenic have been found in some produced water (USDOI, MMS, 1999). The Final EIS for Lease Sale 181 (USDOI, MMS, 2001a; Table IV-8) provides the chemical constituents and typical concentrations in GOM produced waters. Projected quantities for the EPA can be found on pages IV-29 through IV-34 of the Final EIS for Lease Sale 181.

The OCS operators can dispose of their produced-water wastes in three ways: (1) they can meet their NPDES permit conditions by treating the produced water and developing outfall configurations that will allow them to discharge the waste overboard; (2) they can reinject the produced water into offshore injection wells; or (3) they can ship the produced water to shore for disposal at onshore injection wells or at waste disposal facilities. A discussion of the onshore disposal of produced water waste can be found in the Final EIS for Lease Sale 181 (page IV-114).

4.2.4.5. Formation Solids/Sands from Well Testing

Similar to the distinction between produced water and formation water used in this PEA, formation solids are analogous to produced solids, except formation solids are restricted to solids recovered during well testing carried out during the exploration phase. Formations solids are slurried particles used in hydraulic fracturing, accumulated loose formation sand, and mineral scale particles in circulating piping systems. Solids constitute a very small part of the discharge waste stream from exploration activity. They are recovered only if well testing of several hours or more is undertaken. There may be so little formation solids yielded during well testing, volumetrically, that disposal during exploration is not an issue. Small volumes of formation solids may be drained into drums on deck for disposal or are carried through the oily water treatment system and appear as suspended solids in formation-water effluent. Due to the oil wetting of clay particles and the presence of paraffin, grease, and other hydrocarbon-containing materials that are in various quantities in tank bottoms, accumulations in tank bottoms are often referred to as sludge. If sand volumes are large, the solids are removed in cyclone separators, producing a solid phase waste.

No produced sands or sludges, or formation sands generated by well testing during exploration, are discharged offshore into marine waters. The USEPA General NPDES permit covering the EPA sale area imposes a zero discharge on these wastes. Industry will use downhole encapsulation, well injection, or shipment onshore for disposal of formation or produced sands. A fuller discussion of the onshore disposal of produced solids anticipated in the EPA can be found in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a; pages IV-113 through IV-115).

4.2.4.6. Air Emissions

Air quality will be degraded to a limited degree in the immediate vicinity of the drilling rig. Activities that use any equipment that burns a fuel, that transports and/or transfers hydrocarbons, or that results in accidental releases of petroleum hydrocarbons or chemicals, will cause emission of air pollutants, which are regulated by the Clean Air Act and its subsequent amendments. Some of these pollutants are precursors to ozone, which is formed by complex photochemical reactions in the atmosphere.

The criteria pollutants considered here are nitrogen dioxide (NO_2), carbon monoxide (CO), sulphur oxides (SO_x), volatile organic chemicals (VOC), and particulate matter less than 10 microns in size (PM_{10}). Air emissions for the new criteria pollutant $PM_{2.5}$ were not calculated for this analysis because currently established emissions factors for that pollutant are still being compiled by the USEPA. Criteria pollutant emissions from OCS drilling operations and service vessels support are estimated using the emission rates presented in Table 4-3. These emission rates are derived from an MMS inventory of offshore OCS structures between 1991 and 1992 (Steiner et al., 1994).

Helicopter emissions and air pollutant emissions during loading, storage, and transportation of crude oil and gas are calculated using the methodology and emission factors presented in USEPA publication AP-42 of 1985 with supplements A, B, and C.

The quantities calculated in Table 4-3 are projections of total emissions for the 37-83 exploration wells projected for the EPA sale area based on six exploration programs proposed in EP’s received by MMS in 2001 and 2002.

Table 4-3

Average Annual Emission Rates
from OCS Infrastructure in the GOM

	NO_x	CO	SO_x	VOC	PM_{10}
Exploration Well (tons/well)[1]	316.6	69.9	43.1	9.6	9.2

[1]Assumes a 4,115-m borehole, 100-day drilling period, and a power consumption of 120 horsepower hour/foot.

Air quality would be affected if a blowout occurs. Emissions of regulated pollutants from OCS-related oil spill accidents are presented in Table IV-11 of the Final EIS for Lease Sale 181 (USDOE, MMS, 2001a; page IV-40) and in (USDOI, MMS, 1983; ERG, 1981; Kirstein, 1992). It is assumed that emissions of air pollutants from oil spills cease completely after three days. Highly volatile, low-molecular-weight hydrocarbons would be released to the atmosphere from the sea surface. Volatile organic compounds (VOC's) in spilled oil are precursors to photochemically produced ozone. A spike in VOC's could contribute to a corresponding spike in ozone, especially if the release were to occur on a hot and sunny day in a NO_2-rich environment. The nearest onshore areas are all currently in attainment for ozone. If a fire occurs, particulate and combustible emissions will be released in addition to the VOC's.

4.2.4.7. Discharge and Wastes from Onshore Support Bases

As point sources of water pollution are controlled, nonpoint-source pollution remains a leading source of contamination (USEPA, 2001). Runoff from the support facilities may contain antifouling paints from boats, oil, particulate matter, heavy metals, petroleum products, process chemicals, fecal coliform, and high nutrient loads. Runoff could affect local waters and sediments; elevating the contaminant levels, decreasing dissolved oxygen content in water and sediment, and increasing turbidity. The presence of infrastructure and associated access routes alters the natural hydrology and geography of the area over time, resulting in increased storm-water runoff, erosion, and land loss. Runoff attributable to support for exploration activities in the EPA sale area can be acknowledged, but quantification of direct effects from it is probably not possible.

Tributyltin (TBT) has been used since the 1960's as an antifouling agent in marine paints. Paint spall and scrapings from vessels fall into the water if not carefully collected. The TBT enters the marine environment slowly through deterioration of painted surfaces. Since 1989, its use has been banned in paints applied to boats less than 25 m in length, but it is still being used on larger vessels such as aluminum-hulled service boats. Monitoring studies have shown that TBT levels have decreased in the GOM since this ban. Data have shown, however, that marine life in the Gulf may continue to be exposed to butyltin compounds (Kannan et al., 1997). No quantitative information is available on the extent of this problem for OCS operations or non-OCS operations.

Point-source effluents from operation of onshore service bases, such as Port Fourchon, Louisiana, are controlled by requirements in the NPDES permits for these facilities. Domestic and sanitary wastewater are collected in sanitary sewer pipelines and delivered to a municipal treatment plant or discharged through a permitted, on-site, wastewater treatment system. Thus, effluent discharges from these facilities will be negligible and should not contribute to coastal water quality degradation.

An unmeasurable but very small fraction of the need to dredge channels and access ways (and dispose of dredge material) to maintain accessibility to shore support facilities by crew boats and service vessels can be attributable to the proposed action. Dredged materials are disposed in USEPA or COE permitted or selected dump sites. Dredged material disposal sites are generally located in State waters, close to the boundaries with OCS waters off the coasts of Louisiana, Mississippi, and Alabama. The Ocean Disposal Database (ODD, 2002) can be searched to locate and names of dredge disposal sites close to the Mississippi delta and along the Gulf Coast shoreline.

4.2.4.8. Trash, Debris, and Other Wastes

4.2.4.8.1. Bottom Debris

Bottom debris is defined as material resting on the seabed. Debris can consist of cable, tools, pipe, drums, anchors, structural parts of platforms, or objects made of plastic, aluminum, and wood. These materials are lost overboard during hurricanes or they can be accidentally dropped overboard by workers from platforms or vessels. Varying quantities of ferromagnetic bottom debris may be lost per operation. Operators take precautions to avoid dropping any debris overboard and report lost material to MMS per existing regulations. When possible, debris is removed during required, routine, underwater inspections (by divers and/or ROV's). The maximum quantity of bottom debris per operation is estimated to be several tons. Extensive analysis of remote-sensing surveys within developed blocks indicates that the majority of ferromagnetic bottom debris associated with OCS exploration and development activities falls within a 450-m (1,475-ft) radius of the site. The MMS has established requirements and guidelines for removing bottom debris and gear after structure decommissioning and removal operations. There are also requirements to verify that operational debris have been removed from the areas around the platform site (e.g., by trawling the area to verify that the site has, in fact, been cleared of debris). The Fishermen's Contingency Fund was established to provide recourse for recovery of equipment losses due to entanglement in OCS originated debris.

4.2.4.8.2. Solid Wastes

Several kinds of solid wastes may be generated, including commercial waste; industrial solid waste; and construction/demolition debris, garbage, residential solid wastes such as that generated in crew quarters; and trash. Industrial solid wastes and commercial wastes include a variety of wastes generated offshore as part of the gas development process. Examples of industrial wastes include spent filters or laboratory wastes. Construction waste includes metal, concrete, brick, asphalt, roofing materials, sheet rock, shingles, and lumber. No solid waste and equipment can be discharged offshore into marine waters.

Oil and gas operations on the OCS generate waste materials made of paper, plastic, wood, glass, and metal. Most of this waste is associated with galley and offshore food service operations and with operational supplies such as shipping pallets, containers used for drilling muds and chemical additives (sacks, drums, and buckets), and protective coverings used on mud sacks and drill pipes (shrink wrap and pipe-thread protectors). Some personal items, such as hardhats and personal flotation devices, are accidentally lost overboard from time to time. Generally, galley, operational, and household wastes are collected and stored on the lower deck near the loading dock in large receptacles resembling dumpsters. These large containers are generally covered with netting to avoid loss and are returned to shore by service vessels for disposal in approved landfills.

The MMS regulations, the USEPA's NPDES general permit, and the U.S. Coast Guard's (USCG) regulations implementing MARPOL 73/78 Annex V prohibit the disposal of any trash and debris into the marine environment. Victual matter or organic food waste are allowed to be ground up into small pieces and disposed of overboard from structures located more than 20 km (32 mi) from shore.

Information provided by industry gives some indication on the amount of trash historically generated during the drilling of an average offshore well. Historically, a typical well drilled to about 4,300 m (14,100 ft) might require 9,300 mud sacks, 100 pails, 250 pallets, 225 shrink-wrap applications, and two 55-gallon drums. Most drilling muds are now shipped pre-mixed in reusable bulk tanks. This change has resulted in a significant reduction in the amount of solid waste associated with drilling operations. Still, drilling operations require the most supplies, equipment, and personnel and, therefore, generate more solid waste than during production operations.

Over the last several years, companies have employed waste reduction and improved waste-handling practices to reduce the amount of trash offshore that could potentially be lost into the marine environment. Improved waste management practices, such as substituting paper cups and reusable ceramic cups and dishes for those made of styrofoam, recycling offshore waste, and transporting and storing supplies and materials in bulk containers when feasible, are commonplace. Experimental technology, such as reinjection of waste materials reduced to slurry into formations, is also under development. These practices have resulted in a marked decline in accidental loss of trash and debris.

Miscellaneous wastes allowed to be discharged by the USEPA's NPDES general permit for the Eastern GOM include discharge from desalinization units; blowout preventer fluid; uncontaminated ballast water; uncontaminated bilge water; mud, cuttings, and cement at the seafloor; uncontaminated seawater; boiler blowdown; source water and sand; uncontaminated freshwater; excess cement slurry; and diatomaceous earth filter media. At this time in the EPA, chemically treated seawater and freshwater are not allowed to be discharged. No free oil can be released with any of these discharges, as determined by visual sheen.

4.2.4.8.3. Deck Drainage

Deck drainage results from rain runoff, miscellaneous leakage and spills, and wash down of the platforms or drill rigs. Deck drainage is usually contaminated with oil and grease, detergents, and a number of hazardous chemicals and trace metals in low concentrations. During drilling operations, spilled drilling fluids end up as deck drainage. Acids (hydrochloric, hydrofluoric, and various organic acids) used during well treatment or workover operations may also be present in deck drainage. The source of oil in deck drainage includes residual oil from previous spills and the leakage of oils and other production chemicals used on the facility. Oil may also be present due to the wash down solvents. Drill rigs have pans and sumps that collect such drainage. The drainage is gravity separated into waste materials and effluent. Waste materials are recovered in a sump tank and disposed either by return to the drilling mud system, or transport to shore. The liquid effluent, usually primarily washwater and rainwater, can be treated, separated, or combined with produced water and then discharged overboard. The actual discharge rate and quantity are dependent on the rate of rainfall. General NPDES permit requirements prohibit the discharge of free oil. During wastewater discharge, operators must monitor daily to ensure the absence of free oil by observing for visual sheen. Existing measurements of effluent oil and grease content range from 1 to 16,908 ppm; and oil and grease in the discharged drainage range from 1 to 673 ppm, showing that oil and grease in deck drainage can greatly exceed the discharge limits of produced waters (USEPA, 1993a).

The quantities of deck drainage vary greatly depending on the size and location of the facility. An analysis of 950 GOM platforms during 1982-1983 determined that deck drainage averaged 50 bbl/day/platform (USEPA, 1993a and b). It is expected that all deck drainage will be disposed of by discharging overboard after treatment and that discharged drainage would meet the requirements of the current NPDES general permit for the Eastern GOM. The general permit prohibits the discharge of any free oil in the waste stream, as determined by visual sheen.

4.2.4.8.4. Domestic and Sanitary Wastes

Domestic wastes are wastewater originating from sinks, showers, laundries, and galleys, as well as wastewater from safety shower and eyewash stations. This category of waste is often called gray water. The amount of domestic waste discharged is dependent on the conditions of future NPDES permits. It is assumed that, at a minimum, the conditions within the NPDES general permit for the Eastern GOM will be applied to these discharge streams in any permit applied to exploratory drilling in the EPA sale area. The limitations for domestic waste are (1) no discharge of floating solids, (2) no discharge of food waste within 19.2 km (12 mi) of land, and (3) only food waste ground smaller than 25 mm can be discharged beyond 19.2 km. Domestic wastes contain no fecal coliform; therefore, they only need to be ground up by a disposal unit so that the discharge will not result in any floating solids. Domestic wastes may also include solid materials (paper, boxes, etc.) that are combustible.

Sanitary wastes are composed of human body wastes from toilets and urinals. All sanitary wastes generated during exploratory drilling are expected to be discharged overboard. Some drilling rigs combine sanitary and domestic wastewater for treatment; others maintain sanitary wastes separately for treatment by an approved marine sanitation device. In offshore operations, toilets are usually flushed with brackish water or seawater. Concentrations of fecal coliform bacteria serve as an indicator of the pathogen content of water resulting from the disposal of human wastes. Specific levels of suspended solids and chlorine residual in an effluent are indicative of corresponding levels of fecal coliform. If the suspended-solid levels in an effluent are less than 150 mg/l and the chlorine residual is maintained at 1 mg/l, then fecal coliform levels should be less than 200 per 100 ml. Properly operating biological treatment systems on offshore platforms have effluents containing less than 150 mg/l of suspended solids; therefore, chlorine residual is a reasonable control parameter. The limitations for sanitary wastes vary with the number of persons manning the facility. For facilities continuously manned by 10 or more persons, no floating solids and a minimum residual chlorine level of 1 mg/l is required. For other facilities, the residual chlorine content is not applied. In general, a typical manned platform will discharge 35 gal/person/day of treated sanitary waste and 50-100 gal/person/day of domestic waste (USEPA, 1993a and b). It is assumed that that these discharges are rapidly diluted and dispersed into marine waters.

4.2.4.8.5. Minor or Miscellaneous Discharges

Minor discharges include all other discharges not already discussed that may result during oil and gas exploration operations. Minor or miscellaneous wastes include (1) desalination unit discharge, (2) blowout preventer fluid, (3) boiler blowdown, (4) excess cement slurry, and (5) uncontaminated freshwater and saltwater used for ballast. In all cases, no free oil is permitted in these discharges. Unmanned facilities may discharge uncontaminated water through an automatic purge system without monitoring for free oil. The discharge of freshwater or seawater that has been treated with chemicals is permitted providing that the prescribed discharge criteria are met. No projections of volumes or contaminant levels of minor discharges are made for the exploration activity projected for the EPA sale area because these wastes are substantially benign in character and impacts are considered negligible.

4.2.4.9. Discharges and Wastes from Support Vessels

4.2.4.9.1. Discharges

Operational waste generated from vessels that support exploration in the EPA sale area include bilge and ballast waters, trash and debris, and sanitary and domestic wastes. The USCG regulates these wastes. Operators of support vessels, such as crew and supply service boats, tugboats, and drillships, have two options for disposing of their wastes. They can either dispose of their oily waters at onshore terminals capable of accepting residues and mixtures containing oil or noxious liquid substances (33 CFR 158) or, after meeting discharge criteria specified in Annex I of MARPOL 73/78 (33 CFR 151), by discharging the oily water overboard. The oily water, without dilution, must have an oil content that does not exceed 15 ppm. Furthermore, the ship must have oily-water separating equipment that automatically stops the effluent if the oil content exceeds 15 ppm.

Based on a New England River Basin Commission (NERBC, 1976) analysis of bilge water generated as a function of the size and tonnage of workboats, the average bilge water generation rate can be calculated by multiplying the dead weight tonnage of a vessel by 0.004 (gallons/minute) or 0.908 (liters/hour).

It is assumed that all vessels engaged in offshore work and that use ballast water would have clean and segregated ballast tanks so that any discharged ballast water will not be contaminated with oil. There is a growing concern about the possibility that ballast waters may be contain exotic or invasive aquatic plants and animals carried from abroad in ships' ballast waters. Drillships that come into the GOM after drilling in foreign locations could bring aquatic species in their ballast waters. Exotic species have been introduced into U.S. waters from foreign ships, for example the zebra mussel in the Great Lakes, and they can be harmful or deleterious. At present, however, there is no documentation that this is a problem in the GOM.

4.2.4.9.2. Noise

Coastal noise associated with OCS oil and gas development results from helicopter and service-vessel traffic. Sound generated from these activities can be transmitted through both air and water, and may be continuous or transient. The intensity and frequency of the noise emissions are highly variable, both between and among these sources. The level of underwater sound depends on receiver depth and aspect, and strength of the noise source. The time during which a passing airborne or surface sound source can be received underwater is increased in shallow water by multiple reflections. Sound generated from helicopter and service-vessel traffic is transient in nature and extremely variable in intensity.

Helicopter sounds contain dominant tones (resulting from rotors) generally below 500 Hz (Richardson et al., 1995). Helicopters often radiate more sound forward than backward, and the underwater noise is generally brief in duration, compared with audible duration in the air. Water depth and bottom conditions strongly influence propagation and levels of underwater noise from passing aircraft. Lateral propagation of sound is greater in shallow than in deep water. Helicopters, while flying offshore, generally maintain altitudes above 215 m (700 ft) during transit to and from the working area. A range of 1,500-17,787 helicopter trips is projected to occur annually as a result of the proposed action. Service vessels transmit noise through both air and water. The primary sources of vessel noise are propeller cavitation, propeller singing, and propulsion; other sources include auxiliaries, flow noise from water dragging along the hull, and bubbles breaking in the wake (Richardson et al., 1995). Propeller cavitation is usually the dominant noise source. The intensity of noise from service vessels is roughly related to ship size, laden or not, and speed. Sounds from support boats ranges from 400 to 7,000 Hz at 120-160 decibels (USDOC, NMFS, 1984). Large ships tend to be noisier than small ones, and ships underway with a full load (or towing or pushing a load) produce more noise than unladen vessels. Noise increases with ship speed, which would usually be slower in coastal waters. A range of 350-1,275 service-vessel trips is projected to occur annually as a result of the proposed action.

Information on drilling noise in the GOM is unavailable at present. From studies mostly in Alaskan waters, drilling operations often produce noise that includes strong tonal components at low frequencies, including infrasonic frequencies in at least some cases. Drillships are apparently noisier than semisubmersibles (Richardson et al., 1995). Sound and vibration paths to the water are through either the air or the risers, in contrast to the direct paths through the hull of a drillship.

Machinery noise generated during the operation of fixed structures can be continuous or transient, and variable in intensity. Underwater noise from fixed structures ranges from about 20 to 40 dB above background levels within a frequency spectrum of 30-300 Hz at a distance of 30 m from the source (Gales, 1982). These levels vary with type of drilling rig and water depth. Underwater noise from platforms standing on metal legs would be expected to be relatively weak because of the small surface area in contact with the water and the placement of machinery on decks well above the water.

4.2.5. Hydrogen Sulfide

Sulfur may be present in oil as elemental sulfur, within hydrogen sulfide (H_2S), or within organic molecules, all three of which vary in concentration independently. Although sulfur-rich petroleum is often called “sour” regardless of the type of sulfur present, the term “sour” should properly be applied to petroleum containing appreciable amounts of H_2S, and “sulfurous” should be applied to other sulfur-rich petroleum types.

Sour hydrocarbons occur sporadically throughout the Gulf of Mexico OCS (e.g., about 65 total sites), but principally offshore the Mississippi Delta, Mississippi, and Alabama. The occurrences of H_2S offshore Louisiana are mostly on or near salt domes with caprock and are associated with gypsum (calcium sulfate) deposits. Sour oil or gas may also be attributable to the lithology of the source rock from which the hydrocarbon was generated. Source rocks that are fine-grained clastics tend to bind sulfur as iron pyrite in clay minerals. Sulfur in carbonate source rocks does not have the same opportunity to bind and sulfur can remain associated with hydrocarbons. Examination of industry exploration and production data shows that H_2S concentrations vary from fractional parts per million (ppm) in either oil or gas to 650,000 ppm in the gas phase of a single oil well near the Mississippi Delta. The next highest concentrations of H_2S are in the range of 20,000-55,000 ppm in some natural gas wells offshore Mississippi/Alabama.

Safety Requirements and Engineering Standards

The MMS reviews all proposed actions in the Gulf of Mexico OCS for the possible presence of H_2S. Activities found to be associated with a presence of H_2S are subjected to further review and requirements. Federal regulations at 30 CFR 250.417 require all lessees, prior to beginning exploration or development operations, to request a classification of the potential for encountering H_2S. The MMS has requirements for preventing hydrogen sulfide releases, detecting and monitoring hydrogen sulfide and sulfur dioxide, protecting personnel, providing warning systems, and establishing requirements for hydrogen sulfide flaring.

4.2.6. Well Abandonment

When an operator temporarily abandons an exploration well (see Chapter 4.1.2.2, Well Abandonment and Site Clearance), no production structures are emplaced. The operation to temporarily abandon a well follows a set of guidelines (30 CFR §250.1721 and §250.1722) that ensures wellbores are adequately plugged, tested, and monitored. Downhole zones that have been perforated must be isolated with cement plugs. While the well remains temporarily abandoned, the operator provides an annual report to MMS, stating their plans for either putting the well into production or permanently abandoning it. To carry out either temporary or permanent well abandonment operations, a workover rig remains on station for a period of 5-15 days.

The operation to permanently abandon a well also follows plugging guidelines (30 CFR §250.1715) to prevent any hydrocarbon seepage from reaching the seafloor or marine environment, but in addition, the wellhead or casing must be removed to at least 5 m below the mudline (30 CFR §250.1716(a)). Wells are permanently abandoned to assure downhole isolation of hydrocarbon zones and to prevent vertical migration of hydrocarbon between formations or to the seafloor. The operator requests approval from MMS to abandon a well and includes supportive well logs for an exploration well (or production data if the well has been produced), with a plan for the abandonment. At the time an operator decides to permanently abandon an exploration well, the subsea structures in place are usually wellheads or casing stubs that marks the location of the wellbore. These structures can extend 3-6 m above the sea bed.

Because the water depths in the proposed lease sale area range from 1,600 to 3,000 m (5,250-9,850 ft), the types of MODU's expected to be deployed are DP vessels. Most subsea equipment is deployed in a manor that allows retrieval, but any bottom-founded, subsea equipment or mooring devices (if conventionally-moored drill rigs are deployed) that are not fully recoverable must be severed at least 5 m below the mudline (30 CFR §250.1728(a)).

During exploration the seafloor around activity sites have temporary equipment and structures installed on it (i.e., wellheads, casings, casing stubs, etc.). Operators are required to remove all seafloor obstructions from their leases within one year of lease termination. These regulations require the operator to sever bottom-founded mooring structures and their related wellhead components at least 5 m below the mudline to ensure that nothing will be exposed that could interfere with future operators or other activities in the area. Water depths in the proposed lease sale area eliminate the need for surface buoys and fisheries protection devices that avoid entangling nets in wellhead debris.

Severing techniques available for use in the GOM can be grouped into explosive or nonexplosive methodologies. The majority of wells that are permanently abandoned (and production structures) Gulfwide are carried out using explosive charges because it costs less, is faster, and is more reliable. The number of well stubs and wellhead structures Gulfwide that have been removed using explosives in the GOM is unknown at this time because an exact record of the removal method for permanent well abandonment has not been maintained.

Conditions of the Structure Removal NTL 2001-G08 require a Section 7, Endangered Species Act (ESA) Consultation for any removal proposing explosives in water depths greater than 200 m due to possible affects on sperm whales. Discussions with industry representatives have indicated that operators do not intend to use explosives for decommissioning and removal operations in the proposed lease sale area (Broussard, personal communication, 2002). Despite the higher costs and longer times on site, nonexplosive removal techniques offer the operator fewer regulatory restrictions and mitigative conditions. Explosives used to sever and remove structures release energy into the environment in the form of a pressure wave and noise. Possible injury or death to sea life (e.g., sea turtles) from detonating explosives below the seafloor extends at least 915 m from a detonation site and upward to the sea surface (Klima et al., 1988). Because the resulting pressure wave and noise may harass, harm, or kill protected species of fishes, sea turtles, or marine mammals, MMS and NOAA Fisheries have conferred over the use of explosives for removing structures and have instituted a comprehensive program of mitigation measures. For example, if sea turtles, dolphins, or whales are observed in the vicinity of structures to be removed, detonation of the explosives must be postponed until the animals are removed or leave the impact area.

Nonexplosive techniques are available that would allow for either internal or external severing, depending on accessibility and the shape or configuration of the object to be cut. Internal-severing equipment is generally emplaced using the downhole capabilities of a MODU. For operations involving cylindrical objects, internal mechanical cutters are placed into the wellbore or accessible, bottom-founded equipment, and the structure is severed using hydraulically controlled blades. Use of abrasive slurry and abrasive jet cutters is also limited to concentric objects. In place of mechanical blades, a nozzle propels a mixture of pressurized water and abrasive particles (i.e., sand, slag, garnet, etc.) against the walls of the target to sever it. Because of the water depths in the proposed lease sale area, most external-severing devices will need to be deployed using remotely operated vehicles (ROV's). Some abrasive jet cutters have been modified into ROV-deployable, external-severing systems, but like their internal counterparts, they are limited to cylindrical objects. When an operation involves irregular, nonsymmetrical objects, mechanical cutting tools such as blades, hydraulic shears, and diamond wire cutters can be mounted on ROV's. Operators also intend to rely on the versatility and availability of cutter-equipped ROV's for both normal and emergency severing of mooring lines and chains, pipelines, and other open water components. Bottom-founded structures, however, present the main limitation to all external severing methods since it is necessary to jet or remove enough of the seafloor around the object to allow an external cut to be made at least 5 m below the mudline.

Because all water depths are greater than 800 m in the proposed lease sale area, OCS regulations offer operators the option to seek an "alternative removal depth request" to avoid the need for jetting (30 CFR §250.1716(b)(3)) to abandon wells or other bottom-founded facilities (30 CFR §250.1728(b)(3)). Cuts above the mudline will be allowed with minor reporting requirements to MMS on the remnant's description and height above the seafloor. In addition to avoiding explosives for decommissioning and removal operations in the proposed lease sale area, industry representatives have indicated intent to use the alternate removal depth option (depths >800 m) for wellhead equipment and casing stubs, coupled with quick-disconnect equipment (i.e., detachable risers, mooring disconnect systems, etc.) to fully abandon-in-place wellheads, casings, and other minor, subsea equipment without the need to sever and remove the equipment.

Site clearance guidelines for operations in the EPA sale area will be limited to exploration or delineation well sites. Requirements outlined in MMS's Site Clearance NTL 98-26, *Minimum Interim Requirements for Site Clearance (and Verification) of Abandoned Oil and Gas Structures in the Gulf of Mexico,* limits the operator to conducting stationary or towed, high-frequency (500 kHz) sonar verifications over 600 ft (183 m) diameter search areas, centered over the well sites. Since the removal regulations for depths >800 m allow for some equipment to be left on the seafloor, MMS is currently discussing alternatives to the deepwater site clearance requirements, with pending modifications to the NTL.

The NOAA Fisheries has stated their intention to undertake a proposed rulemaking on use of explosives that would include removal of subsea wellhead stubs and equipment. Additional information concerning explosive removal of offshore structures can be found in the CPA/WPA Multisale Final EIS (USDOI, MMS, 2002a; Chapter 4.1.1.4.1, Explosive Removal Disturbance) and in the EPA Multisale Draft EIS (USDOI, MMS, 2002c, Chapter 4.1.1.11, Decommissioning and Removal Operations).

4.2.7. Accidental Events

4.2.7.1. Offshore Oil Spills from Exploratory Drilling

4.2.7.1.1. Introduction

The National Environmental Policy Act (NEPA) requires Federal agencies to consider potential environmental impacts (direct, indirect, and cumulative) of proposed actions as part of agency planning and decision making. The NEPA analyses address many issues relating to potential impacts, including issues that may have a very low probability of occurrence. These issues are included because the public considers them important or because the environmental consequences could be significant if they did occur.

New requirements and technologies for oil drilling, storage, and transportation have successfully corrected many of the conditions that might have resulted in oil spills in the past. Additionally, the enforcement and penalty procedures for oil spillage have become more clearly defined. The past several decades of spill data show that large accidental oil spills associated with oil and gas exploration and development are low-probability events in Federal OCS waters of the GOM. Yet the issue of oil spills remains important to the public based on comments collected at scoping meetings for past environmental impact statements. This chapter summarizes key information about the low probability of impact from accidental spills from offshore oil and gas activities in the Gulf. These data and analyses are used to focus on spill risk for exploratory drilling in the EPA sale area and tier off the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a) and the EPA Multisale Draft EIS (USDOI, MMS, 2002c).

Spill Prevention and Spill Cleanup

The MMS has established comprehensive pollution prevention requirements for operators that include several levels of redundant safety devices, as well as inspection and testing requirements to confirm that these devices work. Many of these requirements have been in place since about 1980. Spill trend analysis for the OCS show that spills from facilities have decreased over time, indicating that the extensive MMS engineering and safety requirements have minimized the potential for spill occurrence and associated impacts. Details regarding MMS engineering and safety requirements can be found at 30 CFR 250.800 Subpart H.

The MMS Oil-Spill Response Program oversees the review of oil-spill response plans, coordinates inspection of oil-spill response equipment, and conducts unannounced oil-spill drills. This program also supports continuing research to foster improvements in spill prevention and response. Studies funded by MMS address issues such as spill prevention and response, *in-situ* burning, and dispersant use.

In addition, MMS works with the USCG and other members of the multi-agency National Response System and their National Strike Force to further improve spill-response capability in the Gulf. The Gulf Strike Force includes 38 members and associated response expertise and equipment. The combined resources of these groups and the resources of commercially contracted oil-spill response organizations result in extensive equipment and trained personnel for spill response.

If a spill does occur, the lease operator is required to take immediate corrective action. Operators in the EPA are required to develop an Oil-Spill Response Plan (30 CFR 254.1) that demonstrates that an operator can respond quickly and effectively whenever there is a spill from the operator's facility. Required information in these response plans includes specifications of appropriate equipment and materials, their availability, and deployment time. An analysis of an operator's ability to respond to a "worst case spill" from a facility is conducted by MMS during the review of these operator oil-spill-response plans. The MMS estimates that spill-response equipment can be deployed to the northernmost part of the EPA sale area within 11.5-17.5 hours.

A number of cleanup techniques are available for response to an oil spill. Open-water response options include mechanical recovery, chemical dispersion, *in-situ* burning, or natural dispersion. Single or multiple spill-response cleanup techniques may be used in abatement. The cleanup technique chosen for a spill response will vary depending upon the shoreline and natural resources that may be impacted; the size, location, and type of oil spilled; weather; and other variables. The overall objective of on-water recovery is to minimize impacts on sensitive nearshore environments by preventing the migration of free-floating oil shoreward.

Generally, mechanical containment and recovery is the primary oil-spill-response method used (33 CFR 153.305(a)). Mechanical recovery is the process of using booms and skimmers to pick up oil from the water surface. It is assumed that 10-30 percent of a spill ≥1,000 bbl of light- to medium-weight oil can be mechanically removed from the water prior to the spill making landfall (U.S. Congress, Office of Technology Assessment, 1990). Even when response efforts occur quickly, smaller spills (<50 bbl) in an offshore environment may not be recoverable by mechanical skimming equipment because such small spills spread quickly to a minimal thickness. Small spills typically dilute and dissipate rapidly in the offshore marine environment, often before equipment reaches the spill site. Natural dispersion may be a preferred option for smaller spills of lighter nonpersistent oils and condensates that form slicks that are too thin to be removed by conventional methods. Should an oil spill occur during a storm, spill response would occur following the storm because of sea-state limitations for skimming vessels and containment boom deployment. Storm wave action would accelerate natural weathering and minimize or eliminate the need for additional response.

Dispersant application may be the preferred response to spills ≥1,000 bbl in water depths >1,000 ft. When dispersants are applied to spilled crude oil, the surface tension of the oil is reduced. This allows normal wind and wave action to break the oil into tiny droplets, which are dispersed into the upper portion of the water column. Natural processes then break down these droplets quicker than they would if the oil were allowed to remain on the water surface.

In-situ burning is an oil-spill cleanup technique that involves the controlled burning of the oil at or near a spill site. The use of this spill-response technique can provide the potential for the removal of large amounts of oil over an extensive area in less time than other techniques. *In-situ* burning involves the same oil collection process used in mechanical recovery, except instead of going into a skimmer, the oil is funneled into a fire boom, a specialized boom that has been constructed to withstand the high temperatures from burning oil. Fire resistant booms are used to isolate the oil from the source of the slick. The oil in the fire boom is ignited and allowed to burn.

Oil Spill Risk Summary

The exploration scenario expects 38-73 exploration or delineation wells over the next 40 years (2003-2043). Chapters 4.2.7.1 through 4.2.6.4 present (1) the chance of a spill(s) occurring, (2) the likely sizes that could occur, (3) the fate of possible spilled oil, and (4) the likelihood that a spill, should one occur, would be transported by winds and currents from deepwater drilling locations to sensitive physical and biological resources.

The results of the risk analysis are as follows:

- there is some chance of a spill occurring from exploration activities but very little chance that a spill ≥1,000 bbl will occur;
- the more likely spill size will be <10 bbl;
- there is very little chance that a slick will contact sensitive resources; and
- it is very unlikely that more than one spill will occur.

The fact that sensitive resources are not expected to be exposed to spilled oil is partly the result of (1) the unlikelihood of a spill of sufficient magnitude occurring, (2) the unlikelihood it will remain a slick for very long prior to dissipating, and (3) the low probability that a slick would be transported to where sensitive resources are concentrated. This is partly a result of the fact that all drilling will occur in water depths from 1,600-3,000 m (5,250-9,850 ft), nowhere closer than 75 mi (120 km) from the nearest land (Mississippi delta), thereby diminishing the risk of shoreline impacts.

The OCS record of oil and gas industry spills was used to determine the likelihood and magnitude of possible future spills. Such background information helps to better understand the risk of spills from all drilling activities. What the data show is that, historically, large oil spills resulting from accidents during drilling activities in the GOM are rare events and have spilled very little oil. From 1971 to 1994, 23,609 wells were drilled (new starts and redrills) and 26 spills ≥50 bbl occurred as part of these operations. Only one spill ≥1,000 bbl occurred (a 1,500-bbl diesel spill).

Unlike spills from production operations, spills from exploration operations do not involve the handling of crude oil because no oil has yet been produced and exploratory drilling is short-lived and carried out from mobile structures. Crude oil can only be spilled if the exploration well discovers a hydrocarbon reservoir and the crude oil accidentally escapes the wellbore from a pressure imbalance and loss of well control, termed a blowout.

The MMS's requirements for well control and blowout prevention equipment, procedures, and inspections can be found at 30 CFR 250.406-409 and 30 CFR 250.514-516. Spill prevention and safety measures put in place during the last 20-30 years have reduced blowouts, and only one crude oil spill of 100 bbl from a blowout has occurred. Blowouts result from a pressure imbalance between the drilling mud and formation pressure that allows the expulsion of formation fluids or gases up the wellbore. Blowout preventors (BOP) are required by MMS. They are used either on the seafloor or on the drill rig to maintain well control in the event of sudden downhole pressure changes. The BOP systems are tested at specific times: (1) when installed, (2) before 14 days have elapsed since the last BOP pressure test, and (3) before "drilling out" each string of casing or a liner (30 CFR 250.407).

Because well blowouts are the kind of spill that the public often identifies with drilling, it is included in a separate chapter below. In reality, the types of oil spills that have occurred during drilling are from routine operations of the vessels themselves, such as from the transfer of diesel fuel back and forth between vessels. Spills of this type are not unique to the oil and gas industry but occur routinely from all vessel operations, such as offshore tanker refueling.

It should be noted that the spill estimates provided by this analysis should be considered conservative (deliberately overestimated) because (1) they are based on data that includes all drilling operations (both exploration and development drilling) and (2) our estimates are based on spill statistics over a broad time period, much of which occurred prior to current drilling protocols that include improvements in design and safety features and limited use of oil-based drilling mud.

4.2.7.1.2. Background Information and Data

Past Record of Oil Spills during OCS Drilling Operations

The MMS's record of all spills ≥1bbl that occurred from 1971 to 1994 is summarized in Table 4-4. The year 1971 was chosen because MMS records of spills prior to that were very incomplete. The year 1994 was chosen because the last detailed analysis of spills from OCS drilling was completed that year.

Table 4-4

Past OCS Gulf of Mexico Spills from All Drilling Operations, 1971-1994
(23,439 new wells drilled)

Spill Size bbl	Number of Spills	Spilled Substance			
		Diesel Fuel Oil	Crude Oil	OBM*	Condensate
1-9.9	158	62	26	70	0
10-49.9	36	15	2	19	0
50-499.9	26	17	0	8	1
500-999.9	3	1	1	1	0
≥1,000 bbl	1	1	0	0	0
Total	224	96	29	98	1

* oil-based mud with diesel or mineral oil.

The dataset in Table 4-4 includes spills that have occurred from all OCS drilling operations, both exploration and development. Isolation of spills from exploratory drilling and spills from development drilling was not possible because, except for spills from blowouts during drilling, the MMS record does not specify if a spill occurred during exploration or development operations. It is assumed that the development drilling activity is sufficiently similar to exploratory drilling activity to apply the spill statistics from both operations to estimate future risk of spills from exploratory drilling alone.

Spill Size

Most spills that have occurred as part of OCS drilling operations have been small. Eighty-seven percent of the incidents in the database that occurred during drilling operations were <50 bbl and 71 percent were <10 bbl.

Spill Cause

Review of the record shows that drilling spills primarily have occurred from the following causes:

- Employee errors or equipment failures;
- Transfer operation mishaps between a supply vessel and the drilling facility, such as transfer line ruptures or coupling failures;
- Well pressure incidents and other accidents in the drilling pipe or well head;
- Mishaps that spill small amounts of oil-based drilling muds (the most frequent accident); and
- Spills from collisions (8 spills were due to collisions, usually with support vessels).

The public has expressed concern about spills that could occur from service-vessel accidents enroute to or from drilling facilities. The MMS has identified no records of past accidents involving supply vessels that spilled ≥238 bbl of oil while enroute to or from OCS offshore oil and gas operations (Etkin, personal communication, 1998).

Many of these spills were not directly related to the drilling activity. Of diesel fuel spills, over 30 percent were a result of an accident that occurred during transferring fuel between a service vessel and a rig or as a result of a collision. Spills of this type are not unique to the oil and gas industry and occur offshore from all vessel operations. Besides transfer spills of diesel fuel, most of the spills of oil-based drilling muds were also due to accidents while transferring the muds from the supply vessels to the drilling platforms, thus making transfer spills by far the most common cause of spills during drilling operations. These kinds of accidents are not as likely to occur in the future because of safety requirements that have been put in place to reduce transfer spill risk.

Type of Oil Spilled

The types of oil that have been spilled include diesel fuel, OBF (the oil being primarily diesel), and crude oil and condensate (the lighter fractions of crude oil) accidentally released from the formation being drilled. For the 24 years analyzed, accidents during drilling operations resulted in 96 spills of diesel fuel oil, 98 spills of oil-based drilling muds (most of which was diesel), 1 condensate spill, and 29 crude oil spills. About 87 percent of the oil spilled was diesel either as fuel or OBF component. Historically, oil spills during drilling operations have mostly been spills of diesel fuel used to run equipment and vessels.

There are major differences between impacts expected from diesel fuel spills and those from crude oil. The NRC (2002), in its recently updated definitive work on inputs, fates, and effects of oil in the marine environment, discusses similarities and differences between diesel and crude oil. Diesel is a distillate of crude oil, i.e., it is a subset of the lighter fraction of organic compounds in crude oil. Just as gasoline evaporates more quickly than motor oil, diesel evaporates more quickly than crude oil. Because of differences in composition, spilled diesel and spilled crude oil weather differently (Jordan and Payne, 1980; ITOPF, 1998).

The type of petroleum is relevant in determining the short-term and long-term toxic effects of a slick. Variations in biological effects are related to the chemical composition of different petroleum products and crude oils. Diesel does not contain as many residual hydrocarbons as does crude oil (Whiticar et al., 1993). Diesel that might be spilled could cause some immediate short-term toxic effects but would dissipate readily and leave relatively little residue that would persist in the water column, in sediments, and on beaches, and would cause no long-term effects. The chemical composition of spilled diesel or crude oil would also influence the spill's physical effects. Physical impacts are controlled more by the location of the spill (small confined area versus open water) and by oceanographic and meteorological conditions that disperse the slick.

4.2.7.1.3. Past Record of Oil Spills ≥1,000 bbl

Larger spills, although very rare, are usually of greatest concern to the public. Such spills can persist for longer time periods on the surface of the water increasing the potential for transport by winds and currents and possible landfall. Below are spills ≥1,000 bbl that have occurred during drilling on the OCS in the GOM since 1971. The single accident resulting in a spill ≥1,000 bbl was a vessel collision that spilled diesel fuel during drilling on the OCS; in 1979, an anchor-handling boat collided with a drilling platform in the Main Pass Area and the rig spilled 1,500 bbl (Table 4-5).

Table 4-5

Offshore Spills ≥1,000 Barrels from Gulf of Mexico OCS, 1971-2001

Year	Volume (bbl)	Product	Area and Block	Water Depth (ft)	Distance from Shore (mi)	Cause
1979	1,500	diesel	MP 151	280	10	*

* Collision in rough seas between service vessel and drilling rig, damaged rig's diesel tank.

4.2.7.1.4. Past Record of Oil Spills from Blowouts during Exploratory Drilling

A blowout occurs when improperly balanced well pressure results in the sudden, uncontrolled release of fluids from a wellbore or wellhead. Blowouts can happen during exploratory drilling, production, well completions, or workover operations. Drilling mud puts pressure on the formations penetrated by the drill bit and maintains a balance between mud weight and formation pore pressure. Mud weight needs to be greater than the formation pore pressure for the well to be under control. A blowout can occur when mud and formation pressure is abruptly thrown out of balance, when, for example, gas flows into the wellbore at high rates and destabilizes the mud balance.

Blowouts are often equated with catastrophic spills; however, since 1971 there has been only one oil spill occurring from a blowout during Gulf OCS exploratory drilling, spilling 100 bbl of crude oil. Subsurface blowouts can also resuspend and disperse abundant sediments within a 300-m radius from the blowout site. The clay-sized sediment fraction could be resuspended for more than 30 days. Sand-sized sediment would probably settle in a few days within 400 m of the blowout site. Subsea spills at the seafloor may be thousands of feet below the sea surface. Results from field trials and research have indicated that, while currents in the water column will affect the rising plume from a subsea oil release, the plume still surfaces relatively near the source (Rye and Brandvik, 1997; Lane and LaBelle, 2000).

Table 4-6 provides an annual summary of MMS records showing the number of blowouts that have occurred each year, the number of wells drilled, and volume of oil spilled from blowouts. Again, only one spill of >100 bbl occurred in the period 1971-1994. Most blowouts involve the release of gas, rather than oil.

Table 4-6

Blowouts during Exploratory Drilling in the GOM, 1971-1994

Year	Well Starts	Number of Blowouts	Volume of Oil Spilled
1971	851	1	0
1972	845	2	0
1973	820	2	0
1974	802	1	0
1975	842	4	0
1976	1,078	1	0
1977	1,240	3	0
1978	1,164	3	0
1979	1,140	4	0
1980	1,158	3	0
1981	1,208	1	0
1982	1,255	1	0
1983	1,180	5	0
1984	1,352	3	0
1985	1,169	3	0
1986	694	0	0
1987	845	2	0
1988	950	1	0
1989	947	2	0
1990	1,009	1	0
1991	732	3	0
1992	509	2	100
1993	876	0	0
1994	943	0	0
Total	23,609	48	100

4.2.7.2. The Fate of Spilled Oil

The potential impact of a spill is determined, in large part, by the length of time that the spill remains a cohesive mass on the water surface. The oils that could spill (diesel oils, oil products such as lubricants, and crude oil) are mixtures of different hydrocarbon compounds that begin reacting with the environment upon being spilled. Once spilled, these oils begin to spread out on the water surface. A number of processes, collectively referred to as weathering, alter the chemical and physical characteristics of the original hydrocarbon mixture. The original mass spilled would partition between the sea surface, the atmosphere, the water column, and the bottom sediments. Besides weathering, the type and amount of cleanup, and the existing meteorological and oceanographic conditions determine the length of time that the slick remains on the surface of the water, as well as the characteristics of the oil at the time of contact with a particular resource.

Chemical, physical, and biological weathering processes operate on the spilled oil to change its hydrocarbon compounds, selectively reducing many of the components in the slick and breaking down the slick until it can no longer be recognized as a cohesive mass floating on the water surface. Weathering processes include (1) evaporation of volatile hydrocarbons into the atmosphere, (2) dissolution of soluble components, (3) dispersion of oil droplets into the water column, (4) emulsification forming oil-in-water emulsions, (5) chemo- or photo-oxidation of specific compounds creating new components that are often more soluble, (6) biodegradation of the slick, and (7) sedimentation.

After the volatile compounds evaporate and the slick spreads on the water surface, the remaining oil is subjected to the action of the sun and waves. The remaining floating oil eventually breaks up and disperses into the water column. The amount of the oil submerged in the water column increases with time. The concentration of oil in the water column under a slick varies but usually is less than 1 ppm. The microorganisms in the seawater rapidly start degrading the water-soluble oil compounds in the water column, removing them completely within a few days, and generally resulting in reduced toxicity to marine organisms (USDOC, NOAA and USDOI, MMS, 2002b). The degradation rates for the less water-soluble, dispersed oil droplets in the water column are slower and range from 30 days to 6 months. Dispersed oil particles tend to adhere to particulate matter suspended in the water column, and deposit on the ocean bottom with the sediment.

Over time, if the slick is not completely dissipated, a tar-like residue may be left, and this floating residue breaks up into smaller tar lumps or tarballs. The petroleum product oils used at drilling rigs such as diesel are distillates that do not contain the hydrocarbon fractions which form tarballs. Not all crude oils form tarballs; many GOM oil types do not (Jefferies, 1979).

4.2.7.3. Risk Characterization of the Proposed Action

This risk characterization focuses on the risk of spills that could occur from exploration operations projected to occur in the EPA over the next 40 years. The MMS projects that 38-73 wells will be drilled in the EPA sale area over this period. Besides estimating the likelihood that a spill will occur and its probable size, MMS evaluated the fate of possible spilled oil and the probability that a spill, should one occur, would be transported by winds and currents from the deepwater areas where drilling operations would take place to the sensitive coastal and offshore resources prior to the slick dissipating.

The MMS provides a numerical expression of risk for spills ≥1,000 bbl that factors in both the risk of a spill ≥1,000 bbl occurring and the risk that it will persist and be transported to locations of known environmental resources based on trajectory modeling. The following subchapters describe the spill occurrence variable (SOV), spill time frame variable (TF) and the spill transport variable (TV). These three variables are used to estimate the overall risk for the proposed action.

4.2.7.3.1. Occurrence of Spilled Oil

The spill occurrence variable (SOV) represents the potential for a spill to occur and its likely size from the proposed action. The MMS estimates a SOV from the likelihood of a spill occurring during future exploratory drilling based on the assumptions that spills will continue at the same rate as they have in the past and that the risk of spills occurring is in proportion to the number of wells drilled. Step one in this approach is to calculate spill rates for different size groupings of past spills by dividing the total number of OCS spills from all causes (fuel transfer overflows, flowline leaks, blowouts, etc.) that have occurred during drilling (shown in Table 4-4) by the number of OCS well drilled for this same time period. Table 4-7 provides these spill rates for different spill size categories in column 2 (spills/total well start). Column 3, the inverse of column 2, (number wells drilled/spill) is a different way to examine the risk and represents the number of wells that are drilled for each spill that occurs. For example, MMS estimates that one spill between 500 and 999.9 bbl will occur for every 7,870 wells that are drilled in the Gulf OCS.

Table 4-7

Spill Rates Used to Estimate Spills from Drilling Operations

Spill Size (bbl)	Spills/Total Well Starts* (rate)	Number Wells Drilled/Spill
1-9.9	0.0067	149
10-49.9	0.0015	656
50-499.9	0.0011	908
500-999.9	0.0001	7,870
≥1,000 bbl	0.00004	23,609
Any Size	0.0095	105

* number of spills in size class (from Table 4-4) per total well starts. Total well starts = 23,439.

Step two is to estimate the mean number of spills likely to occur as a result of exploration activities for different spill size groupings. This number is calculated by multiplying the spill rates from Table 4-7 by the projected number of wells proposed to be drilled (38-73 wells). All of the mean numbers estimated are less than one. Because such small numbers have no real-world value (it is not possible to have a partial spill, for example, a fourth of a spill), the MMS calculates the statistical likelihood of a spill occurring (step three). This is done by applying the Poisson process (USDOI, MMS, 2002a) to the mean estimates and data to obtain the probability of one or more spills occurring and the probability of no spills occurring. These results are provided in Table 4-8.

Table 4-8

Mean Number of Spills and the Probability (percent chance) that
One or More Spills or that No Spills Will Occur from the Proposed Action

Spill Size (bbl)	Mean Number of Spills Estimated to Occur from the Proposed Action		Probability of One or More Spills Occurring from the Proposed Action		Probability of No Spills Occurring from the Proposed Action	
1-9.9	0.256	0.492	23%	39%	77%	61%
10-49.9	0.058	0.112	6%	11%	94%	89%
50-499.9	0.042	0.081	4%	8%	96%	92%
500-999.9	0.005	0.009	<0.5%	1%	>99%	99%
≥ 1,000 bbl	0.002	0.003	<0.5%	<0.5%	>99%	>99%
Any Size	0.363	0.698	30%	50%	70%	50%

The results of SOV calculations are as follows: (1) there is some chance of a spill occurring from the proposed action; (2) its likely size will be <10 bbl; and (3) no more than one spill will occur. These conclusions are derived from the following estimated risk calculations; there is a 30-50 percent risk that a spill of some size will occur, an 89-94 percent chance it will not be between 10 and 50 bbl, and greater than 90 percent that it will not be larger. There is greater than a 99 percent chance that a spill size of ≥1,000 bbl will not occur.

It is important to note that reliance on historical spill records to compute the chance of a spill occurring likely overestimates the real spill risk. The MMS's estimates are based on an analysis of 30 years of data on spills from drilling during both exploration and development operations. These records include spills that occurred during a period when currently required safety features had not been implemented and include spills that occurred during a period in which the use of OBF was much more common than today. The use of OBF has significantly declined since the introduction of SBF in the 1980's. Thus the estimates provide conservative future predictions of spill occurrence because use of OBF is being phased out.

This analysis indicates that spills, especially spills ≥1,000 bbl, are highly unlikely to occur as a result of the proposed action. Because of public concern about spills and because the MMS recognizes that a spill is possible, this PEA provides additional information on the likely fate of a possible spill, should one occur, including its likely movement on the water surface. Information on the fate of spilled oil and its likely trajectory should be sufficient to allow an analysis of the possible environmental consequences of spilled oil resulting from this proposed action, factoring in the estimate of the likelihood of the event occurring.

4.2.7.3.2. Persistence of Spilled Oil

The spill time frame variable (TF) refers to the likely persistence of spilled oil in the environment. The fate of spilled oil and its duration as a cohesive mass on the surface of the water, subject to transport by winds and currents, is an important variable to assess a spill's possible impact to environmental resources. Once oil is spilled, it immediately begins to react with the environment, spreading out, drifting from its origin point, and eventually dispersing into the water column. Such changes significantly affect its potential to cause harmful impacts. The MMS estimates these changes to spilled oil, assuming one will occur, using a computer model that predicts likely weathering and the likely volume of oil remaining on the ocean surface as a function of time. Because the spilled oil's chemical characteristics play a large role in determining its fate, samples of likely oils that could be spilled from EPA drilling operations (crude oils and diesel) were collected, subjected to laboratory analyses, and artificially weathered. These data were then used as inputs to the model. More detailed information on the model is available in Reed (2001). Information on these inputs can be found in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a), the CPA/WPA Multisale Final EIS (USDOI, MMS, 2002a), the EPA Multisale Draft EIS (USDOI, MMS, 2002c), and the OSRA Report supporting the latter two EIS's (USDOI, MMS, 2002d).

Diesel, the oil that has been spilled the most frequently during exploratory drilling, is a distillate of crude oil and does not contain the heavier components that contribute to crude oil's longer persistence in the environment. Without any cleanup, a slick formed from a 1,500-bbl diesel spill (the only spill ≥1,000 bbl that was found in the database) would be broken up and dispersed within 14 days (USDOI, MMS, 2001a).

There have been very few samples of crude oil taken from oil reservoirs in the EPA that can be used to predict spill fate. The MMS estimated the range of likely crude oil characteristics from the few well tests taken from reservoirs located in CPA deepwater that are in plays likely to extend into the EPA, and from shallower CPA fields currently in production. A previous analysis of these oils was performed in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a), which assumed a 4,600-bbl pipeline spill. The analysis used to this PEA concluded that a slick from a crude oil spill ≥1,000 bbl could persist on the water surface between 2 and 30 days (USDOC, NOAA and USDOI, MMS, 2002b). Other past analysis has shown that slicks from crude oil spills <1,000 bbl will persist a few minutes (<1 bbl), a few hours (<10 bbl), or a few days (10-1,000 bbl) on the open ocean.

Given the wide range in slick persistence estimates obtained by previous modeling of likely EPA oil spills, the TF used to analyze possible times of contact due to spill trajectories in this PEA is three time periods: contact within 3, 10, and 30 days, as shown in Table 4-9.

4.2.7.3.3. Transport of Spilled Oil

The spill transport variable (TV) refers to the potential for a spill to be transported to locations of important environmental resources. The characterization of the risk of spill transport (the TV) focuses on spills ≥1,000 bbl. Spills of this magnitude can persist for longer time periods on the surface of the water so that they can be transported some distance away from their source by winds and currents to coastal areas, where the slick may contact sensitive resources. Smaller spills are not expected to remain a cohesive mass long enough to drift far from their origin and be modeled.

The TV is calculated using an oil-spill trajectory model. The TV is the percent chance that a spill beginning at some point (in this case, within one of the two water-depth subareas of the EPA sale area, 1,600-2,400 m and >2,400 m) will reach various locations within a given time of travel (the TV1). These probabilities are shown in Columns 3 and 4 of Table 4-9. They are often referred to as the conditional probabilities of contact because the risk of contact is based on the condition that a spill occurs and on the condition that it will persist long enough to be transported. The TV represents the trajectory simulation portion of the model that estimates the statistical likelihood that wind or currents will transport spills from point "a" to point "b" on the water surface. The probabilities provided in Table 4-9 are an average of all the points spread out at a spacing of 6-7 mi within the two water-depth subareas of the EPA sale area.

The model uses an extensive database of observed and theoretically computed ocean currents and fields that represent a statistically valid sampling of winds and currents that could occur in this part of the GOM (Price et al., 2001). More information on how these data are derived and about the model can be found in the EPA Multisale Draft EIS (USDOI, MMS, 2002c) or in the OSRA report prepared for the EIS (USDOI, MMS, 2002d).

4.2.7.3.4. Risk of Spill Occurrence and Contact with Physical and Biological Resources

Table 4-9 summarizes environmental resources and oil-spill risk to those resources. Resources are the shorelines of counties or parishes, identified resource habitats, and offshore features. Table 4-9 presents the MMS's estimates of the risk of spills that factor in the probability of occurrence and the risk of a spill persisting and being transported to coastal and offshore resources in the Gulf. The final column in Table 4-9 presents the numerical estimate of risk to resources based on an evaluation specific to exploratory drilling in the EPA sale area. These numerical estimates of risk of spill impacts to resources are so low as to be considered near zero.

The spill-risk estimate was calculated by multiplying the mean number of spills ≥1,000 bbl estimated to occur within each depth subarea (SOV) multiplied by the chance of contact from a spill beginning within each subarea (the TV). As Table 4-9 shows, the probability that any offshore or coastal resources would be exposed to spilled oil is extremely low (< 0.5%) in all cases.

The results in Table 4-9 reflect the fact that a number of events and conditions must all occur in order for an oil spill to result in environmental impact. Probability of occurrence by itself does not equate with an impact to resources. Three major events that must occur sequentially include the following:

(1) a spill must happen and must be large enough to persist,

(2) a resource must be exposed to the spilled oil, and

(3) harmful effects must result from the exposure.

Table 4-9 provides information about the likelihood of the first two events occurring. Factors that affect the likelihood of harmful effects include (1) the type of oil, (2) the time of the spill, (3) the weather and other external factors, and (4) the species life stage, activities, and biological abundance, or exact species locations. Such data limitations affect the ability to predict spill effects. Some of these factors are considered in the analyses of impacts to each resource in Chapter 4.3.

Table 4-9

Risk that a Spill ≥1,000 bbl Will Occur during Exploratory Drilling in the EPA Sale Area and Contact Identified Environmental Features or the County/Parish Shorelines
(expressed as percent chance)

Environmental Feature	Spill Occurrence Variable [1] (mean number of spills)	Transport Variable [2, 3] (percent contact within 3/10/30 days from two EPA water-depth subareas)		Spill Risk [4]
County/Parish		1,600-24,00 m	>2,400 m	%
Cameron	0.002 - 0.003	<[5]/</<	</</<	< 0.5
Willacy	0.002 - 0.003	</</<	</</<	< 0.5
Kenedy	0.002 - 0.003	</</<	</</<	< 0.5
Kleberg	0.002 - 0.003	</</<	</</<	< 0.5
Nueces	0.002 - 0.003	</</<	</</<	< 0.5
Aransas	0.002 - 0.003	</</<	</</<	< 0.5
Calhoun	0.002 - 0.003	</</<	</</<	< 0.5
Matagorda	0.002 - 0.003	</</<	</</<	< 0.5
Brazoria	0.002 - 0.003	</</<	</</<	< 0.5
Galveston	0.002 - 0.003	</</<	</</<	< 0.5
Chambers	0.002 - 0.003	</</<	</</<	< 0.5
Jefferson	0.002 - 0.003	</</<	</</<	< 0.5
Cameron	0.002 - 0.003	</</<	</</<	< 0.5
Vermilion	0.002 - 0.003	</</<	</</<	< 0.5
Iberia	0.002 - 0.003	</</<	</</<	< 0.5
St. Mary	0.002 - 0.003	</</<	</</<	< 0.5
Terrebonne	0.002 - 0.003	</</1	</</1	< 0.5
Lafourche	0.002 - 0.003	</</1	</</1	< 0.5
Jefferson	0.002 - 0.003	</</<	</</<	< 0.5
Plaquemines	0.002 - 0.003	</5/13	</2/9	< 0.5
St. Bernard	0.002 - 0.003	</1/4	</</2	< 0.5
Harrison	0.002 - 0.003	</</1	</</<	< 0.5
Jackson	0.002 - 0.003	</</1	</</<	< 0.5
Baldwin	0.002 - 0.003	</</2	</</1	< 0.5
Mobile	0.002 - 0.003	</</<	</</<	< 0.5
Escambia	0.002 - 0.003	</</1	</</<	< 0.5
Santa Rosa	0.002 - 0.003	</</<	</</<	< 0.5
Okaloosa	0.002 - 0.003	</</1	</</<	< 0.5
Walton	0.002 - 0.003	</</1	</</<	< 0.5
Bay	0.002 - 0.003	</</2	</</1	< 0.5
Gulf	0.002 - 0.003	</</1	</</1	< 0.5
Franklin	0.002 - 0.003	</</1	</</<	< 0.5
Wakulla	0.002 - 0.003	</</<	</</<	< 0.5
Jefferson	0.002 - 0.003	</</<	</</<	< 0.5
Taylor	0.002 - 0.003	</</<	</</<	< 0.5
Dixie	0.002 - 0.003	</</<	</</<	< 0.5
Levy	0.002 - 0.003	</</<	</</<	< 0.5
Citrus	0.002 - 0.003	</</<	</</<	< 0.5
Hernando	0.002 - 0.003	</</<	</</<	< 0.5
Pasco	0.002 - 0.003	</</<	</</<	< 0.5

Table 4-9. Risk that a Spill ≥1,000 bbl Will Occur during Exploratory Drilling in the EPA Sale Area and Contact Identified Environmental Features or the County/Parish Shorelines (expressed as percent chance).

Environmental Feature	Spill Occurrence Variable [1] (mean number of spills)	Transport Variable [2, 3] (percent contact within 3/10/30 days from two EPA water-depth subareas)		Spill Risk [4]
Pinellas	0.002 - 0.003	</</<	</</<	< 0.5
Hillsborough	0.002 - 0.003	</</<	</</<	< 0.5
Manatee	0.002 - 0.003	</</<	</</<	< 0.5
Charlotte	0.002 - 0.003	</</<	</</<	< 0.5
Sarasota	0.002 - 0.003	</</<	</</<	< 0.5
Lee	0.002 - 0.003	</</<	</</<	< 0.5
Collier	0.002 - 0.003	</</<	</</<	< 0.5
Monroe	0.002 - 0.003	</</<	</</<	< 0.5
Coastal Recreational Areas				
TX Coastal Bend Beach Area	0.002 - 0.003	</</<	</</<	< 0.5
TX Matagorda Beach Area	0.002 - 0.003	</</<	</</<	< 0.5
TX Galveston Beach Area	0.002 - 0.003	</</<	</</<	< 0.5
TX Sea Rim State Park	0.002 - 0.003	</</<	</</<	< 0.5
LA Beach Areas	0.002 - 0.003	</</1	</</2	< 0.5
AL/MS Gulf Islands	0.002 - 0.003	</</3	</</1	< 0.5
AL Gulf Shores	0.002 - 0.003	</</2	</</1	< 0.5
FL Panhandle Beach Area	0.002 - 0.003	</</6	</</3	< 0.5
FL Big Bend Beach Area	0.002 - 0.003	</</<	</</<	< 0.5
FL Southwest Beach Area	0.002 - 0.003	</</<	</</<	< 0.5
FL Ten Thousand Islands Area	0.002 - 0.003	</</<	</</<	< 0.5
State Offshore Waters				
Mexican Waters	0.002 - 0.003	</</<	</</<	< 0.5
TX State Offshore Waters	0.002 - 0.003	</</<	</</<	< 0.5
LA West State Offshore Waters	0.002 - 0.003	</5/12	</3/11	< 0.5
LA East State OffshoreWaters	0.002 - 0.003	</5/14	</1/7	< 0.5
MS State Offshore Waters	0.002 - 0.003	</</3	</</1	< 0.5
AL State OffshoreWaters	0.002 - 0.003	</1/4	</</1	< 0.5
FL Panhandle State Offshore Waters	0.002 - 0.003	</1/8	</</4	< 0.5
FL Peninsula State Offshore Waters	0.002 - 0.003	</</<	</</<	< 0.5
Bird Habitats				
Diving Bird Habitat	0.002 - 0.003	</4/20	</2/12	< 0.5
Gulls, Terns, and Charadriid Allies Habitat	0.002 - 0.003	</6/26	</3/17	< 0.5
Raptor Bird Habitat	0.002 - 0.003	</1/7	</</3	< 0.5
Charadriid Shorebird Habitat	0.002 - 0.003	</6/25	</3/16	< 0.5
Wading Bird Habitat	0.002 - 0.003	</5/21	</2/12	< 0.5
Waterfowl Habitat	0.002 - 0.003	</7/30	</3/18	< 0.5
Endangered Bird Habitats				
Snowy Plover Habitat	0.002 - 0.003	</1/9	</</5	< 0.5
Brown Pelican Habitat	0.002 - 0.003	</4/15	</2/9	< 0.5
Whooping Crane Habitat	0.002 - 0.003	</</<	</</<	< 0.5
Bald Eagle Habitat	0.002 - 0.003	</6/21	</3/14	< 0.5

Table 4-9. Risk that a Spill ≥1,000 bbl Will Occur during Exploratory Drilling in the EPA Sale Area and Contact Identified Environmental Features or the County/Parish Shorelines (expressed as percent chance).

Environmental Feature	Spill Occurrence Variable [1] (mean number of spills)	Transport Variable [2, 3] (percent contact within 3/10/30 days from two EPA water-depth subareas)		Spill Risk [4]
Piping Plover Habitat	0.002 - 0.003	</7/21	</3/13	< 0.5
Endangered Mice/Fish Habitats				
Alabama Beach Mouse	0.002 - 0.003	</</2	</</1	< 0.5
Choctawhatchee Beach Mouse	0.002 - 0.003	</</1	</</1	< 0.5
Perdido Key Beach Mouse	0.002 - 0.003	</</1	</</<	< 0.5
St. Andrew Beach Mouse	0.002 - 0.003	</</1	</</1	< 0.5
Gulf Sturgeon -- Known Shoreline Locations	0.002 - 0.003	</5/25	</2/13	< 0.5
Marine Mammal Habitats				
Mexico Marine Mammal Habitat	0.002 - 0.003	</</<	</</<	< 0.5
TX Marine Mammal Habitat	0.002 - 0.003	</</<	</</<	< 0.5
LA West Marine Mammal Habitat	0.002 - 0.003	</5/12	</3/11	< 0.5
LA East Marine Mammal Habitat	0.002 - 0.003	</5/14	</1/7	< 0.5
MS Marine Mammal Habitat	0.002 - 0.003	</</3	</</1	< 0.5
AL Marine Mammal Habitat	0.002 - 0.003	</1/4	</</1	< 0.5
FL Panhandle Marine Mammal Habitat	0.002 - 0.003	</1/8	</</4	< 0.5
FL Peninsula Marine Mammal Habitat	0.002 - 0.003	</</<	</</<	< 0.5
FL Tortugas Marine Mammal Habitat	0.002 - 0.003	</</<	</</<	< 0.5
LA/MS/AL Manatee Area (Apr-Nov)	0.002 - 0.003			
FL Panhandle Manatees Area (Apr-Nov)	0.002 - 0.003	</</6	</</3	< 0.5
FL Big Bend Manatees Area (Apr-Nov)	0.002 - 0.003	</</<	</</<	< 0.5
FL Big Bend Manatees Area (Dec-Mar)	0.002 - 0.003	</</<	</</<	< 0.5
FL Southwest Manatees Area (Apr-Nov)	0.002 - 0.003	</</<	</</<	< 0.5
FL Southwest Manatees Area (Dec-Mar)	0.002 - 0.003	</</<	</</<	< 0.5
FL 10,000 Islands Manatees Area (Apr-Nov)	0.002 - 0.003	</</<	</</<	< 0.5
FL 10,000 Islands Manatees Area (Dec-Mar)	0.002 - 0.003	</</<	</</<	< 0.5
Sea Turtle Habitats				
Mexico Sea Turtle Nesting Habitat	0.002 - 0.003	</</<	</</<	< 0.5
Mexico Sea Turtle Mating Habitat	0.002 - 0.003	</</<	</</<	< 0.5
Mexico Sea Turtle General Coastal Habitat	0.002 - 0.003	</</<	</</<	< 0.5
TX Sea Turtle Nesting Habitat - Galveston Area	0.002 - 0.003	</</<	</</<	< 0.5
TX Sea Turtle Nesting Habitat - Matagorda Area	0.002 - 0.003	</</<	</</<	< 0.5

Table 4-9. Risk that a Spill ≥1,000 bbl Will Occur during Exploratory Drilling in the EPA Sale Area and Contact Identified Environmental Features or the County/Parish Shorelines (expressed as percent chance).

Environmental Feature	Spill Occurrence Variable [1] (mean number of spills)	Transport Variable [2, 3] (percent contact within 3/10/30 days from two EPA water-depth subareas)		Spill Risk [4]
TX Sea Turtle Nesting Habitat - Coastal Bend Area	0.002 - 0.003	</</<	</</<	< 0.5
TX Sea Turtle Nesting Habitat - Sea Rim Area	0.002 - 0.003	</</<	</</<	< 0.5
TX Sea Turtle Mating Habitat	0.002 - 0.003	</</<	</</<	< 0.5
TX Sea Turtle General Coastal Habitat	0.002 - 0.003	</</<	</</<	< 0.5
LA Sea Turtle Nesting Habitat	0.002 - 0.003	</3/8	</</4	< 0.5
LA Sea Turtle Mating Habitat	0.002 - 0.003	</2/5	</</2	< 0.5
LA Sea Turtle General Coastal Habitat - West	0.002 - 0.003	</5/12	</3/11	< 0.5
LA Sea Turtle General Coastal Habitat - East	0.002 - 0.003	</5/14	</1/7	< 0.5
MS/AL Sea Turtle Nesting Habitat	0.002 - 0.003	</1/5	</</2	< 0.5
MS Sea Turtle Mating Habitat	0.002 - 0.003	</</2	</</1	< 0.5
MS Sea Turtle General Coastal Habitat	0.002 - 0.003	</</3	</</1	< 0.5
AL Sea Turtle Mating Habitat	0.002 - 0.003	</</2	</</1	< 0.5
AL Sea Turtle General Coastal Habitat	0.002 - 0.003	</1/4	</</1	< 0.5
FL Sea Turtle Nesting Habitat - Panhandle Area	0.002 - 0.003	</</6	</</3	< 0.5
FL Sea Turtle Mating Habitat - Panhandle Area	0.002 - 0.003	</1/6	</</3	< 0.5
FL Sea Turtle General Coastal Habitat - Panhandle Area	0.002 - 0.003	</1/8	</</4	< 0.5
FL Sea Turtle Nesting Habitat - Peninsula Area	0.002 - 0.003	</</<	</</<	< 0.5
FL Sea Turtle Mating Habitat - Peninsula Area	0.002 - 0.003	</</<	</</<	< 0.5
FL Sea Turtle General Coastal Habitat - Peninsula Area	0.002 - 0.003	</</<	</</<	< 0.5
FL Sea Turtle Nesting Habitat - Tortugas Area	0.002 - 0.003	</</<	</</<	< 0.5
FL Sea Turtle Mating Habitat - Tortugas Area	0.002 - 0.003	</</<	</</<	< 0.5
FL Sea Turtle General Coastal Habitat - Tortugas Area	0.002 - 0.003	</</<	</</<	< 0.5
FL Sea Turtle Nesting Habitat - Keys Area	0.002 - 0.003	</</<	</</<	< 0.5
FL Sea Turtle Mating Habitat - Keys Area	0.002 - 0.003	</</<	</</<	< 0.5
FL Sea Turtle General Coastal Habitat - Keys Area	0.002 - 0.003	</</<	</</<	< 0.5

Table 4-9. Risk that a Spill ≥1,000 bbl Will Occur during Exploratory Drilling in the EPA Sale Area and Contact Identified Environmental Features or the County/Parish Shorelines (expressed as percent chance).

Environmental Feature	Spill Occurrence Variable [1] (mean number of spills)	Transport Variable [2, 3] (percent contact within 3/10/30 days from two EPA water-depth subareas)		Spill Risk [4]
Offshore Resources				
7 1/2 Fathoms	0.002 - 0.003	</</<	</</<	< 0.5
Big Bend Seagrass	0.002 - 0.003	</</<	</</<	< 0.5
Chandeleur Islands	0.002 - 0.003	</3/9	</</4	< 0.5
Flordia Keys National Marine Sanctuary	0.002 - 0.003	</</<	</</<	< 0.5
Florida Middle Ground	0.002 - 0.003	</</1	</</<	< 0.5
Flower Gardens Banks Marine Sanctuary	0.002 - 0.003	</</<	</</<	< 0.5
Mexican Waters	0.002 - 0.003	</</<	</</<	< 0.5
North Florida Straits	0.002 - 0.003	</</<	</</<	< 0.5
Sonnier Bank	0.002 - 0.003	</</<	</</<	< 0.5
South Florida Straits	0.002 - 0.003	</</<	</</1	< 0.5
Stetson Bank	0.002 - 0.003	</</<	</</<	< 0.5
Tortugas Ecological Reserve	0.002 - 0.003	</</<	</</<	< 0.5

[1] The mean number of spills ≥1,000 bbl estimated to occur, derived by multiplying the spill rate times the number of wells estimated to be drilled.

[2] The percent chance that winds and currents will move from a point starting within one of the two subareas in the EPA sale area, identified by water depth, and ending at specified coastal or offshore features. The results are calculated using a numerical model that simulates the trajectory of a drifting point projected onto the surface of the GOM waters using temporally and spatially varying winds and ocean current fields. These probabilities do not factor in the risk of spill occurrence or consideration of the spill size, any spill response or cleanup actions, or any dispersion and weathering, except as they relate to the choice of specified time periods of 3, 10, and 30 days (see footnote 3).

[3] These time periods represent the likely persistence of a spill slick and are the length of time of the modeled simulation. In this case, the point is allowed to drift on the water surface for up to 30 days, with results reported for contact within 3 days and within 10 days. The persistence of a slick is determined by a large number of factors, including the oil type, characteristics, environmental conditions at the time of a spill, the spill size, and the amount of oil lost due to weathering and cleanup.

[4] The probability of a spill ≥1,000 bbl occurring and contacting the shoreline of counties/parishes, the shoreline of identified environmental resource habitats, or the overlying waters above offshore features. The probability represents weighted spill risk that accounts for both the risk that a spill of this magnitude will occur and the risk that it will contact locations where the resources occur.

[5] The symbol < is used to represent <0.5%.

4.2.7.3.5. Chemical and Drilling Fluid Spills

A recent study of chemical usage associated with OCS activities determined that only two chemicals could potentially impact the marine environment – zinc bromide and ammonium chloride (Boehm et al., 2001). Both of these chemicals are used for well treatment or completion and are not in continuous use. Most other chemicals are either nontoxic or used in small quantities.

Zinc bromide is of particular concern because of the toxic nature of zinc. The Boehm et al. (2001) study modeled a spill of 45,000 gallons of a 54-percent aqueous solution, which would result in an increase in zinc concentrations to potentially toxic levels. Direct information on the toxicity of zinc to marine organisms is not available; however, the toxicity of zinc to a freshwater crustacean (*Ceriodaphnia dubia*) indicated that exposure to 500 ppb zinc resulted in measurable effects. One factor not considered in the model is the rapid precipitation of zinc in marine waters, which would rapidly remove zinc from the aqueous system and minimize the potential for impact.

Ammonium chloride was modeled using potassium chloride as a surrogate. The model looked at a spill of 4,717 kg (10,400 lb) of potassium chloride powder. The distribution of potassium would overestimate the distribution of ammonia released during a spill. The model indicated that close to the release point, ammonia concentrations could exceed toxic levels for time scales of hours to days. Additional information on the degradation of ammonia in seawater would be needed for a more complete evaluation.

It has been mentioned that the use of OBF has significantly declined since the introduction of SBF. For example, between 1970 and 1990, an average of about five spills of OBF occurred annually, but from 1990 to 1995, only one occurred per year on average. Accidental riser disconnects could result in the release of SBF contained in the riser. Three accidental riser disconnects occurred during 2000-2001 on the GOM OCS. The contents of the riser discharged within an hour of the disconnection. In each case, approximately 600-800 bbl of SBF discharged at the seafloor. The fate and effects of such a release of SBF have not been studied. A review and discussion of the environmental impacts of SBF (Neff et al., 2000) indicates that the initial degradation of the SBF would result in localized anoxic conditions in the sediment and bottom water a few centimeters above it, in the absence of currents that could oxygenate the bottom environment. Complete recovery should occur within 3-5 years in deepwater environments and probably much faster in shallow water because of greater aeration and circulation.

Blowouts may cause release of the drilling fluid in use at the time of occurrence. The upper part of deepwater wells is expected to be drilled with WBF, and the lower part with SBF. The point at which SBF could be substituted for WBF could take place anywhere between 1,500 and 6,000 ft below mudline, depending on well-specific drilling mud programs. The generic well schematic (Figure 4-1) uses a mud switchover point at 2,500 ft below mudline. The SBF could also be spilled during transport of the used drilling fluids, particularly as the result of collision. Such a spill would not be released at the seafloor and would be diluted and dispersed in the water column. The MMS has prepared several EIS's that provide information on spills and potential impacts to resources (USDOI, MMS, 2001a; USDOI, MMS, 2002a; USDOI, MMS, 2002c).

4.2.7.3.6. Collisions

Most collision mishaps are the result of service vessels colliding with platforms or vessel collisions with pipeline risers. From 1995-2001, there were 56 OCS-related collisions. Approximately 10 percent of vessel collisions with platforms in the OCS caused diesel-fuel spills. The earliest date included in oil-spill modeling is 1971. The largest diesel spill occurred in 1979 when an anchor-handling boat collided with a drill rig in the Main Pass Area, spilling 1,500 bbl (Table 4-5). In 1969, a 2,500-bbl crude oil spill occurred when a vessel collided with a drilling rig causing a blowout.

In a study on a generic deepwater platform facility and marine vessel traffic in the GOM by the National Offshore Safety Advisory Committee (NOSAC, 1999), the total collision frequency was found to be approximately one collision per 250 facility-years (3.6×10^{-3} per year). Safety fairways, traffic separation schemes, and anchorages at buoys that are not located at the drill rig itself are the most effective ways to mitigate vessel collisions with structures in the OCS. In general, no fixed structures, such as platforms and drill rigs, are allowed in fairways. Temporary underwater obstacles, such as anchors and attendant cables or chains attached to floating or semisubmersible drill rigs, may be placed in a fairway under certain conditions. Vessel collisions with OCS structures are minimized by USCG requirement to locate fixed structures on nautical charts and to mark fixed structures and moored objects with lights, sound-producing devices, and radar reflectors. In addition, the USCG 8th District's Local Notice to Mariners (monthly editions and weekly supplements) informs GOM users about the addition or removal of drill rigs and platforms, locations of aids to navigation, and defense operations involving temporary moorings.

Vessels supporting OCS operations could collide with marine mammals or turtles during transit (Chapters 4.3.2.6.3 and 4.3.2.7.2). To limit such collisions, NOAA Fisheries provides guidelines to all boat operators.

4.3. CONSEQUENCES OF EXPLORATION ACTIVITIES

The impact-producing factors and environmental impacts evaluated in this PEA are those that would result as a consequence of carrying out the exploratory drilling, and well completion or abandonment activities defined in the industry EP's MMS receives. Lessees have the option to submit EP's for (1) any blocks leased during Lease Sale 181 and (2) any blocks leased previously and subsequently in this area. The potential impacts that accompany exploratory drilling in this area of the Gulf encompass only one part of the total spectrum of OCS Program activity considered in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a). Not considered herein are the impacts from development drilling or hydrocarbon production.

The EPA sale area encompasses about 1.5 million ac located 100-200 mi (160-320 km) offshore Alabama and is nowhere less than 75 mi (120 km) southeast of the nearest land (Louisiana). Water depth ranges from 5,085 to 9,840 ft (1,550 to 3,000 m) in the EPA sale area

The MMS estimates that 15-115 MMbbl of oil and 225-750 Bcf of gas could be discovered and produced as a result of the proposed action. The cumulative environmental impacts to the sensitive marine resources in the EPA sale area that would occur if exploratory drilling took place would be insignificant to none.

4.3.1. Physical Resource Impact Analysis

4.3.1.1. Impacts on Air Quality

This chapter focuses on the impacts from exploratory drilling in the EPA sale area on the air quality of the coastal and offshore marine environments. The following OCS activities potentially degrade air quality: platform construction and emplacement; platform operations; drilling activities; flaring and burning; survey and support-vessel operations; pipeline laying and burial operations; evaporation of volatile petroleum hydrocarbons during transfers and from surface oil slicks; and fugitive emissions.

Of these activities, exploration in the EPA sale area would include (1) well drilling, (2) survey and support-vessel operations, (3) flaring and burning, (4) evaporation of volatile petroleum hydrocarbon during transfers and from surface leaks and spills, and (5) fugitive emissions.

Emission Constituents

Emissions of certain air pollutants are known to be detrimental to public health and welfare. Some of these pollutants are directly emitted into the air, while others are formed in the atmosphere through chemical reactions. Nitric oxide and nitrogen dioxide constitute nitrogen oxide (NO_x) emissions. Nitrogen dioxide, a by-product of all combustion processes, is emitted from sources such as internal combustion engines, natural gas burners, and flares. Nitrogen dioxide is a precursor pollutant involved in photochemical reactions that yield ozone. Nitrogen dioxide is an irritating gas that may increase susceptibility to infection and may constrict the airways of people with respiratory problems. Further, nitrogen dioxide can react with water to form nitric acid, which is harmful to vegetation and materials, as a result of increased acidity in precipitation.

Carbon monoxide (CO) is a by-product of incomplete combustion and is primarily contained in engine exhaust. Carbon monoxide is readily absorbed into the body through the lungs, where it reacts with hemoglobin in the blood reducing the transfer of oxygen within the body. CO particularly affects people with cardiovascular and chronic lung diseases.

Sulfur dioxide (SO_2) may cause constriction of the airways and particularly affects individuals with respiratory diseases. Sulfur dioxide can combine with water and oxygen, thus increasing the acidity in precipitation, which can be harmful to vegetation and materials. The flaring of hydrogen sulfide (H_2S), which is found naturally occurring in "sour" gas, and the burning of liquid hydrocarbons result in the formation of SO_2. The amount of SO_2 produced is directly proportional to the sulfur content of the hydrocarbons being flared or burned. The concentration of the H_2S varies substantially from hydrocarbon reservoir to reservoir, and even varies to some degree within the same reservoir. Flaring or burning of sour production is also of concern because it could significantly impact onshore areas, particularly when considering the short-duration averaging periods (3 and 24 hr) for SO_2. The combustion of liquid fuels is the primary source of sulfur oxides (SO_x) when considering the annual averaging period. To prevent inadvertently exceeding established criteria for SO_2 for the 3-hr and 24-hr averaging periods, all incinerating events involving H_2S or liquid hydrocarbons are evaluated individually during the MMS review process for OCS EP's.

Volatile organic compounds (VOC's) are precursor pollutants involved in a complex photochemical reaction with NO_x in the atmosphere to produce ozone. The primary sources of VOC's are venting and evaporative losses that occur during the processing and transporting of natural gas and petroleum products. A more concentrated source of VOC's comes from glycol dehydrator still vents.

Particulate matter is comprised of finely divided solids or liquids such as dust, soot, fumes, and aerosols. PM_{10} particles are small enough to bypass the human body's natural filtration system and can be deeply inhaled into the lungs, affecting respiratory functions. PM_{10} can also affect visibility, primarily by scattering of light by particles, and by light absorption to a lesser extent. This analysis considers mainly PM_{10} matter.

Ozone is a nearly colorless gas with a faint but distinctive odor, somewhat similar to chlorine. It is formed in the atmosphere from complex chemical reactions involving hydrocarbons and nitrogen oxides in the presence of sunlight. At ground level, ozone can cause or aggravate respiratory problems, interfere with photosynthesis, and can damage vegetation and crack rubber. Children, the elderly, and healthy people who exercise strenuously outdoors are particularly sensitive to ozone concentrations. In the upper atmosphere, ozone is essential to life as we know it. The upper ozone layer shields the Earth's surface from harmful ultraviolet radiation. Depletion of the upper ozone layer is one of the most complex environmental issues facing the world today. This analysis does not include impacts on upper atmospheric ozone.

Emissions of air pollutants would occur during exploratory drilling activities. Typical emissions for OCS exploration and development drilling activities presented in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a; Section IV.A.2.f.) show that emissions of NO_x are the primary pollutant of concern. These emission estimates are based on a drilling scenario of a 4,115-m hole during exploration activities and a 3,050-m hole during development activities. Emissions during exploratory drilling are higher than emissions during development drilling due to increased power requirements and the longer time required for drilling the deeper hole used in the scenario.

Platform emission rates for the GOM region are provided from the 1992 emission inventory of OCS sources compiled by MMS (Steiner et al., 1994), taking into account deepwater activities. It states that there are a total of 1,857 OCS facilities with air-emitting equipment. The primary pollutants of concern are NO_x and VOC's, both considered precursors to ozone. Emission factors for other activities, such as support vessels, helicopters, tankers, and loading and transit operations, were obtained from Jacobs Engineering Group, Inc. (1989) and USEPA AP-42 (1985).

Accidents, such as oil spills, blowouts, and pipeline ruptures, are another source of potential emissions related to OCS operations. Typical emissions from OCS accidents consist of hydrocarbons; only fires produce a broader array of pollutants, including all NAAQS-regulated primary pollutants. Emissions from a 6,300-bbl spill cannot be sustained for long periods due to the rapid volatilization of the hydrocarbons, with emission rates peaking during the second hour and after 24 hours slowing to only a few percent of the slick's volume. Hydrogen sulfide may also be released during an accident. Hydrogen sulfide is a toxic gas; at lower concentrations it is readily recognized by the "rotten egg" smell. Accidents involving high concentrations of H_2S could result in deaths as well as environmental damage.

Once pollutants are released into the atmosphere, atmospheric transport and dispersion processes begin circulating the emissions. Transport processes are carried out by the prevailing net wind circulation. Dispersion depends on emission height, atmospheric stability, mixing height, exhaust gas temperature and velocity, and wind speed. For emissions inside the atmospheric boundary layer, the vertical heat flux, which includes effects from wind speed and atmospheric stability (via air-sea temperature differences), is a better indicator of turbulence available for dispersion (Lyons and Scott, 1990). Heat flux calculations in the EPA (USDOI, MMS, 1988) indicate a year-round upward flux, being highest during winter and lowest in summer.

The mixing height is very important because it determines the space available for spreading the pollutants. The mixing height is the height, above the surface, of the top of the layer through which vigorous vertical mixing occurs. Vertical mixing is most vigorous during unstable conditions. Vertical motion is suppressed during stable conditions and, hence, the mixing height for such times is undefined; these stagnant conditions generally result in the worst periods of air quality. The mixing height tends to be higher in the afternoon, more so over land than over water. Further, the mixing height tends to be lower in winter, with daily changes smaller than in summer.

Analysis of Impacts

The total OCS emissions (in tons over the 40-year life of OCS Program activities) for the criteria pollutants are indicated in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a; Table IV-12). Exploratory drilling in the EPA sale area would contain similar emissions proportions, but in much lower overall because the longer duration activities of development and production are excluded.

NO_x is the major emittent, while TSP (or PM_{10}) is the least emitted pollutant. Combustion intensive operations, such as well drilling, and service-vessel activities contribute mostly NO_x. Exploration wells and developmental wells contribute considerable amounts of all pollutants. Well emissions are temporary in nature and typically occur over a 100-day drilling period. Support for OCS activities includes crew and supply boats, helicopters, and pipeline vessels; emissions from these sources consist mainly of NO_x and CO. These emissions are directly proportional to the number and type of OCS operations requiring support activities. Most support emissions occur during transit between port and offshore oil and gas development drilling activities, while a smaller percentage results from idling at the platform. A smaller percentage, in similar proportions, would result from exploratory drilling as a separate activity category. Platform and well drilling emissions were calculated using the integration of projected well and platform activities over time.

Projected total emissions for all OCS activities for each offshore subarea of the EPA are presented in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a; Table IV-13). The MMS regulations (30 CFR 250.303 through 304) do not establish annual significance levels for CO and VOC for the OCS areas under MMS jurisdiction. For CO, a comparison of the projected emission rate to the MMS exemption level will be used to assess impacts. The formula to compute the emission rate in tons/yr for CO is $3{,}400 \bullet D^{2/3}$; D represents distance in statute miles from the shoreline to the source. This formula is applied to each facility. The CO exempt emission level is 7,072 tons/yr at the State boundary line of 3 mi, which is greater than CO peak emissions from the whole EPA.

The VOC emissions are best addressed as their corresponding ozone impacts, which were studied in the Gulf of Mexico Air Quality Study (GMAQS). The GMAQS indicated that OCS activities have little impact on ozone exceedance episodes in coastal nonattainment areas. Total OCS contributions to the exceedance (greater than 120 ppb) episodes studied were <2 ppb. In the GMAQS, the model was also run using double emissions from OCS petroleum production activities associated with offshore facilities and the resulting attributable ozone concentrations, during modeling exceedance episodes, were still small, ranging 2-4 ppb. The activities analyzed in this PEA would not result in a doubling of the emissions and because the proposed activities are substantially smaller than this worst-case scenario, it is logical to conclude that their impact would be substantially smaller as well (Systems Applications International et al., 1995). Additionally, 30 CFR 250.303(f)(2) requires that, if a facility would significantly impact (defined as exceeding the MMS significance level) an onshore nonattainment area, it would have to reduce its impact fully through the application of Best Available Control Technology (BACT) and possibly through source emission offsets as well.

No blowouts are expected to occur over the duration of exploration activity from 2003 to 2043, because only 38-73 wells are projected. The air pollutant emissions from blowouts depend on the amount of oil and gas released, duration of the accident, and the occurrence or not of fire during the blowout. Because of technological advances, the duration of blowouts has decreased. Most blowouts occur without fire. The amount of oil released during these accidents has been small. No statistics exist on the amount of gas released during a blowout; however, a rate of 1 Bcf per day is assumed. Assuming a blowout occurs in the EPA area, total blowout VOC emissions are estimated to be between 1 and 5 tons. These estimates are conservative (overestimated) and the total amount of VOC is very likely less.

The MMS expects that oil spills would result in low impacts on air quality because total emissions would be of short duration. Table IV-2 in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a) shows that after day 2 the incremental increase in evaporation is <2 percent. By 3 days, approximately 25 percent of the original volume of spilled oil has evaporated. Air quality impacts from a spill size projected to occur as a result of the analysis completed for the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a; Tables IV-24 and IV-25) would be dependent on a variety of factors including location, meteorological conditions at the time, and duration of the spill. No more than one large spill, estimated to be 6,300 bbl (pipeline rupture), was projected to occur as a result of Lease Sale 181 (USDOI, MMS, 2001a; Tables IV-24 and IV-25). Pollutant concentrations reaching onshore would generally be low due to dispersion of the emissions with distance over water and due to the fact that emissions decrease with time and become more diffuse as the spill spreads over a large area with time. Any potential air quality impacts from a large spill would be rare, very localized, and of short duration.

The Breton National Wilderness Area is a Class I air quality area administered by FWS. Under the Clean Air Act, MMS will notify the National Park Service and FWS if emissions from proposed projects may impact the Breton Class I Area. Mitigating measures, including low-sulphur diesel fuels and stricter air emissions monitoring and reporting requirements, are required for sources that are located within 100 km of the Breton Class I Area and that exceed emission levels agreed upon by the administering agencies.

The MMS studied the impacts of offshore emissions using the Offshore and Coastal Dispersion (OCD) Model, Version 5. Tables IV-44 and IV-45 from the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a) summarize the results (including all phases of activities, i.e., exploration, development, and production). The tables show the predicted contributions to onshore pollutants from OCS activities resulting from Lease Sale 181 and compare them with the maximum allowable increases over a baseline concentration established under the air quality regulations. While the tables show that these activities in the area proposed for Lease Sale 181, by itself, would result in concentration increases that are well within the maximum allowable limits for Class I and Class II Areas, a direct comparison between the two sets of figures is not possible. This is because the actual maximum allowable increase depends on the net change in emissions from all other sources in the area, both offshore and onshore, since the date the baseline level was established. Sources that were already in place at the applicable baseline date are included in the establishment of the baseline and corresponding concentration and do not count in the determination of the maximum allowable increment. The PM_{10} are emitted at a substantially smaller rate than NO_2 and SO_2 and, hence, impacts from PM_{10} would be expected to be even smaller since chemical decay was not considered in this plume dispersion model.

Suspended particulate matter is important because of its potential in degrading the visibility in national wildlife refuges or recreational parks designated as PSD Class I Areas. The impact depends on emission rates and particle size. Particle size represents the equivalent diameter, which is the diameter of a sphere that would have the same settling velocity as the particle. Particle distribution in the atmosphere has been characterized as being largely trimodal (Godish, 1991), with two peaks located at diameters smaller than 2 m and a third peak with diameters larger than 2 m. Particles with diameters of 2 μm or larger would settle very close to the source (residence time of approximately 0.5 day; Lyons and Scott, 1990). For particles smaller than 2 μm, which do not settle quickly, wind transport determines their impacts. Projected PM_{10} concentrations are expected to have a low impact on the visibility of PSD Class I Areas. Due to the distance of the EPA sale area from the coastline (nowhere closer than 75 mi), it is not expected that the accidental releases of H_2S from exploratory drilling activities would have any significant impacts on air quality along the coastline.

Summary and Conclusion

Emissions of pollutants into the atmosphere from the activities associated with exploratory drilling in the EPA sale area are not expected to have significant impacts on air quality onshore because of the prevailing atmospheric conditions, emission heights, emission rates, and the distance of these emissions from the coastline. Emissions from exploration activities are not expected to have concentrations that would change onshore air quality classifications. Increases in onshore annual average concentrations of NO_x, SO_x, and PM_{10} are estimated to be less than the maximum increases allowed under the PSD program. No impacts are expected along the coastline from the accidental release of H_2S.

4.3.1.2. Impacts on Water Quality

This chapter focuses on the impacts from exploratory drilling on the water quality of coastal and offshore marine environments. An overview of the present status of water quality in the coastal and marine waters of the potentially impacted area is given in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a; Section III.B.2).

Chapter 4.2.7 (Accidental Events) discusses the likelihood of oil spills as a result of exploration and delineation drilling in the EPA sale area based on historical data and the volumes of oil that have been spilled in accidental events, such as a well blowout, compared to the activities in the proposed action. Accidental spills of oil, diesel fuel, or drilling fluids are not expected to significantly impact the quality of coastal or offshore marine waters. Spill volumes from the exploration activities are extremely unlikely to be large enough to impact these resources. Those spills of oil, diesel fuel, or drilling fluids that might occur in the deep marine environment of the EPA sale area would not be large enough to persist long enough to significantly impact water quality.

4.3.1.2.1. Coastal Waters

Rivers that drain two-thirds of the contiguous U.S. and enter the Gulf dominate contaminant inputs to coastal waters. Both upriver and coastal sources and activities contribute to coastal water quality degradation. These include the following: (1) the petrochemical industry; (2) agriculture, including croplands and livestock farming; (3) forestry, including pulp and paper mills; (4) urban expansion; (5) municipal and camp sewerage; (6) power generation; (7) marinas and recreational boating; (8) maritime shipping; and (9) hydromodification activities. Hydromodification includes channelization, channel modification, dams, and stream bank and shoreline activities. The petrochemical industry encompasses the development, transportation, and processing of the extensive oil and gas resources found onshore in Louisiana and Texas, offshore on the OCS, and shipped into the area from other states and countries. In addition, coastal waters from Mississippi to the Florida Keys are heavily used for recreation, which contributes sewerage, bilge water, diesel, and oil from the thousands of recreational vehicles and boats. The Gulf Coast has been heavily used and signs of environmental stress are evident. At least a portion of every estuary has impaired water quality primarily due to nutrient enrichment and pathogen indicators. A more detailed discussion of the Gulf's coastal water quality conditions is presented in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a; Section III.B.2).

Nearshore Oil Spills

Spills that occur from exploration activity in the EPA sale area are expected to be quantitatively few and volumetrically small. As explained in Chapter 4.2.7.1.4 (Past Record of Oil Spills from Blowouts), no blowouts are projected as a result of exploratory drilling in the EPA sale area based on trends in the historical GOM data and the number of exploration and delineation wells expected to be drilled in this area.

Oil spills from OCS activities generally are of short duration and have less of an overall impact than other long-duration discharges (produced water, for example). Spills of both crude oil and petroleum products can occur in offshore waters from pipelines, vessel and transfer accidents, and blowouts. If a large spill (≥1,000 bbl) were to occur at the surface, the majority of the oil would form a surface slick, or if a subsea blowout, the oil would rise to the surface to form a slick. Response efforts can recover or disperse some of the slick while still at sea. High surf could break up the slick, and weathering and evaporation of volatile organics can degrade a slick while at sea. Slicks existing for 10 days or more have a small chance of washing ashore.

Coastal environments, such as beaches, can take several years to recover from oiling, as was observed in Texas after the *Ixtoc* spill in 1979-1980. Oil can also be trapped in the marsh grass of coastal wetlands where it would slowly degrade, affecting the local water quality.

Miscellaneous Wastes

Some wastes generated from offshore OCS exploratory drilling are brought ashore for disposal. Because they are brought ashore they may potentially affect coastal environments; however, the disposal facilities for these waste products generally lie inland rather than directly on the shoreline. These waste materials include OBF and cuttings, liquid wastes (fracing fluids, emulsifiers, workover fluids, mud additives, etc.), and possibly well test solids. These wastes, commonly known as nonhazardous oil-field wastes (NOW), may be exempt from the Federal Resource Conservation and Recovery Act (RCRA). The management and disposal of these wastes are regulated by the States and disposed in approved or permitted facilities. The NOW wastes can be contaminated with toxic or hazardous compounds, heavy metals, oil and grease, and naturally occurring radioactive material (NORM). Wastes containing NORM have additional requirements for disposal. Once ashore, many of these wastes are transported via barge or truck to landfills for disposal. Improper storage and disposal of these wastes can adversely impact surrounding surface and ground waters and wetland areas. The Final EIS for Lease Sale 181 (USDOI, MMS, 2001a; Sections IV.B.1.f. and IV.B.2.c) provides more information on onshore storage and disposal locations and practices for offshore oil-field wastes.

Drilling Fluids and Cuttings

Disposal of fluids, muds, and cuttings from exploratory drilling in the GOM are governed by a USEPA NPDES permit. Mud and cuttings in the EPA sale area would be either discharged overboard (WBF and cuttings) or returned to the mainland for disposal of mud and cuttings (OBF), or recycling of mud and disposal of cuttings (SBF). Within the EPA sale area, which is under the present USEPA Region 4 NPDES general permit, overboard discharge of SBF and cuttings is not allowed. The remoteness of the EPA sale area from coastal waters introduces tremendous dilution factors with respect to any waste or byproducts discharged overboard and an extremely small likelihood of affecting any physical or biological coastal water resources.

Analysis of Impacts

Water quality in coastal waters along the northeastern Gulf may be altered by exploratory drilling in the EPA sale area. Spills from offshore operations may reach coastal waters. Transport of exploration well discharges, and spills from transport of small amounts of petroleum from well tests may also have effects on water quality.

Table IV-3 in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a) lists existing and projected infrastructure by coastal subarea assumed to support, to some degree, future OCS operations in the EPA sale area. Oil and gas support facilities have not been identified as major sources of coastal water quality degradation with the exception of refinery complexes. Refineries were identified by USEPA (USEPA, 1990) as major sources of point-source discharge contamination to the coastal zone in the Gulf, but refineries only partially support OCS production (about 20% of overall capacity). Vessel traffic associated with exploratory drilling in the EPA sale area would be most frequent in coastal Mississippi, Alabama, and Louisiana. With an average duration of 42 days, the average exploration well would require 6-9 support vessel trips per week in support of drilling operations, amounting to 36-54 service vessel trips in support of each well. Approximately 1,300-3,900 vessel trips would be needed to support the estimated total number of exploration wells in the EPA sale area (38-73) to carry supplies and crew between offshore drill rigs and onshore service bases. An average of 70 liters per hour of bilge water per vessel is discharged from these types and sizes of vessels (NERBC, 1976). The total volume is small relative to the volume of receiving waters but may affect water quality in confined, low-circulation areas such as ports. The average usage of navigation channels by the OCS industry has been estimated to be about 12 percent (Turner and Cahoon, 1988; Appendix B), but it can be as high as 75 percent for Bayou Boeuf and 70 percent for Bayou Teche and Vermilion River in Louisiana.

An oil spill originating in the EPA sale area could dissipate at sea or, much less likely, wash into nearshore environments to create a continuous source that would affect coastal water quality until all the oil is degraded by bacteria, dispersed by surf conditions, or buried in the sediments. If a slick from an OCS-related oil spill were to reach shallow, protected bays or wetland areas, oil could accumulate in thick layers on clumps of marsh vegetation, protected pools, or embayments.

If a large spill occurs, the likelihood of contact with coastal waters is dependent on its origin point and its trajectory (as determined by oceanographic and wind movements). The Oil Spill Risk Analysis (OSRA) model provides the percent chance that an offshore spill ≥1,000 bbl starting at a particular location offshore would contact a resource within 3, 10, or 30 days. The OSRA modeling completed for the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a) inferred a pipeline rupture as the most likely scenario for an oil spill ≥1,000 bbl in the proposed sale area. The EPA sale area is much smaller than the proposed Lease Sale 181 area and is also located in the deepest area of that tract. To obtain a spill ≥1,000 bbl originating from exploratory drilling activities in the EPA sale area would require the blowout of an exploration well. The probability for an exploration well blowout to occur in the EPA sale area that is ≥1,000 bbl is 1 in 100,000. If a large spill from an exploration well blowout were to occur, the spill would contact land within 30 days (USDOI, MMS, 2001a; Table IV-27). The most likely coastal waterbodies of contact are eastern Louisiana State waters, Alabama State waters, and the Florida Panhandle. Large spills are assumed to be severe enough to alter water quality for up to a year after impact. A ≥1,000-bbl spill reaching or occurring in shallow, confined, low-energy areas, would result in degradation of coastal water quality for up to 10 years after the spill. In the case of smaller spills, there could be adverse changes in water quality parameters lasting from six months (for spills >1 but <50 bbl) to five years (for spills >50 but <1,000 bbl). Background water quality conditions are assumed to return to normal within six weeks in wetlands after spills of <1 bbl.

Summary and Conclusion

Oil spilled during exploration in the EPA sale area could impact coastal waters of Louisiana, Alabama, or Florida. It is possible that a well blowout could result in a spill of ≥1,000 bbl of oil, but the historical data shows that the probability is very small (1 in 100,000). Because this PEA pertains to activities supporting the drilling of exploration wells, there is an exceedingly small chance, therefore, that a large spill ≥1,000 bbl could affect coastal marine waters. Small spills caused by vessel transfer accidents or offloading activities are expected to either dissipate at sea before any impacts can occur to coastal waters, or small portions would make landfall in a highly degraded state. Impacts are expected to be limited to small areas for short periods.

4.3.1.2.2. Offshore and Deep Marine Waters

This PEA considers the impacts that would occur from exploratory drilling in the EPA sale area. Sources of oil available to impact offshore and deep marine waters include oil spilled from a well blowout, or oil spilled in collisions of vessels or barges containing small quantities of oil produced from exploration well tests or from tanks carrying the boats' fuel supply. A blowout could also increase turbidity through resuspension of bottom sediments. The introduction of various effluents and discharges that result from exploratory drilling into marine waters can also degrade water quality.

The EPA sale area is everywhere at least 75 mi (120 km) from the shoreline of the nearest State (Louisiana). Water depths in the EPA sale area range from 1,550 to 3,000 m (5,085-9,850 ft). The deep marine waters and environment would, therefore, be the most directly affected by exploratory drilling in the EPA sale area.

Degradation of GOM marine waters is associated with coastal runoff, riverine inputs, effluent discharges, such as drilling muds, from offshore OCS oil and gas drilling and support activities, and activities that resuspended fine-grained sediment causing turbidity. These impacts are in addition to those contributed by non-OCS sources.

Emplacement and removal of DP exploration drilling rigs increase water-column turbidity in the vicinity of the wellbore by resuspending bottom sediments. The duration of these activities is short (days), and increases in turbidity would last a matter of days to weeks. The use of a conventionally-moored and anchored, semisubmersible drilling rig would result in similar increased turbidity during the placement of the anchors over a bottom footprint, ranging up to about 5 ac.

Contaminants from vessels transporting oil or supplies to and from offshore platforms can enter marine waters through routine operational discharges or accidental spills. Service vessels, including the tugs pushing oil barges, routinely discharge sanitary and domestic wastes and bilge waters. Shuttle tankers only discharge sanitary and domestic wastes; bilge waters are taken to onshore receptacles. The method of disposal into the environment, the mixing of the wastes through turbulence and large-scale currents, and the chemical properties of each source will influence the fate of the discharge within marine waters. The large volume of the receiving water in the deepwater EPA sale area and the dispersion that can occur before discharges reach sea bottom minimizes the impact on sediments. Impact-producing factors from offshore oil and gas exploration operations that may lead to water quality degradation include the following: (1) the overboard discharge of operational wastes during drilling or well testing; (2) overboard or sea bottom discharge of drilling mud, rig floor and sanitary waste effluents; (3) resuspension of bottom sediments through rig emplacement and removal; (4) discharges and spills from vessel operations; and (5) accidental spills or blowouts.

Offshore Oil Spills

Support vessels using coastal waters may degrade water quality through bilge water discharges, discharges of treated sanitary and domestic wastes, wake erosion of channel banks, incidental trash and debris, deck drainage, and dredging operations to maintain channels used by support vessels. New MARPOL regulations that further restrict the levels of oil and grease in bilge water discharges in coastal areas (40 CFR 110) were designed to diminish the types of impacts that have been historically noted from such discharges. Spills of diesel fuel are most likely to occur in connection with offloading and onloading activity and fueling carried out by or on support vessels. Spills of diesel or other fuels originating under these circumstances are expected to be small and to evaporate quickly, affecting water quality for a few days at most.

Oil or diesel fuel spilled from a drilling rig, support vessel, or in a well blowout constitutes the most visible source of degradation to offshore water quality from exploration activities. The frequency of occurrence, the chemistry of the spilled oil, the amount of the spilled oil, and the length of time that petroleum hydrocarbons remain in the water column are the major factors determining the extent of the impact of oil spills on water quality. Historically, most oil spills have impacted water quality during the life of the spill and only for a short time afterwards, especially spills occurring far out at sea. The majority of spilled oil floats on the surface as a slick because hydrocarbons are relatively insoluble in water. In a blowout scenario that releases oil at the sea bottom, typically 1-5 percent of the surface slick volume dissolves into the water column. Another 10-15 percent disperses naturally in the water column. Additional oil would mix into the water column, if dispersants were used at the surface to break up the slick.

As explained in Chapter 4.2.7.1.4 (Past Record of Oil Spills from Blowouts), no blowouts are projected as a result of exploratory drilling in the EPA sale area based on trends in the historical GOM data and the number of exploration and delineation wells expected to be drilled in this area. A well blowout would be the only type of accident from exploration activity likely to cause a spill large enough to have an impact on physical or biological resources. The likelihood for such a spill, however, is very remote based on historical data.

If a large spill (≥1,000 bbl) occurs from a well blowout in the EPA sale area, high waves could break up the slick and weathering and evaporation of volatile organics could degrade it while still at sea. The relative amount of oil that resides in the water column is a function of the oil's characteristics, the point of release (surface vs. subsurface), and the hydrographic conditions affecting the surface slick. Oceanographic processes, bacterial action, and dilution should disperse the oil remaining in the water column after the surface slick is removed or moves away, dependent on the energy of the system being impacted.

Mud volcanoes that vent hydrocarbon, hydrocarbon seeps, and brine seeps are part of the geological regime of the deep Gulf of Mexico (Roberts and Carney, 1997). The bottom disturbance from a blowout is likely to have impacts analogous to the effects of natural phenomena present in the deepwater environment.

Drilling Fluids and Cuttings

Exploratory drilling generates a number of wastes that have the potential to degrade marine water quality. The discharge of drilling fluids and cuttings from exploratory drilling is expected to be the primary impact-producing factor. The effluents and discharges from exploratory drilling, however, are spatially limited and temporally short. Small amounts of formation water may be commingled with drilling mud, or well treatment or completion fluids during testing of an exploration well that is carried out to confirm the extent and producibility of a discovered resource. The discharge of drilling muds and cuttings are governed by USEPA NPDES permit. Under the current NPDES general permit, only WBF and cuttings that meet NPDES toxicity requirements may be discharged. The discharge of WBF from exploration activity in the EPA sale area would add barite, and trace metals associated with barite, to the environment. On January 22, 2001, the USEPA promulgated new effluent guidelines to address overboard discharge of SBF and cuttings (66 CFR 6850). This guideline established technology-based effluent limitations for existing and new sources. Discharge of SBF-wetted cuttings wastes could be addressed with the reissuance of the USEPA Region 4 general permit in October 2003. All OBF and associated cuttings must be retained and disposed onshore due to their toxicity. The greatest impact from exploratory drilling in the EPA sale area would be on disposal facilities located onshore approved to handle SBF-wetted cuttings.

The primary impacts of offshore discharge of WBF and cuttings would be smothering or burial of sessile benthic organisms, alteration of sediment grain size distribution by the addition of cuttings. Assuming the discharge of dried cuttings was permitted in the EPA sale area, the primary effect would be the addition of organic matter that can result in localized oxygen deficiency while the organic components in the SBF degrade, as well as alteration of grain size distribution by the cuttings. Neither SBF nor their degradation products are known to bioaccumulate. It is expected that rig-dried cuttings that had been wetted with SBF should degrade within 2-3 years after discharge. Sediments in the local area would be impacted for only a maximum of 2-3 years, and the water quality would be affected for only a matter of days to weeks.

The Final EIS for Lease Sale 181 (USDOI, MMS, 2001a; Table IV-7) gives estimated volumes of muds and cuttings that may be discharged from the drilling of an "average" well. In this PEA, Table 4-1 provides projected volumes for an exploration well in the EPA sale area.

Other Rig Discharges

Impacts to marine waters and sediment from the overboard discharge of effluents are dependent on the water depth and current speed. The discharge of treated sanitary and domestic wastes and deck drainage from rigs, platforms, and support vessels may increase suspended solids, nutrients, chlorine, and biochemical oxygen demand (BOD) in a small area near the point of discharge. The constituents of these waste streams are known to dilute quickly, however, when discharged into open marine Gulf waters. These discharges are regulated by USEPA NPDES permits that specify contaminant levels in waste streams that are permitted for overboard discharge.

Analysis of Impacts

Drilling of the projected 38-73 exploration and delineation wells over the 40-year OCS Program in the EPA sale area would be expected to generate 8,700-18,000 bbl of WBF, 114,000-241,000 bbl of cuttings, and 3,800-7,300 bbl of SBF adhered to the cuttings during the period 2003-2043 (see Chapter 4.2.4.1, Drilling Muds and Cuttings, for discussion). The discharge of muds and cuttings is expected to be the primary impact-producing factor associated with exploratory drilling in the EPA sale area. The USEPA Region 4 general NPDES permit does not allow the discharge of either SBF or cuttings at this time. The SBF cuttings would be transported to a licensed disposal facility while the fluid fraction is transported ashore to be recycled. This activity could increase the impacts from supply vessels. To date, no ecological alterations have been documented in offshore waters from the types of contaminants discharged from OCS operations.

Bottom area disturbance occurs during the emplacement and anchoring of drill rigs. Increased water-column turbidity in local areas of offshore waters is caused by resuspension of bottom sediments from pile driving anchors. Bottom disturbance from emplacement operations produces localized temporary impacts on water quality by increasing turbidity and resuspending any settled pollutants, such as trace metals, and excess nutrients that may have accumulated. These effects are temporally short and spatially small.

The exploration activities carried out by operators in the EPA sale area are not expected to occur closely enough in time to result in combined effects; that is, impacts would only occur individually from each exploratory drilling operation, resulting in localized, temporary changes in water quality conditions. Blowouts could also increase water-column turbidity. Not all blowout incidents would result in jetting of formation sediment or resuspension of bottom sediment. In cases where sediments are released, the sand generally settles within 400 m for a 30-m water depth and 25 cm/sec blowout. During an extremely large blowout occurrence, sands would settle within 400 m, but finer sediments could remain in suspension for periods of 30 days or longer and thus be dispersed over large distances.

As explained in Chapter 4.2.7.1.4 (Past Record of Oil Spills from Blowouts), no blowouts are projected as a result of exploratory drilling in the EPA sale area based on trends in the historical GOM data and the number of exploration and delineation wells expected to be drilled in this area. Given the extremely low likelihood of blowout events expected for the EPA sale area during the exploration phase, and given that not all blowouts result in the release of oil, or are of short duration, blowouts are not expected to be a factor affecting future water quality.

Oil spills related to exploration activities are expected to be mostly very small events, such as a fuel transfer spill, with spills >50 bbl occurring very infrequently.

Summary and Conclusion

The offshore effluents and discharges from exploratory drilling are spatially limited (discharge plume occurring across 10-100 ac) and temporally short (4-8 week duration of the typical deepwater well). The discharge of WBF from exploration activity in the EPA sale area would add effluent to the water containing clay minerals, barite, and trace metals (such as mercury) that can be associated with barite. The trace metals in drilling mud discharge are in a chemical form that is not readily taken up by organic systems. These trace elements are expected to be detected out to 3,000-m downcurrent from the discharge point during deepwater exploratory drilling operations. No ecological effects to water-column organisms are expected, however, from the contaminant levels permitted to be discharged. Biologically adverse effects from OCS discharges are most likely to occur in the sediments downcurrent from and within 100 m of the discharge point. Effects to sediment in a deepwater operation would require high discharge rates and low current activity. Drilling discharges from deepwater facilities located in waters deeper than 400 m could reach the seafloor but would result in extremely low levels of sediment contamination, and any cuttings would be distributed in very thin accumulations. Because water depths in the EPA sale area are significantly deeper than 400 m, only a thin veneer of cuttings would accumulate within 1,000 m of the drilling operation, with most being disbursed by currents to a larger, wider area beyond 1,000 m.

Sediment disturbance from the emplacement of exploration drill rigs is expected to result in minor, localized, temporary increases in water-column turbidity in offshore waters.

Spills that occur from exploration activity in the EPA sale area are expected to be quantitatively few and volumetrically small. Spills >50 bbl are expected to occur very infrequently. Given these numbers and expected duration of any impacts, spills from exploratory drilling in the EPA sale area would cause degraded water conditions for a short-duration (from a few days to 3 months) and affect only a small area of offshore waters at any one time. Contaminants discharged from routine operations or those entering Gulf waters from spills would contribute <1 percent to any possible long-term, offshore water quality degradation that may be occurring.

4.3.2. Biological Resource Impact Analysis

4.3.2.1. Impacts on Barrier Islands and Dunes

This chapter focuses on the impacts from exploratory drilling in the EPA sale area on barrier beaches and dunes of the coastal environment. The impact-producing factors associated with exploration and delineation drilling in the EPA sale area that could affect barrier beaches and dunes include oil spills from blowouts or vessel collisions, chemical and drilling fluid spills, spill response, and cleanup.

Oil Spills

Chapter 4.2.7 (Accidental Events) discusses the likelihood of oil spills as a result of exploration and delineation drilling in the EPA sale area based on historical data and the volumes of oil that have been spilled in accidental events, such as a well blowout, compared to the activities in the proposed action. Accidental spills of oil, diesel fuel or drilling fluids are not expected to impact barrier islands or dunes. Spill volumes from exploration activities are extremely unlikely to be large enough to impact these physical resources. Those spills of oil, diesel fuel, chemicals, or drilling fluids that might occur would not be large enough to persist long enough in the deepwater marine environment of the EPA sale area to make landfall. Because landfall of spilled oil, diesel fuel, drilling fluids, or chemicals is highly unlikely, the consequences of landfall, i.e., spill response or cleanup of beaches and dunes on barrier islands, would not be incurred.

Table IV-22 in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a) indicates the oil-spill occurrence rates in the Gulfwide area. The statistics show that there have been numerous spills of >1 but <50 bbl but very few spills ≥1,000 bbl for all OCS operations per billion barrels of oil handled. A blowout is the only accident category that could yield a spill ≥1,000 bbl for the duration of the OCS Program in the EPA sale area. The probability of a blowout is small, less than 1 in 100,000, and the combined probability of a spill ≥1,000 bbl making landfall in adjacent states is extremely small. No spills due to exploration activity in the EPA sale area are expected because only 38-73 exploration wells are expected in the EPA sale area over the next 40 years.

The likelihood of contact with barrier island beaches and dunes is dependent on the meteorological and Gulf current conditions at the time of the spill, and the quantity and location of the spill. In coastal Louisiana, heights of dune lines range from 0.5 to 1.3 m above mean high tide levels. In Mississippi and Alabama, dune elevations exceed those in Louisiana. Florida dunes are typically even higher. An analysis of 37 years of tide-gauge data from Grand Isle, Louisiana, shows that the probability of water levels reaching lower sand dune elevations ranges up to 16 percent. For spilled oil to move into and across dunes, strong southerly winds must persist for an extended time prior to or immediately after the spill to elevate water levels. Strong winds would also accelerate oil-slick dispersal, spreading, and weathering, thereby reducing impact severity at a landfall site. Significant dune contact by a spill associated with the proposed activity is considered very unlikely except during abnormally high water levels. A study in Texas showed that oil disposal on sand and vegetated sand dunes had little deleterious effects on the existing vegetation or on the recolonization of the oiled sand by plants (Webb, 1988).

Cleanup of oil spills that contact beaches is described in the Final EIS for Lease Sale (USDOI, MMS, 2001a; Section IV.A.3.i.(2)). Cleanup of large volumes of oil from barrier beaches can affect beach stability if large quantities of sand are removed. To some degree, any sand removal will result in a new beach profile at the site of removal. Beach profiles adjust in response to wind- and water-induced movements of available sand volume. The net result of these changes could range from no noticeable change to accelerated rates of shoreline erosion. Increased erosion rates are of greatest concern at sand-starved, eroding beaches, as found along the Louisiana Gulf Coast or at the beaches of southern Bay and northern Gulf Counties in Florida. State governments around the northern Gulf have recognized these problems and have established policies to limit sand removal by cleanup operations. Some beached oil and tarballs would penetrate or be buried to various depths under the sand, depending upon the viscosity of the oil; wind and wave energies; and the temperature, wetness, and nature of the sand. Some of this oil may be beneath the reach of cleanup methods and may remain in the sand.

Analysis of Impacts

Spills that occur from exploration activity in the EPA sale area are expected to be quantitatively few and volumetrically small. As explained in Chapter 4.2.7 (Accidental Events), no blowouts are projected as a result of exploratory drilling in the EPA sale area based on trends in the historical GOM data and the number of exploration and delineation wells expected to be drilled in this area. The only type of accident from exploration activity likely to cause a spill large enough to have an impact on physical or biological resources would be a well blowout.

Though considered highly unlikely, a blowout is possible, and is therefore considered. If an offshore spill ≥1,000 bbl from an exploration well blowout occurred in the EPA sale area, the coastal areas having the highest probabilities of contact are the Chandeleur Islands (13%); Baldwin County, Alabama (land segment 24, 27%); and Escambia and Santa Rosa Counties, Florida (land segment 25, 12%), if the landfall is within 10 days of the spill.

As explained in Chapter 4.2.7.3.4 (Risk of Oil Spill Occurrence), the probabilities of landfall in adjacent states of a large spill (≥1,000 bbl) originating from exploration activity is very low. Should a spill of this magnitude occur, in most cases mechanical cleanup methods would be used and the volume of oil in a slick would be reduced concurrently with the volume reduction resulting from spill weathering while still at sea. Beach sand removal would be minimized and assumed to cause no permanent effects on barrier beach stability. Within a few months to 2 years after cleanup, the disturbed beach would adjust to approximately pre-disturbance conditions. Mechanical cleanup at sea is assumed to collect up to 10 percent of spilled oil and approximately 30 percent is assumed to be chemically dispersed, reducing the overall probability and severity of beach contact. Mechanical cleanup onshore would occur with minimal sand removal. The duration of effects to barrier beaches from accidental spills related to exploratory drilling in the EPA sale area would be 2 years.

Oil, tarballs, and other fractional components of oil that remain in the sand after cleanup could remain for several years and would be released periodically when storms and high tides resuspend or flush through beach sediments. During days when sand temperatures are raised sufficiently, tarballs buried near the surface of the beach sand may liquefy and oil may ooze to the surface. Oil or its components that remain in the sand after cleanup may be (1) released periodically when storms and high tides resuspend or flush beach sediments, (2) decomposed by biological activity, or (3) volatilized and dispersed during hot or sunny days.

Exploration activities are expected to be supported from existing service bases in Louisiana, Mississippi, and Alabama. According to the model for projected use of service bases, the access channel to Port Fourchon would receive <2 percent of the traffic projected to support exploration activity in the EPA sale area. Exploration activities would then be responsible for little to none of the need for deepening the Port Fourchon access channel or the resulting impacts. Cumulative impacts are discussed in Final EIS for Lease Sale 181 (USDOI, MMS, 2001a; Section IV.D.1.e.).

Summary and Conclusion

Exploration activities are not expected to impact or alter barrier beach or dune configurations. There is a very low probability of a spill from exploration activities in the EPA sale area contacting barrier beaches. Should offshore spill cleanup proceed as prescribed, impacts to barrier beaches and dunes would be minimal to insignificant. Therefore, no significant, long-term impacts to the physical shape and structure of barrier beaches and associated dunes are expected to occur.

4.3.2.2. Impacts on Wetlands and Seagrass Communities

This chapter focuses on the impacts from exploratory drilling in the EPA sale area on wetlands and submerged vegetation in coastal environments. The impact-producing factors associated with exploratory drilling that could affect wetlands and submerged vegetation include oil spills from blowouts or vessel collisions, chemical and drilling fluid spills, and spill response and cleanup. This analysis includes forested wetlands (bottomland and swamp), bay and canal-fringing wetlands, and marshes. Seagrasses in the area are generally restricted to bays, shallow areas behind barrier islands in Mississippi and Chandeleur Sounds, and littoral zones in bays. Most beds of submerged aquatic vegetation located between the Southwest Pass of the Mississippi River and Cape San Blas, Florida, are inland of the barrier shorelines. Beds of submerged vegetation are found in lower-salinity settings farther inland and discontinuously throughout the coastal zone of this area (USDOI, MMS, 2001a; Section III.B.1.c.). Most submerged vegetation in this region usually remains submerged, due to the micro-tidal regime of the northern Gulf. Only during extremely low, wind-driven tidal events would large areas be exposed to the air. Even then, their roots and rhizomes remain buried in the water bottom.

Oil Spills

Chapter 4.2.7 (Accidental Events) discusses the likelihood of oil spills as a result of exploration and delineation drilling in the EPA sale area based on historical data and the volumes of oil that have been spilled in accidental events, such as a well blowout, compared to the activities in the proposed action. Accidental spills of oil, diesel fuel, or drilling fluids are not expected to impact wetlands or submerged vegetation. Spill volumes from exploration activities are extremely unlikely to be large enough to impact these physical resources. Those spills of oil, diesel fuel, or drilling fluids that might occur would not be large enough to persist long enough in the deepwater marine environment of the EPA sale area to make landfall.

Though considered highly unlikely, a blowout is possible, and is therefore considered. If an offshore spill ≥1,000 bbl from an exploration well blowout occurred in the EPA sale area, the coastal areas having the highest probabilities of contact are the Chandeleur Islands (13%); Baldwin County, Alabama (land segment 24, 27%); and Escambia and Santa Rosa Counties, Florida (land segment 25, 12%), if the landfall is within 10 days of the spill.

The likelihood of contact of a spill from the EPA sale area with wetlands or submerged vegetation is dependent on the meteorological and Gulf current conditions at the time of the spill, the quantity of the spill, as well as the location of the spill. Numerous investigators have studied the immediate impacts of oil spills on wetland habitats in the Gulf area. Often, seemingly contradictory conclusions are generated from these impact assessments, which can be explained by differences in oil concentrations contacting vegetation, the chemical composition of the oil spilled, vegetation type and density, season of year, pre-existing stress level on the vegetation, sediment types, water levels, weather, and numerous other factors. In overview, the data suggest that vegetation that is lightly oiled will experience plant die-back, followed by recovery without replanting. Therefore, most impacts to vegetation are considered to be short term and reversible (Webb et al., 1985; Alexander and Webb, 1987; Lytle, 1975; Delaune et al., 1979; Fischel et al., 1989).

Offshore oil spills are much less likely to contact submerged vegetation than are inshore spills, because the beds are remote from deep marine waters and are generally protected by barrier islands, peninsulas, sand spits, and currents. The degree of impact on submerged vegetation from oil spills depends on location of the spill, oil slick characteristics, water depth, currents, and weather. Some oils can emulsify; suspended particles in the water column will adsorb oil in a slick, decreasing the oil's ability to remain in suspension and causing some of the oil to be dispersed downward into the water column. Typically, submerged vegetation reduces water velocity among the vegetation as well as for a short distance above it. Minute oil droplets, whether or not they are bound to suspended particulates, may adhere to the vegetation or other marine life, ingested by animals, or settle onto bottom sediments. In all of these situations, oil has a limited life exposed at the surface since it will be degraded chemically and biologically.

If a spill makes landfall and must be actively cleaned up, impacts could occur. Should weather conditions or currents increase water turbulence sufficiently, some oil from the surface slick will be dispersed downward into the water column. Suspended particles in the water column will adsorb to the dispersed oil droplets as well as to some of the oil in the sheen. Typically, submerged vegetation reduces water velocity among the vegetation and enhances deposition of sediment. Typically, this will not cause long-term or permanent damage to the submerged vegetation. Some die-back of leaves would be expected for one growing season. No permanent loss of seagrass habitat is projected to result from the spill unless an unusually low tidal event allows direct contact between the slick and vegetation. The most probable danger under these more likely circumstances is a reduction, for up to 2 years, of the diversity or population of epifauna and benthic fauna found in grass beds. No significant burial of oil is expected to occur from any spill.

Microbes, which are found in all marine environments, are considered the greatest degraders of oil (Zieman et al., 1984). Because estuaries have a greater suspended particulate load and greater microbial population, oil degrades more rapidly there (Lee, 1977). Oil that penetrates deeply into the sediments is less available for dissolution, oxidation, or microbial degradation. If buried, oil may be detectable in the sediments for 5 years or more, depending upon the circumstances.

Cleanup of slicks in shallow or protected waters (<5 ft deep) may be performed using john boats or booms, anchors, and skimmers mounted on boats or shore vehicles. Personnel assisting in oil-spill cleanup in water shallower than 3-4 ft may often wade through the water to complete their tasks. Cleanup of slicks that settle over submerged vegetation in shallow waters may damage the seagrass beds where propellers, anchors, boat bottoms, treads, wheels, trampling, and dragging booms crush or uproot plants.

In coastal Louisiana, the critical concentration of oil and diesel fuel that results in long-term impacts to wetlands is assumed to be 0.1 liter per square meter (l/m^2). This concentration will cause mortality of most contacted vegetation; 35 percent of the affected area will recover within 4 years. Concentrations less than this will cause die-back of the above-ground vegetation for one growing season, but limited mortality.

Wetlands in Mississippi, Alabama, and western Florida occur on a more stable substrate and receive more inorganic sediment per unit of wetland area than wetlands in Louisiana. These wetlands have not experienced the extensive alterations caused by canal dredging and rapid submergence rates that affect wetlands in Louisiana. Hence, these wetlands are not as stressed. In addition, the wetlands of Alabama and Florida are protected from Gulf waters by barrier islands and beaches. The works of Webb and his colleagues (Webb et al., 1981 and 1985; Alexander and Webb, 1983 and 1985) have been used in this analysis to evaluate and project wetland impacts of spills along the Mississippi, Alabama, and Florida coasts. The critical oil concentration here is assumed to be 1.0 l/m^2 (Alexander and Webb, 1983). Concentrations below this will result in short-term, above-ground, die-back for one growing season. Concentrations above this will result in longer-term impacts to wetland vegetation, including plant mortality extensive enough to require recolonization.

If a spill contacts wetlands that are exposed to wave and tidal actions, erosion will be accelerated, as documented by Alexander and Webb (1987). Based upon the above research, permanent loss of 10 percent of the affected wetland area is assumed to result from accelerated erosion in Louisiana after 10 years; 6 percent is assumed for the remaining area outside of Louisiana not experiencing subsidence that is as rapid.

Using the studies referenced above, the following model was developed for expected impacts of oil spills on wetlands. For every 50 bbl of oil spilled and contacting wetland vegetation under typical, non-storm conditions, approximately 2.7 ha (6.6 ac) of wetland vegetation will experience die-back. Thirty percent of these damaged wetlands are assumed to recover within 4 years; 85 percent within 10 years. Permanent conversion of about 10 percent of the contacted wetlands to open-water habitat is projected. Under storm conditions, the slick would be more broadly dispersed such that much of the oil may be spread so thinly that less vegetative die-back would occur per volume of oil coming ashore. For the purpose of the analysis during a storm, the area of wetland that would be significantly impacted would be reduced by 40 percent. About 5 percent of the area impacted would be converted to open water.

Analysis of Impacts

Spills that occur from exploration activity in the EPA sale area are expected to be quantitatively few and volumetrically small. No blowouts are projected as a result of exploratory drilling in the EPA sale area based on trends in the historical GOM data and the number of exploration and delineation wells expected to be drilled in this area over the 40-year program scenario (38-73 exploration or delineation wells).

Though considered highly unlikely, a blowout is possible, and is therefore considered. If an offshore spill ≥1,000 bbl from an exploration well blowout occurred in the EPA sale area, the coastal areas having the highest probabilities of contact are the Chandeleur Islands (13%); Baldwin County, Alabama (land segment 24, 27%); and Escambia and Santa Rosa Counties, Florida (land segment 25, 12%), if the landfall is within 10 days of the spill.

Wetlands

If spilled oil were to enter bays or estuaries, it would likely further disperse as the waters of these bays and other estuaries are warmer and contain much more suspended particulate matter than offshore Gulf waters. Suspended particles provide sites for oil to adhere, which accelerates dispersion of the slick. Elevated tides or strong southerly winds would be needed to deliver any remaining oil into vegetated wetlands located behind the narrow inland beaches or further inland where there are no inland beaches, as seen in Louisiana. Strong southerly winds and tidal currents would also further disperse the oil. For these reasons, no offshore spills related to exploration activities are projected to significantly impact inshore wetlands. Should contact occur, oiling would be very light and spotty with short-term impacts to vegetation.

The impact of the exploratory drilling scenario can be analyzed by considering the likelihood of a spill ≥1,000 bbl occurring and contacting land within 10 days. The OSRA results from the analysis completed in the EA for the revised proposal for Lease Sale 181 (USDOI, MMS, 2001b; page 10) stated that if a spill in the EPA sale area is large enough to persist (≥1,000 bbl), survives weathering, and is not cleaned up, there is <5 percent chance that some oil from the slick would contact Louisiana shores and <1 percent chance for contact with Alabama, Mississippi, and Florida shores (USDOI, MMS, 2001a; Section IV.D.1.e).

Seagrasses

Should an oil slick pass over submerged vegetation, damage would occur if an unusually low tide were to occur, causing contact between the two. A more damaging scenario would be that a slick might pass over and remain over a submerged bed of vegetation in a protected embayment during typical fair-weather conditions. This would reduce light levels in the bed. If light reduction continues for several days, chlorophyll content in the leaves will reduce (Wolfe et al., 1988), causing the grasses to yellow and reducing their productivity. Shading by an oil slick of the sizes described should not last long enough to cause mortality, depending upon the slick thickness, currents, weather, and the nature of the embayment. In addition, a slick that resides over submerged vegetation in an embayment also will reduce or eliminate oxygen exchange between the air and the water of the embayment. Oxygen depletion is a serious problem for seagrasses (Wolfe et al., 1988). If currents flush little oxygenated water between the embayment and the larger waterbody and the biochemical oxygen demand (BOD) is high, as it would be in a shallow water bed of vegetation, and then enhanced by an additional burden of oil, the grasses and related epifauna will be stressed and perhaps suffocated. In this situation, the degree of suffocation will depend upon the reduced oxygen concentration and duration of those conditions. Oxygen concentrations and their duration depend upon currents, tides, weather, temperature, percentage of slick coverage, and BOD.

The impact of the exploration drilling can be analyzed by considering the likelihood of a spill ≥1,000 bbl occurring and contacting land within 10 days. The OSRA results from the analysis completed for the EA for the revised proposal for Lease Sale 181 (USDOI, MMS, 2001b; page10) stated that if a spill in the EPA sale area is large enough to persist (≥1,000 bbl) survives weathering, and is not cleaned up, there is <8 percent chance that some oil from the slick would contact eastern Louisiana State waters and 2 percent chance for contact with Alabama, Mississippi, and Florida State waters.

Cumulative impacts are discussed in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a; Section IV.D.1.e).

Summary and Conclusions

Projections of subsidence along the Louisiana deltaic plain suggest that during the next century, the coastline environments will experience a relative sea level rise of from 15 to 40 in (38 to 101 cm) (UCSUSA, 2002b). The impacts on coastal environments from oil and gas exploration in the EPA sale area would take place in a regime of significant subsidence and sea level rise, making the former difficult to separate from these more dominant influences of the latter.

Wetlands and the more inland beds of submerged vegetation are generally protected from offshore spills by barrier islands, shoals, shorelines, and currents. These physical resources are generally more susceptible to contact by inshore spills, which also have a low probability of occurrence. Inshore vessel collisions, possibly related to support for exploration activity. The likelihood for an oil spill accident in the EPA sale area is extremely low, coupled with the low likelihood for a large quantity (≥1,000 bbl) of spilled oil to contact these resources, and the chance of contacting and impacting these nearshore physical resources is highly remote.

4.3.2.3 Impacts on Beach Mice and the Salt Marsh Vole

Sources of oil available to impact the several subspecies of beach mice or salt marsh vole include oil spilled from a well blowout or oil spilled in collisions of vessels or barges containing small quantities of oil from exploration well tests.

The major impact-producing factors associated with exploratory drilling in the EPA sale area that may affect the mice and the salt marsh vole include (1) beach trash and debris, (2) efforts undertaken for the removal of marine debris or for beach restoration operations, (3) offshore and coastal crude oil spills, and (4) spill-response activities. Trash and debris may be mistakenly consumed by beach mice or ensnare them. Efforts undertaken for the removal of marine debris or for beach restoration, such as sand replenishment, may temporarily displace beach mice or voles, destroy their food resources such as sea oats, collapse openings to their burrows, or bury the burrows themselves. Direct contact with spilled oil can cause skin and eye irritation or blindness. Other direct toxic effects include asphyxiation from inhalation of fumes, oil ingestion, and food contamination. Indirect oil impacts include food reduction or degradation in quality. Vehicular traffic and other activities associated with oil-spill cleanup can degrade preferred habitat and cause displacement of mice from these areas. Spill-response activities may also attract predators.

Major impact-producing factors and potential effects on the salt marsh vole are similar to those discussed above for beach mice.

Analysis of Impacts

The activity of exploratory drilling in the EPA sale area is expected to contribute negligible marine debris or disruption to beach mice or vole individuals or habitat areas. The low probabilities, projected sizes, and causes of crude oil spills that could occur during exploratory drilling in the EPA sale area present insignificant impacts to the beach mice or vole populations. In the unlikely event of crude oil contact, spill-cleanup activities are not expected to disturb beach mice, salt marsh vole, or their habitats. The home range of the beach mice is designated habitat that receives particular consideration during spill cleanup, as directed by OPA 90. Because of the critical designation and general status of protected species habitats, spill contingency plans include requirements to minimize adverse effects from vehicular traffic during cleanup activities and to maximize protection efforts within beach mouse or vole habitat.

Summary and Conclusion

An impact from the exploration activities on the Alabama, Choctawhatchee, St. Andrew, and Perdido Key beach mice is possible but highly unlikely as a result of beach trash and debris, efforts to cleanup beach trash and debris, beach restoration, direct or indirect oil-spill effects, or spill-response activities. The vast majority of trash on shorelines or beaches originates from visitors to these localities, and the percent contributed by OCS activities in general is under 15 percent based on trash origin analyses carried out during Gulf beach sweeps. The Florida salt marsh vole's critical habitat is so far from the exploration activity in the EPA sale area that there is no plausible scenario that can be constructed by which this exploration activity could have an impact. No impacts are expected to individual Alabama, Choctawhatchee, St. Andrew, and Perdido Key beach mice or the Florida salt marsh vole, or any of their critical habitats.

The impacts of exploratory drilling in the EPA sale area on beach mice and the salt marsh vole are not expected to be significant.

4.3.2.4. Impacts on Chemosynthetic Communities

The nearest documented chemosynthetic community is approximately 25 mi (40 km) to the north-northwest of the northwest corner of the EPA sale area in Viosca Knoll Block 826 (USDOI, MMS, 2001a; Figure III-6). Although no chemosynthetic communities have been reported in the EPA sale area, it is possible that they could be discovered there.

The greatest potential for adverse impacts on deepwater chemosynthetic communities from the exploration activities involves mechanical bottom-disturbing activities associated with anchoring and structure emplacement, as well as from a seafloor blowout. These activities cause localized but severe bottom disturbances and disruption of benthic communities in the immediate area. An estimated sea-bottom footprint for each anchor of a conventionally-moored semisubmersible is 2.1 ha (5.2 ac). Semisubmersible MODU's commonly have 6-8 anchors. If it is assumed that all exploration drill rigs deployed for the exploratory drilling have eight anchors and that each deployment drills five wells, the range of area for potential sea bottom disturbed from the exploratory drilling would be between 315 and 607 ac, or between 5 and 10 percent of the area of one OCS block.

Anchors from semisubmersible drill rigs and support ships (or, as assumed for deepwater exploration depths, from buoys set up to moor these vessels) cause severe disturbances to small areas of the seafloor. The areal extent and severity of the impact are related to the size of the mooring anchor and its configuration, the length of chain resting on the bottom, and the swing arc that a chain length might allow on the sea bottom. Excessive length that allows swing movement of the mooring chain could disturb a much larger bottom area than an anchor alone, depending on the prevailing wind and current directions. A 50-m radius of chain movement on the sea bottom around a mooring anchor could destroy chemosynthetic communities in an area of nearly 8,000 m^2 (2 ac). Larger anchors and longer anchor chains or mooring lines are expected for operations in deep water as compared to operations on the shelf. Many oil and gas support operations involving ships and boats would not result in anchor impacts on deepwater chemosynthetic communities because the vessels would tie-up directly to surface structures or mooring buoys. In addition, there are drillships operating in the GOM that rely on dynamic positioning rather than conventional anchors to maintain their position during operations; therefore, anchoring would not be a consideration in these situations. The area affected by anchoring operations would depend on the water depth, length of the chain, size of the anchor, and currents. Anchoring will destroy those sessile organisms actually hit by the anchor or anchor chain during anchoring, or it could cause destruction of underlying carbonate structures on which organisms rely for dispersion of hydrocarbon food sources. While such an area of disturbance may be small in absolute terms, it may be large in relation to the area inhabited by dense chemosynthetic communities.

A blowout at the seafloor could create a crater, and resuspend and disburse large quantities of bottom sediments within a 300-m radius from the blowout site, burying epifaunal organisms and interfering with nearby sessile filter feeders. Anchoring and other bottom-disturbing activities could resuspend bottom sediments, but not at magnitudes as great as blowout events.

The impacts from bottom-disturbing activities on chemosynthetic communities are expected to be relatively rare. Should they occur, these impacts could be quite severe to the immediate area affected, with recovery times as long as 200 years for mature tube-worm communities, with the possibility of the community never recovering. Mitigations that are required if known chemosynthetic communities are discovered, such as setback distances, are expected to protect these resources if they are identified during the proposed activities.

Discharges

Water depths in the EPA sale area range from 1,550 to 3,000 m (5,085-9,850 ft), a depth range often referred to as ultra-deepwater. Because of these great depths, discharges of drilling fluids and cuttings at the surface are spread across broad areas of the seafloor and are, in general, distributed in thinner accumulations than in shallower areas on the continental shelf. Recent information about the effects of surface discharge of drilling fluids (muds) and cuttings at a well in 565-m water depth have been reported by Gallaway and Beaubien (1997). In this situation, a veneer of cuttings was observed scattered over the bottom, in some cases as thick as 20-25 cm. Chemical evidence of synthetic-based drilling fluid components (used during this operation) was found at distances of at least 100 m from the well site (sampling limited by the ROV tether length). Other information from a geophysical survey documented the extent of drilling discharges at several previously drilled oil and gas sites in about 400-m water depths (Nunez, personal communication, 1994). At these sites, the areal coverage of cuttings was found extending from the previous well locations in splay or finger-like projections to a maximum of about 610 m, with an average of about 450 m. An examination of side-scan-sonar records of these splays indicates that they were distributed in accumulations less than 30-cm thick. Effluents from routine OCS operations (sanitary, domestic, deck wash) in deep water would be subject to rapid dilution and dispersion and are not projected to impact the seafloor when operating at depths greater than 100 m.

Impacts from muds and cuttings are also expected from two additional sources: initial well drilling and installation of casing prior to the use of a riser to circulate returns to the surface and the potential use of various dual gradient or subsea mudlift drilling techniques in deepwater settings. Pre-riser casing installation typically involves a 91-cm (36-in) casing that may be set to a depth of 91 m (300 ft) and 66-cm (26-in) casing that may be set to a depth of 488 m (1,600 ft). Jetted or drilled cuttings from the initial wellbore could total as much as 226 m^3 (Halliburton Company, 1995). With DGD techniques, the upper portion of the wellbore will be "drilled" similar to conventional well initiation techniques with cuttings being discharged at the seafloor. After the blowout preventer stack is installed, subsea mudlift pumps will circulate the drilling fluid and cuttings to the surface for conventional well solids control. Discharges from the dual gradient drilling operations are expected to be similar to conventional drilling operations. Although the full areal extent and depth of burial from these initial activities are not known, the potential impacts are expected to be localized and short term. Since these areas would occupy a tiny portion of the available seafloor in the deepwater GOM, these impacts are not considered significant by area or temporally, provided that sensitive communities (e.g., chemosynthetic communities) are avoided.

MacDonald et al. (1995) indicates that the vulnerability of chemosynthetic communities to oil and gas drilling may depend on the type of community present. Tube-worm and mussel communities may be more vulnerable than clam communities because clam communities are semi-mobile and sparsely distributed. The primary impact related to mud and cutting discharges is that of burial. Although chemosynthetic organisms thrive with some part of their anatomy located next to or inside of chemically toxic and/or anoxic environments, all chemosynthetic biota (including the symbiotic bacteria) also require some level of oxygen to live. Burial by sediments or rock fragments originating from drilling fluids and cuttings discharges would smother and kill most chemosynthetic organisms (motile clams being one possible exception). Depending on the organism type, just a few centimeters of burial could cause mortality.

The tolerance of various community components to burial is not completely understood and would depend on the depth of burial. Detrimental effects due to burial are expected to decrease in the same manner that the depth of discharge accumulation decreases with distance from the origin. The severity of these impacts is such that there may be incremental losses of productivity, reproduction, community relationships, and overall ecological functions of the community, and incremental damage to ecological relationships with the surrounding benthos.

High-density, Bush Hill-type communities are areas that are considered to be most at risk from oil and gas operations. The disturbance of a Bush Hill-type environment could lead to the destruction of a community from which recovery would occur only over long time intervals (200+ years for a mature tube-worm colony and 25-50 years for a mature mussel community) or would not occur at all. A long span of time is required for the precipitation of enough carbonate rock to support a large population of tube worms. As dense tube-worm communities require hard substrate as well as very active seepage at any point in space, existing communities covered by sediment or that are physically damaged would likely never recover (Fisher, 1995).

Information is limited about the vulnerability of tube worms to smothering by sedimentation. Individual tube worms are often found buried for more than half the length of their tubes by hemipelagic sediment (MacDonald, 1992). Presumably, this burial occurs over long time intervals. Evidence of catastrophic burial of high-diversity chemosynthetic communities can be found in the paleorecord as documented by Powell (1995), but the importance of this phenomenon in extinguishing these populations was reported as minor. These burials were probably caused by mass movements initiated by seismic events, or salt movement.

Methanotrophic mussel communities have strict chemical requirements that tie them directly to areas of the most active seepage. Physical disturbance of an active mussel bed is thought not to have a long-lasting effect on the community due to high growth rates of individuals (Fisher, 1995). Catastrophic mud burial would be one possible cause of a mussel community death. It is predicted that a mussel community completely eliminated by physical disturbance could be resettled and mature within 20 years.

Oil and chemical spills are not considered to be a potential source of measurable impacts on chemosynthetic communities because of the water depths at which these communities are located. Oil spills from the surface would tend not to sink. Accidental oil discharges at depth or on the bottom would tend to rise in the water column and similarly not impact the benthos. Evidence from direct observation and remote imagery from space indicates oil slicks on the sea surface, originating from natural seeps, occur relatively close to known seep locations on the bottom. Shipboard observations during submersible operations located the surface expression of rising oil at a horizontal distance of only 100 m from the origin of the seep on the bottom (MacDonald et al., 1995).

There is some reason to believe the presence of oil may not have an impact in the first place since these communities live among oil and gas seeps; however, natural seepage is very constant and at very low rates as compared to a blowout or pipeline rupture. All seep organisms also require unrestricted access to oxygenated water at the same time as exposure to hydrocarbon energy sources.

Reservoir Depletion

There has been speculation about the potential impact to chemosynthetic communities resulting from oil and gas withdrawal and depletion of the reservoir energy source (hydrocarbons) sustaining the chemosynthetic organisms. There is evidence that both removal and reinjection of material into reservoirs that supply seeps on land in California affect the seepage rates. Quigley et al. (1996) reported evidence that suggested offshore California oil production resulted in reduced seepage due to reduction in reservoir pressure. The seeps and faults around which chemosynthetic animals live are supplied from the deep reservoirs that transport the gas or oil to the seafloor through combined effects of buoyancy and pressure. The amount of resource that can be economically extracted by current technology is estimated to be 30 percent or less of the total hydrocarbons in place. When all of the recoverable hydrocarbons from these reservoirs are withdrawn by production operations, it is possible that oil and gas venting or seepage would also slow or (less likely) stop. It is not possible to determine whether reduced reservoir pressure would actually reduce the seepage (as observed onshore) or whether there may be enough oil already in the conduit to the surface to continue adequate levels of seepage for long periods, perhaps thousands of years or more. Conversely, there have been reports that oil reservoirs can be recharged from their deep sources on the scale of decades (Cooke, 2002), which places the issue of oil production, short-term reservoir recharge, and chemosynthetic community dependency on produced reservoirs into and arena of uncertainty. The distribution of chemosynthetic communities is known to occur in association with precise levels and types of chemical gradients at the seafloor; alterations to these gradients may potentially impact the type and distribution of the associated community.

Analysis of Impacts

Because high-density chemosynthetic communities are found only in water depths greater than 400 m, they could be found in the EPA sale area. None are now recognized, however.

NTL 2000-G20 (previously NTL 98-11 and originally NTL 88-11) was approved in December 2000. It redefined new avoidance distances, and along with its predecessor NTL's, has provided a measure for the protection of chemosynthetic communities since February 1, 1989. NTL 2000-G20 (*Deepwater Chemosynthetic Communities*) makes mandatory the search for and avoidance of dense chemosynthetic communities (such as Bush Hill-type communities) or areas that have a high potential for supporting these community types, as interpreted from geophysical records. The NTL is exercised on all applicable leases and is not an optional protective measure. Under the provisions of this NTL, lessees intending to explore in water depths greater than 400 m are required to conduct geophysical surveys of the area of proposed activities and to evaluate the data for indications of conditions that may support chemosynthetic communities. If such conditions are indicated, the lessee must either move the operation to avoid the potential communities or provide photodocumentation of the presence or absence of dense chemosynthetic communities of the Bush Hill type. If such communities are indeed present, no drilling operations or other bottom-disturbing activities may take place in the area; if the communities are not present, drilling, anchoring, etc. may proceed. To date, in almost all cases, operators have chosen to avoid any areas that show the potential to support chemosynthetic communities. The basic assumptions underlying the provisions of this mitigation measure are (1) that dense chemosynthetic communities are associated with gas-charged sediments or seeps; (2) that the gas-charged sediment zones or seeps have physical characteristics that will allow them to be identified by geophysical surveys, e.g., higher bottom amplitudes; and (3) that dense chemosynthetic communities are not found in areas where gas-charged sediments or seeps are not indicted on the geophysical survey data. These assumptions have not been totally verified, but they have served as a working construct for several years. A definitive correlation between the geophysical characteristics recorded by geophysical surveys and the presence of chemosynthetic communities has not been proven.

Although there are few examples of field verification, the requirements set forth in NTL 2000-G20 are considered effective in identifying potential areas of chemosynthetic communities. Although there has generally been compliance with NTL 2000-G20, compliance does not guarantee avoidance of high-density communities without visual confirmation in every case. On rare occasions, high-density chemosynthetic community areas may not be properly identified using the geophysical techniques and indicators specified in the existing NTL. Oil- or gas-saturated sediments and other related characteristic signatures cannot be determined without high-resolution acoustic records or the interpretation of subsurface 3-D seismic data. The potential for any impact could be lessened by the refinement of techniques used in the interpretations of geophysical records. The use of differential global positioning system (GPS) has also been required on anchor-handling vessels when placing anchors near an area that has potential for supporting chemosynthetic communities. As new information becomes available, the NTL will be further modified as necessary.

High-density, Bush Hill-type communities are, as noted above, largely protected from direct physical impacts by the provisions of NTL 2000-G20. A limited number of these communities have been found to date but none have been found in the EPA; however, it is likely that additional communities exist in the OCS GOM. Observations of the surface expression of seeps from space images indicate numerous other communities have conditions amenable for their occurrence (MacDonald et al., 1993 and 1996). Most chemosynthetic communities are of low density and are relatively widespread throughout the deepwater areas of the Gulf. Physical disturbance or destruction of a small, low-density area would not result in a major impact to chemosynthetic communities as an ecosystem. Low-density communities may occasionally sustain major or minor impacts from discharges of drill muds and cuttings, bottom-disturbing activities, or resuspended sediments. Areas so impacted could be repopulated from nearby undisturbed areas (although this process may be quite slow, especially for vestimentiferans). It is not expected that detectable levels of muds and cuttings discharged from separate exploratory drilling operations in adjacent lease blocks would impact deepwater benthic communities due their physical separation and great water depth in the EPA sale area.

The frequency of such impacts is expected to be low due to routine avoidance of all known chemosynthetic communities (not just high-diversity types) through NTL 2000-G20. The severity of such impacts is judged to result in minor disturbance to ecological function of the community. No alteration of ecological relationships with the surrounding benthos is significant. Recolonization after a disturbance would not exactly reproduce the community existing before the impact, but it could be expected that some similar pattern and species composition would eventually be reestablished if similar conditions of sulfide or methane seepage persists after the disturbance.

Summary and Conclusion

Exploratory drilling in the EPA sale area is not expected to cause impacts or damage to the ecological function or biological productivity of the widespread, low-density chemosynthetic communities, should they be present in the EPA sale area. The rarer, widely scattered, high-density, Bush Hill-type chemosynthetic communities could experience minor impacts from drilling discharges or resuspended sediments located more than 1,500 ft away, as required by NTL 200-G20, should they be present. Chemosynthetic communities are susceptible to physical impacts from drill rig emplacement and anchoring. The provisions of NTL 2000-G20 greatly reduce the risk of these physical impacts by requiring avoidance of potential chemosynthetic communities identified on required geophysical survey records or by requiring photodocumentation to establish the absence of chemosynthetic communities prior to approval of the structure emplacement. Also, much of the exploratory drilling in the EPA sale area is expected to be completed with dynamically positioned MODU's that do not require anchoring.

If the presence of a high-density community were missed under current stipulations and using existing procedures, potentially severe impacts could occur by direct physical impacts of crushing, disrupting, or smothering by resuspended sediment, and due to partial or complete burial by muds and cuttings associated with pre-riser discharges or some types of riserless drilling. Variations in the dispersal and toxicity of synthetic-based drilling fluids may contribute to the potential areal extent of these impacts. The severity of such an impact is such that there would be incremental losses of productivity, reproduction, community relationships, and overall ecological functions of the community, and incremental damage to ecological relationships with the surrounding benthos.

Studies indicate that time periods as long as hundreds of years are required to reestablish a seep community once it has disappeared (depending on the community type), although it may reappear relatively quickly once the process begins, as in the case of a mussel community. Tube-worm communities may be the most sensitive of all communities because of the combined requirements of hard substrate and active hydrocarbon seepage. Mature tube-worm bushes have been found to be several hundred years old. There is evidence that substantial impacts on these communities would permanently prevent reestablishment.

The impacts of exploratory drilling in the EPA sale area on chemosynthetic communities are not expected to be significant.

4.3.2.5. Impacts on Other Benthic Communities

Nonchemosynthetic, soft-bottom benthic communities from deep and ultra-deepwater environments are known primarily from box cores or photographs. Typical reports (Gallaway et al., 1988) include associations of bacteria, meiofauna, and larger megafauna such as sea cucumbers, brittle stars, and various infaunal organisms such as polycheate worms. Factors considered to impact the deepwater benthic communities of the GOM include both OCS-related and non-OCS activities. The latter type of impacts includes activities such as fishing and trawling. Bottom fishing and trawling efforts in the deepwater EPA sale area are currently minimal, and impacts are not significant. Of particular concern are deepwater coral communities that can occur on exposed carbonate outcrops in the deep Gulf. There are no known areas of hard substrate near the sale area. Essentially no anchoring from non-OCS-related activities occurs at the water depths characterizing the EPA sale area (1,550-3,000 m (5,085-9,850 ft)), where deepwater communities are found.

The OCS activity of exploratory drilling includes drill rig or platform anchoring and emplacement, anchoring of service vessels, drilling mud and cutting discharges, discharge of operational effluents, and accidental seafloor blowouts.

Exploratory drilling in the EPA sale area would be accompanied by impacts to the deepwater benthos from bottom disturbances and disruption of the seafloor. The extent of this disturbance would be determined by the intensity of exploration in these deepwater regions, as well as the types of drilling structures and mooring systems used. Over the 40-year OCS scenario (2003-2042), a total of 38-73 exploration or delineation wells are projected to be drilled in the EPA sale area. No blowouts are expected with this projected number of exploration wells based on the frequency rates established with historical data.

The physical effects of drilling structures deployed for exploratory drilling disturbs a bottom area of approximately 2.1 ha (5.2 ac) per anchor for a conventionally-moored semisubmersible (see discussion in Chapter 4.3.2.4, Impacts on Chemosynthetic Communities). Much of the exploratory drilling in the EPA sale area is expected to be completed with dynamically-positioned MODU's that do not require anchoring. Many oil and gas support operations involving workboats and crewboats would not result in anchor impacts on deepwater benthos because the vessels would tie-up directly to rigs or mooring buoys.

Sudden deposition of sediment blankets of 12-16 in are probably lethal for most mobile benthic invertebrates or sessile animals living in burrows. Escape traces of mobile and sessile benthic invertebrates buried by sediment are known from the fossil record (Dodd and Stanton, 1983). These burial events can be interpreted to have been due to storms or turbidites; both representing circumstances when a blanket of sediment can be deposited suddenly on a living benthic community. All benthic animals have some adaptive strategy to avoid sudden burial; however, research suggests that macroinvertebrates generally cannot escape from rapid burial by more than approximately 30 cm of sediment (Frey, 1975, page 135; Basan et al., 1978, page 20; Ekdale et al., 1984, page 92).

Routine discharges of drilling muds and cuttings have been documented to reach the seafloor in water depths greater than 400 m, but discharges in deep water are distributed across wider areas and in thinner accumulations than found in shallower water depths on the continental shelf. In a deepwater setting it is unlikely that 30 cm of cuttings would be deposited rapidly enough, or in accumulations thick enough, to kill off the local benthos or even to have deleterious effects. Considering the water depths in the EPA sale area, a widespread and thin (a few centimeters) distribution of mud and cuttings on the seafloor would be expected from drillrigs discharging overboard. Potential impacts could result from bottom accumulations of muds and cuttings from consistent hydrographic conditions, causing material concentrations in a single direction or "splay." It is not expected that detectable levels of muds and cuttings discharges from separate exploratory drilling projects from adjacent lease blocks would act as a cumulative impact to deepwater benthic communities due to their physical separation and great water depth in the EPA sale area.

Due to the great water depths, sanitary and domestic wastes and deck-wash effluent are not expected to have adverse impacts to any soft-bottom, deepwater benthic communities. These effluents discharged at the surface would undergo dilution and dispersion and are not likely to ever directly or indirectly impact organisms living on the seafloor.

Should a well blowout occur at the seafloor, it could resuspend large quantities of bottom sediments and even form a large crater. Increased turbidity could foul the filter-feeding mechanisms of fauna living on the sediment surface (epifauna). Epifauna could be buried and smothered by redeposition of sediment put into suspension by a blowout.

Oil and chemical spills are not considered to be a potential source of measurable impacts on soft-bottom benthic communities because of the water depth. Oil spills from the surface would not tend to sink to impact soft-bottom benthos. Oil discharges on the bottom would tend to rise in the water column and not impact the benthos, except when accompanied by secondary effects such as resuspension of bottom sediment.

Analysis of Impacts

The most serious impact-producing factor of exploratory drilling that threatens soft-bottom benthic communities is physical disturbance of the seafloor, which would tend to bury or kill epifaunal and infaunal organisms. Such disturbance would come from exploration activities associated with anchoring and drill rig emplacement, discharge of drilling muds and cuttings, operational effluents, and seafloor well blowouts. Drilling discharges and resuspended sediments have a potential to cause minor, mostly sublethal impacts to soft-bottom benthic communities, but burial by substantial accumulations greater than 30 cm is likely to result in mortality for all sessile benthos and for most mobile benthic organisms. Sea bottom accumulations of drill cuttings are not expected to approach thickness likely to be lethal to the majority of bottom-dwelling organisms. Because of the water depths in the EPA sale area and the low density of potentially commercially valuable fishery species, deep line or trawl activities are not expected to impact deepwater benthic comminutes.

Summary and Conclusion

Exploration activities are expected to have little impact on the ecological function or biological productivity of the widespread, low-density communities of soft-bottom benthos. Physical disruption or crushing by anchoring of exploration rigs and burial by drilling discharges are the most likely forms of disturbance; however, such areas are very small in absolute terms. When placed in context of the vast expanse of potentially suitable and habitable area in the deepwater GOM, the impacts are extremely small. Recruitment of new organisms would take place from nearby areas, or emigration of individuals could occur into disrupted areas after the disturbance ceases.

4.3.2.6. Impacts on Marine Mammals

The major impact-producing factors affecting marine mammals from exploratory drilling in the EPA sale area include the following: (1) degradation of water quality from operational discharges; (2) noise from helicopters and vessel traffic; operating platforms, and drillships; (3) collision potential with service vessels; (4) oil spills; (5) spill-response activities; and (6) discarded trash and debris from service vessels and OCS structures.

Discharges

Drilling muds and cuttings are routinely discharged into offshore marine waters and are regulated by the USEPA's NPDES permits. Most operational discharges are diluted and dispersed when released in offshore areas and are considered to have sublethal effects (API, 1989; NRC, 1983; Kennicutt, 1995). Any potential impacts from drilling fluids would be indirect, either as a result of impacts to prey or possibly through ingestion via the food chain (API, 1989). Contaminants in drilling muds or waste discharge may biomagnify and bioaccumulate in the food web, which may kill or debilitate important prey species of marine mammals or species lower in the marine food web (for further information on bioaccumulation, see the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a; Section IV.A.3.d.)). Marine mammals generally are inefficient assimilators of petroleum compounds in food (Neff, 1990). Analyses of samples from stranded GOM bottlenose dolphins showed high levels of organochlorides and heavy metals (e.g., Salata et al., 1995; Kuehl and Haebler, 1995). The significance of this cannot be determined, however, because of the lack of baseline information with which to make comparisons. Many heavy metals presumably are acquired from food, but the ultimate sources are poorly known or not understood (API, 1989). It is known that coastal cetacean species tend to have higher levels of metals than those frequenting deeper water (Johnston et al., 1996). Whales and dolphins feeding on cephalopods have higher levels of cadmium in their tissues than comparable fish-eating species (Johnston et al., 1996). Open-ocean marine mammals have higher cadmium concentrations than coastal species. There also is, in many cases, a striking difference between the high mercury levels in the toothed whales and the lower values found in baleen whales, which is probably attributable to the lower position of baleen whale prey in the food chain and differences in the habitat (Johnston et al., 1996).

Aircraft

Aircraft (helicopter) overflights in proximity to whales and dolphins can elicit a startle response. Whales often react to aircraft overflights by hasty dives, turns, or other changes in behavior. Responsiveness varies widely depending on factors such as the activity of the animals and water depth (Richardson et al., 1995). Whales engaged in feeding or social behavior are often insensitive to overflights. Whales in confined waters, or those with calves, sometimes seem more responsive. This behavioral response could be a result of noise and/or visual disturbance. The effects appear to be transient, and there is no indication that long-term displacement of whales would occur. Absence of conspicuous responses to an aircraft does not prove that the animals are unaffected. It is not known whether these subtle effects are biologically significant (Richardson and Würsig, 1997).

Guidelines and regulations promulgated by NOAA Fisheries under the authority of the Marine Mammal Protection Act includes provisions specifying helicopter pilots to maintain an altitude of 1,000 ft within 91 m (300 ft) of marine mammals. It is unlikely that whales and dolphins would be affected by routine OCS helicopter traffic at these altitudes. It is expected that 10 percent of helicopter trips would occur at altitudes below the specified minimums listed above as a result of inclement weather. Routine overflights may elicit a startle response from and interrupt nearby cetaceans (depending on the activity of the animals) (Richardson et al., 1995). Occasional overflights probably have no long-term consequences on whales and dolphins; however, frequent overflights could have long-term consequences if they occur repeatedly and disrupt vital functions, such as feeding and breeding. Helicopters supporting OCS activity are not the only aircraft that fly over the coastal and offshore areas. Military, private, and commercial air traffic also traverse these areas and have the potential to cause impacts to marine mammals.

Vessel Traffic

Toothed whales (and baleen whales, to a lesser extent) show some tolerance of vessels, but may react at distances of several kilometers or more when confined by habitat features or when they learn to associate the vessel with harassment. Evidence suggests that certain whales have reduced their use of certain areas heavily utilized by ships (Richardson et al., 1995), possibly avoiding or abandoning important feeding areas, breeding areas, resting areas, or migratory routes. The continued presence of various dolphin and whale species in areas with heavy boat traffic indicates a considerable degree of tolerance to ship noise and disturbance. An experiment involving playback of low-frequency sound in the Canary Islands suggests that sperm whales, from an area that has heavy vessel traffic, have a high tolerance for noise (Andre et al., 1997). Increased ship traffic from support vessels supporting exploratory drilling in the EPA sale area could increase the probability of collisions between ships and marine mammals. These collisions can cause major wounds or be fatal to whales and dolphins (e.g., northern right whale, Kraus, 1990, and Knowlton et al., 1997; bottlenose dolphin, Fertl, 1994; sperm whale, Waring et al., 1997). Limited observations on a NOAA Fisheries cruise off the mouth of the Mississippi River in the summer of 2000 indicated that sperm whales appeared to actively avoid passing service vessels. Slow-moving whales (e.g., northern right whale) or those that spend extended periods of time at the surface in order to restore oxygen levels within their tissues after deep dives (e.g., sperm whale) might be expected to be the most vulnerable. Smaller dolphins often approach vessels that are in transit to bow-ride.

There is the possibility of short-term disruption of movement patterns and behavior of whales and dolphins, but such disruptions are unlikely to affect survival or productivity, unless they occur frequently. Long-term displacement of animals, in particular baleen whales, from an area is also a consideration. It is not known whether toothed whales exposed to recurring vessel disturbance are stressed or otherwise affected in a negative, but inconspicuous way (Richardson et al., 1995). Stress or "alert" responses could occur quite early during an encounter. For example, Myrick and Perkins (1995) found stress responses occurring as early as the chase stage in purse-seine netting on dolphins.

It is possible, though highly unlikely, that manatees could occur in the EPA sale area where they could be affected by support vessels for exploratory drilling rigs. If a manatee should be present in an area where there is vessel traffic, they could be injured or killed in a boat collision (Wright et al., 1995). Inadequate hearing sensitivity at low frequencies may be a contributing factor to the manatees' inability to effectively detect boat noise and avoid collisions with boats (Gerstein et al., 1999).

Noise

Drillships produce an acoustically wide range of sounds at frequencies and intensities that can be detected by whales and dolphins. Some of these sounds could mask cetaceans' reception of sounds produced for echolocation and communication. Toothed whales use sounds at frequencies that are generally higher than the dominant sounds generated by offshore drilling and production activities. Low-frequency hearing has not been studied in many species, but bottlenose dolphins can hear sounds at frequencies as low as 40-125 Hz. Below 1 kHz, where most industrial noise energy is concentrated, sensitivity seems poor (Richardson et al., 1995). Pilot whales and sperm whales changed their behavior (in particular, ceased vocalizations) during low-frequency transmissions from the Heard Island Feasibility Test in the southern Indian Ocean (Bowles et al., 1994), throwing doubt on the assumed insensitivity of toothed whale hearing at low frequencies. Baleen whales mainly utter low-frequency sounds that overlap broadly with the dominant frequencies of many industrial sounds. There are indirect indications that baleen whales are sensitive to low- and moderate-frequency sounds (Richardson et al., 1995). Drilling noise from conventional metal-legged structures and semisubmersibles is not intense and is strongest at low frequencies, averaging 5 Hz and 10-500 Hz, respectively (Richardson et al., 1995). There is particular concern for baleen whales that are apparently more dependent on low-frequency sounds than are other marine mammals. Drillships produce higher levels of underwater noise than other types of platforms. There are few published data on underwater noise levels near production platforms and on the marine mammals near those facilities (Richardson et al., 1995). However, underwater strong noise levels may often be low, steady, and not very disturbing (Richardson et al., 1995). Stronger reactions would be expected when sound levels are elevated by support vessels or other noisy activities (Richardson et al., 1995). Noise from service-vessel traffic may elicit a startle and/or avoidance reaction from whales and dolphins and mask their sound reception. It is expected that the extent of service-vessel traffic could affect cetaceans either through active avoidance behavior or displacement of individuals or groups. (Reaction will most likely vary with species, age, sex, and psychological status; the most vulnerable might be perinatal females and nursing calves, and those animals stressed by parasitism and disease.) The presence of multiple noise sources is expected to cause more frequent masking, behavioral disruption, and short-term displacement (Richardson et al., 1995).

Human-made sounds may affect the ability of marine mammals to communicate and to receive information about their environment (Richardson et al., 1995). Such noise may interfere with or mask the sounds used and produced by these animals and thereby interfere with their natural behavior. These sounds may frighten, annoy, or distract marine mammals and lead to physiological and behavioral disturbances. Response threshold may depend on whether habituation (gradual waning of behavioral responsiveness) or sensitization (increased behavioral responsiveness) occurs (Richardson et al., 1995). Sounds can cause reactions that might include disruption of marine mammals' normal activities (behavioral and/or social disruption), and, in some cases, short- or long-term displacement from areas important for feeding and reproduction (Richardson et al., 1995). The energetic consequences of one or more disturbance-induced periods of interrupted feeding or rapid swimming, or both, have not been evaluated quantitatively. Energetic consequences would depend on whether suitable food is readily available. Additionally, animals subject to a high-energy drain, especially females in late pregnancy or lactation, probably would be most severely affected. Sounds may also disturb the species (such as fishes, squids, and crustaceans) upon which the marine mammals prey (NRC, 1994). Human-made noise may cause temporary or permanent hearing impairment in marine mammals if the noise is strong enough. Such impairment would have the potential to diminish the individual's chance for survival. Tolerance of noise is often demonstrated, but this does not prove that the animals are unaffected by noise; for example, they may become stressed, making the animal(s) more vulnerable to parasites, disease, environmental contaminants, and/or predation. Noise-induced stress is possible, but little studied in marine mammals.

Trash and Debris

In recent years, there has been increasing concern about manmade debris (lost accidentally or discarded from offshore and coastal sources) and its impact on the marine environment (e.g., Shomura and Godfrey, 1990; Laist, 1997). Both entanglement in and ingestion of debris has caused the death or serious injury of marine mammals (Heneman and Center for Environmental Education, 1988; MMC, 1998). The debris items most often found entangling animals are net fragments and monofilament line from commercial and recreational fishing boats, as well as strapping bands and ropes probably from all types of vessels. Plastic bags and small plastic fragments are the most commonly reported debris items in the digestive tracts of cetaceans and manatees (e.g., Barros and Odell, 1990; Tarpley and Marwitz, 1993; Laist, 1997; MMC, 1998). Many types of plastic materials are used during drilling and production activities. The offshore oil and gas industry was shown to contribute 13 percent of the debris found at Padre Island National Seashore (Miller et al., 1995). The MMS prohibits the disposal of equipment, containers, and other materials into coastal and offshore waters by lessees (30 CFR 250.40). Prohibition of the discharge and disposal of vessel- and offshore structure-generated garbage and solid waste items into both offshore and coastal waters was established January 1, 1989, via the enactment of MARPOL, Annex V, Public Law 100-220 (101 Statute 1458), which the U.S. Coast Guard enforces. Educational videos and placards posted on vessels and structures instruct offshore personnel in procedures to eliminate accidental introduction of marine debris.

Oil Spills

Each major grouping of marine mammals confronts spilled hydrocarbons in different ways. Oil spills could affect marine mammals through various pathways: surface contact, inhalation, ingestion, and baleen fouling (Geraci, 1990). Much of the information on the effects of oil on marine mammals comes from studies of fur-bearing marine mammals. Sea otters exposed to the 1989 *Exxon Valdez* spill experienced high incidences of emphysema, petroleum hydrocarbon toxicosis, abortion, and stillbirths (Williams and Davis, 1995). Direct contact with oil and/or tar for whales and dolphins can lead to irritation and damage of skin and soft tissues (such as mucous membranes of the eyes), fouling of baleen plates so as to hinder the flow of water and interfere with feeding, and incidental ingestion of oil and/or tar. Studies by Geraci and St. Aubin (1982 and 1985) have shown that the cetacean epidermis functions as an effective barrier to noxious substances found in petroleum. Unlike other mammals, penetration of such substances in cetacean skin is impeded by tight intercellular bridges, the vitality of the superficial cells, the thickness of the epidermis, and the lack of sweat glands and hair follicles (Geraci and St. Aubin, 1985). The cetacean epidermis is nearly impenetrable, even to the highly volatile compounds in oil, and when skin is breached, exposure to these fractions does not impede the progress of healing (Geraci and St. Aubin, 1985). Cetacean skin is free from hair or fur, which in other marine mammals, such as pinnipeds and otters, tends to collect oil and/or tar, which effectively reduces the insulating properties of the fur (Geraci, 1990). Dolphins maintained at a captive site in Sevastopol, Ukraine, that were exposed to petroleum products initially exhibited a sharp depression of food intake along with an excitement in behavior, eye inflammation, and changes in hemoglobin as well as erythrocyte content (Lukina et al., 1996). Prolonged exposure to oil led to a depression of blood parameters, as well as changes in breathing patterns and gas metabolism, while nervous functions became depressed and skin injuries and burns appeared (Lukina et al., 1996). Experiments with harbor porpoise in similar conditions possibly resulted in aspiration pneumonia (Lukina et al., 1996). Dolphins exposed to oil at a Japanese aquarium that draws seawater from the ocean began developing cloudy eyes (Reuters, 1997).

Fresh crude oil or volatile distillates release toxic vapors that when inhaled can lead to irritation of respiratory membranes, lung congestion, and pneumonia. Subsequent absorption of volatile hydrocarbons into the bloodstream may accumulate into such tissues as the brain and liver, causing neurological disorders and liver damage (Geraci and St. Aubin, 1982; Hansen, 1985; Geraci, 1990). Toxic vapor concentrations just above the water's surface (where cetaceans draw breath) could reach critical levels for the first few hours after a spill, prior to evaporation of volatile aromatic hydrocarbons and other light fractions (Geraci and St. Aubin, 1982).

Trained, captive bottlenose dolphins exposed to oil could not detect light oil sheen but could detect thick dark oil based on visual, tactile, and presumably echolocation cues (Geraci et al., 1983; Smith et al., 1983). Captive studies also showed that dolphins completely avoided surfacing in slick oil after a few brief, initial tactile encounters. The reaction of free-ranging cetaceans to spilled oil appears varied, ranging from avoidance to apparent indifference (reviewed by Geraci, 1990; Smultea and Würsig, 1991). In contrast to captive studies, bottlenose dolphins during the *Mega Borg* spill did not consistently avoid entering slick oil, which could increase their vulnerability to potentially harmful exposure to oil chemicals (Smultea and Würsig, 1991 and 1995). It is possible that some overriding behavioral motivation (such as feeding) induced dolphins to swim through the oil, that slick areas were too large for dolphins to feasibly avoid; or that bottlenose dolphins have become accustomed to oil due to the extent of oil-related activity in the Gulf (Smultea and Würsig, 1995). The latter could result in temporary displacement from migratory routes. After the *Exxon Valdez* spill, killer whales did not seem to attempt to avoid oil; however, none were observed in the presence of heavier slicks of oil (Matkin et al., 1994). It is unknown whether animals in some cases are simply not affected by the presence of oil, or perhaps are even drawn to the area in search of prey organisms attracted to the oil's protective surface shadow (Geraci, 1990). The probable effects on cetaceans swimming through an area of oil would depend on a number of factors, including ease of escape from the vicinity, the health of the individual animal, and its immediate response to stress (Geraci and St. Aubin, 1985). Although an interaction with small spills may occur, few animals would likely be affected due to possible avoidance by the animals and natural dispersion/weathering of a spill in the offshore environment. The effects would likely have virtually no effect on the range, size, or productivity of any marine mammal population.

Spilled oil can also lead to the reduction or contamination of prey. Feeding strategies of cetaceans could lead to ingestion of oil-contaminated food or incidental ingestion of floating or submerged oil or tar. Zooplankton may become contaminated by direct contact and/or by ingesting oil droplets and tainted food. Marine fish also take up petroleum hydrocarbons from both water and food, though apparently do not accumulate high concentrations of hydrocarbons in tissues, and may transfer them to predators (Neff, 1990). Harmful hydrocarbon fractions might be swallowed or consumed through contaminated prey (Geraci, 1990) and by fouling of the feeding apparatus, in the case of baleen whales (though laboratory studies suggest that such fouling has only transient effects) (Geraci and St. Aubin, 1985). In general, the potential for ingesting oil-contaminated prey organisms with petroleum-hydrocarbon, body-burden content is highest for benthic feeding whales and pinnipeds. The potential is lower for plankton-feeding whales, and lowest for fish-eating whales and pinnipeds (Würsig, 1990). Baleen whales from the GOM feed on small pelagic fishes (such as herring, mackerel, and pilchard) and cephalopods (Cummings, 1985). An analysis of stomach contents from captured and stranded odontocetes suggest that they are deep-diving animals, feeding predominantly on mesopelagic fish and squid or deepwater benthic invertebrates (Heyning, 1989; Mead, 1989). Dolphins feed on fish and/or squid, depending upon the species (Mullin et al., 1991).

As noted by St. Aubin and Lounsbury (1990), there has been no experimental study and only a handful of observations suggesting that oil harmed manatees. A manatee was accidentally hit and killed by a boat off Louisiana (Schiro et al., 1998). Indirect consequences of oil pollution on marine mammals are those effects that may be associated with changes in the availability or suitability of various food sources (Hansen, 1992). No long-term effects from bioaccumulation of hydrocarbons have been demonstrated; however, an oil spill may physiologically stress an animal (Geraci and St. Aubin, 1980), making them more vulnerable to disease, parasitism, environmental contaminants, and/or predation.

Spill Response

Spill-response activities include the application of dispersant chemicals to the affected area designed to break up oil on the water's surface into minute droplets, which then break down in seawater. Virtually nothing is known about the effects of oil dispersants on whales and dolphins, except that removal of the oil from the surface would reduce the risk of contact and render it less likely to adhere to skin, baleen plates, or other body surfaces (Neff, 1990). The acute toxicity of most oil dispersant chemicals is considered to be low when compared to the constituents and fractions of crude oil and refined products, and studies have shown that the rate of biodegradation of dispersed oil is equal to or greater than that of undispersed oil (Wells, 1989). A variety of aquatic organisms readily accumulate and metabolize surfactants from oil dispersants. Enzymatic hydrolysis of the surfactant yields hydrophilic and hydrophobic components. The former probably are excreted via the gills and kidneys, whereas the latter accumulate in the gallbladders of fish and are excreted very slowly (Neff, 1990). Metabolism of surfactants is thought to be rapid enough that there is little likelihood of food chain transfer from marine invertebrates and fish to consumers, including marine mammals (Neff, 1990). Biodegradation is another process used for removing petroleum hydrocarbons from the marine environment, utilizing chemical fertilizers to augment the growth of naturally occurring hydrocarbon-degrading microorganisms. Toxic effects of these fertilizers on whales and dolphins are presently unknown.

Analysis of Impacts

The major impact-producing factors resulting from exploratory drilling in the EPA sale area affecting whales and dolphins include (1) water quality degradation from drilling fluids, (2) cuttings and operational discharges, (3) noise from helicopters, (4) service-vessel traffic, (5) exploration rigs and drillships, (6) oil spills and spill-response activities, and (7) discarded debris from service vessels and exploration rigs.

Drilling fluids and cuttings that would be discharged offshore may come into contact with whales and dolphins. Contact with these discharges is expected to be highly diluted, and direct effects to cetaceans are expected to be sublethal. It should be noted, however, that noncompliance with permitted limits, in discharges or effluents, could poison and debilitate or kill marine mammals and adversely affect the food web and other key elements of the Gulf ecosystem on which they rely (Tucker & Associates, Inc., 1990). Many types of plastic materials are used during drilling and production operations. Some of this material is accidentally lost overboard where whales and dolphins can consume or become ensnared in it. The result of plastic ingestion is certainly deleterious and could be lethal. The probabilities of occurrence of ingestion, however, and the lethal effect are unknown.

The FAA Advisory Circular 91-36C encourages pilots to maintain higher than minimum altitudes over noise-sensitive areas. NOAA Fisheries regulations state minimum height and distances to be maintained from marine mammals. Routine overflights may elicit a startle response and/or interrupt whales and dolphins while, resting, feeding, breeding, or migrating. Occasional overflights probably have no long-term consequences on whales or dolphins; however, frequent overflights could have long-term consequences if they repeatedly disrupt vital functions, such as feeding and breeding. It is unlikely that whales and dolphins would be affected by routine helicopter traffic operating at prescribed altitudes.

Noise from service-vessel traffic may elicit a startle and/or avoidance reaction from whales and dolphins or mask their sound reception. There is the possibility of short-term disruption of movement patterns and behavior, but such disruptions are unlikely to affect survival or productivity. Long-term displacement of animals from an area is also uncertain. It is not known whether toothed whales exposed to recurring vessel disturbance will be stressed or otherwise affected in a negative but inconspicuous way. Increased ship traffic could increase the probability of collisions between ships and marine mammals, resulting in injury or death to some animals. Smaller dolphins may approach vessels that are in transit to bow-ride. The behavioral disruptions apparently caused by noise and the presence of service-vessel traffic are unlikely to affect long-term survival or productivity of whale or dolphin populations in the northern GOM.

Exploration wells and platforms could produce sounds at intensities and frequencies that could be heard by whales and dolphins. It is expected that noise from exploratory drilling activities would be relatively constant and last no longer than 50-100 days per well. Toothed whales echolocate and communicate at higher frequencies than the dominant sounds generated by drillships. Bottlenose dolphins, one of the few species in which low-frequency sound detection has been studied, have been found to have poor sensitivity levels at the level where most industrial noise energy is concentrated. There is some concern for baleen whales since they are apparently more dependent on low-frequency sounds than other marine mammals. Except for the Bryde's whale, which is considered uncommon, baleen whales are extralimital or rare in occurrence in the GOM (Würsig, 2000). Potential effects on GOM marine mammals include disturbance (subtle changes in behavior, interruption of previous activities, or short- or long-term displacement), masking of sounds (calls from conspecifics, reverberations from own calls, and other natural sounds such as surf or predators), physiological stress, and hearing impairment. The behavioral or physiological responses to drilling rig noise, however, are unlikely to affect long-term survival or productivity of whale or dolphin populations in the northern GOM.

Oil spills and spill-response activities have the potential to adversely affect whales and dolphins by causing soft tissue irritation, fouling of baleen plates, respiratory stress from inhalation of toxic fumes, food reduction or contamination, direct ingestion of oil and/or tar, and temporary displacement from preferred habitats or migration routes. Some short-term (0-1 month) effects of oil may be as follows: (1) changes in cetacean distribution associated with avoidance of aromatic hydrocarbons and surface oil, (2) changes in prey distribution, and human disturbance; (3) increased mortality rates from ingestion or inhalation of oil; (4) increased petroleum compounds in tissues; and (5) impaired health (e.g., immunosuppression) (Harvey and Dahlheim, 1994). Several mechanisms for long-term injury can be postulated: (1) initial sublethal exposure to oil causing pathological damage; (2) continued exposure to hydrocarbons persisting in the environment, either directly or through ingestion of contaminated prey; and (3) altered availability of prey as a result of the spill (Ballachey et al., 1994).

While no conclusive evidence of an impact on whales and dolphins by the 1989 *Exxon Valdez* spill was uncovered (Dahlheim and Matkin, 1994; Harvey and Dahlheim, 1994; Loughlin, 1994), investigations on the effects on sea otters and harbor seals revealed pathological effects on the liver, kidney, brain (also evidenced by abnormal behavior), and lungs, as well as gastric erosions (Ballachey et al., 1994; Lipscomb et al., 1994a; Lowry et al., 1994; Spraker et al., 1994). In addition, harbor seal pup production and survival appeared to be affected (Frost et al., 1994).

Oil spills have the potential to cause greater chronic (longer-term lethal or sublethal oil-related injuries) and acute (spill-related deaths occurring during a spill) effects on mammals than originally suggested. A few long-term effects include (1) change in distribution and abundance because of reduced prey resources or increased mortality rates; (2) change in age structure because certain year-classes were impacted more by oil; (3) decreased reproductive rate; and (4) increased rate of disease or neurological problems from exposure to oil (Harvey and Dahlheim, 1994). It has been speculated that new mortalities of killer whales may be linked to the *Exxon Valdez* spill (Matkin and Sheel, 1996). There was no evidence to directly link the Gulf War oil spill to marine mammal deaths that occurred during that time (Preen, 1991; Robineau and Fiquet, 1994). Effects of cleanup activities are unknown, but increased human presence (e.g., vessels) could add to changes in whale and dolphin behavior and/or distribution, thereby additionally stressing animals, and perhaps making them more vulnerable to various physiologic and toxic effects. There are no long-term effects known with confidence on the vitality or productivity of whales and dolphin populations caused by oil spills. There is, however, substantial circumstantial evidence based on affects documented in other marine mammals that deleterious effects from contact with spilled oil by individual whales or dolphins can be expected.

Evidence gathered from the studies of the *Exxon Valdez* spill indicates that oil spills have the potential to cause chronic (sublethal oil-related injuries) and acute (spill-related deaths) effects on marine mammals. Also, whales and dolphins do not always avoid contact with oil (e.g., Smultea and Würsig, 1995). Although an interaction with a spill could occur, primarily sublethal effects are expected due to avoidance and natural dispersion and weathering of the spill in the offshore environment. Contact by whales and dolphins with spilled oil as a result of exploratory drilling in the EPA sale area is of such low probability and the duration of contact between a spill and mobile animals is so fleeting, that the effects on these marine mammals are expected to be insignificant.

Summary and Conclusion

A few individuals from different species or populations of marine mammals could be injured or killed by chance collision with service vessels or by eating indigestible trash, particularly plastic items, lost from drilling rigs and service vessels. Contaminants in waste discharges and drilling muds might indirectly affect marine mammals through food-chain biomagnification. There is no conclusive evidence whether anthropogenic noise has or has not caused long-term displacements of, or reductions in, marine mammal populations. Although an interaction with a spill could occur, primarily sublethal effects are expected due to avoidance of a slick by animals, and natural dispersion and weathering of the spill in the offshore environment. The biological significance of mortalities that might occur as a result of any affects would depend, in part, on the size and reproductive rates of the affected stocks, as well as the number, age, and size of animal(s) affected.

4.3.2.7. Impacts on Sea Turtles

The major impact-producing factors that may affect loggerhead, Kemp's ridley, hawksbill, green, and leatherback turtles, all listed as endangered species, include (1) water-quality degradation from drill cuttings and operational discharges, (2) noise from helicopter and vessel traffic, (3) drilling rigs and drillships, (4) possible collisions with service vessels, (5) brightly-lit drilling facilities, (6) OCS-related trash and debris, (7) oil spills, and (8) spill-response activities.

Discharges

Drilling muds and cuttings are routinely discharged into offshore marine waters and are regulated by USEPA NPDES permits. Most operational discharges, as regulated, are diluted and dispersed when released in offshore areas and are considered to have sublethal effects (API, 1989; Kennicutt, 1995). Any potential that might exist for impact from drilling fluids would be indirect, either by impact on prey items or possibly through ingestion via the food chain (API, 1989). Contaminants in drilling muds or other permitted operational discharges may biomagnify and bioaccumulate in the food web, which may debilitate or kill important sea turtle prey species or species lower in the marine food web. Sea turtles could potentially bioaccumulate chemicals such as heavy metals that occur in drilling mud. This might ultimately reduce reproductive fitness in the turtles, an impact that the already diminished population(s) likely cannot tolerate. Samples from stranded turtles in the GOM carry high levels of organochlorides and heavy metals (Sis et al., 1993).

Aircraft and Vessel Traffic

There have been no systematic studies of the reactions of sea turtles to aircraft overflights. Even anecdotal reports are scarce; however, it is assumed that aircraft noise could be heard by a sea turtle at or near the surface and could cause the animal to alter its normal behavior pattern (Advanced Research Projects Agency, 1995). Noise from service-vessel traffic may elicit a startle reaction from sea turtles and produce a temporary sublethal stress (NRC, 1990). Startle reactions may result in increased surfacings, possibly causing an increase in risk of vessel collision. In the wild, most sea turtles spend at least 3-6 percent of their time at the surface. Despite the brevity of their respiratory phases, sea turtles sometimes spend as much as 19-26 percent of their time at the surface, engaged in surface basking, feeding, orientation, and mating (Lutcavage et al., 1997). Sea turtles located in shallower coastal areas have a short surface interval, whereas turtles occurring in deeper, offshore areas have longer surface intervals. It is not known whether turtles exposed to recurring vessel disturbance would be stressed or otherwise affected in a negative but inconspicuous way. Increased ship traffic could increase the probability of collisions between ships and turtles, resulting in injury or death to some animals.

Vessel-related injuries were noted in 13 percent of turtles examined from strandings in the GOM and on the Atlantic Coast during 1993 (Teas, 1994), but this figure includes those that may have been struck by boats post-mortem. In Florida, where coastal boating is popular, the frequency of boat injuries between 1991 and 1993 was 18 percent of strandings (Lutcavage et al., 1997). Reactions such as any avoidance behavior might result in disruption of normal activities, including feeding, and important habitats may be avoided due to noise in the vicinity. There is no information regarding the possible consequences these disturbances may have on sea turtles over a long period.

Noise

Exploration structures, as well as drillships, produce an acoustically wide range of sounds at frequencies and intensities that could possibly be detected by turtles. Drilling noise from conventional metal-legged structures and semisubmersibles is not particularly intense and is strongest at low frequencies (Richardson et al., 1995). Sea turtle hearing sensitivity is not well studied. A few preliminary investigations using adult green, loggerhead, and Kemp's ridley turtles suggest that they are most sensitive to low-frequency sounds (Ridgway et al., 1969; Lenhardt et al., 1983; Moein-Bartol et al., 1993). It has been suggested that sea turtles use acoustic signals from their environment as guideposts during migration and as a cue to identify their natal beaches (Lenhardt et al., 1983). Bone-conducted hearing appears to be a reception mechanism for at least some of the sea turtle species, with the skull and shell acting as receiving structures (Lenhardt et al., 1983).

Captive loggerhead and Kemp's ridley turtles exposed to brief, audio-frequency vibrations initially showed startle responses of slight head retraction and limb extension (Lenhardt et al., 1983). Sound-induced swimming has been observed for captive loggerheads and greens (O'Hara and Wilcox, 1990; Moein Bartol et al., 1993; Lenhardt, 1994). Some loggerheads exposed to low-frequency sounds responded by swimming towards the surface at the onset of the sound, presumably to lessen the effects of the transmissions (Lenhardt, 1994). Sea turtles have been seen to begin to noticeably increase their swimming behavior in response to an operating seismic source. An anecdotal observation of a free-ranging leatherback's response to the sound of a boat motor suggests that leatherbacks may be sensitive to low-frequency sounds, but the response could have been to mid- or high-frequency components of the sound (Advanced Research Projects Agency, 1995). The potential direct and indirect impact of sound on sea turtles includes physical auditory effects (temporary threshold shift), behavioral disruption, long-term effects, masking, and adverse impacts on the food chain. Low-frequency sound transmissions could potentially cause increased surfacing behavior and deterrence from the area near the sound source (Lenhardt et al., 1983; O'Hara and Wilcox, 1990; McCauley et al., 2000). The potential for increased surfacing behavior could place turtles at greater risk of vessel collisions and potentially greater vulnerability to natural predators. If sound affects any prey species, negative consequences to sea turtles would depend on the extent to which prey availability might be altered. Noise-induced stress has not been studied in sea turtles.

Brightly-lit Drilling Facilities

Brightly-lit, offshore drilling facilities present a potential danger to hatchlings (Owens, 1983). Hatchlings are known to be attracted to light (Raymond, 1984; Witherington and Martin, 1996; Witherington, 1997) and could be expected to orient toward lighted offshore facilities (Chan and Liew, 1988). If this occurs, hatchling predation would increase dramatically since large birds and predacious fish also congregate around the platforms (Owens, 1983; Witherington and Martin, 1996). The very short duration of the light attraction for hatchlings, however, would indicate that this is a risk only for facilities very close to nesting beaches.

Trash and Debris

A wide variety of trash and debris is commonly observed in the Gulf. Marine trash and debris comes from a variety of land-based and ocean sources (Cottingham, 1988). Some of this material is accidentally lost or discarded during drilling and production operations. The offshore natural gas industry was shown to contribute 13 percent of the trash and debris found at Padre Island National Seashore (Miller et al., 1995). Turtles may become physically entangled in drifting debris and ingest small fragments of synthetic materials (Carr, 1987; USDOC, NOAA, 1988; Heneman and the Center for Environmental Education, 1988). Entanglement usually involves fishing line or netting (Balazs, 1985). Once entangled, turtles may drown, suffer impaired ability to catch food or avoid predators, incur wounds and infections from the abrasive or cutting action of attached debris, or exhibit altered behavior patterns that place them at a survival disadvantage (Laist, 1987). Both entanglement and ingestion have caused the death or serious injury of individual sea turtles (Balazs, 1985). Balazs (1985) compiled dozens of records of sea turtle entanglement, ingestion, and impaction of the alimentary canal by ingested plastics worldwide. Tar was the most common item ingested. The marked tendency of leatherbacks to ingest plastic has been attributed to misidentification of the translucent films as jellyfish. Lutz (1990) concluded that turtles will actively seek out and consume plastic sheeting. Ingested debris may block the digestive tract or remain in the stomach for extended periods, thereby lessening the feeding drive, causing ulcerations and injury to the stomach lining, or perhaps even providing a source of toxic chemicals (Laist, 1987). Weakened animals may then be more susceptible to predators and disease and less fit to breed or nest successfully.

The initial developmental stages of all marine turtle species are passed in the open sea. Hatchlings spend their "lost years" in sargassum rafts; ocean currents concentrate or trap floating debris in sargassum (Carr, 1987). Witherington (1994) studied post-hatchling loggerheads in drift lines 14-65 km (8-35 nmi) east of Cape Canaveral and Sebastian Inlet, Florida. Out of 103 turtles captured, 17 percent of the animals revealed plastic or other synthetic fibers in their stomachs or mouths. The southeastern U.S. had the highest number of turtle strandings affected by debris (49.1%), followed by the GOM (35.9%) (Witzell and Teas, 1994). Even though the Kemp's ridley is the second most commonly stranded turtle, for some unknown reason they are apparently less susceptible to the adverse impacts of debris than the other turtle species (Witzell and Teas, 1994). The MMS prohibits the disposal of equipment, containers, and other materials into offshore waters by lessees (30 CFR 250.40). In addition, MARPOL, Annex V, Public Law 100-220 (101 Statute 1458) prohibits the disposal of any plastics at sea or in coastal waters.

Oil Spills

When an oil spill occurs, the severity of effects and the extent of damage to sea turtles are affected by (1) geographic location, (2) hydrocarbon type, (3) duration of contact, (4) weathering state of a slick, (5) impact area, (6) oceanographic and meteorological conditions, (7) season, and (8) growth stage of the animal (NRC, 1985). All sea turtle species and life stages are vulnerable to the harmful effects of oil through direct contact or by fouling of their habitats and food. Van Vleet and Pauly (1987) suggested that discharges of crude oil from tankers were having a significant effect on sea turtles in the Eastern GOM. Experiments on the physiologic and clinicopathologic effects of hydrocarbons have shown that major body systems in sea turtles are adversely affected by short exposure to weathered oil. Sea turtles accidentally exposed to oil or tarballs may suffer inflammatory dermatitis, ventilatory disturbance, salt gland dysfunction or failure, red blood cell disturbances, immune responses, and digestive disorders or blockages (Vargo et al., 1986; Lutz and Lutcavage, 1989; Lutcavage et al., 1995). Although disturbances may be temporary, long-term effects remain unknown, and chronically ingested oil may accumulate in organs. Exposure to hydrocarbons may be fatal, particularly to juvenile and hatchling sea turtles. Direct contact with oil may harm developing turtle embryos.

Oil can adhere to the body surface of marine turtles. Oil has been observed to cling to the nares, eyes, and upper esophagus, and to even seal the mouth (Witham, 1978; Overton et al., 1983; Van Vleet and Pauly, 1987; Gramentz, 1988; Lutcavage et al., 1995). Turtles may become entrapped by tar and oil slicks and rendered immobile (Witham, 1978; Plotkin and Amos, 1988; Gramentz, 1988). Periocular tissues and other mucous membranes would presumably be most sensitive to contact with hydrocarbons. Skin damage in turtles is in marked contrast to that observed in dolphins, where all structural and biochemical changes in the epidermis were minor and reversible. Changes in the skin are consistent with an acute, primary contact or irritant dermatitis. A break in the skin barrier could act as a portal of entry for pathogenic organisms, leading to infection, neoplastic conditions, and debilitation (Vargo et al., 1986).

Turtles surfacing in an oil spill will inhale oil vapors. Any interference with operation of the lungs could reduce a sea turtle's capacity for sustained activity (aerobic scope) and its dive time. Either effect could decrease the turtle's chance for survival.

Lutcavage et al. (1995) found that operation of the salt gland in sea turtles was disrupted with exposure to hydrocarbons, but the disturbance did not appear until several days after exposure. The salt glands did recover function when tested after two weeks of recovery. Prolonged interference with salt gland functioning could have serious consequences since it would interfere with both water balance and ion regulation.

Studies on the effect of oil on digestive efficiency are underway, but Lutcavage et al. (1995) report finding oil in the feces of turtles that had swallowed oil in experiments. Van Vleet and Pauly (1987) reported that oil ingested by turtles did not pass rapidly through the digestive tract, but was retained within the system for a period of several days. The likelihood that toxic components of the oil could be passed on to other internal organs and tissues of the turtle would be increased.

Significant changes in blood chemistry following contact with hydrocarbons have been reported (Lutcavage et al., 1995). Hematocrit and hemoglobin concentration decreased slightly during contact; these parameters are critical components of the blood's oxygen transport system. The most striking hematologic finding was an elevation of white blood cell count, which may indicate a "stress" reaction related to oil exposure and/or toxicity.

Some captive turtles exposed to oil either reduced the amount of time spent at the surface, possibly avoiding the oil, or became agitated and had short submergence levels (Lutcavage et al., 1995). Sea turtles pursue and swallow tarballs, and there is no concrete evidence that free-ranging turtles can detect and avoid oil (Odell and MacMurray, 1986). A loggerhead turtle sighted during an aerial survey in the GOM surfaced repeatedly within a surface oil slick for over an hour (Lohoefener et al., 1989). Oil might have a more indirect effect on the behavior of marine turtles. The effect on reproductive success could therefore be significant.

Contact with hydrocarbons may not cause direct or immediate death but cumulative sublethal effects, such as salt gland disruption or liver impairment, could impair the marine turtle's ability to function effectively in the marine environment (Vargo et al., 1986; Lutz and Lutcavage, 1989). Although many observed physiological insults are resolved in a 21-day recovery period, the impact of tissue oil intake on the long-term health and survival of sea turtles remains unknown (Lutcavage et al., 1995). There is evidence of bioacummulation in sea turtles exposed for longer periods of time. After the Gulf of Iraq war, a stranded green turtle did not appear to have contacted hydrocarbons, but upon necropsy, was found to have large amounts of oil in its liver and stomach tissues (Greenpeace, 1992).

A study of turtles collected during the 1979-1980 *Ixtoc* spill determined that the three animals found dead had oil hydrocarbons in all tissues examined and that there was selective elimination of portions of this oil. This would indicate that exposure to the oil was chronic and the turtles evidently did not encounter the oil shortly before death, but had been exposed to it for some time (Hall et al., 1983). The low metabolic rate of turtles may cause a limited capacity to metabolize hydrocarbons. Prolonged exposure to oil may have caused the poor body condition observed in the turtles, perhaps disrupting feeding activity. In such weakened condition, the turtles may have succumbed to some toxic component in the oil or some undiscovered agent.

The possibility of oil spilled from an exploration well blowout in the EPA sale area reaching landfall is unlikely, but possible. Eggs, hatchlings, and small juveniles are particularly vulnerable to contact (Fritts and McGehee, 1982; Lutz and Lutcavage, 1989). Female sea turtles crawling through tar to lay nests can transfer the tar to the nest; this was noted on St. Vincent National Wildlife Reserve in 1994 (USDOI, FWS, 1997). Potential toxic impacts to embryos will depend on the type of oil and degree of weathering, type of beach substrate, and especially upon the developmental stage of the embryo. Turtle egg development may be altered or arrested by contact with oil, and hatchlings are especially vulnerable to impacts (Fritts and McGehee, 1982). Fresh oil was found to be highly toxic, especially during the last quarter of the incubation period, whereas aged oil produced no detectable effects. Fritts and McGehee (1982) concluded that oil contamination of nesting beaches would have its greatest impact on nests that were already constructed, as nests made on fouled beaches are less likely to be affected, if at all. Hatchling and small juvenile turtles are particularly vulnerable to contacting or ingesting hydrocarbons because the currents that concentrate oil spills also form the debris mats in which young turtles are sometimes found (Carr, 1980; Collard and Ogren, 1990; Witherington, 1994). This would also be true for juvenile sea turtles that are sometimes found in floating mats of sargassum. The result of sea turtles feeding selectively in surface convergence lines could be prolonged contact with viscous weathered oil (Witham, 1978; Hall et al., 1983). High rates of oil contact in very young turtles suggest that bioaccumulation may occur over their potentially long lifespan. A female coming from the offshore waters to nest might be fouled with oil. During the nesting process, she might push oil mixed with sand into the nest and contaminate the eggs (Chan and Liew, 1988). Assuming olfaction is critical to the process, oil-fouling of a nesting area might disturb imprinting of hatchling turtles, or confuse the turtles on their return migration after a 6- to 8-year absence (Geraci and St. Aubin, 1985; Chan and Liew, 1988).

Spill Response

In addition to impacts from contact with hydrocarbons, spill-response activities could adversely affect sea turtle habitat and cause displacement from these preferred areas. Studies are completely lacking regarding the effects of dispersants and coagulants on sea turtles (Tucker and Associates, Inc., 1990). Individual turtles covered with oil have been cleaned, rehabilitated, and released (e.g., FDEP et al., 1997). The strategy for cleanup operations should vary, depending on the season, recognizing that disturbance to the nest may be more detrimental than the oil (Fritts and McGehee, 1982). As mandated by OPA 90, seagrass beds and live-bottom communities are expected to receive individual consideration during spill cleanup. Required spill contingency plans include special notices to minimize adverse effects from vehicular traffic during cleanup activities and to maximize protection efforts to prevent contact of these areas with spilled oil.

Analysis of Impacts

Drilling fluids to be used during exploratory drilling in the EPA sale area create cuttings that require disposal along with the used drilling fluid. These wastes are regulated by the USEPA's NPDES permits and are routinely discharged into offshore marine waters. Turtles may have some interaction with these discharges. Very little information exists on the impact of drilling muds on Gulf sea turtles (Tucker and Associates, Inc., 1990).

Approximately 1,300-3,900 service-vessel trips would be needed to support the projected total number of exploration wells (38-73) projected for the EPA sale area. Transportation corridors would be through areas where loggerhead turtles have been sighted. Approximately 684-4,380 helicopter round trips would be needed to support the exploratory drilling in the EPA sale area. Noise from service-vessel traffic and helicopter overflights may elicit a startle reaction from sea turtles. There is the possibility of short-term disruption of movement patterns and behavior. Sounds from approaching aircraft are detected in the air far longer than in water. For example, an approaching Bell 214ST helicopter became audible in the air over 4 minutes before passing overhead, while it was detected underwater for only 38 seconds at 3-m depth and 11 seconds at 18-m depth (Greene, 1985 in Richardson et al., 1995). There have been no systematic studies of the reactions of sea turtles to aircraft overflights and even anecdotal reports are scarce. It is assumed that aircraft noise could be heard by a sea turtle at or near the surface and that it could cause it to alter its normal behavior pattern (Advanced Research Projects Agency, 1995).

A total of 38-73 exploration wells are projected to be drilled as a result of the proposed action. Drilling rigs could produce sounds at intensities and frequencies that can be heard by turtles. There is some evidence suggesting that turtles may be receptive to low-frequency sounds, which is at the level where most industrial noise energy is concentrated. Potential effects on turtles include disturbance (subtle changes in behavior, interruption of behavior), masking of natural sounds (e.g., surf, predators), and stress (physiological).

Sea turtles can become entangled in or ingest debris produced by exploration operations in the EPA sale area. Leatherback turtles that mistake plastics for jellyfish may be singularly more vulnerable to stomach blockage. The probability of occurrence for sea turtle plastic ingestion or entanglement is unknown.

Sea turtle habitat in the Gulf includes both offshore and inshore areas. Sea turtles could be contacted by spills that could occur during the drilling of exploration wells and during service-vessel support operations.

In general, on a yearly basis, about 1 percent of strandings identified by the U.S. Sea Turtle Stranding Network are associated with oil (e.g., Teas and Martinez, 1992). Contact with oil by stranded sea turtles occurs at a rate of 3 percent in south Florida. Turtles do not always avoid contact with oil (e.g., Lohoefener et al., 1989). Contact with petroleum and consumption of oil and oil-contaminated prey may seriously impact turtles. There is direct evidence that turtles have been seriously harmed by petroleum spills. Oil spills have the potential to cause direct spill-related deaths and indirect longer-term lethal or sublethal health effects on sea turtles. Several mechanisms for long-term injury can be postulated: (1) sublethal initial exposure to oil causing pathological damage and weakening of body systems or reproductive success; (2) continued exposure to hydrocarbons persisting in the environment or through ingestion of contaminated prey; and (3) altered prey availability as a result of the spill.

Contact by sea turtles with spilled oil as a result of exploratory drilling in the EPA sale area is of such low probability, and the duration of contact between a spill at sea and mobile animals is so fleeting, that the effects on sea turtles are expected to be insignificant. Few deaths are expected as a result of oil spill acute direct or chronic indirect effects because of the small area of contact involved and the rapid dispersion and loss of oil in the open marine environment. Few juvenile deaths or impacts to young or newly-hatch sea turtles in nesting zones and habitats are expected because the probability of shoreline impact by an oil spill from an exploration well blowout in the EPA sale area is very small. Further, if oil were spilled in a blowout event, the spill quantity would be unlikely to survive weathering at sea or sea conditions would be unlikely to bring it to shore from the EPA sale area. Due to spill response and cleanup efforts at sea, much of a spill would be recovered before it reached the coast, and what is not recovered would either dissipate rapidly at sea or be in a weathered state because of evaporation of volatile organic compounds. Oil spills and spill-response activities, such as beach sand removal, can negatively affect sea turtles. Although spill response activities such as vehicular and vessel traffic during nesting season are assumed to contact sea turtle habitats, harm to sea turtles is expected to be minimized because of protection efforts to prevent contact of these areas with spilled oil as mandated by OPA 90.

Increased human presence could add to changes in turtle behavior and/or distribution, thereby additionally stressing animals, and perhaps making them more vulnerable to various physiologic and toxic effects.

Summary and Conclusion

Activities resulting from exploratory drilling in the EPA sale area have the potential to cause detrimental effects to sea turtles. These animals could be impacted by the degradation of water quality resulting from drilling muds and operational discharges, helicopter and vessel traffic noise, exploration rig platform and drillship noise, brightly-lit platforms, oil spills, spill-response activities, and discarded trash and debris from service vessels and OCS structures. Lethal effects are most likely to be from chance collisions with OCS service vessels and ingestion of plastic materials. Few lethal impacts are expected to result from exploratory drilling in the EPA sale area. Contact with oil and consumption of hydrocarbons or contaminated prey, may seriously impact turtles. There is direct evidence that turtles have been seriously harmed by hydrocarbon spills. Exploratory drilling activity is expected to have sublethal effects consisting of possible behavioral effects and nonfatal exposure to, or intake of, exploration contaminants or debris. Contaminants in waste discharges and drilling muds might indirectly affect sea turtles through food-chain biomagnification. Chronic sublethal effects or stress resulting in persistent physiological or behavioral changes and/or avoidance of impacted areas could cause declines in survival or productivity, and result in either acute or gradual population declines.

4.3.2.8. Impacts on Fish and Essential Fish Habitat

Effects on fish resources and essential fish habitat (EFH) from activities associated with exploratory drilling in the EPA sale area could result from coastal and marine environmental degradation, petroleum spills, subsurface blowouts, and offshore discharges of drilling muds and permitted effluents.

Healthy fish resources and fishery stocks depend on EFH waters and substrate necessary for fish to spawn, breed, feed, and grow to maturity. Due to the wide variation of habitat requirements for all life history stages for managed species, EFH has been identified throughout the GOM, including all coastal and marine waters and substrates from the shoreline to the seaward limit of the Exclusive Economic Zone (EEZ). Collectively, the adverse impacts on coastal EFH and marine EFH are called, respectively, coastal and marine environmental degradation in this analysis.

Because many of the commercial species harvested within the EPA are estuary dependent, coastal environmental degradation resulting from the proposed action, although indirect, has the potential to adversely affect EFH and commercial fisheries. The environmental deterioration and effects on EFH and commercial fisheries result from the loss of Gulf wetlands and coastal estuaries as nursery habitat and from the functional impairment of existing habitat through decreased water quality (Chambers, 1992; Stroud, 1992).

Wetlands and estuaries within Mississippi, Alabama, and the Florida Panhandle from Escambia to Gulf County may be affected by activities resulting from exploratory drilling in the EPA sale area. These activities include the maintenance of onshore facilities in or near wetland areas, usage and maintenance of navigable channels by support vessels, inshore disposal of exploration wastes, and spills from transportation or exploration well blowout.

Water quality in coastal waters along the Gulf may be altered by a number of coastal operations supporting offshore OCS oil or gas exploration. Trash and debris, discharges and effluents, and oil may be spilled or released from onshore facilities and vessel traffic. Besides coastal sources, offshore spills and trash in association with exploration operations may reach coastal waters to impact water quality.

Environmental degradation of marine waters resulting from exploratory drilling, although indirect, has the potential to adversely affect EFH and commercial fisheries. Offshore EFH includes both high- and low-relief live bottoms and both natural and artificial reefs. No natural reefs or live bottoms have been documented within the deepwater environment of the EPA sale area. No artificial reefs have been emplaced there, or are expected to be emplaced there because of the extreme water depth. Impact-producing factors that could affect EFH include drill rig anchoring and emplacement, operational exploration waste discharges, and blowouts.

Impact-producing factors that could result in water quality degradation from routine offshore exploration activities include drill rig installation and removal, and the discharge of operational wastes. Offshore accidents, including blowouts and spills from drillrigs and service vessels, could also occur and potentially alter offshore water quality.

Chronic, low-level pollution is a persistent and recurring event resulting in nonfatal, persistent physiological irritation to those resources that lie within the range of impact. The geographic range of the effects depends on the mobility of the resource, the characteristics of the contaminant, and the tolerance of the resource to the contaminant (hydrocarbons). Adult fish must experience continual exposure to relatively high levels of hydrocarbons over several months before secondary toxicological compounds that represent biological harm are detected in the liver (Payne et al., 1988). Adult fish are likely to actively avoid a diesel spill, thereby limiting the effects and lessening the extent of damage (Baker et al., 1991; Malins et al., 1982; Maki et al., 1995).

The direct effects of spilled petroleum on fish occur through the ingestion of hydrocarbons or contaminated prey, through the uptake of dissolved petroleum products through the gills and epithelium by adults and juveniles, and through the death of eggs and decreased survival of larvae (NRC, 1985). Upon exposure to spilled petroleum, liver enzymes of fish oxidize soluble hydrocarbons into compounds that are easily excreted in the urine (Spies et al., 1982). When contacted by spilled hydrocarbon, floating eggs and larvae, with their limited mobility and physiology, and most juvenile fish are killed (Linden et al., 1979; Longwell, 1977). Ordinary environmental stresses may increase the sensitivity of fish to petroleum toxicity. These stresses may include changes in salinity, temperature, and food abundance (Evans and Rice, 1974; NRC, 1985).

Large numbers of fish eggs and larvae have been killed by oil spills. Sublethal effects on larvae, including genotoxic damage, have been documented from sites oiled from the *Exxon Valdez* (DeMarty et al., 1997). Hose and Brown (1998) also detected genetic damage in Pacific herring from sites within the oil trajectory of the *Exxon Valdez* spill two months after the spill with decreasing rates of genotoxicity for two additional months after the spill. No detectable genotoxicity was detectable from sampling conducted two years following the spill. Mortality rates for pink salmon embryos were found to be significantly higher than controls at exposure levels of 1 ppb total polycyclic aromatic hydrocarbons (PAH) concentration (Heintz, 1999).

The effects on and the extent of damage to fisheries from a petroleum spill are restricted by time and location. Spills that contact coastal bays and estuaries of the OCS when pelagic eggs and larvae are present have the greatest potential to affect commercial fishery resources. Migratory species, such as mackerel, cobia, and crevalle, could be impacted if a spill contacts nearshore open waters. A spill contacting a low-energy inshore area would affect localized populations of commercial fishery resources, such as menhaden, shrimp, and blue crabs. Chronic petroleum contamination in an inshore area would affect all life stages of a localized population of a sessile fishery resource such as oysters.

For OCS-related spills to have an effect on a commercial fishery resource, whether estuary dependent or not, eggs and larvae would have to be abnormally concentrated in the immediate spill area (Pearson et al., 1995). Hydrocarbon components also would have to be present in highly toxic concentrations when both eggs and larvae are in the pelagic stage (Longwell, 1977). There is no evidence at this time that commercial fisheries in the Gulf have been adversely affected on a regional population level by spills or chronic contamination from the totality of OCS operations. Development abnormalities in juveniles occur naturally in wild fish populations, and the frequency of these abnormalities is increased in populations chronically exposed to petroleum. These abnormal fish do not survive long. Such early death is likely to have an insignificant impact on fish resources, as are the immediate deaths following a petroleum spill (Pearson et al., 1995).

Benthic disturbance from subsurface blowouts of both oil and natural gas wells in water depths less than 152 m (500 ft) may be detrimental to commercial fisheries. Blowouts can resuspend sediments, and the loss of well control can release varying amounts of hydrocarbons into the water column (USDOI, MMS, 1987). Resuspended sediments may clog gill epithelia of both finfish and shellfish with resultant smothering. Settlement of resuspended sediments may directly smother invertebrates or cover burrows of commercially important shellfish. Sandy sediments are quickly redeposited within 400 m (130 ft) of the blowout location; however, finer sediments are widely dispersed and redeposited over a period of 30 days or longer within a few thousand meters. Released hydrocarbons are diluted to background levels within a few thousand meters of the blowout site, rise to the surface to form a slick, and degrade quickly without major biological effect. Gas-well blowouts are even less of an environmental risk, resulting in little resuspended sediments and increased levels of natural gas for a few days very near the source of the blowout. Loss of gas-well control does not release liquid hydrocarbons into the water. Natural gas consists mainly of methane, which rapidly disperses upward into the air (Van Buuren, 1984).

Drilling muds contain materials, such as mercury, lead, and cadmium, which in high concentrations are toxic to fishery resources. Although dependent on winds and currents, mud discharge plumes disperse rapidly within 3,000 m of the outfall point (Avanti Corporation, 1993a; USDOI, MMS, 2001a; Section IV.A.3.d.).

Plankton

Zooplankton consist mostly of small copepods that graze on phytoplankton, which are a major link to fishes higher in the food web. Sources of possible impacts on zooplankton include drilling discharges from the drilling rigs, other chronic operational discharges, and oil spills. Discharges may interfere with filter-feeding organs or mechanically damage them. Ingestion of suspended inorganic particles may reduce energy intake, causing mortality of some subadult copepodite stages important in the diet of some fish larvae. Lack of ovarian development may affect the availability of copepod eggs that are vital in the diet of first-feeding larvae of many fish species. Sublethal concentrations of petroleum hydrocarbons could result in cellular and physiological changes, which could lead, at least initially, to abnormal behavior such as disruption of feeding and/or reproductive patterns.

Although quantitative data are not available, it is assumed that the abundance of grazing zooplankton would, under certain circumstances, be limited by the availability of phytoplankton as food. This could occur during periods of decreased phytoplankton availability following a phytoplankton bloom, when zooplankton may still be abundant. The impacts on zooplankton from hydrocarbon pollution effects on phytoplankton are therefore difficult to quantify. Similarly, in the absence of quantitative data, it is reasonable to assume that fish stocks would, under certain conditions, be limited by availability of zooplankton. The impacts on fish resources due to hydrocarbon pollution effects on zooplankton are therefore difficult to quantify. Causes correlated with effects cannot usually be determined in ecosystems because of the ever-present problem of proxy correlation.

Impacts on phytoplankton populations in the immediate vicinity of discharged drill muds would be minimal because of the low toxicity and quick dilution of the muds, the volume of the receiving waters, and the rapid regeneration rates of phytoplankton populations (e.g., the large dinoflagellate *Prorocentrum micans* can divide 1.3 times daily under optimum conditions) (Williams, 1973). The rapid dilution and dispersion of the drilling mud and cuttings released at the drill sites minimizes the effects on plankton further afield. Organisms proximal to permitted discharge outfalls can receive concentrations of organic materials or chemicals that are deleterious and toxic and individual plankters may be subject to lethal or sublethal effects for short periods. There would be no persistent environmental consequences, however.

An NRC (1985) summary stated that phytoplankton populations have demonstrated no mass toxic effect in the field, either from an oil spill or from chronic input conditions. This may be the result of the rapid regeneration time exhibited by algal cells (only several hours or days) and recruitment from adjacent waters. Since concentrations of hydrocarbons would not persist long enough to consistently cause lethal or sublethal toxic effects, no significant impacts on phytoplankton populations are anticipated. Contamination of sediment in shallow water may affect benthic resting spores of certain species of shallow water phytoplankton that form after the end of a stage of phytoplankton succession.

Analysis of Impacts

Exploratory drilling in the EPA sale area is projected to cause a very small increase in canal traffic within navigation channels to and from service bases from Louisiana to Alabama. This would result in some incremental, though small, erosion of wetlands along the channels, particularly in Louisiana, and minor degradation of coastal water quality in the vicinity of support bases for EPA exploration. Due to the upland and developed nature of the banks of the navigation channels that would be used in Mississippi and Alabama, little erosion is expected. Should an offshore spill of ≥1,000 bbl occur from an exploration well blowout, estuarine wetlands in the northern Chandeleur Sound area to Choctawhatchee Bay in Florida would have the highest risk (8-27%) of contact if the spill endured 10 days. Due to weathering, inlet dynamics, and higher suspended particulates in estuarine waters, it is unlikely that inland wetlands would be contacted. Should such contact occur, it would be light and localized, causing no significant wetland loss.

Besides the risk of contact from an offshore spill, Louisiana, Alabama, and Mississippi coastal waters could experience a coastal spill along their waterways from activities in support of exploratory drilling in the EPA sale area. Such spills occurring in Louisiana, Alabama, or Mississippi's coastal zone would likely result in impacts that are localized and acute and diffused in coastal waters in general. According to the USCG, 95 percent of all reported coastal spills each year are <24 bbl, so the great majority of coastal spills would likely be small and disperse quickly.

It is expected that coastal environmental degradation from exploratory drilling in the EPA sale area would have little effect on fish resources or EFH. Wetland loss and conversion to open water could occur due to a petroleum spill contacting brackish and inland areas. Recovery of fish resources or EFH can occur from more than 99 percent, but not all, of the potential coastal environmental degradation. Fish populations, if left undisturbed, will regenerate in one generation and most EFH can recuperate quickly, but the loss of wetlands as EFH is likely to be permanent. At the expected level of effect, the resultant influence on fish resources or EFH from exploratory drilling would be insignificant and indistinguishable from natural population variations.

Recovery from impacts caused by unregulated operational discharges or an accidental blowout during exploration would take place within several years. Exploration in the EPA sale area will be regulated by USEPA's Region 4 and the discharge requirements specified in USEPA NPDES individual discharge permits. In the unlikely event of an offshore spill, the biological resources of hard/live bottoms would remain unharmed as spilled oil from an exploration well blowout would be floating long before approaching any areas with sensitive live bottoms. The spilled oil would, at the most, impact the seafloor and any biota in minute concentrations. These minute quantities may cause very short-term sublethal effects (changes in physiology) in benthic organisms that would recover quickly.

Contaminant levels in the EPA sale area are low and reflect the lack of pollution sources and high-energy environment of much of this deepwater region. Bottom disturbance from drill rig anchoring or emplacement operations for exploratory drilling would only produce localized, temporary increases in resuspended sediment resulting in decreased water clarity and little reintroduction of pollutants. Given the exposure of the area to high levels of suspended sediments and the low probability that a large blowout would occur, blowouts are not expected to significantly affect future water quality. There is a low risk of any serious water quality degradation occurring from spills associated with exploratory drilling due to (1) the small size of the most likely spills, (2) the small maximum surface area that would be affected by such small spills, and (3) the ability of the spilled material to be dissipated over a fairly short time period.

The major sources of discharges associated with exploratory drilling are the discharges of drilling mud and cuttings. Mud contains various contaminants of concern (e.g., trace metals in WBF and petroleum-based organics in OBF) that may have environmental consequences on marine water quality and aquatic life. Drilling mud discharges contain chemicals toxic to marine fishes at four to five orders of magnitude greater than at diluted or disbursed concentrations. These levels are attained only within a few meters of the discharge point. Offshore discharges of drilling mud would dilute to background levels within 1,000 m of the discharge point.

It is expected that marine environmental degradation from exploratory drilling would have little effect on fish resources or EFH. The impact of marine environmental degradation is expected to contribute to an undetectable decrease in fish populations or EFH. Recovery of fish resources or EFH can occur from more than 100 percent of the potential marine environmental degradation. Fish populations, if left undisturbed, would regenerate in one generation. Offshore live bottoms would not be impacted because depths in the EPA sale area are deeper than the range for live-bottom communities protected by the Pinnacle Trend or Live Bottom (Low-Relief) Stipulations on the shelf. No live-bottom or pinnacle trend communities have been documented in the EPA sale area. Offshore discharges and subsequent changes to marine water quality will be regulated by USEPA NPDES permits. At the expected level of effect, the resultant influence on fish resources or EFH would be insignificant and indistinguishable from natural population variations.

Estimates of impacts to fish resources from petroleum spills comes from examinations of recent spills such as the *North Cape*, *Breton Point*, *Sea Empress*, and *Exxon Valdez* (Brannon et al., 1995; Maki et al., 1995; Mooney, 1996; Pearson et al., 1995). The amount of petroleum spilled by each event, and its estimated impact to fish resources, was used as a guideline to estimate the impacts on fish resources in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a; Section IV.D.1.a.(10.)). Spills that contact coastal bays, estuaries, and offshore waters from the Mississippi Delta to Cape San Blas, Florida, have the greatest potential to affect fish resources when pelagic eggs and larvae are present. If spills due to exploratory drilling were to occur in or penetrate coastal bays, estuaries, or waters of the OCS proximate to mobile adult finfish or shellfish, the spill would likely be degraded and weathered. The effects on these resources would likely be nonlethal. The extent of damage would be reduced due to the capability of adult fish and shellfish to avoid a spill, to metabolize hydrocarbons, and to excrete both metabolites and parent compounds. For eggs and larvae contacted by a spill, the effect is expected to be lethal. Non-mobile shellfish (e.g., oysters) would not be able to avoid a spill but are capable of shutting down filtering for some period of time, depending on the water temperature and other environmental conditions.

Spills could occur at onshore support bases from Louisiana to Alabama that support exploratory drilling. However, there is a small risk of spills occurring during shore-based support activities (USDOI, MMS, 2001a; Section IV.B.2.e.(1)). According to the USCG, 95 percent of all reported coastal spills each year are <24 bbl, so the great majority of coastal spills would likely be small and disperse quickly (USDOT, CG, 1997). All of these possible incidents would occur at or near the shore base. The effect of petroleum spills on fish resources and EFH as a result of exploratory drilling is expected to cause less than a 1 percent decrease in fish resources or standing stocks of any fish population. At the expected level of impact, the resultant influence on fish populations within or in the general vicinity of the EPA sale area would be insignificant and indistinguishable from natural population variations.

Subsurface blowouts of exploration wells have the potential to adversely affect fish resources. It is expected that subsurface blowouts that may occur as a result of exploratory drilling would have a negligible effect on fish resources of the Gulf. Fish populations that come into contact with spilled oil are expected to avoid the area, be unaffected by it, or recover to undisturbed levels in one generation. At the expected level of impact, the resultant influence on fish resources and EFH would be insignificant and indistinguishable from natural population variations.

Because concentrations of mud discharge or spilled oil would not persist long enough to consistently cause lethal or sublethal toxic effects to phytoplankton or zooplankton, no significant impacts on these populations are anticipated. Drilling mud discharges contain chemicals toxic to marine fishes at four to five orders of magnitude greater than in diluted or disbursed concentrations. These levels are attained only within a few meters of the discharge point. Offshore discharges of drilling mud would dilute to very near background levels within 1,000 m of the discharge point and have an insignificant effect on fish resources in the EPA sale area.

Summary and Conclusion

It is expected that coastal and marine environmental degradation from exploratory drilling in the EPA sale area would have little effect on fish resources or EFH. The impact of coastal and marine environmental degradation is expected to cause an unmeasurable decrease in fish resources or in EFH. Recovery of fish resources and EFH can occur from more than 99 percent, but not all, of the expected coastal and marine environmental degradation. Fish populations, if left undisturbed, would regenerate in one generation. Loss of wetlands as EFH, if it occurs, is expected to be permanent. No long-term effects on the size or productivity of any fish species or economic population stock in the GOM are expected.

Offshore live bottoms would not be impacted. None are documented within the EPA sale area. Offshore discharges and subsequent changes to marine water quality will be regulated by USEPA NPDES permits. At the expected level of impact, the resultant influence on fish resources and EFH would be insignificant and indistinguishable from natural population variations.

Activities such as subsurface exploration well blowouts and discharge of drilling muds would cause insignificant impacts and would not deleteriously affect fish resources or EFH. At the expected level of impact, the resultant influence on fish resources would cause less than a 1 percent change in fish populations or EFH. As a result, there would be little disturbance to fish resources or EFH. It would require one generation for fish resources to recover from 99 percent of the impacts. Recovery from habitat loss due to the loss of wetlands would not occur.

4.3.2.9. Impacts on the Gulf Sturgeon

Existing occurrences of Gulf sturgeon in 1996 extended from the Mississippi River to Charlotte Harbor in western Florida (Patrick, personal communication, 1996). The Gulf sturgeon is listed as endangered. Spawning has been documented in most of the major river systems of the fish's range. Oil spills resulting from the blowout of an exploration well is the most likely and significant impact on the Gulf sturgeon. Oil can affect Gulf sturgeon through direct ingestion or ingestion of oiled prey or by the absorption of dissolved petroleum products through the gills. Upon any exposure to spilled oil, liver enzymes of adult fish oxidize soluble hydrocarbons into compounds that are easily excreted in the urine

(Spies et al., 1982). Behavior studies of other fish species suggest that adult sturgeon are likely to actively avoid an oil spill, thereby limiting the effects and lessening the extent of damage (Baker et al., 1991; Malins et al., 1982).

Analysis of Impacts

The major impact-producing factors analyzed below are related to the exploration activities and include oil spills. Contact with or ingestion/absorption of spilled oil can result in death or nonfatal physiological irritation, especially of gill epithelium and liver function in adult Gulf sturgeon. No long-term effects are expected on the size or productivity of any distinct interbreeding Gulf sturgeon population stock in the GOM.

No coastal spills ≥1,000 bbl are estimated to occur. According to the USCG, 95 percent of all reported coastal spills each year are <24 bbl, so the great majority of coastal spills would likely be small and disperse quickly.

Summary and Conclusion

The Gulf sturgeon could be impacted by oil spills resulting from exploratory drilling. The likelihood of a spill from an exploration well blowout of a size and duration to persist long enough in the environment to oil the sturgeon's estuarine habitats is very small. Contact with oil spills could cause the fish to temporarily migrate from the affected area and could cause nonfatal irritation of gill epithelium and an increase of liver function in a few adults that are nonlethal.

4.3.2.10. Impacts on the Smalltooth Sawfish

Fishing and habitat alteration and degradation in the past century have reduced the U.S. population of the smalltooth sawfish (USDOC, NMFS, 2000). At present, the smalltooth sawfish is primarily found in southern Florida in the Everglades and Florida Keys. Historically, this species was common in neritic and coastal waters of Texas and Louisiana. Many records of the smalltooth sawfish were documented in the 1950's and 1960's from the northwestern Gulf in Texas, Louisiana, Mississippi, and Alabama. Since 1971, however, there have been only three published or museum reports of the species captured in the region, all from Texas (1978, 1979, and 1984). Additionally, reports of captures have dropped dramatically. Louisiana, an area of historical localized abundance, has experienced marked declines in sawfish landings. The lack of smalltooth sawfish records since 1984 from the area west of peninsular Florida is a clear indication of their rarity in the northwestern Gulf.

Analysis of Impacts

The most serious potential impacts to the smalltooth sawfish from exploration activities would arise from accidental oil spills. Contact with or ingestion/absorption of spilled oil can result in death or nonlethal physiological irritation of gill epithelium and liver function. No long-term effects on the size or productivity of interbreeding smalltooth sawfish population stocks in the GOM are expected; however, the locations or behavior of interbreeding populations are poorly understood.

No coastal spills ≥1,000 bbl are estimated to occur. According to the USCG, 95 percent of all reported coastal spills each year are <24 bbl, so the great majority of coastal spills near OCS shore bases in Louisiana, Mississippi, and Alabama would likely be small and disperse quickly. The subsurface ecosystem with prey and feeding habitat for sawfish would have little chance to contact a surface slick, emulsified oil, or chemically dispersed oil even in shallow water.

The impact from spilled oil is expected to be negligible because the sawfish's known current range is in coastal southern Florida. Occurrence of the sawfish or displacement of individuals from the area of the exploration activities is not expected, because the current population is primarily found in the Everglades and Florida Keys. Therefore, the most likely impact to these rare animals is expected to be negligible.

Summary and Conclusion

The smalltooth sawfish could be impacted by oil spills resulting from exploratory drilling. The likelihood of a spill from an exploration well blowout of a size and duration to persist long enough in the environment to oil the sawfish's coastal habitats of south Peninsular Florida is very small. Contact with oil spills could cause the fish to temporarily migrate from the affected area and could cause nonfatal irritation of gill epithelium and an increase of liver function in adults coming into contact with spilled oil.

4.3.2.11. Impacts on Coastal and Marine Birds

This chapter discusses the possible effects of exploratory drilling in the EPA sale area on coastal and marine birds of the GOM and its contiguous waters and wetlands. Major, potential impact-producing factors for marine birds in the offshore marine environment include air emissions, oil spills, oil-spill response activities, degradation of water quality, helicopter and service-vessel traffic and noise, and discarded trash and debris from exploration structures or from service vessels. Any effects are especially critical for intensively managed populations. For example, endangered and threatened species may be harmed by any impact on viable reproductive population size or disturbance of a few key habitat factors.

The major effects of air pollution include direct mortality, debilitating injury, disease, physiological stress, anemia, hypocalcemic condition, bioaccumulation of air pollutants with associated decrease in resistance to debilitating factors, and population declines (Newman, 1979). Contamination of wildlife by air emissions can occur in three ways: inhalation, absorption, and ingestion. Inhalation is the most common mode of contamination for birds (Newman, 1980). Direct effects can be either short-term and acute, such as sudden mortality from hydrogen sulfide, or long-term and chronic, such as fluorosis from fluoride emissions. The magnitude of effect, acute or chronic, is a function of the contaminant, its ambient concentration, pathway of exposure, duration of exposure, and the age, sex, reproductive condition, nutritional status, and health of the animal at the time of exposure (Newman, 1980). For metals in air emissions, chemical composition as well as size of particulate compounds has been shown to influence the toxicity levels in animals. Particulate size affects retention time and clearance from and deposition in the respiratory tract (Newman, 1981).

Levels of sulphur oxide (mainly sulphur dioxide, SO_2) emissions from hydrocarbon combustion from OCS-related activities are of concern for birds. Research specific to birds has elucidated both short-term acute and chronic effects from SO_2 inhalation (Fedde and Kuhlmann, 1979; Okuyama et al., 1979). Due to their lack of tracheal submucosal glands, birds appear to have more tolerance for inhaled SO_2 than most mammals (Llacuna et al., 1993; Okuyama et al., 1979). This suggestion stems from laboratory investigations where the test subject was the domestic chicken. Acute exposure of birds to 260 $\mu g/m^3$ SO_2 produced no alteration in heart rate, blood pressure, lung tidal volume, respiratory frequency, arterial blood gases, or blood pH. Exposure to 1,300 $\mu g/m^3$ SO_2 increased respiratory mucous secretion, and exposure to 13,000 $\mu g/m^3$ SO_2 caused rapid mortality (Fedde and Kuhlmann, 1979). Chronic (two weeks) exposure of birds to 8.8 $\mu g/m^3$ SO_2 produced no apparent impact and very little change at the cellular level. Chronic exposure to 48 $\mu g/m^3$ SO_2 resulted in cellular changes characteristic of persistent bronchitis (Okuyama et al., 1979).

The indirect effects of air emissions on wildlife include food web contamination and habitat degradation, as well as adverse synergistic effects of air emissions with natural and other manmade stresses. Air emissions can cause shifts in trophic structure that alter habitat structure and change local food supplies (Newman, 1980).

Air pollutants may cause a change in the distribution of certain bird species (e.g., Newman, 1977; Llacuna et al., 1993). Migratory bird species will avoid potentially suitable habitat in areas of heavy air pollution in favor of cleaner areas if available (Newman, 1979). The abundance and distribution of passerine birds, both active and sedentary, and migratory species, as well as nonpasserine and nonmigratory varieties, are also greatly affected by natural factors such as weather and food supply. Therefore, any reduction in the numbers of birds within a given locale does not have a diagnostic certainty pointing to air emissions (Newman, 1980).

Oil spills pose the greatest potential impact to coastal and marine birds. Pneumonia is not uncommon in oiled birds and can occur when birds, attempting to clean their feathers through preening, inhale droplets of oil. Exposure to oil can cause severe and fatal kidney damage (reviewed by Frink, 1994). Ingestion of oils might reduce the function of the immune system and, thus, reduce resistance to infectious diseases (Leighton, 1990). Ingested oil may cause toxic destruction of red blood cells and varying degrees of anemia (Leighton, 1990). Stress and shock enhance the effects of exposure and poisoning. It is not clear which, if any, of the pathological conditions noted in necropsies are directly caused by petroleum hydrocarbons or are a final effect in a chain of events with oil as the initiating cause followed by generalized stress resulting as an intermediate effect (Clark, 1984). Low levels of oil could stress birds by interfering with food detection, feeding impulses, predator avoidance, territory definition, homing of migratory species, susceptibility to physiological disorders, disease resistance, growth rates, reproduction, and respiration.

If physical oiling of individuals or local groups of birds occurs, some degree of both acute and chronic physiological stress associated with direct and secondary uptake of oil would be expected. Raptors, such as the bald eagle and peregrine falcon, feed upon weakened or dead birds (and fish, in the case of the eagle) and as a result may become physically oiled or affected by the ingestion of the oiled prey. Pelicans are active swimmers and plunge dive for prey. They are therefore susceptible to both physical oiling and secondary effects via ingestion of oiled prey fish. Plovers can physically oil themselves while foraging on oiled shores or secondarily contaminate themselves through ingestion of oiled intertidal sediments and prey. The least tern captures fish by means of shallow splash diving and surface dipping techniques. Some physical oiling could occur during these dives, as well as secondary toxic effects through the uptake of prey. It is possible that some death of endangered/threatened (as well as nonendangered and nonthreatened) species could occur, especially if spills occur during winter months when raptors and plovers are most common along the coastal Gulf or if spills contact preferred or critical habitat. Small coastal spills, pipeline spills, and spills resulting from accidents in navigation waterways can contact and affect many of the different groups of coastal and marine birds, most commonly marsh birds, waders, waterfowl, and certain shorebirds. Some bird deaths from these groups are to be expected. Recruitment through successful reproduction is expected to take one or more growing seasons or generations, depending upon the species and existing conditions.

Many of these birds are merely oil-stained as a result of their foraging behaviors (Vermeer and Vermeer, 1975). Birds can ingest oil when feeding on contaminated food items or drinking contaminated water. Oil contamination can affect prey upon which birds depend. Prey populations after the 1990 *Arthur Kill* spill on the south coast of New York had not returned to normal a year after the spill.

Geese and herbivorous ducks feed at a lower trophic level than the other species of waterbirds and may not suffer damaging effects when oil is biomagnified, or at least not to the same degree (Maccarone and Brzorad, 1994). However, they still may have encountered lower food availability, owing to the localized destruction of aquatic vegetation. Birds, such as ibises, that sift through mud and other sediments for small invertebrates may be exposed to high toxin levels in the invertebrates (Maccarone and Brzorad, 1994). Chapman (1981) noted that oil on the beach from the 1979-1980 *Ixtoc* spill caused habitat shifts by the birds. Many birds had to feed in less productive feeding habitats. Similar observations were made for wading birds after the *Arthur Kill* spill (Maccarone and Brzorad, 1995). Composition of prey populations changed after the spill. Shoreline vegetation may die after prolonged exposure to water contaminated with oil. Lush vegetation helps to conceal sparsely placed nests and their contents from potential predators. With destruction of vegetation, aerial predators may have easier access to eggs and chicks (Maccarone and Brzorad, 1994). Population recovery following destruction of a local breeding colony or a large group of wintering migrants would likely be slow for many species because of their inherently low reproductive potential and/or distance to neighboring colonies, which may act as refugia by attracting recruits (Cairns and Elliot, 1987; Trivelpiece et al., 1986; Samuels and Ladino, 1983/1984). For many coastal and marine species, spills may delay the maturation and reproduction process in juveniles, and this could cause a decrease in reproductive success for at least one season (Butler et al., 1988). Disruption of pair bonds and altered cycles of reproductive hormones might also affect reproductive success (Leighton, 1990).

Oil-spill cleanup methods often require heavy trafficking of beaches and wetland areas, application of oil dispersant and bioremediation chemicals, and the distribution and collection of oil containment booms and absorbent material. The presence of humans, along with boats, aircraft, and other technological creations, will also disturb coastal birds after a spill. Investigations have shown that oil-dispersant mixtures pose a threat similar to that of oil to successful reproduction in birds (Albers, 1979; Albers and Gay, 1982). The external exposure of adult birds to oil/dispersant emulsions may reduce chick survival more than exposure to oil alone would; however, successful dispersal of a spill will generally reduce the probability of exposure of coastal and marine birds to oil (Butler et al., 1988). It is possible that changes in size of an established breeding population may also be a result of disturbance in the form of increased human activity for cleanup and monitoring efforts or to the intensified research activity after the oil spills (Maccarone and Brzorad, 1994). Studies are indicating that rescue and cleaning of oiled birds makes no effective contribution to conservation, except conceivably for species with a small world population

(Clark, 1978 and 1984). A growing number of studies indicate that current rehabilitation techniques are not effective in returning healthy birds to the wild (Anderson et al., 1996; Boersma, 1995; Sharp, 1995 and 1996). Preventative methods, such as scaring birds from the path of an approaching oil slick or the use of booms to protect sensitive colonies in an emergency, have extremely limited applicability (Clark, 1984).

The transportation or exchange of supplies, materials, and personnel between coastal infrastructure and offshore oil and gas structures is accomplished with helicopters, aircraft, and boats and a variety of service vessels. Major concerns are short-term intense aversion, and panic following a bird's collision with human-made structures such as power lines. Disturbances from helicopter or service-vessel traffic on coastal birds can result from the mechanical noise or physical presence (or wake) of the vehicle. The degree of disturbance exhibited by groups of coastal birds to the presence of air or vessel traffic is highly variable, depending upon the bird species in question, type of vehicle, altitude or distance of the vehicle, the frequency of occurrence of the disturbance, and the season. Helicopter and service-vessel traffic supporting exploration activities could sporadically disturb feeding, resting, or nesting behavior. Disturbance can also lead to permanent desertion of active nests or of critical or preferred habitat, which could contribute to the relocation of a species or group to less favorable areas or to a decline of species through reproductive failure resulting from nest abandonment. When birds are flushed prior to or during migration, the energy cost could be great enough that they might not reach their destination, or they may be more susceptible to diseases (Anderson, 1995). Waterfowl are more overtly responsive to noise than other birds and seem particularly responsive to aircraft, possibly because aerial predators frequently harass them (Bowles, 1995). The FAA and corporate helicopter policy advise helicopters to maintain a minimum altitude of 700 ft while in transit offshore and 500 ft while working between platforms. When flying over land, the specified minimum altitude is 1,000 ft over unpopulated areas or across coastlines and 2,000 ft over populated areas and biologically sensitive areas such as wildlife refuges and national parks. Many undisturbed coastal areas and refuges provide preferred and/or critical habitat for feeding, resting (or staging), and nesting birds. The effect of low-flying aircraft within the vicinity of aggregations of birds on the ground or on the water typically results in mass disturbance and abandonment of the immediate area. However, pilots traditionally have taken great pride in not disturbing birds. Compliance to the specified minimum altitude requirements significantly reduces effects of aircraft disturbance on coastal and marine birds. Routine presence of aircraft at sufficiently high altitudes results in acclamation of birds to routine noise. As a result of inclement weather, about 10 percent of helicopter trips would occur at altitudes somewhat below the minimums listed above. Although these incidents are very short term in duration and sporadic in frequency, they can disrupt coastal bird behavior and, at worst, possibly result in habitat or nest abandonment. Birds in flight over water typically avoid helicopters. Low-flying aircraft may temporarily disrupt feeding or flight paths. Routine presence and low speeds of service vessels within inland and coastal waterways would diminish the effects of disturbance from service vessels on nearshore and inland populations of coastal and marine birds. Birds can lose eggs and young when predators attack nests after parents are flushed into flight by service vessel noise.

The greatest negative impact to coastal and marine birds is loss or degradation of preferred or critical habitat. The extent of bird displacement resulting from habitat loss is highly variable between different species, based upon specific habitat requirements and availability of similar habitat in the area. Generally, destruction of habitat from OCS pipeline landfalls and onshore construction displaces localized groups or populations of these species. As these birds move to undisturbed areas of similar habitat, their presence augments habitat utilization pressure on these selected areas as a result of intra- and interspecific competition for space and food. Coastal and marine birds are highly susceptible to entanglement in floating, submerged, and beached marine debris; specifically in plastics discarded from both offshore sources and land-derived litter and waste disposal (Heneman and the Center for Environmental Education, 1988). Interaction with plastic materials is therefore very serious and can lead to permanent injuries and death. Studies in Florida reported that 80 percent of brown pelicans showed signs of injury from entanglement with fishing gear (Clapp and Buckley, 1984). In addition, seabirds ingest plastic particles and other marine debris more frequently than do any other taxon (Ryan, 1990). Interaction with plastic materials is therefore very serious and can lead to permanent injuries and death. Ingested debris may have three basic effects on seabirds: irritation and blockage of the digestive tract, impairment of foraging efficiency, and release of toxic chemicals (Ryan, 1990; Sileo et al., 1990a). Long-term effects of plastic ingestion may include physical deterioration due to malnutrition; plastics often cause a distention of the stomach, thus preventing its contraction and simulating a sense of satiation

(Ryan, 1988). Some birds also feed plastic debris to their young, which could reduce survival rates. The chemical toxicity of some plastics can be high, posing a significant hazard in addition to obstruction and impaction of the gut (Fry et al., 1987). Sileo et al. (1990b) found that the prevalence of ingested plastic found within the gut of examined birds varied greatly among species. Those species that seldom regurgitate indigestible stomach contents are most prone to the aforementioned adverse effects (Ryan, 1990). Within the GOM, these include the phalaropes, petrels, storm petrels, and shearwaters. It is expected that coastal and marine birds will seldom become entangled in or ingest OCS-related trash and debris as a result of MMS prohibitions on the disposal of equipment, containers, and other materials into offshore waters by lessees (30 CFR 250.40). In addition, MARPOL, Annex V, Public Law 100-220 (101 Statute 1458), which prohibits the disposal of any plastics, garbage, and other solid wastes at sea or in coastal waters, went into effect January 1, 1989, and is enforced by the U.S. Coast Guard.

Analysis of Impacts

Emissions of pollutants into the atmosphere from the activities associated with the exploration activities would have minimum effects on offshore and onshore air quality because of the prevailing atmospheric conditions, emission heights and rates, and pollutant concentrations. Such emissions would have negligible effects on onshore air quality. Average steady state conditions are the basis for these judgments. However, there will be days of low mixing heights, low wind speeds, and low-pressure systems (winter storms) that could further decrease air quality. These conditions are characterized by fog formation, which in the Gulf occurs about 35 days a year, mostly during winter. Impacts from offshore sources of pollutants are reduced in winter and the removal of pollutants by rain increases. The summer is more conducive to air quality effects as onshore wind flow occurs more frequently, approximately 61 percent of the time. Estimated increases in onshore annual average concentrations of NO_x, SO_x, and TSP would be <1 microgram/m^3 per the modeled steady state concentrations. These concentrations are less than the allowable Class I PSD increments for those particular pollutants and are far below concentrations that could harm coastal and marine birds.

The number of spills estimated to occur within coastal waters from the Gulfwide OCS Program activities is shown in Table IV-39 of the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a). No coastal spills ≥1,000 bbl are estimated to occur. Coastal spills could contact habitats of marine and coastal birds and result in some degradation of that habitat. For example, spoil banks that provide nesting for flocks of pelicans and feeding habitats for congregations of plovers could be affected by such spills.

Small spills are expected to pose impacts to only aquatic seabirds as these spills are not expected to persist for very long or to contact coastal waters or the shoreline. A small spill would affect only seabirds in the immediate vicinity of the spill and would likely not attract birds nearby. The estimated number of spills of ≤1 bbl would create scattered, temporary disturbance to small numbers of birds or have no impact at all. A spill of 17 bbl would spread and dissipate rapidly, and would be cleaned up in light or moderate seas using technologically current equipment. In heavy seas the slick would be dissipated, dissolved, and vaporized by wave action. An offshore spill ≥50 bbl and <1,000 bbl, estimated to be 160 bbl, would displace or oil offshore birds in a broad area after spreading out into a slick of about 0.01-0.1 mm thick. Wave action would likely fragment the slick and surface currents would widely disperse it, if it were not to make landfall within a few days.

The subsurface ecosystem with prey for some water birds would have little contact with a slick floating overhead, even in shallow water, unless the slick was emulsified into the water column by chemical dispersants or dissipated in heavy seas. However, birds would have to penetrate the oil slick and get oiled to reach prey below. The magnitude of bird mortality following an oil spill would depend on (1) the size of the local bird population (often a function of season), (2) foraging behavior(s), (3) whether or not the population is aggregated or dispersed into smaller subunits at the time of the spill, (4) the quantity of oil spilled, and (5) its persistence in the environment (NRC, 1985).

The extent to which the oil affects a bird differs according to the species. The range of effects are (1) the time of the bird's life stage when contact occurs, (2) the type of petroleum product involved, (3) the amount of time between the release of the oil, (4) its contact with the bird (the degree of weathering of that oil), and (5) the length of contact with that oil (Maccarone and Brzorad, 1994). The birds most vulnerable to direct effects include those species spending most of their time swimming on and under the sea surface and often living in dense flocks (Piatt et al., 1990; Vauk et al., 1989). This group includes loons, grebes, sea ducks and pochards, and cormorants.

The potential causes, sizes, and probabilities of oil spills that could occur during exploratory drilling are discussed in Chapter 4.2.7 (Accidental Events). Spills <50 bbl from exploration activity in the EPA sale area are expected to occur. Blowouts resulting in spills ≥1,000 bbl are not expected based on historical rates of occurrence and the number of wells that constitute the duration of exploration activity. Spills >50 bbl are expected to occur very infrequently. Given these numbers and expected duration of any impacts, spills from exploratory drilling in the EPA sale area would be degraded if they remain at sea long enough to make contact with shoreline environments with bird populations or preferred habitat. An offshore spill would have to reach shore to impact shorebirds, marsh birds, and wading birds. Crude oil reaching low-salinity areas may affect estuarine waterfowl. Coastal birds, including shorebirds, waders, marsh birds, and certain waterfowl, may be the hardest hit by oil spills indirectly through destruction of their feeding habitat and/or food source when oil accumulates at the shoreline.

Sensitive species include the endangered piping plover and the southeastern snowy plover. Both species have a large number of nests per 160 km (100 mi) in the eastern part of the area of Lease Sale 181 (Florida Panhandle; Fort Walton Beach to Apalachicola and Panama City to Apalachicola, respectively).

As for shorebirds, wading birds are very common on the vulnerable parts of the shoreline. It is assumed that land between Plaquemines Parish, Louisiana, and Bay County, Florida, represent the primary shoreline area vulnerable to oil spills that could occur from exploratory drilling. The OSRA results show that this shoreline stretch exhibits probabilities of being contacted by an OCS oil spill that are greater than 5 percent. Wading birds use more than 20 percent of the available shoreline vulnerable to oil spills. Diving birds and waterfowl use almost all of the available shoreline vulnerable to oil spills. However, these birds do not nest along this shoreline. Passerines are almost nonexistent in this area. Pelagic birds usually nest on oceanic islands and none of their nests were found in the area. However, the birds used 25-75 percent of the available shoreline for non-nesting habitat. Alcids were not located anywhere in the EPA sale area. Gulls and terns were abundant almost everywhere, nest in abundance along the coast, and could easily absorb local mortality from spill events. Many raptors require open land or open water to hunt, and raptors range across 70-100 percent of available shoreline for the vulnerable stretch identified above. The only raptor nests along land segments 22-29 were five in land segment 29. Data on eagles' nests in Louisiana are available as counts per parish rather than per land segment. Counts of nests for coastal parishes are 0 for Cameron, 15 for St. Mary, 2 for Jefferson, 0 for Vermilion, 51 for Terrebonne, 1 for Plaquemines, and 2 for Iberia (Shiveley, personal communication, 2000).

Expected degradation of coastal and estuarine water quality resulting from exploration activity discharges in the EPA sale area would be insignificant because of the distance between the sale area and these resources and tremendous dilution factors. Coastal and marine birds that feed exclusively within these locations would experience no more chronic, or nonfatal, physiological stress to which they were already subject. Changes in reproductive success would be indistinguishable from natural population variations. Seabirds (e.g., laughing gulls) that remain and feed in the vicinity of offshore drilling rigs could be affected by operational discharges or runoff in the offshore environment

Approximately 684-4,380 helicopter round trips would be needed to support the number of exploration wells (38-73) projected for the EPA sale area. Helicopter traffic would periodically disturb coastal and marine birds but adhering to FAA and corporate helicopter protocol on service altitudes would minimize the most disturbing fly-over episodes.

Approximately 1,300-3,900 service-vessel trips would be needed to support the projected total number of exploration wells (38-73) projected for the EPA sale area. Service vessels supporting exploratory drilling would use selected nearshore and coastal (inland) navigation waterways, or corridors, and adhere to protocol set forth by the USCG for reduced vessel speeds within these inland areas. Service-vessel traffic would seldom disturb populations of coastal and marine birds existing within these coastal waterways. The effects of service-vessel traffic that support exploratory drilling on offshore birds would be insignificant.

It is expected that plastic debris and trash originating from exploratory drilling or any supporting activities will be minimized by MMS's trash-packaging requirements and will seldom interact with coastal and marine birds; therefore, the effect would be insignificant.

Summary and Conclusion

Activities resulting from exploratory drilling activity may affect endangered/threatened and nonendangered/nonthreatened coastal and marine birds. It is expected that the majority of effects from the major impact-producing factors on coastal and marine birds would be sublethal (behavioral effects and nonfatal exposure to or intake of OCS-related contaminants or discarded debris), causing temporary disturbances and displacement of localized groups inshore. Chronic sublethal stress, however, is often undetectable in birds. As a result of stress, individuals may weaken (an impact especially serious for migratory species), facilitating infection and disease. Lethal effects could result primarily from a major offshore oil spill and associated spill-response activities, and are especially serious for an endangered/threatened species where any reduction in population size represents a threat to its existence. No long-term effects are expected on the size or productivity of threatened or endangered coastal or marine bird species or breeding stock in the GOM.

The potential for a large oil spill ≥1,000 bbl originating from an exploration well blowout in the EPA sale area is very small, and the chance for a smaller spill remaining intact long enough to reach landfall is also small. A spill contacting a biologically sensitive area could kill a number of individuals from any or all groups of birds. The net effect would be the alteration of the species composition of the affected area and possibly the reduction of the overall carrying capacity of the area. Recovery of affected habitat could take up to several years.

4.3.2.12. Impacts on Areas of Special Biological Concern

Five areas of special biological concern are addressed in this SEA because they are listed as environmental resources with a probability of contact (within 30 days) should an oil spill resulting from an accidental blowout occur during drilling. The probability that an oil spill ≥1,000 bbl would occur in the EPA sale area and contact any of these areas is <0.5 percent.

The Florida Keys National Marine Sanctuary (FKNMS) lies more than 345 mi (555 km) from the EPA sale area. The location of the sanctuary on the southern tip of the Florida coast is so distant that there is no credible likelihood of impact.

The minimum water depth of the Florida Middle Ground (FMG) is about 23 m, which would tend to insulate this environment from the effects of an oil spill on the surface. Similar to the FMG, the special management areas that protect fish spawning sites (Madison/Swanson and Steamboat Lumps) are in water 70-100 m deep and would not be impacted by oil spills on the sea surface.

Oil spills would affect the Big Bend Seagrass Aquatic Preserve (BBSAP) in the same manner as an oil spill or spill-response activities would affect other submerged seagrass habitats; however, these habitats are not closer than approximately 140 mi (225 km) from the EPA sale area.

Analysis of Impacts

Oil spills or spill-response activity would affect the seagrass communities in the BBSAP in the same manner as other submerged seagrass habitats described in Chapter 4.3.1.2 (Impacts on Wetlands and Seagrass Communities). Considering the distances of the BBSAP from the EPA sale area and the weathering that would occur to any oil spilled from exploration activity, the likelihood that any measurable impact would be discerned is remote if a spill made landfall in the BBSAP. No significant impacts are likely to occur to the FMG, the fisheries management areas, and the FKNMS. These areas are not shoreline habitats, and oil slicks would not likely impact them. In addition, the distances between them and the exploration activity that would take place in the EPA sale area are substantial.

Summary and Conclusion

Distance from the EPA sale area to all of the areas of special biological concern are sufficient to conclude that no significant impacts resulting from exploratory drilling and well testing would occur.

4.3.3. Socioeconomic and Human Resource Impact Analysis

4.3.3.1. Impacts on Commercial Fisheries

Effects on commercial fishing from activities associated with exploratory drilling in the EPA sale area could result from underwater OCS obstructions, drilling mud discharges, and subsurface blowouts that result in petroleum spills. Healthy fishery stocks depend on EFH. The EFH constitutes the waters and substrate necessary for fish to spawn, breed, feed, and grow to maturity. Due to the wide variation of habitat requirements for all life history stages for species in the EPA, EFH for the GOM includes all coastal and marine waters and substrates as described in Chapter 4.3.1.2 (Impacts on Water Quality), from the shoreline to the seaward limit of the EEZ. The adverse impacts on coastal EFH and marine EFH are called coastal and marine environmental degradation in this analysis.

Since many of the commercial species harvested within the EPA are estuary dependent, coastal environmental degradation resulting from exploratory drilling, although indirect, has the potential to adversely affect commercial fisheries. The environmental deterioration and effects on commercial fisheries result from the loss of Gulf wetlands and coastal estuaries as nursery habitat and from the functional impairment of existing habitat through decreased water quality (Chambers, 1992; Stroud, 1992).

Wetlands and estuaries within Louisiana, Mississippi, Alabama, and the Florida Panhandle from Escambia to Gulf County may be affected by activities resulting from exploration activity. These activities include vessel usage and maintenance of navigation channels and access canals, inshore disposal of OCS exploration wastes, and spills from offshore exploration activities. Water quality in coastal waters along the Gulf may also be altered by trash, discharges, and runoff. Spills may be released from exploration drill rigs and support-vessel traffic. Since many of the commercial species harvested within the EPA are dependent on offshore water, marine environmental degradation resulting from exploratory drilling, although indirect, has the potential to adversely affect commercial fisheries. Impact-producing factors that could affect commercial fisheries include drill rig anchoring and emplacement, operational offshore waste discharges, and blowouts.

Impact-producing factors that could result in water quality degradation from routine offshore exploration activities include drill rig and platform installation and removal, and the discharge of operational wastes. Offshore accidents including blowouts and spills from platforms, and service vessels could also occur and potentially alter offshore water quality. The surface area occupied by structures, anchor cables, and safety zones associated with exploratory drilling would be unavailable to commercial fishermen and could cause space-use conflicts. Exploration drilling rigs would spend approximately 30-150 days on site and would cause short-lived interference to commercial fishing. A semisubmersible exploration drill rig in deeper water requires as much as 5 ha (12.3 ac) of navigation safety zone.

Underwater obstructions resulting from exploratory drilling are relatively minor. They present a problem only when an exploration well has been temporarily abandoned and is left with a casing stub or other wellhead equipment exposed at the sea bottom. Obstructions could also be created by accidental equipment or material losses overboard during exploration. Water depths in the EPA sale area are deep enough so that no problems would be caused by sea-bottom obstructions.

Chronic, low-level pollution is a persistent and recurring event resulting in frequent but nonlethal physiological irritation to those resources that lie within the range of impact and that are likely to be adversely affected by the pollution. The geographic range of the contaminant depends on the mobility of the resource, the characteristics of the contaminant, and the tolerance of the resource to the contaminant in question. Drilling muds contain materials, such as lead and cadmium, that in high concentrations are toxic to commercial fishery resources. Drilling mud discharges contain chemicals toxic to marine fishes at four to five orders of magnitude greater than at diluted or disbursed concentrations. These levels are attained only within a few meters of the discharge point. The plume disperses rapidly and is very near background levels at a distance of 1,000 m, and usually undetectable at distances greater than 3,000 m.

There is no evidence at this time that commercial fisheries in the Gulf have been adversely affected on a regional population level by spills or chronic contamination. The direct effects of spilled petroleum on fish occur through the ingestion of hydrocarbons or contaminated prey, through the uptake of dissolved petroleum products through the gills and epithelium by adults and juveniles, and through the death of eggs and decreased survival of larvae (NRC, 1985). Upon exposure to spilled petroleum, liver enzymes of fish oxidize soluble hydrocarbons into compounds that are easily excreted in the urine (Spies et al., 1982). When contacted by spilled hydrocarbon, floating eggs and larvae, with their limited mobility and physiology, and most juvenile fish are killed (Linden et al., 1979; Longwell, 1977). Ordinary environmental stresses may increase the sensitivity of fish to petroleum toxicity. These stresses may include changes in salinity, temperature, and food abundance (Evans and Rice, 1974; NRC, 1985). Adult fish must experience continual exposure to relatively high levels of hydrocarbons over several months before secondary toxicological compounds that represent biological harm are detected in the liver (Payne et al., 1988). Adult fish are likely to actively avoid a diesel spill, thereby limiting the effects and lessening the extent of damage (Baker et al., 1991; Malins et al., 1982; Maki et al., 1995).

The effects on and the extent of damage from a petroleum spill to Gulf commercial fisheries are restricted by time and location. Spills that contact coastal bays and estuaries of the OCS when pelagic eggs and larvae are present have the greatest potential to affect commercial fishery resources. Migratory species, such as mackerel, cobia, and crevalle, could be impacted if a spill contacts nearshore open waters. A spill contacting a low-energy inshore area would affect localized populations of commercial fishery resources, such as menhaden, shrimp, and blue crabs. Chronic petroleum contamination in an inshore area would affect all life stages of a localized population of a sessile fishery resource such as oysters. Boat rental, charter boat services, and bait suppliers are likely to be affected by a large or prolonged spill that steers fishermen away from an area.

For an exploration blowout in the EPA sale area to have an effect on a commercial fishery resource, whether estuary dependent or not, eggs and larvae would have to be abnormally concentrated in the immediate spill area (Pearson et al., 1995). Hydrocarbon components also would have to be present in highly toxic concentrations when both eggs and larvae are in the pelagic stage (Longwell, 1977).

Exploration well blowouts can resuspend sediments, and the loss of well control can release varying amounts of hydrocarbons into the water column (USDOI, MMS, 1987). Resuspended sediments may clog gill epithelia of both commercial finfish and shellfish with resultant smothering. Settlement of resuspended sediments may directly smother invertebrates or cover burrows of commercially important shellfish. Sandy sediments are quickly redeposited within 400 m (1,300 ft) of the blowout site and finer sediments are widely dispersed and redeposited over a period of 30 days or longer within a few thousand meters. Released hydrocarbons are diluted to background levels within a few thousand meters of the blowout site and degrade quickly without major biological effect. Gas-well blowouts are even less of an environmental hazard, resulting in little resuspended sediments and increased levels of natural gas for a few days very near the source of the blowout. Loss of gas-well control does not release liquid hydrocarbons into the water. Natural gas consists mainly of methane, which rapidly disperses upward into the air (Van Buuren, 1984).

Analysis of Impacts

The estimates of impacts to commercial fishing from petroleum spills comes from examinations of recent spills such as the *North Cape*, *Breton Point*, *Sea Empress*, and *Exxon Valdez* (Brannon et al., 1995; Maki et al., 1995; Mooney, 1996; Pearson et al., 1995). The amount of petroleum spilled by each event and its estimated impact to commercial fishing activities was used as a guideline to estimate the impacts to commercial fishing from spilled oil.

Spills that may occur as a result of exploratory drilling in the EPA sale area have the potential to affect commercial fishing in the Gulf. If spills due to an exploration well blowout were to occur, the effects on adult finfish or shellfish would likely be nonfatal and the extent of damage would be reduced due to the capability of adult fish and shellfish to avoid a spill. Commercial fishermen will actively avoid the area of a spill. Even if fish resources successfully avoid spills, tainting (oily-tasting fish), public perception of tainting, or the potential of tainting commercial catches will prevent fishermen (either voluntarily or imposed by regulation) from initiating activities in the spill area. This in turn could decrease landings and/or value of catch for several months. However, GOM species can be found in many adjacent locations. Gulf commercial fishermen do not fish in one locale and have responded to past petroleum spills, such as that in Lake Barre in Louisiana, without discernible loss of catch or income by moving elsewhere for a few months.

Besides the risk of contact from an offshore spill, Louisiana, Alabama, and Mississippi coastal waters could experience a coastal spill along their waterways from activities in support of exploratory drilling in the EPA sale area. According to the USCG, 95 percent of all reported coastal spills each year are <24 bbl, so the great majority of coastal spills would likely be small and disperse quickly. Spills could occur at onshore support bases from Louisiana to Alabama that support exploratory drilling. Most of these possible incidents would occur at or near the shore base and are expected to affect a highly localized area. Due to spill response and cleanup efforts, most of the inland spill would be recovered and what is not recovered would affect a very small area and dissipate rapidly.

Although the quantity of commercial landings of migratory species in the GOM is comparatively small, these species are of high value. Migratory species could be affected by spills occurring and reaching coastal areas inhabited by migratory species. Only large offshore spills (≥1,000 bbl), none of which are expected to result from the proposed action, would remain as an intact slick on the surface beyond 3 days to be transported inshore by surface currents and winds. The likelihood of a large spill (≥1,000 bbl) occurring from exploratory drilling in the EPA sale area is extremely small.

The MMS assumes that a petroleum spill, probably degraded, will occasionally contact and affect nearshore and coastal areas of migratory Gulf fisheries. Migratory species are expected to avoid the spill area. The effect of oil spills on commercial fishing is expected to cause less than a 1 percent decrease in commercial fishing efforts, landings, or value of those landings. Any affected commercial fishing activity would recover within 6 months. At the expected level of effect, the resultant influence on commercial fishing activities is negligible and would be indistinguishable from variations due to natural causes.

Subsurface blowouts of both oil and natural gas wells have the potential to adversely affect commercial fishing. No blowouts are expected to result from exploratory drilling in the EPA sale area based on the historical record and the number of exploration wells that constitute the proposed action. Commercial fishermen would avoid an area where there are ongoing attempts to regain control of a blowout. In addition, it is unlikely that commercial fishermen would actively avoid areas of increased turbidity since many areas that receive heavy fishing pressure in the Gulf are highly turbid. The resultant influence on commercial fishing activities is insignificant and would be indistinguishable from variations due to natural causes.

Summary and Conclusion

Exploration accidents such as subsurface blowouts that spill large amounts of oil (≥1,000 bbl) are not expected to occur. Smaller spills that might occur from a blowout, vessel collision, or offloading accident would cause insignificant impacts and would not deleteriously affect commercial fishing activities. Operations such as drill rig anchoring and emplacement, and petroleum spills would cause slightly greater impacts on commercial fishing. At the expected level of impact, the resultant influence on commercial fishing would be indistinguishable from variations due to natural causes and there would be very little impact to commercial fishing.

Exploratory drilling is expected to result in less than a 1 percent change in activities, in pounds landed, or in the value of landings. It would require less than six months for fishing activity to recover from any impacts. No long-term effects are expected on size or productivity of any commercial fisheries in the GOM.

4.3.3.2. Impacts on Recreational Fishing

Effects on recreational fishing from activities associated with exploratory drilling in the EPA sale area could result from underwater OCS obstructions, drilling mud discharges, and subsurface blowouts that result in a petroleum spill. Recreational fishing could be indirectly impacted by adverse effects on fish stocks or EFH. The analyses of the potential impacts of exploratory drilling on fish resources and EFH are discussed in Chapter 4.3.2.8 and impacts on commercial fisheries are discussed in Chapter 4.3.3.1.

The degradation of water quality and impact on fish important to recreational fishermen caused by drilling mud discharge and from the potential for oil spills from blowout of an exploration well produce impacts on recreational fishing only to the extent that fishermen are present to use the resource. No artificial reefs lie within the EPA sale area, nor will any be emplaced due to the extreme water depth. Recreational fishing boats may encounter a degraded spill slick inshore that could soil boat hulls. The estimated number and size of potential spills associated with exploratory drilling in the EPA sale area are unlikely to decrease recreational fishing activity. Very few fishing trips go beyond the 200-m isobath in the DeSoto Canyon OCS area, or are >100 mi (160 km) from shore.

Analysis of Impacts

Although it is evident from available information that offshore recreational fishing is a popular, productive, and economically-significant activity in the offshore waters of the northeastern GOM, no definitive information exists on the level and precise location of recreational fishing in the 256 OCS blocks of the EPA sale area.

Recreational fishing boats inadvertently contacting accidental spills or the mud discharge plume from an exploration rig could be soiled, which may require the fishermen to temporarily modify their fishing plans, or power wash their boat's hull back in port. A spill may divert the location or timing of a few planned fishing trips that may coincide in time or space with a deepwater exploration well. Recreational fishermen do not frequent the water depths of the EPA sale area.

Summary and Conclusion

Exploratory drilling and service-vessel traffic in the EPA sale area would not attract additional recreational fishing activity to drill rig structures. It is likely that by the time an operator completed an exploration program in the EPA sale area and moved off station, recreational fishermen may not even have known it was there. Because exploratory drilling rigs are transient structures, they would not act as a long-term, *de facto* artificial reef, although they would temporarily support a community of sport fish and improve fishing prospects in the immediate vicinity if a recreational fisherman was there to fish. Mud discharges and accidental oil spills resulting from exploration activity could have temporary and minor adverse impacts on recreational fishing. No effects are more likely because the EPA sale area is effectively beyond the distance from shore or water depths used by recreational fishermen. No long-term effects are expected on the size or productivity of any recreational fisheries in the GOM.

4.3.3.3. Impacts on Recreational Resources

Major recreational beaches are defined as those frequently visited sandy areas along the shoreline that are exposed to the GOM and that support a range of recreational activity, most of which is focused at the land and water interface. These areas include (1) Gulf Islands National Seashore; (2) State parks and recreational areas; (3) county and local parks; (4) urban beaches; (5) private resort areas; and (6) State and private environmental preservation and conservation areas. The primary impact-producing factors associated with exploratory drilling in the EPA sale area, and those most widely recognized as major threats to the enjoyment and use of recreational beaches, are oil spills, trash, and debris. These factors, either individually or collectively, may adversely affect the number and quality of recreational beach visits made by users.

Oil spills can be associated with the blowout of an exploration well. Major oil spills contacting recreational beaches can cause short-term displacement of recreational activity from the areas directly affected including closure of beaches directly impacted for periods of 2-6 weeks, or until the cleanup operations are complete. Factors such as (1) season, (2) extent of pollution, (3) beach type and location, (4) condition and type of oil washing ashore, (5) tidal action, (6) cleanup methods (if any), and (7) publicity can bear on the severity of effects a spill may have on a recreational beach and its use.

Widely publicized and investigated oil-spill events include the 1969 Santa Barbara Channel spill, the1979-1980 *Ixtoc* spill (Restrepo and Associates, 1982), the 1984 *Alvenus* tanker spill, and the 1989 *Exxon Valdez* tanker spill in Prince William Sound, Alaska. All have demonstrated that large oil spills (≥1,000 bbl) can severely impact beaches and their recreational use. However, findings from an in-depth study of the *Ixtoc* oil-spill impact on three south Texas shoreline beach parks indicated no significant decrease in park visitations as a result of the oil spill (Freeman et al., 1985). Sorensen (1990) reviewed the socioeconomic effects of several historic major oil spills on beaches and concluded a spill near a coastal recreation area would reduce visitation in the area by 5-15 percent over one season. It would have no long-term effect on tourism, but it may degrade the visitor experience for a period of time.

Because of the characteristics of the heavier crude oil expected to be produced in the deepwater EPA, tarballs (the floating residue remaining after an oil slick dissipates) are likely to result from a large spill. Tarballs are known to persist as long as 1-2 years in the marine environment. An investigation on the abundance and sources of tarballs on the recreational beaches of the CPA concludes that their presence along the Louisiana coastline is primarily related to marine transportation activities. The effect on recreational use is below the level of social and economic concern (Henry et al., 1993). A large oil spill resulting from exploration activity in the EPA sale area would acutely threaten shoreline recreational resources for up to 30 days. Beyond 30 days, natural processes (weathering and dispersion) significantly change the nature and form of the oil to the point that it is unlikely to be a major threat to beach recreational resources.

Trash, debris, and tarballs originating from exploration operations can wash ashore on GOM recreational beaches and reduce their attractiveness as recreational resources. Some trash items, such as glass, pieces of steel, and drums with chemical or chemical residues, can also be a health threat to users of recreational beaches. Cleanup of trash and debris originating from OCS activity from coastal beaches adds to operation and maintenance costs for coastal beach and park administrators.

Analysis of Impacts

The potential causes, sizes, and probabilities of oil spills that could occur during exploratory drilling are discussed in Chapter 4.2.7 (Accidental Events). Spills that occur from exploration activity in the EPA sale area are expected to be quantitatively few and volumetrically small. Spills <50 bbl are expected to occur. Blowouts resulting in spills ≥1,000 bbl are not expected based on historical rates of occurrence and the number of wells that constitute the proposed action. Spills ≥50 bbl are expected to occur very infrequently. Given these numbers and expected duration of any impacts, spills from exploratory drilling in the EPA sale area would cause degraded water conditions from a few days to 3 months and would affect only a small area of offshore waters at any one time.

If a large spill does occur, the likelihood of contact to recreational beaches is dependent on the spill's origin point and its trajectory (as determined by oceanographic and wind movements). The OSRA modeling also shows that, should a spill ≥1,000 bbl occur, the likelihood of contact with shoreline resources is very small—in all cases <5 percent. Smaller spills that may occur would be subject to weathering and dispersion. Should one make landfall, it is likely to be in a degraded state and if such a spill interacted with recreational beaches, the area impacted could be closed for a short time during cleanup and temporarily inconvenience recreational users of the impacted beach area.

Some litter from OCS accidents, carelessness, and noncompliance with OCS antipollution regulations and directives is likely to come ashore on recreational beaches. New industry waste management practices, in addition to training and awareness programs focused on the beach litter problem, are expected to minimize the level of indiscriminate and irresponsible trash disposal and accidental loss of solid wastes from OCS oil and gas operations. Recreational beaches west of the Mississippi River are most likely to be impacted by waterborne trash from the OCS. For OCS-related operations closest to shore east of the Mississippi River, trash and debris lost in the marine environment would most likely impact Alabama and Florida beaches.

Incremental effects from exploratory drilling in the EPA sale area on litter are unlikely to be perceptible by beach users or administrators because exploration activities would constitute only a small percentage of the total OCS program activity in the GOM. Impacts from litter associated with exploratory drilling are likely to be offset by industry's continuing efforts to minimize, track, and control offshore waste as well as their ongoing participation in Gulf beach cleanup and adoption programs. Litter on recreational beaches from OCS operations would adversely affect the ambience of the beach environment, would detract from the enjoyment of beach activities, and can increase administrative costs on maintained beaches.

Drilling rigs and platforms placed 3-10 mi from shore are within sight range of shoreline recreational beaches and present aesthetic problems. Because the EPA sale area is everywhere more than 75 mi (120 km) from the shoreline of the nearest state (Louisiana), exploration rigs would not be in sight of land while in operation under any circumstances. The support of exploratory drilling operations in the EPA sale area would stimulate and redirect vessel and helicopter traffic to the area. Some vessel trips and helicopter coastal crossings are projected to result in coastal areas from Louisiana to Alabama. Some new traffic around and above the Gulf Islands National Seashore, Dauphin Island, and Pleasure Island is likely. Service-vessel trips using the Pascagoula/Bayou Casotte ship channel between Horn Island and Petit Bois Island may increase as a result of exploratory drilling, depending on the operator's preferences. With no helicopter hubs in coastal Mississippi and only one in coastal Alabama, minimal additional, if any, air traffic is expected over Gulf Islands National Seashore and Wilderness Area from exploration activity. It is assumed that vessels use established nearshore traffic lanes and helicopters comply with aerial clearance restrictions 90 percent of the time. Boats and aircraft servicing offshore and nearshore oil and gas operations may still be seen and heard by some recreational and wilderness beach users, but this level of impact should not decrease the amount or quality of recreational beach use.

Summary and Conclusion

A few small offshore spills resulting from exploration activity in the EPA sale area may affect portions of Alabama or Florida beaches with little disruption of recreational activities. Marine debris would be lost from time to time from OCS operations associated with exploratory drilling or support vessels. The impact from intermittent trash and debris that washes up on Gulf Coast beaches should be minimal. Helicopter and vessel traffic would add very little additional noise pollution and is not likely to affect wilderness beach users.

Exploration activities are expected to result in small pollution events that could temporarily affect the enjoyment or use of some beach segments in Alabama or Florida. It is likely that users would never notice the effects and would not alter the number of beach users or tourism. No long-term effects on the number of recreational beach users, or the quality of the experience, are expected in the northern Gulf.

4.3.3.4. Impacts on Archaeological Resources

Major impact-producing factors that could affect both prehistoric and historic archaeological resources are direct physical contact from emplacing drilling rig anchors, the introduction of ferromagnetic debris, and the effects of spilled oil.

Prehistoric

The EPA sale area is not located within either of the MMS's designated high-probability areas for the occurrence of prehistoric archaeological resources. Lease blocks with a high probability for prehistoric archaeological resources may only be found landward of a line that roughly follows the 60-m (200-ft) bathymetric contour. The MMS recognizes the 12,000 B.P. date and 60-m water depth as the seaward extent of prehistoric archaeological potential on the OCS. The water depth in the EPA sale area ranges from 1,550 to 3,000 m (5,085 to 9,850 ft). Based on the extreme water depth, there is no potential for prehistoric archaeological resources; therefore, no impacts can occur.

Historic

There are known areas of the northern GOM that are considered to have a high probability for historic period shipwrecks, as defined by an MMS-funded study and shipwreck model (Garrison et al., 1989). Garrison et al. expanded the shipwreck database in the GOM from 1,500 to more than 4,000. Statistical analysis of shipwreck location data identified two specific types of high-probability areas. The first is within 10 km (6 mi) of the shoreline, and the second is proximal to historic ports, barrier islands, and other shipwreck loss traps (Anuskiewicz, 1989; page 76). High-probability search polygons associated with individual shipwrecks were created to afford protection to wrecks located outside the two high-probability areas. A more recent study by Pearson et al. (2002) revised and refined the Garrison et al. shipwreck list and model, listing 3,344 shipwrecks in this database.

Several impact-producing factors may cause adverse impacts to unknown historic archaeological resources. Offshore exploratory drilling would disturb a small area of the sea bottom. Anchors are required if drilling units are deployed that are not dynamically positioned. A direct impact footprint per anchor is approximately 2.1 ha (5.2 ac). Direct contact with a shipwreck site by drilling-unit anchors or service-vessel anchors could destroy fragile ship remains, such as the hull and wooden or ceramic artifacts, and could disturb the site context. The result would be the loss of archaeological data on ship construction, cargo, and the social organization of the vessel's crew, and loss of information on maritime culture for the time period from which the ship dates. Pile driving associated with drilling rig emplacement may also cause sediment liquefaction an unknown distance from the piling, disrupting sea bottom stratigraphy in the area of liquefaction.

Petroleum spills that might vent in a well blowout have the potential to affect historic archaeological resources. Impacts to historic resources would be limited to visual and aesthetic impacts and possibly to physical impacts associated with spill cleanup operations. Exploratory drilling activity is an industrial operation carried out over water. Tons of ferromagnetic hardware, structures, and debris are involved. If equipment is lost, at the wellsite or more distant locations, they are required to be cleared as part of site clearance activity at the time of permanent well abandonment. If not cleared, bottom debris would tend to mask or confuse magnetic signatures or give false positive readings of significant historic archaeological resources during magnetometer surveys. The task of locating historic resources with an archaeological survey is, therefore, made more difficult by ferromagnetic debris on the sea bottom.

Analysis of Impacts

Exploration activity includes the drilling of 38-73 exploration or delineation wells by operators in the EPA sale area between 2003 and 2043. The MMS recognizes both the 12,000 B.P. date and 60-m (200-ft) isobath as the seaward extent of prehistoric resource potential on the OCS. The water depth in the

EPA sale area ranges from 1,550 to 3,000 m (5,085 to 9,850 ft). Water depths are at least 1,540 m deeper than the minimum depth where the earliest prehistoric archaeological sites in the GOM basin are known.

Reviews by Garrison et al. (1989) and Pearson et al. (2002) indicate three possible shipwrecks that fall within the EPA sale area (Table 3-10). The compilations of Garrison et al. and Pearson et al. should not be considered exhaustive lists of Gulf shipwrecks; however, they are the most comprehensive available. Eleven of the 256 OCS blocks in the EPA sale area fall within the MMS shipwreck high-probability area and may possibly contain a shipwreck. Prior to any exploration activity in the EPA sale area, a remote-sensing survey is required by MMS regulation (30 CFR 250.196) and a geophysical report is required in an operator's EP indicating that no seafloor features suggestive of historic shipwrecks were recorded during a side-scan sonar survey. Bottom, sonar-scan surveys are estimated to be 90 percent effective at identifying possible historic shipwreck sites, but this estimate is made without a measurable basis.

The greatest potential impact to a historic shipwreck from exploratory drilling would result from the emplacement of anchor pilings directly on a historic resource, crushing it and disturbing the stratigraphy of nearby sediments. An estimated sea-bottom footprint from each anchor is 2.1 ha (5.2 ac) for conventionally-moored semisubmersibles, assuming that some of these MODU's would be deployed. In the 256 blocks comprising the EPA sale area, this area of sea bottom is insignificant.

Ferromagnetic debris associated with exploration activity has the potential to mask the magnetic signatures of historic shipwrecks. It is expected, however, that most ferromagnetic debris associated with the exploratory drilling would be removed from the seafloor during the required postlease site clearance and verification procedures. No onshore development in support of exploratory drilling is expected, such as construction of new onshore facilities, which could result in the direct physical impact to previously unidentified or unknown historic sites on land. Should an oil spill occur and contact a coastal historic site, such as a fort or a lighthouse, the major impact would be temporary and reversible, consisting of visual insult and aesthetic impacts on the site and its environment.

Summary and Conclusion

The exploration activities cannot result in an impact to an inundated prehistoric archaeological site due to the water depth. Exploration activities in the EPA sale area could impact a shipwreck due to incomplete knowledge with respect to the location of shipwrecks in the Gulf. Although this occurrence is not probable, such an event would result in the disturbance or destruction of important historic archaeological information. Other factors associated with exploration activities are not expected to impact historic archaeological resources.

4.3.3.5. Impacts on Human Resources

In the following subchapters, MMS projects how and where future human resource changes would occur and whether they correlate with the relatively minor action of exploratory drilling in the 256-block EPA sale area. In Alabama and Florida, State and local governments, as well as their citizens, have expressed concerns about the cycle of development of petroleum in the Eastern GOM and the related effects on the social and economic well being of their coastal communities. In the Final EIS for Lease Sale181 (USDOI, MMS, 2001a; Section III.D.4), MMS defined two regions of potential impact.

The first, smaller region is most geographically proximal to the EPA sale area and consists of the 10 counties along the northeastern portion of the GOM: Jackson County, Mississippi; Mobile and Baldwin Counties, Alabama; and Escambia, Santa Rosa, Okaloosa, Walton, Bay, Gulf, and Franklin Counties, Florida.

The second, larger region is based on the major industrial and service markets for activities potentially associated with exploratory drilling in the EPA sale area. This second area is discussed in detail in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a; Section III.D.5.c), where it was first defined, and includes 12 counties in the Florida Panhandle, 21 parishes in Louisiana, 4 counties in Mississippi, 2 counties in Alabama, and 24 counties in Texas. The smaller area is a subset of the larger area. Subsequent discussions in this PEA refer to the smaller 10-county/parish area as the proximal area.

The addition of any new human activity, such as exploratory drilling in a new OCS area, brings a variety of effects on local communities. Typically, these effects are in the form of people or money, or both. Consequences can be seen in the local social and economic institutions and in land-use patterns;

however, these effects may be beyond the ability to characterize well because they are immersed in broader trends.

Demographics

Demographic factors such population, age structure, education levels, and land use patterns are analyzed for the 10-county area proximal to the EPA sale area.

Population

Current estimates of population growth for the 10-county area show a continuation of growth, but at a slower rate. Baldwin and Santa Rosa Counties will remain popular targets of in-migration at least until the year 2020. The most populated county is projected to be Mobile County, Alabama, while the least populated county is projected to be Franklin County, Florida.

No marked increase in population is expected in either Jackson County, Mississippi, or in Mobile County, Alabama, where OCS-oriented businesses are both expanding and locating. While much of the labor force will be local, not all of the highly skilled employees needed to fill newly created jobs can be drawn from the existing populace. Hence, there may be a very small increase in population that is not easily measured outside of larger trends may result.

Population throughout the proximal area will increase irrespective if the proposed action, at markedly different rates and for reasons that are largely not related to OCS activity. Population changes associated with exploratory drilling in the EPA sale area are projected to be <0.5 percent of total population in any given coastal subarea.

Median Age

The 1990 Census and 1997 population estimates reflect the diversity in the age of the residents in the urban counties of Jackson, Mississippi; Mobile, Alabama; and Escambia and Bay, Florida. Given both the projections of population growth and industrial expansion, this pattern is expected to continue into the year 2040 as well. Exploratory drilling in the EPA sale area is not expected to affect the region's median age.

Educational Levels

Research in the social sciences links educational achievement with class, income, and occupation. Beaulieu et al. (1997), examine the national *High School and Beyond* study to highlight the experiences of high-school graduates who do not go on to college. Much of their description is applicable to the populations of the 10 counties in the proximal area. If the assumption is made that education, class, income, and occupation are causally interrelated, then increases in these demographic and economic characteristics of a region will result in a greater emphasis on education. Counties such as Okaloosa and Santa Rosa in Florida, with high numbers of well-educated residents, will continue to show higher percentages of adults with high-school degrees and beyond as long as they remain centers of in-migration of upper income retirees. Current educational levels for the region are not expected to be significantly affected by exploratory drilling in the EPA sale area.

Analysis of Impacts

Bayou Casotte in Jackson County, Mississippi, and Theodore in Mobile County, Alabama, currently have boat and helicopter facilities, and the onshore base to support exploratory drilling in the EPA sale area. Jackson and Mobile Counties already have strong industrial bases and designated industrial parks to accommodate future growth in hydrocarbon extraction businesses. The remaining eight counties, Baldwin County, Alabama, and the seven Florida Panhandle counties, do not have any such industrial concentrations. Current estimates of population growth for the 10-county proximal area show a continuation of growth, but at a slower rate. Mobile County, Alabama, based on its projected population growth, is expected to continue as the proximal region's most populated county, while Franklin County, Florida, is expected to remain the least populated. Baldwin County, Alabama, and Santa Rosa County, Florida, are expected to remain popular targets of non-OCS-related in-migration. Only contained and minimal changes in land use are expected throughout the region from exploratory drilling.

Summary and Conclusion

The demographics of population distribution, age, income, land-use patterns, and education level in the 10-county proximal area are not expected to be impacted significantly by exploration activity. The exploration activity that takes place in the EPA sale area is not expected to add additional businesses, but some businesses that already provide support to OCS operations might expand, particularly in Alabama. No long-term effects are expected on human resources in the GOM.

4.3.3.6. Impacts on Economic Factors

Employment

The importance of the oil and gas industry to the coastal communities of the GOM is significant, particularly in Louisiana, eastern Texas, and coastal Alabama. Dramatic changes in the level of OCS oil and gas activity over recent years have resulted in similar fluctuations in population, labor, and employment in the GOM region. This economic analysis focuses on the potential direct, indirect, and induced impacts of the OCS oil and gas industry on the population and employment of the counties and parishes in the larger impact region extending along the perimeter of the U.S. Gulf Coast. There are no publicly available models that estimate the expenditures resulting from offshore oil and gas activities. To improve regional economic impact assessments and to make them more consistent with each other, the MMS recently developed a new methodology for estimating changes to employment and other economic factors. The methodology developed to quantify these impacts on population and employment takes into account changes in OCS-related employment, along with population impacts resulting from these employment changes within each individual coastal subarea. The Final EIS for Lease Sale 181 (USDOI, MMS, 2001a) was the first NEPA document in which this model is used and where Gulf "subareas" are established and defined.

The model for the GOM region has two steps. The first step estimates the expenditures resulting from the totality of OCS activity and assigns these expenditures to industrial sectors in the eight MMS subareas defined in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a; Section III.D.4.b). These activities include (1) exploratory drilling; (2) development drilling; (3) production operations and maintenance; (4) platform fabrication and installation; (5) pipeline construction, (6) pipeline operations and maintenance; (7) gas processing and storage construction; (8) gas processing and storage operations and maintenance; (9) workovers; and (10) platform removal and abandonment. The second step uses multipliers from the commercial input-output model IMPLAN (using 1997 data, the latest available data) to translate these expenditures into direct, indirect, and induced employment and other economic factors. Direct employment results from the first round of industry spending. It is the employment that results from the initial dollars spent by the oil and gas industry on the 10 activities listed above. Indirect employment results as the initial spending multiplies through the economy. First, the suppliers of the goods and services for the 10 activities spend the initial direct dollars from the industry. Then, these dollars are re-spent by other suppliers until the initial dollars have trickled throughout the economy. Labor income produces induced spending by the households receiving that income.

Both the level (the amount spent) and the sectoral (the industry in which it is spent) allocation of expenditures can vary considerably by the phase of OCS activity and by the water depth of the activities. For example, an exploration well in 0-60 m of water is expected to be drilled using a jack-up rig and cost about $5 million, whereas an exploration well in 900 m or greater water depth is expected to be drilled using a drillship and cost about $15-60 million, or more, to complete. In addition, spending on materials such as steel will be much higher for platform fabrication and installation than for operations and maintenance once production begins. Therefore, the model estimates and allocates expenditures by 10 kinds of activities in four water-depth categories: 0-60 m; 61-200 m; 201-900 m; and >900 m.

The MMS expects projected employment associated with exploratory drilling in the EPA sale area to be filled primarily by persons already engaged in OCS oil- and gas-related jobs and by unemployed, underemployed, or transitioning persons living in the larger, encompassing impact area. Given the present amount of OCS-related jobs along the Gulf Coast, there should be only minor workforce fluctuations. Some importation of skilled labor may be required on a temporary basis.

Infrastructure, Land Use, and Ports

While the oil and gas infrastructure and land use to support exploration activities should increase or remain stable in the locations of onshore support bases, such as Port Fourchon, Louisiana, there is sufficient land designated in commercial and industrial parks and adjacent to the existing port to minimize disruption to current residential and business use patterns. While the oil and gas infrastructure and land use in the local area will change over time, the majority of this change is will be part of general regional growth, and propelled by initiatives other than exploratory drilling in the EPA sale area alone.

Supply and crew boats are expected to make from 1,300-3,900 vessel trips to support the 38-73 exploration and delineation wells projected for the EPA sale area for the 40-year duration of exploration activity, or from 36-54 vessel trips per well. All of these trip would originate from one of the onshore support bases for exploratory drilling in the EPA sale area: Venice, Grand Isle, Port Fourchon, Leeville, and Port Morgan, Louisiana; Pascagoula, Mississippi; Dauphin Island, Theodore, and Mobile, Alabama (Figure 3-3). These bases are capable of providing the services necessary for the proposed activities; therefore, no onshore expansion, relocation, or construction is anticipated to be needed expressly for, or as a result of, exploration activities in the EPA sale area.

Changes in land use throughout the region as a result of the proposed action are expected to be minimal. Exploratory drilling in the EPA sale area may cause some businesses that already provide support to OCS operations to expand or add additional employees. Mobile County, Alabama, has adequate industrial/commercial sites along Mobile Bay, especially at Theodore Industrial Park and Canal and the recently built Naval Homeport site now under the auspices of the Alabama State Docks. In addition, the dozen shipbuilding firms in Bayou LaBatre in south Mobile County claim the capacity to meet new demands (Foster and Associates, Inc., 1997). In the remaining eight counties, land use may be affected in Escambia and Bay Counties because their ports have the capacity to serve as sites for new OCS-focused businesses.

No changes to established land-use patterns, for example, the relocation of major employers in Mobile, Alabama; Pascagoula, Mississippi; or the greater New Orleans area of Louisiana, would be expected to occur as a result of exploratory drilling in the EPA sale area.

Analysis of Impacts

Based on the distance from shore and the water depths in the EPA sale area, there would be very little economic stimulus to the Florida Panhandle region and only minor economic changes in the rest of the GOM coastal areas. Exploratory drilling is expected to generate a small increase in employment in the coastal parts of Louisiana, Mississippi, and Alabama. A quantitative estimate of impact is not available because the increase is so small and because it would be well within the model's margin of measurement error. In other words, a quantitative estimate can be attributed as much to error in the modeling as to a meaningful trend.

No net influx of workers for the large area businesses in Mobile, Alabama, and Pascagoula, Mississippi, would be expected as a result of exploratory drilling in the EPA sale area, but a shift in specialties could occur in positions requiring specialized education or training. Large employers are likely to adjust workforce structures according to the necessities of supply and demand based on ongoing activity through lay offs and furloughs of workers with certain skill sets, and hiring or retraining other workers with different skills to fill different or evolving roles.

No net changes to existing the oil and gas infrastructure, land use, or port facilities will be caused by, or result from, exploration activities in the EPA sale area alone.

Summary and Conclusion

No short or long-term effects on the economic resources in the GOM are expected to result from exploratory drilling in the EPA sale area.

4.3.3.7. Impacts on Environmental Justice

Executive Order 12898, entitled *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, directs Federal agencies to assess whether their actions have disproportionate environmental effects on people of ethnic or racial minorities or with low incomes.

Those environmental effects encompass human health, social, and economic consequences. The Federal agency in charge of permitting the exploration activities must provide opportunities for community input in the NEPA process. Community involvement includes identifying both potential effects and mitigation measures developed in consultation with the affected communities.

The exploration activities analyzed in this PEA are already authorized by law. Exploratory drilling in the EPA sale area is assumed in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a). No specific action, project, or proposal is being evaluated and recommended to a decision maker, beyond the ability of a valid leaseholder to submit an EP to exercise the option to drill an exploration well. The siting of onshore facilities related to OCS activities is usually based on economics, logistical considerations, zoning restrictions, and permitting requirements. Because of the need for contiguous land and the attraction of lower land values, such facilities, with their environmental implications, are often near low-income or minority populations. In the case of federally sponsored actions, potential impacts on these populations would come within the purview of Executive Order 12898. Within the 10-county proximal impact region, the individuals potentially affected by exploration in the EPA sale area are African-Americans living in Mississippi, Alabama, and the upper Panhandle of Florida; Asian-Americans in Alabama; and low-income fishermen and timber harvesters in coastal Alabama, and Gulf and Franklin Counties in Florida. Native Americans are few and widely dispersed throughout the five states.

The 10 counties in the impact region are not physically, culturally, or economically homogenous. Communities range in size from small municipalities, such as Bayou LaBatre in Alabama, to the urban centers of Mobile, Alabama, and Pensacola and Panama City, Florida. The racial and ethnic composition of the counties varies widely as does the distribution of income. While people of these minority groups are scattered throughout the impact region, there are concentrations. Figure III-12 in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a) shows persons with incomes above and below $25,000 per year by census tract. For a family of four, this is close to the poverty level established by the U.S. Bureau of the Census. Concentrations of low-income households in select areas along the Gulf Coast are evident: Pascagoula, Mississippi; the city and the county of Mobile, Alabama; and Bay, Gulf, and Franklin Counties in Florida.

Given the State of Florida’s opposition to oil and gas extraction in OCS waters off its coast, MMS does not anticipate any negative environmental effects on the minority or low-income people in the Florida counties. In Jackson County, Mississippi, and Mobile County, Alabama, there is the possibility of petroleum-related activities affecting low-income households. Since low income often means minority person, there may be questions of environmental justice. At present, however, disproportionate and negative effects should not occur as a result of exploratory drilling in the EPA sale area because the facilities, the land use, and the jobs already exist along the coasts of the four states. If these change, especially if they increase and cause disruptions of local neighborhoods, then the relevant regulatory agencies should pay particular attention to how these neighborhoods are affected.

Analysis of Impacts

The racial and ethnic diversity, and the physical, cultural, and economic composition of the population in the 10-county proximal area varies widely. The presence of discrete polities of minority persons is marked in cities such as Pritchard, Alabama, and Pascagoula, Mississippi, and in unincorporated areas such as Mon Louis Island in south Mobile County, Alabama, and Carabelle, Florida.

There may be disproportionate environmental effects associated with slight population increases in Mississippi and Alabama, if currently located petroleum-related activities and facilities change in size or location. No changes to the larger scale distributions of minority polities in the 10-county proximal area are expected to occur from the exploratory drilling in the EPA sale area.

Summary and Conclusion

No impacts to the current distribution of environmental equities are expected to occur from exploratory drilling in the EPA sale area. The data on combined probabilities for shoreline contact by potential oil spills (Table 4-9) indicates that shoreline counties with minority or low income populations are no more or less likely to be contacted by spilled oil.

5. CONSULTATION AND COORDINATION

Consultation and coordination efforts for the prelease process and the Final EIS for Lease Sale 181 identified the issues for this PEA. The MMS conducted early coordination with appropriate Federal and State agencies and other concerned parties to discuss and coordinate the prelease process for the proposed lease sale and EIS. Key agencies and organizations included NOAA Fisheries, FWS, DOD, USCG, USEPA, State Governors' offices, and industry groups. The MMS also conducted early coordination with State agencies of Louisiana, Alabama, and Florida.

Scoping efforts and other coordination meetings continued throughout the prelease process and development of the EIS. For example, the annual MMS GOM Region's Information Transfer Meetings (ITM) provide an opportunity for EIS analysts to attend technical presentations related to OCS Program activities and to meet with representatives from Federal, State, and local agencies; industry; MMS contractors; and academia. Formal opportunities for input occur during the prelease and NEPA processes, including the Call for Information, Notice of Intent to Prepare an EIS, public scoping meetings, public hearings on the Draft EIS, and public review of the Draft EIS. Scoping meetings for Lease Sale 181 were held in Port Sulphur and Houma, Louisiana; Mobile, Alabama; and Pensacola and Tallahassee, Florida, in July 1999. Public hearings on the Draft EIS for Lease Sale 181 were held in New Orleans, Louisiana; Mobile, Alabama; and Pensacola and Tallahassee, Florida, in January 2001.

On June 3, 2002 a notice was published in the *Federal Register* (2002) reporting that a PEA was in preparation. The notice asked interested parties to submit comments regarding any new information or issues that should be addressed in the PEA. No comments pertaining to this notice were received by MMS.

On July 12, 2002, MMS sent letters to the Governors of Louisiana, Alabama, Mississippi, and Florida. The letter informed them that a PEA was in preparation that considered areawide resources and impacts pertaining to exploratory drilling in the EPA sale area, and solicited new information or issues for consideration in the PEA.

The State of Florida replied on August 26, 2002, stating seven issues with respect to the scope of the PEA. Florida advocated that the PEA contain or address the following: (1) adequate environmental and technological information to accurately assess the range of impacts expected from exploration; (2) accurate, comprehensive, and current descriptions of the affected environment and technological analyses; (3) the effect of deep circulation to move spilled materials or permitted discharges onto the Florida shelf; (4) analysis of synthetic drilling muds to understand impacts on coastal and marine resources; (5) the short- and long-term effects of persistence or bioaccumulation of discharged materials; (6) the potential for OCS facilities to become vectors for exotic species; (7) trash and debris generated by OCS activites; and (8) space-use conflicts with military missions, recreational activities, marine protected areas, commercial and recreational fishing, methane hydrates, cruise ship traffic, and aquaculture.

The State of Alabama replied on August 8, 2002, stating that the State's concerns were expressed in earlier letters to the GOM Regional Director dated September 26, 2001, and May 28, 2002, regarding the Draft 2003-2007 Multisale EIS for the CPA and WPA and the Proposed Notice of Sale for the Eastern GOM Lease Sale 181, respectively. The State was concerned about visual impacts presented by OCS drilling or production structures less than 15 mi offshore Alabama's coastline and about the potential for mercury contamination in association with OCS platforms. The former concern is not applicable since the proposed exploration activity would take place approximately more than 100 mi south of the Alabama coastline.

The States of Louisiana and Mississippi did not reply to the GOM Regional Director's July 12, 2002, letter to offer scoping input.

Endangered Species and Essential Fish Habitat Consultations

The Endangered Species Act (ESA) establishes a national policy designed to protect and conserve threatened and endangered species and the ecosystem upon which they depend. The ESA is administered by FWS and NOAA Fisheries. Section 7 of the ESA governs interagency cooperation and consultation. Under Section 7, MMS formally consults with NOAA Fisheries and FWS to ensure that activities in the OCS under MMS jurisdiction do not jeopardize the continued existence of threatened or endangered species and/or result in adverse modification or destruction of their critical habitat. The results of these consultations are presented as a Biological Opinion (BO). The FWS and NOAA Fisheries make recommendations on the modification of oil and gas operations to minimize adverse impacts, although it remains the responsibility of MMS to ensure that proposed OCS activities do not impact threatened and endangered species.

The consultations completed for Lease Sale 181 (USDOI, MMS, 2001a) serve as the MMS's consultations for this PEA. The Final EIS for Lease Sale 181 and the requests for consultation under Section 7 of the ESA included in exploratory drilling activities projected for the entire area originally proposed for Lease Sale 181. This PEA addresses exploratory drilling activities in the EPA sale area, which is a subset of the activities and area addressed in the EIS and the BO's.

The FWS BO for Lease Sale 181 (dated June 8, 2001) includes seven *Conservation Recommendations*. The BO is included Appendix B of the Final EIS for Lease Sale 181. The NOAA Fisheries BO for Lease Sale 181 (dated June 15, 2001) includes two *Reasonable and Prudent Measures*, seven *Terms and Conditions*, and seven *Conservation Recommendations*. The BO is included in Appendix B of the Final EIS for Lease Sale 181. In addition to protective measures resulting from this BO, MMS has issued a NTL regarding seismic survey mitigation measures and is preparing NTL's containing measures to further protect marine mammals, sea turtles, and other marine animals from potential impacts from marine trash and debris and vessel strikes.

The MMS has and continues to take a proactive role in the stewardship and research of protected species inhabiting the offshore environment where oil and gas development occurs or is projected to occur. Potential impacts to wildlife, including sea turtles and marine mammals, from oil and gas industry activities in the GOM are of serious concern to MMS and staff. The MMS is proactively managing industry activities to ensure a healthy balance is achieved to protect the environment and meet our nation's demand for fossil fuels.

The Magnuson Fishery Conservation and Management Act of 1976 was reauthorized through passage of the Sustainable Fisheries Act of 1996. The Act, as amended, established eight Regional Fishery Management Councils (FMC's) to exercise sound judgment in the stewardship of fishery resources through the preparation, monitoring, and revision of fishery management plans (FMP). The reauthorization requires that the FMC's identify Essential Fish Habitat (EFH). The GOM FMC *Draft Generic Amendment for Addressing Essential Fish Habitat Requirements* identifies threats to EFH and makes a number of general and specific habitat preservation recommendations for pipelines and oil and gas exploration and production activities within State waters and OCS areas. A discussion of these recommendations and MMS implementation can be found in Section III.B.10.c. in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001a). To promote the protection of EFH, Federal agencies are required to consult with NOAA Fisheries on activities that may adversely affect EFH designated in the FMP's.

In their comment letter on the Draft EIS for Lease Sale 181 (dated December 22, 2000; pages V-17 through V-18 of the Final EIS), NOAA Fisheries provided five *EFH Conservation Recommendations.* The MMS letter of response to NOAA Fisheries is included in Appendix C of the Final EIS.

6. BIBLIOGRAPHY

Advanced Research Projects Agency. 1995. Final environmental impact statement/environmental impact report (EIS/EIR) for the California Acoustic Thermometry of Ocean Climate (ATOC) Project and its associated Marine Mammal Research Program (MMRP) (Scientific Research Permit Application [P557A]), Vol. 1.

Albers, P.H. 1979. Effects of Corexit 9527 on the hatchability of mallard eggs. Bull. Environ. Contam. and Toxicol. 23:661-668.

Albers, P.H. and M.L. Gay. 1982. Effects of a chemical dispersant and crude oil on breeding ducks. Bull. Environ. Contam. and Toxicol. 9:138-139.

Alexander, S.K. and J.W. Webb. 1983. Effects of oil on growth and decomposition of *Spartina alterniflora*. In: Proceedings, 1983 Oil Spill Conference . . . February 28-March 3, 1983, San Antonio, TX. Washington, DC: American Petroleum Institute. Pp. 529-532.

Alexander, S.K. and J.W. Webb. 1985. Seasonal response of *Spartina alterniflora* to oil. In: Proceedings, 1985 Oil Spill Conference . . . February 25-28, 1985, Los Angeles, CA. Washington, DC: American Petroleum Institute. Pp. 355-357.

Alexander, S.K. and J.W. Webb. 1987. Relationship of *Spartina alterniflora* growth to sediment oil content following an oil spill. In: Proceedings, 1987 Oil Spill Conference . . . April 6-9, 1987, Baltimore, MD. Washington, DC: American Petroleum Institute. Pp. 445-450.

American Petroleum Institute (API). 1989. Effects of offshore petroleum operations on cold water marine mammals: a literature review. Washington, DC: American Petroleum Institute. 385 pp.

Amos, A.F. 1989. The occurrence of hawksbills (*Eretmochelys imbricata*) along the Texas coast. In: Proceedings of the Ninth Annual Workshop on Sea Turtle Conservation and Biology, February 7-11, 1989, Jekyll Island, GA. NOAA-TM-NMFS-SEFC-232. Miami, FL.

Anderson, S.H. 1995. Recreational disturbance and wildlife populations. In: Knight, R.L. and K.J. Gutzwiller, eds. Wildlife and recreationists: coexistence through management and research. Washington, DC: Island Press. Pp. 157-168.

Anderson, D.W., F. Gress, and D.M. Fry. 1996. Survival and dispersal of oiled brown pelicans after rehabilitation and release. Mar. Poll. Bull. 32:711-718.

Angelovic, J.W. 1989. Written communication. Condition of the fisheries. St. Petersburg, FL: U.S. Dept. of Commence. National Marine Fisheries Service, Southeast Fisheries Center, Internal Memorandum. 5 pp.

Anuskiewicz, R.J. 1989. A study of maritime and nautical sites associated with St. Catherines Island, Georgia. Ph.D. dissertation presented to the University of Tennessee, Knoxville, TN. 90 pp.

Aten, L.E. 1983. Indians of the upper Texas coast. New York, NY: Academic Press.

Avanti Corporation. 1993a. Ocean discharge criteria evaluation for the NPDS general permit for the Western Gulf of Mexico OCS. Prepared for the U.S. Environmental Protection Agency, Water Management Division, Region VI. EPA Contract No. 68-C9-0009.

Avanti Corporation. 1993b. Environmental analysis of the final effluent guideline, offshore subcategory, oil and gas industry. Volume II: Case impacts. Prepared for the U.S. Environmental Protection Agency, Water Management Division, Region VI. EPA Contract No. 68-C9-0009.

Bahr, L.M. 2002. Subsidence: implication for coastal wetlands restoration in Louisiana. Internet site. (August 23, 2002). http://bigfoot.wes.army.mil/5915.html

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.

Bakus, R.H., J.E. Craddock, R.L. Haedrich, and B.H. Robison. 1977. Atlantic mesopelagic zoogeography. In: Gibbs, R.H. Jr., ed. Fishes of the Western North Atlantic. Pp. 266-287.

Balazs, G.H. 1985. Impact of ocean debris on marine turtles: entanglement and ingestion. In: Shomura, R.S. and H.O. Yoshida, eds. Proceedings, Workshop on the Fate and Impact of Marine Debris, November 26-29, 1984, Honolulu, HI. U.S. Dept. of Commerce. NOAA Tech. Memo. NMFS-SWFSC-54. Pp. 387-429.

Ballachey, B.E., J.L. Bodkin, and A.R. DeGange. 1994. An overview of sea otter studies. In: Loughlin, T.R., ed. Marine mammals and the *Exxon Valdez*. San Diego, CA: Academic Press. Pp. 47-59.

Barkuloo, J.M. 1988. Report on the conservation status of the Gulf of Mexico sturgeon, *Acipenser oxyrhunchus desotoi.* U.S. Dept. of the Interior, Fish and Wildlife Service, Panama City, FL.

Barras, J., M. Swain, and L. Barras. 1990. A study of marsh management practice in coastal Louisiana: Atlas of Louisiana coastal habitats. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. 20 pp.

Barron, G.L. and T.A. Jefferson. 1993. First records of the melon-headed whale (*Peponocephala electra*) from the Gulf of Mexico. Southw. Natural. 38:82-85.

Barros, N.B. and D.K. Odell. 1990. Ingestion of plastic debris by stranded marine mammals from Florida. In: Shomura, R.S. and M.L. Godfrey, eds. Proceedings of the Second International

Conference on Marine Debris, 2-7 April 1989, Honolulu, HI. U.S. Dept. of Commerce, NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFSC-154. P. 746.

Basan, P.B., C.K. Chamberlain, R.W. Frey, J.D. Howard, A. Seilacher and J.E. Warme. 1978. Trace fossil concepts. Society of Economic Paleontologists and Mineralogists, Short Course No. 5, Tulsa, OK. 181 pp.

Baumgartner, M.F. 1995. The distribution of select species of cetaceans in the northern Gulf of Mexico in relation to observed environmental variables. M.Sc. Thesis, University of Southern Mississippi.

Baud, R.D., R.H. Peterson, G.E. Richardson, L.S. French, J. Regg, T. Montgomery, T.S. Williams, C. Doyle, and M. Dorner. 2002. Deepwater Gulf of Mexico 2002: America's Expanding Frontier. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA, OCS Report MMS 2002-021, 133 pp.

Baumgartner, M.F. 1997. The distribution of Risso's dolphin (*Grampus griseus*) with respect to the physiography of the northern Gulf of Mexico. Mar. Mamm. Sci. 13:614-638.

Bea, R.G., N.W. Lai, A.W. Niedoroda, and G.H. Moore. 1983. Gulf of Mexico shallow-water wave heights and forces. In: Proceedings of the Offshore Technology Conference, Houston, TX, May 1983. OTC-4586. Pp. 49-62.

Beaulieu, L.J., G.D. Israel, and R.E. Cluck. 1997. Non-college bound youth: their background characteristics and labor force experiences. Mississippi State University: Southern Rural Development Center.

Beaver, C. 2001. Personal communication. Texas A&M University at Corpus Christi, Center for Coastal Studies, Corpus Christi, TX.

Bent, A.C. 1926. Life histories of North American marsh birds. New York: Dover Publications.

Bernard, H.J. and S.B. Reilly. 1999. Pilot whales *Globicephala* (Lesson, 1828). In: Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals, Vol. 6: Second book of dolphins. San Diego, CA: Academic Press. Pp. 245-279.

Bigelow, H.B. and W.C. Schroeder. 1953. Sawfishes, guitarfishes, skates and rays. In: Tee-Van, J., C.M Breder, A.E. Parr, W.C. Schroeder, and L.P. Schultz (eds). Fishes of the Western North Atlantic, Part Two. Mem. Sears Found. Mar. Res. I. Pp.1-54.

Boehm, P., D. Turton, A. Raval, D. Caudle, D. French, N. Rabalais, R. Spies, and J. Johnson. 2001. Deepwater program: Literature review, environmental risks of chemical products used in the Gulf of Mexico deepwater oil and gas operations; Volume I: Technical Report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2001-011. 326 pp.

Boersma, P.D. 1995. Prevention is more important than rehabilitation: oil and penguins don't mix. In: Proceedings, The Effects of Oil on Wildlife, 4th International Conference, April, Seattle, WA.

Boothe, P.N. and B.J. Presley. 1989. Trends in sediment trace element concentrations around six petroleum drilling platforms in the northwestern Gulf of Mexico. In: Drilling Wastes. Engelhardt, F.R., J.P. Ray, and A.H. Gillam, eds. New York: Elsevier Applied Science Publishers, LTD. Pp. 3-20.

Bowles, A.E. 1995. Responses of wildlife to noise. In: Knight, R.L. and K.J. Gutzwiller, eds. Wildlife and recreationists: coexistence through management and research. Washington, DC: Island Press. Pp. 109-156.

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.

Boyd, R. and S. Penland, eds. 1988. A geomorphologic model for Mississippi Delta evolution. In: Transactions - Gulf Coast association of geological societies, Volume XXXVIII.

Brannon, E.L., L.L. Moulton, L.G. Gilbertson, A.W. Maki, and J.R. Skalski. 1995. An assessment of oil spill effects on pink salmon populations following the *Exxon Valdez* oil spill. Part 1: Early life history. In: Wells, P.G., J.N. Butler, and J.S. Hughes, eds. *Exxon Valdez* oil spill: Fate and effects in Alaskan waters. American Society for Testing and Materials, Philadelphia. ASTM STP 1219. Pp. 548-584.

Brongersma, L. 1972. European Atlantic turtles. Zool. Verh. Mus., Leiden. 121:1-3.

Brooks, J.M., ed. 1991. Mississippi-Alabama continental shelf ecosystem study: Data summary and synthesis. Volume II: Technical narrative. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Regional Office, New Orleans, LA. OCS Study MMS 91-0063. 862 pp.

Brown, Jr. L.F., J.L. Brewton, J.H. McGowen, T.J. Evans, W.L. Fisher, and C.G. Groat 1976. Environmental geologic atlas of the Texas coastal zone: Corpus Christi area. The University of Texas at Austin, Bureau of Economic Geology, Austin TX.

Brown, Jr. L.F., J.L. Brewton, J.H. McGowen, T.J. Evans, and W.L. Fisher. 1977. Environmental geologic atlas of the Texas coastal zone: Kingsville area. The University of Texas at Austin, Bureau of Economic Geology, Austin TX.

Broussard, T.J. 2002. Structure removal operations, meeting notes. . U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. June 12.

Butler, R.G., A. Harfenist, F.A. Leighton, and D.B. Peakall. 1988. Impact of sublethal oil and emulsion exposure on the reproductive success of Leach's storm-petrels: short-and long-term effects. Journal of Applied Ecology 25:125-143.

Byles, R., C. Caillouet, D. Crouse, L. Crowder, S. Epperly, W. Gabriel, B. Gallaway, M. Harris, T. Henwood, S. Heppell, R. Marquez-M., S. Murphy, W. Teas, N. Thompson, and B. Witherington. 1996. A report of the turtle expert working group: results of a series of deliberations held in Miami, FL, June 1995-June 1996.

Cairns, D.K. and R.D. Elliot. 1987. Oil spill impact assessment for seabirds: the role of refugia and growth centers. Biological Conservation 40:1-9.

Caldwell, D.K. and M.C. Caldwell. 1989. Pygmy sperm whale *Kogia breviceps* (de Blainville, 1838): dwarf sperm whale *Kogia simus* (Owen, 1866). In: Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Vol. 4: River dolphins and the larger toothed whales. London: Academic Press. Pp. 235-260.

Campbell, K.J. 1999. Deepwater geohazards: how significant are they? The Leading Edge 18(4):514-519.

Carney, R. 1993. Presentation at the Thirteenth Gulf of Mexico Information Transfer Meeting. Sponsored by the U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA, December 4-6, 1993.

Carr, A.F., Jr. 1980. Some problems of sea turtle ecology. Amer. Zoo. 20:489-498

Carr, A. 1987. Impact of nondegradable marine debris on the ecology and survival outlook of sea turtles. Mar. Poll. Bull. 18:352-356.

Carr, A. and D.K. Caldwell. 1956. The ecology and migration of sea turtles. I. Results of field work in Florida, 1955. Amer. Mus. Novit. 1793:1-23.

Casey, D. 1997. Gulflandia. *Business Register*, Fall 1997. Mobile, AL: Mobile Register. Pp. 8-13.

Chambers, J.R. 1992. Coastal degradation and fish population losses. In: Proceedings of the National Symposium of Fish Habitat Conservation, March 7-9, 1991, Baltimore, MD. 38 pp.

Chan, E.H. and H.C. Liew. 1988. A review on the effects of oil-based activities and oil pollution on sea turtles. In: Proceedings, 11th Annual Seminar of the Malaysian Society of Marine Sciences. Pp. 159-167.

Chapman, B.R. 1981. Effects of the Ixtoc I oil spill on Texas shorebird populations. In: Proceedings, 1981 Oil Spill Conference . . . March 2-5, 1981, Atlanta, GA. Washington, DC: American Petroleum Institute.

Chiles, L. 1995. Written communication. Letter from the Governor dated August 23, 1995, providing comments on Chevron's supplemental plan of exploration for Destin Dome Block 57 to K. Stauffer, Chief of Plans and Pipelines, U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico Region, New Orleans, LA.

Clapp, R.B. and P.A. Buckley. 1984. Status and conservation of seabirds in the southeastern United States. In: Croxall, J.P., P.G.H. Evans, and R.W. Schreiber, eds. Status and conservation of the world's seabirds. ICBP Technical Publication No. 2. Pp. 135-155.

Clapp, R.B., R.C. Banks, D. Morgan-jacobs, and W.A. Hoffman. 1982. Marine birds of the southeastern United States and Gulf of Mexico. 3 Vols. Washington, DC: U.S. Dept. of the Interior, Fish and Wildlife Service, Office of Biological Services. FWS/OBS-82/01.

Clark, R.B. 1978. Oiled seabird rescue and conservation. Journal of the Fisheries Research Board of Canada 35:675-678.

Clark, R.B. 1984. Impact of oil pollution on seabirds. Environ. Pollut. Ser. A. 33:1-22.

Clarke, M.R. 1996. Cephalopods as prey. III. Cetaceans. Phil. Trans. R. Soc. Lond. B: Biol. Sci. 351:1053-1065.

Clugston, J.P. 1991. Gulf sturgeon in Florida prey on soft-bodied macroinvertebrates. U.S. Dept. of the Interior, Fish and Wildlife Service, Research Information Bulletin No. 90-31. 2 pp.

Coastal Environments, Inc. (CEI). 1977. Cultural resources evaluation of the northern Gulf of Mexico continental shelf. Prepared for Interagency Archaeological Services, Office of Archaeology and Historic Preservation, National Park Service, U.S. Dept. of the Interior. Baton Rouge, LA. 4 vols.

Coastal Environments, Inc. (CEI). 1982. Sedimentary studies of prehistoric archaeological sites. Prepared for the Division of State Plans and Grants, National Park Service, U.S. Dept. of the Interior, Minerals Management Service. New Orleans, LA.

Coastal Environments, Inc. (CEI). 1986. Prehistoric site evaluation on the Northern Gulf of Mexico outer continental shelf: ground truth testing of the predictive model. Prepared for the U.S. Dept. of the Interior, Minerals Management Service. New Orleans, LA.

Coastal Preserves Program. 1999. Mississippi's coastal wetlands. Published by the Mississippi Dept. of Marine Resources, Biloxi, MS. 19 pp.

Collard, S.B. and A. Lugo-Fernández. 1999. Coastal upwelling and mass mortalities of fishes and invertebrates in the northeastern Gulf of Mexico during spring and summer 1998. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 99-0049. 20 pp.

Collard, S.B. and L.H. Ogren. 1990. Dispersal scenarios for pelagic post-hatchling sea turtles. Bull. Mar. Sci. 47:233-243.

Collum, L.A. and T.H. Fritts. 1985. Sperm whales (*Physeter catodon*) in the Gulf of Mexico. Southw. Natural. 30:101-104.

Continental Shelf Associates, Inc. (CSA). 1997. Characterization and trends of recreational and commercial fishing from the Florida panhandle. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. USGS/BRD/CR-1997-0001 and OCS Study MMS 97-0020. 333 pp.

Cooke, R. 2002. Oil field's free refill. Internet website (April 16, 2002): http://www.newsday.com

Cottingham, D. 1988. Persistent marine debris: challenge and response: the federal perspective. Alaska Sea Grant College Program. 41 pp.

Council on Environmental Quality (CEQ). 1997. Environmental justice: Guidance under the National Environmental Policy Act. Council of Environmental Quality, Office of the President.

Cummings, W.C. 1985. Bryde's whale - *Balaenoptera edeni*. In: Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Vol. 3: The sirenians and baleen whales. London: Academic Press. Pp. 137-154.

Curry, B.E. and J. Smith. 1997. Phylogeographic structure of the bottlenose dolphin (*Tursiops truncatus*): stock identification and implications for management. In: Dizon, D.E., S.J. Chivers, and W.F. Perrin, eds. Molecular genetics of marine mammals. Society for Marine Mammalogy, Special Publication 3. Pp. 227-247.

Dahl, T.E. 1990. Wetlands losses in the United States 1780's to 1980's. U.S. Dept. of the Interior, Fish and Wildlife Service., Washington DC. 21 pp.

Dahlheim, M.E. and J.E. Heyning. 1999. Killer whale *Orcinus orca* (Linnaeus, 1758). In: Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Vol. 6: Second book of dolphins. San Diego, CA: Academic Press. Pp.281-322.

Dahlheim, M.E. and C.O. Matkin. 1994. Assessment of injuries to Prince William Sound killer whales. In: Loughlin, T.R., ed. Marine mammals and the *Exxon Valdez*. San Diego, CA: Academic Press. Pp. 163-171.

Dames and Moore. 1979. The Mississippi, Alabama, Florida, outer continental shelf baseline environmental survey, MAFLA 1977/1978. Volume 1-A: Program synthesis report. U.S. Dept. of the Interior, Bureau of Land Management, Washington DC. BLM/YM/ES-79/01-Vol.-1-A. 278 pp.

Darnell, R.M. 1992. Ecological history, catastrophism, and human impact on the Mississippi/Alabama continental shelf and associated waters: a review. Gulf Research Reports 8:375-386.

Darnell, R.M. and J.A. Kleypas. 1987. Eastern Gulf shelf bio-atlas: a study of the distribution of demersal fishes and penaeid shrimp of soft bottoms of the continental shelf from the Mississippi River Delta to the Florida Keys. OCS Study MMS 86-0041. 548 pp.

Davis, R.W. and G.S. Fargion, eds. 1996. Distribution and abundance of cetaceans in the north-central and western Gulf of Mexico: final report. Volume II: Technical Report. Prepared by the Texas Institute of Oceanography and the National Marine Fisheries Service. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 96-0027. 357 pp.

Davis, R.W., G.A.J. Worthy, B. Würsig, S.K. Lynn, and F.I. Townsend. 1996. Diving behavior and at-sea movements of an Atlantic spotted dolphin in the Gulf of Mexico. Mar. Mamm. Sci. 12:569-581.

Davis, R.W., G.S. Fargion, N. May, T.D. Leming, M. Baumgartner, W.E. Evans, L.J. Hansen, and K. Mullin. 1998. Physical habitat of cetaceans along the continental slope in the north-central and western Gulf of Mexico. Mar. Mamm. Sci. 14: 490-507.

Davis, R.W., W.E. Evans, and B. Würsig. 2000. Cetaceans, sea turtles and seabirds in the northern Gulf of Mexico: Distribution, abundance and habitat associations. Volume II: Technical Report. Prepared by Texas A&M University at Galveston and the National Marine Fisheries Service. U.S. Dept. of the Interior, Geological Survey, Biological Resources Division, USGS/BRD/CR-1999-0006 and Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2000-003. 346 pp.

Delaune, R.D., W.H. Patrick, and R.J. Bureh. 1979. Effect of crude oil on a Louisiana *Spartina alterniflora* salt marsh. Environ. Poll. 20:21-31.

DeMarty, G.D., J.E. Hose, M.D. McGurk, E.D. Evelyn, and D.E. Hinton. 1997. Histopathology and cytogenetic evaluation of Pacific herring larvae exposed to petroleum hydrocarbons in the laboratory or in Prince William Sound, Alaska, after the Exxon Valdez oil spill. Canadian Journal of Fisheries and Aquatic Sciences 54(8):1846-1857.

Deutsch, C.J., J.P. Reid, R.K. Bonde, D.E. Easton, K.I. Kochman, and T.J. O'Shea. 1999. Winter movements among thermal refugia by West Indian manatees (*Trichechus manatus*) along the U.S.

Atlantic coast. Absttracts, 13th Biennial Conference on the Biology of Marine Mammals, Wailea, Maui, 28 Novembe – 3 December.

Ditty, J.G., G.G. Zieske, and R.F. Shaw. 1988. Seasonality and depth distribution of larval fishes in the northern Gulf of Mexico above 26°N Fish. Bull. 86:811-823.

Dodd, C.K., Jr. 1988. Synopsis of the biological data on the loggerhead sea turtle *Caretta caretta* (Linnaeus 1758). U.S. Dept. of the Interior, Fish and Wildlife Service. Biological Report 88(14). Gainesville, FL: National Ecology Research Center. 119 pp. Available from NTIS: Springfield, VA. PB89-109565.

Dodd, J.R. and R.J. Stanton. 1983. Paleoecology, concepts and applications. John Wiley and Sons.

Doherty, P. and T. Fowler. 1994. An empirical test of recruitment limitation in a coral reef fish. Science 263:935-939.

Douglass, S.L., B. Pickel and B. Greathouse, 1999. State-of-the-beaches of Alabama: 1998. University of South Alabama. College of Engineering Report No. 99-1.

Eckert, S.A., D.W. Nellis, K.L. Eckert, and G.L. Kooyman. 1986. Diving patterns of two leatherback sea turtles (*Dermochelys coriacea*) during internesting intervals at Sandy Point, St. Croix, U.S. Virgin Islands. Herpetologica 42:381-388.

Ecomar, Inc. 1980. Maximum and discharge study conducted for Offshore Operators Committee, Environmental Subcommittee under direction of Exxon Production Research Company. New Orleans, LA: Offshore Operators Committee. 114 pp.

Ehrhart, L.M. 1978. Choctawhatchee beach mouse. In: Layne, J.N., ed. Rare and endangered biota of Florida. Volume I: Mammals. Gainesville: University Presses of Florida. Pp. 18-19.

Eckdale, A.A., R.G. Bromley and S.G. Pemberton. 1984. Ichnology; the use of trace fossils in sedimentology and stratigraphy. Society of Economic Paleontologists and Mineralogists, Short Course No. 15. Tulsa, OK. 317 pp.

Energy Resources Group (ERG). 1981. Air quality impact of proposed OCS Sale No. 68, offshore Southern California; prepared for Bureau of Land Management, Los Angeles, CA. POC Technical Paper No. 81-87.

Engelhardt, F.R., J.P. Ray, and A.H. Gillam, eds. 1989. Drilling wastes. New York: Elsevier Science Publishers, LTD. 708 pp.

Equifax National Decision Systems. 1997. ArcData sets: 1990 Census tract boundary files; 1990 census socioeconomic pac; demographic update pac; and business facts pac. San Diego, CA.

Erickson, P., B. Fowler, and D.J. Thjomas. 1989. The fate of oil-based drilling muds at two artificial island sites in the Beaufort Sea. In: Engelhart, F.R., J.P. Ray, and A.H. Gillam, eds. Drilling Wastes. New York, NY: Elsevier Science Publishers, LTD. Pp. 23-58.

Etkin, D.S. 1998. personal communication. Research Analyst for the Oil Spill Intelligence Report. Cutter Information Corp.

Evans, D.R. and S.D. Rice. 1974. Effects of oil on marine ecosystems: a review for administrators and policy makers. Fishery Bull. 72(3):625-637.

Fedde, M.R. and W.D. Kuhlmann. 1979. Cardiopulmonary responses to inhaled sulfur dioxide in the chicken. Poultry Science 58:1584-1591.

Federal Register. 1985. Endangered and threatened wildlife and plants; removal of the brown pelican in the southeastern United States from the list of endangered and threatened wildlife. 50 FR 23.

Federal Register. 1995. Fish and Wildlife Service. 50 CFR 17. RIN 1018-AC48. Endangered and threatened wildlife and plants; final rule to reclassify the bald eagle from endangered to threatened in all of the lower 48. 60 FR 133, pp. 36000-36010.

Federal Register. 1997a. National ambient air quality standards for particulate matter; final rule (40 CFR Part 50): Part II, Environmental Protection Agency. 62 FR 138, pp. 38651-38701.

Federal Register. 1997b. National ambient air quality standards for ozone; final rule (40 CFR Part 50): Part V, Environmental Protection Agency. 62 FR 138, pp. 11-37 (prepublication).

Federal Register. 2002. Preparation of a programmatic environmental assessment for exploration activities in the sale area of the Eastern Planning Area of the Gulf of Mexico Outer Continental Shelf. Minerals Management Service. 67 FR 106, pp. 38289-38290.

Fertl, D. 1994. Occurrence, movements, and behavior of bottlenose dolphins (*Tursiops truncatus*) in association with the shrimp fishery in Galveston Bay, Texas. M.Sc. Thesis, Texas A&M University, College Station.

Fertl, D. and B. Würsig. 1995. Coordinated feeding by Atlantic spotted dolphins (*Stenella frontalis*) in the Gulf of Mexico. Aquat. Mamm. 21:3-5.

Fertl, D., A.J. Schiro, and D. Peake. 1997. Coordinated feeding by Clymene dolphins (*Stenella clymene*) in the Gulf of Mexico. Aquat. Mamm. 23:111-112.

Fischel, M., W. Grip, and I.A. Mendelssohn. 1989. Study to determine the recovery of a Louisiana marsh from an oil spill. In: Proceedings, 1989 Oil Spill Conference . . . February 13-16, 1989, San Antonio, TX. Washington, DC: American Petroleum Institute.

Fisher, C.R. 1995. Characterization of habitats and determination of growth rate and approximate ages of the chemosynthetic symbiont-containing fauna. In: MacDonald, I.R., W.W. Schroeder, and J.M. Brooks, eds. 1995. Chemosynthetic ecosystems study: final report. Volume 2: Technical report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 95-0022. Pp. 5.1-5.47.

Fisher, W.L., J.H. McGowen, L.F. Brown Jr., and C.G. Groat. 1972. Environmental geologic atlas of the Texas coastal zone: Galveston-Houston area. The University of Texas at Austin, Bureau of Economic Geology, Austin TX.

Fisher, W.L., J.H. McGowen, L.F. Brown Jr., and C.G. Groat. 1973. Environmental geologic atlas of the Texas coastal zone: Beaumont-Port Arthur area. The University of Texas at Austin, Bureau of Economic Geology, Austin TX.

Fisher, C.R., I. Urcuyo, M.A. Simpkins, and E. Nix. 1997. Life in the slow lane: growth and longevity of cold-seep vestimentiferans. Marine Ecology 18:83-94.

Florida Dept. of Environmental Protection (FDEP), National Oceanic and Atmospheric Administration, and U.S. Dept. of the Interior. 1997. Damage assessment and restoration plan/environmental assessment for the August 10, 1993, Tampa Bay oil spill. Vol. 1 - Ecological injuries.

Florida Game and Freshwater Fish Commission. 1996. Descriptions of plant communities for Landsat habitat mapping. Written communication (letter) of July 5, 1966, from John E. Stys, Biological Scientist of the Office of Environmental Services, Florida Game and Freshwater Fish Commission.

Foster and Associates, Inc. 1996. Destin Dome 56 Unit: Economic, fiscal and infrastructure impacts – 1996 data update and model re-estimation. Volumes IV.A. and B. Prepared for Chevron U.S.A., Inc., New Orleans, LA.

Foster and Associates, Inc. 1997. Social and economic consequences of onshore OCS-related activities in coastal Alabama: final baseline report. Economic baseline of the Alabama coastal region. Report prepared for the U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. 102 pp.

Fox, D.A. and J. Hightower. 1998. Identification of Gulf sturgeon spawning habitat in the Choctawhatchee River System, Alabama. Final report to North Carolina Cooperative Fish and Wildlife Research Unit, Raleigh, NC. 51 pp.

Freeman, R.L., S.M Holland, and R.B. Ditton. 1985. Measuring the impact of the Ixtoc 1 oil spill on visitation at three Texas public parks. CZM Journal 13(2):177-200.

Frey, R.W. 1975. The study of trace fossils; a synthesis of principles, problems, and procedures in ichnology. New York, NY: Springer-Verlag. 562 pp.

Frink, L. 1994. Rehabilitation of contaminated wildlife. In: Burger, J., ed. Before and after and oil spill: The Arthur Kill. New Brunswick, NJ: Rutgers University Press. Pp. 82-98.

Fritts, T.H. and M.A. McGehee. 1982. Effects of petroleum on the development and survival of marine turtle embryos. Prepared for the U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. Contract no. 14-16-0009-80-946.

Fritts, T.H. and R.P. Reynolds. 1981. Pilot study of the marine mammals, birds and turtles in OCS areas of the Gulf of Mexico. U.S. Dept. of the Interior, Fish and Wildlife Service, Biological Services Program. FWS/OBS-81/36.

Fritts, T.H., A.B. Irvine, R.D. Jennings, L.A. Collum, W. Hoffman, and M.A. McGehee. 1983. Turtles, birds, and mammals in the northern Gulf of Mexico and nearby Atlantic waters. U.S. Dept. of the Interior, Fish and Wildlife Service, Division of Biological Services, Washington, DC. FWS/OBS-82/65. 455 pp.

Fry, D.M., S.I. Fefer, and L. Sileo. 1987. Ingestion of plastic debris by laysan albatross and wedge-tailed shearwaters in the Hawaiian islands. Mar. Poll. Bull. 18(6B):339-343.

Fu, B. and P. Aharon. 1998. Sources of hydrocarbon-rich fluids advecting on the seafloor in the northern Gulf of Mexico. Gulf Coast Association of Geological Societies Transactions. 48:73-81.

Fuller, D.A. and A.M. Tappan. 1986. The occurrence of sea turtles in Louisiana coastal waters. Baton Rouge, LA: Louisiana State University, Center for Wetland Resources. LSU-CFI-86-28.

Gales, R.S. 1982. Effects of noise of offshore oil and gas operations on marine mammals - an introductory assessment. Technical Report 844. Naval Ocean Systems Center, San Diego, CA.

Gallaway, B.J. and D.K. Beaubien. 1997. Initial monitoring at a synthetic drilling fluid discharge site on the continental slope of the northern Gulf of Mexico: The Pompano Development. In: McKay, M. and J. Nides, eds. Proceedings, Seventeenth Annual Gulf of Mexico Information Transfer Meeting, December 1997. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 99-0042.

Gallaway, B.J., L.R. Martin, and R.L. Howard, eds. 1988. Northern Gulf of Mexico continental slope study: annual report, year 3. Volume I: Executive Summary. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 87-0059. 154 pp.

Gambell, R. 1985. Sei whale -- *Balaenoptera borealis*. In: Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Vol. 3: The sirenians and baleen whales. San Diego, CA: Academic Press. Pp. 155-170.

Garrison, E.G., C.P. Giammona, F.J. Kelly, A.R. Tripp, and G.A. Wolff. 1989. Historic shipwrecks and magnetic anomalies of the northern Gulf of Mexico: reevaluation of archaeological resource management zone 1. Volume 2: Technical narrative. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 89-0024. 241 pp.

Gartner, J.V., Jr. 1993. Patterns of reproduction on the dominant lanternfish species (Pisces: Myctophidae) of the eastern Gulf of Mexico, with a review of reproduction among tropical-subtropical Myctophidae. Bull. Mar. Sci. 52(2):721-750.

Gartner, J.V., Jr., T.L. Hopkins, R.C. Baird, and D.M. Milliken. 1987. The lanternfishes of the eastern Gulf of Mexico. Fish. Bull. 85(1):81-98.

Geraci, J.R. 1990. Physiologic and toxic effects on cetaceans. In: Geraci, J.R. and D.J. St. Aubin, eds. Sea mammals and oil: confronting the risks. San Diego, CA: Academic Press, Inc. Pp. 167-197.

Geraci, J.R. and D.J. St. Aubin. 1980. Offshore petroleum resource development and marine mammals: a review and research recommendations. Marine Fisheries Review 42:1-12.

Geraci, J.R. and D.J. St. Aubin. 1982. Study of the effects of oil on cetaceans. Final report prepared for the U.S. Dept. of the Interior, Bureau of Land Management, New York OCS Office, July 20, 1982. 274 pp.

Geraci, J.R. and D.J. St. Aubin. 1985. Expanded studies of the effects of oil on cetaceans, part I. Final report prepared for the U.S. Dept. of the Interior, Minerals Management Service, Washington, DC.

Geraci, J.R., D.J. St. Aubin, and R.J. Reisman. 1983. Bottlenose dolphins, *Tursiops truncatus*, can detect oil. Can. J. Fish. Aquat. Sci. 40(9):1515-1522.

Gerstein, E.R., L. Gerstein, S.E. Forsythe, and J.E. Blue. 1999. The underwater audiogram of the West Indian manatee (*Trichechus manatus*). Journal of the Acoustical Society of America 105:3575-3583.

Godish, T. 1991. Air quality. 2nd ed. Michigan: Lewis Publishers, Inc. 422 pp.

Gore, J.A., and C.A. Chase III. 1989. Snowy plover breeding distribution., Final performance report from Nongame Wildlife Section, Division of Wildlife, Florida Game and Fresh Water Fish Commission, Tallahassee, FL.

Gosselink, J.G., C.L. Cordes, and J.W. Parsons. 1979. An ecological characterization study of the Chenier Plain coastal ecosystem of Louisiana and Texas. 3 vols. U.S. Dept. of the Interior, Fish and Wildlife Services. FWS/OBS-78/9 through 78/11.

Gosselink, J.G. 1984. The ecology of delta marshes of coastal Louisiana: a community profile. U.S. Dept. of the Interior, Fish and Wildlife Service, Division of Biological Services. FWS/OBS-84-09. Louisiana State University, Baton Rouge, LA.

Govoni, J.J. and C.B. Grimes. 1992. The surface accumulation of larval fishes by hydrodynamic convergence within the Mississippi River plume front. Cont. Shelf Res. 12(11):1265-1276.

Govoni, J.J., D.E. Hoss, and D.R. Colby. 1989. The spatial distribution of larval fishes about the Mississippi River plume. Limnol. Oceanogr. 34:178-187.

Gramentz, D. 1988. Involvement of loggerhead turtle with the plastic, metal, and hydrocarbon pollution in the central Mediterranean. Mar. Poll. Bull. 19:11-13.

Greenpeace. 1992. The environmental legacy of the Gulf War. Greenpeace International, Amsterdam.

Griffin, R.B. 1999. Sperm whale distributions and community ecology associated with a warm-core ring off Georges Bank. Mar. Mamm. Sci. 15: 33-51.

Griffin, R.B. and N.J. Griffin. 1999. Distribution and habitat differentiation of *Stenella frontalis* and *Tursiops truncatus* on the eastern Gulf of Mexico continental shelf. Abstracts, 13th Biennial Conference on the Biology of Marine Mammals, Wailea, Maui, 28 November - 3 December.

Grimes, C.B. and J.H. Finucane. 1991. Spatial distribution and abundance of larval and juvenile fish, chlorophyll and macrozooplankton around the Mississippi River discharge plume, and the role of the plume in fish recruitment. Mar. Ecol. Prog. Ser. 75:109-119.

Grimes, C.B., A. Hamilton, and D.J. Kushner. 1992. A larval index to the Gulf of Mexico spawning stock of Spanish mackerel, *Scomberomorus maculatus*, 1984-1986. Report to the U.S. Dept. of Commerce, National Marine Fisheries Service, Panama City, FL, and Pascagoula, MS. 16 pp.

Gulf of Mexico Fishery Management Council (GMFMC). 1995. Draft Amendment 8 environmental assessment (effort management amendment) to the Reef fishery management plan for the reef fish resources of the Gulf of Mexico. Gulf of Mexico Fishery Management Council, Tampa, FL. 56 pp.

Gulf of Mexico Fishery Management Council (GMFMC). 1998. Generic amendment for addressing essential fish habitat requirements. Gulf of Mexico Fishery Management Council, Tampa, FL. NOAA Award No. NA87FC0003. 238 pp. + appendices. May 8, 1999.

Hall, E.R. 1981. The mammals of North America: Volume II. New York: John Wiley and Sons. Pp. 667-670.

Hall, R.J., A.A. Belisle, and L. Sileo. 1983. Residues of petroleum hydrocarbons in tissues of sea turtles exposed to the *Ixtoc* I spill. Journal of Wildlife Diseases 19:106-109.

Halliburton Company. 1995. Halliburton Redbook: Halliburton cementing tables.

Hansen, D.J. 1985. Potential effects of oil spills and other chemical pollutants on marine mammals occurring in Alaskan waters. U.S. Dept. of the Interior, Minerals Management Service, Alaska OCS Region, Anchorage, AK. OCS Study MMS 85-0031. 21 pp.

Hansen, L.J., ed. 1992. Report on investigation of 1990 Gulf of Mexico bottlenose dolphin strandings. U.S. Dept. of Commerce, National Marine Fisheries Service, Southeast Fisheries Center, Miami, FL. Report MIA-92-93-21. 219 pp.

Harris, InfoSource. 1998. 1998 Alabama manufacturing directory. Twinsburg, OH: Harris InfoSource.

Hartman, D.S. 1979. Ecology and behavior of the manatee (*Trichechus manatus*) in Florida. American Society of Mammalogists, Special Publication 5. St. Lawrence, KS. 153 pp.

Harvey, J.T. and M.E. Dahlheim. 1994. Cetaceans in oil. In: Loughlin, T.R., ed. Marine mammals and the *Exxon Valdez*. San Diego, CA: Academic Press. Pp. 257-264.

Hayman, P., J. Marchant, and T. Prater. 1986. Shorebirds: An identification guide to the waders of the world. Boston, MA: Houghton Mifflin Co. 412 pp.

Heintz, R.A., J.W. Short, and S.D. Rice. Sensitivity of fish embryos to weathered crude oil: Part II. Increased mortality of pink salmon (*Oncorhynchus gorbuscha*) embryos incubation downstream from weathered *Exxon Valdez* crude oil. Environmental Toxicology and Chemistry. 18(3)494-503.

Heneman, B. and the Center for Environmental Education. 1988. Persistent marine debris in the North Sea, northwest Atlantic Ocean, wider Caribbean area, and the west coast of Baja California. Final report for MMC. Contract MM3309598-5. Washington, DC. Available from NTIS, Springfield, VA: PB89-109938. 161 pp.

Henfer, L.M., B.O. Wilen, T.E. Dahl, and W.E. Frayer. 1994. Southeast wetlands: Status and trends, mid-1970's to mid-1980's. U.S. Dept. of the Interior, Fish and Wildlife Service, Atlanta, GA. 32 pp.

Henry, C.B., P.O. Roberts, and E.B. Overton. 1993. Characterization of chronic sources and impacts of tar along the Louisiana coast. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico Region, New Orleans, LA. OCS Study MMS 93-0046. 64 pp.

Hersh, S.L. and D.A. Duffield. 1990. Distinction between northwest Atlantic offshore and coastal bottlenose dolphins based on hemoglobin profile and morphometry. In: Leatherwood, S. and R.R. Reeves, eds. The bottlenose dolphin. San Diego, CA: Academic Press. Pp. 129-139.

Hersh, S.L. and D.K. Odell. 1986. Mass stranding of Fraser's dolphin, *Lagenodelphis hosei*, in the western North Atlantic. Mar. Mamm. Sci. 2:73-76.

Hess, N.A., and C.A. Ribic. 2000. Seabird ecology. Chapter 8. In: Davis, R.W., W.E. Evans, and B. Wursig, eds. 2000. Cetaceans, sea turtles and seabirds in the northern Gulf of Mexico: Distribution, abundance and habitat associations. Volume II. Technical report. Prepared by Texas A&M University at Galveston and the National Marine Fisheries Service. U.S. Dept. of the Interior, Geological Survey, Biological Resources Division, USGS/BRD/CR-1999-0006 and the Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2000-003.

Heyning, J.E. 1989. Cuvier's beaked whale - *Ziphius cavirostris* (G. Cuvier, 1823). In: Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Vol. 4: River dolphins and the larger toothed whales. London: Academic Press. Pp. 289-308.

Hildebrand, H.H. 1982. A historical review of the status of sea turtle populations in the western Gulf of Mexico. In: Bjorndal, K.A., ed. Biology and conservation of sea turtles. Washington, DC: Smithsonian Institution Press. Pp. 447-453.

Hirth, H.F. 1997. Synopsis of the biological data on the green turtle *Chelonia mydas* (Linnaeus 1758). U.S. Dept. of the Interior, Fish and Wildlife Service. Biological Report 97(1).

Hoffman, W. And T.H. Fritts. 1982. Sea turtle distribution along the boundary of the Gulf Stream current off eastern Florida. Herpetologica 39:405-409.

Holder, S.W., Jr. and A. Lugo-Fernandez. 1993. Relationships between the Barataria Basin tidal prism and the Basin's barrier islands. In: Symposium Proceedings, Louisiana Shoreline Erosion; Emphasis on Grand Isle, Grand Isle, LA. Pp. 31-42.

Hopkins, T.L. and R.C. Baird. 1985. Feeding ecology of four hatchetfishes (Sternoptychidae) in the eastern Gulf of Mexico. Bull. Mar. Sci. 36(2):260-277.

Hopkins T.L. and T.M. Lancraft. 1984. The composition and standing stock of mesopelagic micronekton at 27°N 86°W in the eastern Gulf of Mexico. Contrib. Mar. Sci. 27:143-158.

Hose, J.E. and E.D. Brown. 1998. Field applications of the piscine anaphase aberration test: Lessons form the *Exxon Valdez* oil spill. Mutation Research. 399(2):167-178.

Houde, E.D., J.C. Leak, C.E. Dowd, S.A. Berkeley, and W.J. Richards. 1979. Ichthyoplankton abundance and diversity in the eastern Gulf of Mexico. Report prepared for the U.S. Dept. of the Interior, Bureau of Land Management. Available from NTIS, Springfield, VA: PB-299839. 546 pp.

Hudgins, C.M., Jr. 1989. Chemical treatments and usage in offshore oil and gas production systems. Prepared for American Petroleum Institute, Offshore Effluent Guidelines Steering Committee. 46 pp.

Hughes, G.R., P. Luschi, R. Mencacci, and F. Papi. 1998. The 7000-km oceanic journey of a leatherback tracked by satellite. J. Exper. Mar. Biol. Ecol. 229:209-217.

Hummel, R.L. 1990. Main Pass and the ebb-tidal delta of Mobile Bay, Alabama. Geological Society of Alabama, Energy and Coastal Geology Division, Circular 146.

International Tanker Owners Pollution Federation Limited (ITOPF). 2002. Internet Website. Fate and Effects. reviewed August 2002. No date of last update provided at the website. http://www.itopf.com/effects.html

Irion, J.B. and R.J. Anuskiewicz. 1999. MMS seafloor monitoring project: the first annual technical report, 1997 field season. Minerals Management Service, Gulf of Mexico Region, OCS Report MMS 99-0014. New Orleans, LA.

Jacobs Engineering Group, Inc. 1989. Air quality impact of proposed OCS lease sale no. 95, final report. Contract No. 14-12-0001-30127.

Jefferies, L.M. 1979. Status of knowledge. In: Summary of the tar ball workshop. Hosted by the Texas Dept. of Water Resources and National Oceanographic and Atmospheric Administration, Office of Marine Pollution Assessment, June 26-27, 1979, Austin, TX.

Jefferson, T. A. 1995. Distribution, abundance, and some aspects of the biology of cetaceans in the offshore Gulf of Mexico. Ph.D. Thesis, Texas A&M University, College Station, TX. 232 pp.

Jefferson, T.A. and A.J. Schiro. 1997. Distribution of cetaceans in the offshore Gulf of Mexico. Mamm. Rev. 27:27-50.

Jefferson, T.A., S. Leatherwood, and M.A. Webber. 1993. FAO species identification guide. Marine Mammals of the World. Rome: Food and Agriculture Organization.

Jochens, A.E. and W.D. Nowlin, Jr., eds. 1999. Northeastern Gulf of Mexico chemical oceanography and hydrography study: Year 2 – Annual Report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 99-0054. 123 pp.

Jochens, A.E., S.F. DiMarco, W.D. Nowlin, Jr., R.O. Reid, and M.C. Kennicutt II. 2002. Northeastern Gulf of Mexico chemical oceanography and hydrography study: Synthesis report. U.S. Dept of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans. LA. OCS Study MMS 2002-055. 586 pp.

Johnston, P.A., R.L. Stringer, and D. Santillo. 1996. Cetaceans and environmental pollution: the global concern. In: Simmonds, M.P. and J.D. Hutchinson, eds. The conservation of whales and dolphins. Chichester, England: John Wiley & Sons. Pp. 219-261.

Jones, J.I., R.E. Ring, M.O. Rinkel, and R.E. Smith, eds. 1973. A summary knowledge of the Eastern Gulf of Mexico. SUSIO (State University System of Florida Institute of Oceanography), St. Petersburg, FL. 402 pp.

Jonhsgard, P.A. 1975. Waterfowl of North America. Bloomington and London: Indiana University Press.

Kannan K., K. Senthilkumar, B.G. Loganathan, S. Takahashi, D.K. Odell, and S. Tanabe. 1997. Elevated accumulation of tributyltin and its breakdown products in bottlenose dolphins (*Tursiops truncatus*) found stranded along the U.S. Atlantic and Gulf Coasts. Environmental Science & Technology 31:296-301.

Kennicutt II, M.C., ed. 1995. Gulf of Mexico offshore operations monitoring experiment, Phase I: Sublethal responses to contaminant exposure, final report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 95-0045. 709 pp.

Kesel, R.H. 1988. The decline in the suspended load of the lower Mississippi River and its influence on adjacent wetlands. Environ. Geol. Water Sci. 11(3):271-281.

Kirstein, B.E. 1992. Adaptation of the Minerals Management Service's oil-weathering model for use in the Gulf of Mexico Region. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 92-0023. 64 pp.

Klima, E.F., G.R. Gitschlag, and M.L. Renaud. 1988. Impacts of the explosive removal of offshore petroleum platforms on sea turtles and dolphins. Mar. Fish. Rev. 50:33-42.

Knowlton, A.R. and B. Weigle. 1989. A note on the distribution of leatherback turtles (*Dermochelys coriacea*) along the Florida coast in February 1988. Proceedings, 9th Annual Workshop on Sea Turtle Conservation and Biology. NOAA Tech. Memo. NMFS-SEFSC-232.

Knowlton, A.R., S.D. Kraus, D.F. Meck, and M.L. Mooney-Seus. 1997. Shipping/right whale workshop. New England Aquarium, Aquatic Forum Series, Report 97-3.

Koike, B.G. 1996. News from the bayous - Louisiana Sea Turtle Stranding and Salvage Network. Proceedings,15th Annual Workshop on Sea Turtle Conservation and Biology. NOAA Tech. Memo. NMFS-SEFSC-387.

Kraus, S.D. 1990. Rates and potential causes of mortality in North Atlantic right whales (*Eubalaena glacialis*). Mar. Mamm. Sci. 6:278-291.

Kruse, S., D.K. Caldwell, and M.C. Caldwell. 1999. Risso's dolphin *Grampus griseus* (G. Cuvier, 1812). In: Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Vol. 6: Second book of dolphins. San Diego, CA: American Press. Pp. 183-212.

Kuehl, D.W. and R. Haebler. 1995. Organochlorine, organobromine, metal, and selenium residues in bottlenose dolphins (*Tursiops truncatus*) collected during an unusual mortality event in the Gulf of Mexico, 1990. Archives of Environmental Contamination and Toxicology. 28:494-499.

Kwon, H.J. 1969. Barrier islands of the northern Gulf of Mexico coast: Sediment source and development. Coastal Studies Series Number 23. Baton Rouge, LA: Louisiana State University Press.

Laist, D.W. 1997. Impacts of marine debris: entanglement of marine life in marine debris including a comprehensive list of species with entanglement and ingestion records. In: Coe, J.M. and D.B. Rogers, eds. Marine debris: sources, impacts, and solutions. New York: Springer-Verlag. Pp. 99-139.

Landry, Jr., A.M. and D. Costa. 1999. Status of sea turtle stocks in the Gulf of Mexico with emphasis on the Kemp's ridley. In: Kumpf, H., K. Steidinger, and K. Sherman, eds. The Gulf of Mexico Large Marine Ecosystem: Assessment, Sustainability, and Management. Blackwell Science. Pp. 248-268.

Lane, J.S. and R.P. LaBelle. 2000. Meeting the challenge of potential deepwater spills: Cooperative research effort between industry and government. Paper presented at the Society of Petroleum

Engineers' International Conference on Health, Safety, and the Environment in Oil and Gas Exploration and Production, Stavanger, Norway, 26-28 June 2000. SPE 61114. 6 pp.

Leary, T.R. 1957. A schooling of leatherback turtles, *Dermochelys coriacea coriacea*, on the Texas coast. Copeia 1957:232.

Leatherwood, S. and R.R. Reeves. 1983. Abundance of bottlenose dolphins in Corpus Christi Bay and coastal southern Texas. Contributions in Marine Science 26:179-199.

Leighton, F.A. 1990. The toxicity of petroleum oils to birds: An overview. Oil Symposium, Herndon, VA.

Leis, J.L. 1991. The pelagic stage of reef fishes: The larval biology of coral reef fishes. In: Sale, P.F., ed. The ecology of fishes on coral reefs. New York, NY: Academic Press. Pp. 183-230.

Lenhardt, M.L. 1994. Seismic and very low frequency sound induced behaviors in captive loggerhead marine turtles (*Caretta caretta*). In: Proceedings, Fourteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Tech. Memo. NMFS-SEFSC-351.

Lenhardt, M.L., S. Bellmund, R.A. Byles, S.W. Harkins, and J.A. Musick. 1983. Marine turtle reception of bone-conducted sound. Journal of Auditory Research 23:119-125.

Linden, O., J.R. Sharp, R. Laughlin, Jr., and J.M. Neff. 1979. Interactive effects of salinity, temperature, and chronic exposure to oil on the survival and development rate of embryos of the estuarine killfish *Fundulus heteroclitus*. Mar. Biol. 51:101-109.

Lipscomb, T.P., R.K. Harris, A.H. Rebar, B.E. Ballachey, and R.J. Haebler. 1994a. Pathology of sea otters. In: Loughlin, T.R., ed. Marine mammals and the *Exxon Valdez*. San Diego, CA: Academic Press. Pp. 265-279.

Llacuna, S., A. Gorriz, M. Durfort, and J. Nadal. 1993. Effects of air pollution on passerine birds and small mammals. Arch. Environ. Contam. Toxicol. 24:59-66.

Lohoefener, R.R., W. Hoggard, C.L. Roden, K.D. Mullin, and C.M. Rogers. 1988. Distribution and relative abundance of surfaced sea turtles in the north-central Gulf of Mexico: spring and fall 1987. Proceedings, 8th Annual Workshop on Sea Turtle Conservation and Biology. NOAA Tech. Memo. NMFS-SEFSC-214.

Lohoefener, R.R., W. Hoggard, C.L. Roden, K.D. Mullin, and C.M. Rogers. 1989. Petroleum structures and the distribution of sea turtles. In: Proceedings, Spring Ternary Gulf of Mexico Studies Meeting. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 89-0062. Pp. 31-35.

Lohoefener, R., W. Hoggard, K. Mullin, C. Roden, and C. Rogers. 1990. Association of sea turtles with petroleum platforms in the north-central Gulf of Mexico. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 90-0025. 90 pp.

Longwell, A.C. 1977. A genetic look at fish eggs and oil. Oceanus 20(4):46-58.

Lore, G.L., D.A. Marin, E.C. Batchelder, W.C. Courtwright, R.P. Desselles, and R.J. Klazynski. 2001. 2000 assessment of conventionally recoverable hydrocarbon resources of the Gulf of Mexico and Atlantic Outer Continental Shelf as of January 1, 1999. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Report MMS 2001-087.

Louisiana Coastal Wetlands Conservation and Restoration Task Force. 1993. Louisiana coastal wetlands restoration plan: main report and environmental impact statement.

Louisiana Dept. of Environmental Quality (LDEQ). 1996. Air quality annual report, 1996. Office of Air Quality and Radiation Protection, Baton Rouge, LA. 28 pp. + apps.

Louisiana Dept. of Environmental Quality (LDEQ). 1997. Written communication. Ambient air quality data (monthly). Louisiana Dept. of Environmental Quality, Office of Air Quality, Baton Rouge, LA.

Louisiana Dept. of Wildlife and Fisheries. 1994. A fisheries management plan for Louisiana penaeid shrimp fishery: Summary and action items. November 1992, Baton Rouge, LA. 16 pp.

Lukina, L., S. Matisheva, and V. Shapunov. 1996. Ecological monitoring of the captivity sites as a means of studying the influence of contaminated environment on cetaceans. In: Öztürk, B., ed. Proceedings, First International Symposium on the Marine Mammals of the Black Sea, 27-30 June 1994, Istanbul, Turkey. Pp. 52-54.

Lutcavage, M.E., P.G. Bushnell, and D.R. Jones. 1990. Oxygen transport in the leatherback sea turtle, *Dermochelys coriacea*. Physiol. Zool. 63:1012-1024.

Lutcavage, M.E., P.L. Lutz, G.D. Bossart, and D.M. Hudson. 1995. Physiologic and clinicopathologic effects of crude oil on loggerhead sea turtles. Arch. Environ. Contam. Toxicol. 28:417-422.

Lutcavage, M.E., P. Plotkin, B. Witherington, and P.L. Lutz. 1997. Human impacts on sea turtle survival. In: Lutz, P.L. and J.A. Musick, eds. The biology of sea turtles. Boca Raton, FL: CRC Press. Pp. 387-409.

Lutz, P.L. 1990. Studies on the ingestion of plastic and latex by sea turtles. In: Shomura, R.S. and M.L. Godfrey, eds. Proceedings, Workshop on the Fate and Impact of Marine Debris, November 26-29, 1984, Honolulu, HI. U.S. Dept. of Commerce. NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-154. Pp. 719-735.

Lutz, P.L. and M. Lutcavage. 1989. The effects of petroleum on sea turtles: applicability to Kemp's ridley. In: Caillouet, C.W., Jr. and A.M. Landry, Jr., comps. Proceedings of the First International Symposium on Kemp's Ridley Sea Turtle Biology, Conservation, and Management. TAMU-SG-89-105.

Lyczkowski-Shultz, J. 1999. Early life stages of fishes in the vicinity of the DeSoto Canyon. In: McKay, M. and J. Nides, eds. Proceedings, Seventeenth Annual Gulf of Mexico Information Transfer Meeting, December 1997. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 99-0042. Pp. 293-299.

Lyons, T.J. and W.D. Scott. 1990. Principles of air pollution meteorology. Boca Raton, FL: CRC Press, Inc. 225 pp.

Lytle, J.S. 1975. Fate and effects of crude oil on an estuarine pond. In: Proceedings, Conference on Prevention and Control of Oil Pollution, San Francisco, CA. Pp. 595-600.

Maccarone, A.D. and J.N. Brzorad. 1994. Gulf and waterfowl populations in the Arthur Kill. In: Burger, J., ed. Before and after an oil spill: The Arthur Kill. New Brunswick, NJ: Rutgers University Press. Pp. 595-600.

Maccarone, A.D. and J.N. Brzorad. 1995. Effects of an oil spill on the prey populations and foraging behavior of breeding wading birds. Wetlands 15:397-407.

MacDonald, I.R., ed. 1992. Chemosynthetic ecosystems study literature review and data synthesis; Volumes I-III. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 92-0033 through 92-0035.

MacDonald, I.R., ed. 1998. Stability and change in Gulf of Mexico chemosynthetic communities: interim report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 98-0034. 114 pp.

MacDonald, I.R., N.L. Guinasso, Jr., J.F. Reilly, J.M. Brooks, W.R. Callender, and S.G. Gabrielle. 1990. Gulf of Mexico hydrocarbon seep communities: VI. Patterns in community structure and habitat. Geo-Marine Letters 10:244-252.

MacDonald, I.R., N.L. Guinasso Jr., S.G. Ackleson, J.F. Amos, R. Duckworth, R. Sassen, and J.M. Brooks. 1993. Natural oil slicks in the Gulf of Mexico visible from space. J. Geophysical Res. 98:16,351-16,364.

MacDonald, I.R., W.W. Schroeder, and J.M. Brooks, eds. 1995. Chemosynthetic ecosystems study: final report. Volume 2: Technical report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 95-0022. 319 pp.

MacDonald, I.R., J.F. Reiley, Jr., S.E. Best, R. Sassen, N.L. Guinasso, Jr., and J Amos. 1996. Remote sensing inventory of active oil seeps and chemosynthetic communities in the northern Gulf of Mexico. In: Schumacher, D. and M.A. Abrams, eds. Hydrocarbon migration and its near-surface expression. AAPG Memoir 66. Pp. 27-37.

Madge, S. and H. Burn. 1988. Waterfowl: An identification guide to the ducks, geese, and swans of the world. Boston: Houghton Mifflin.

Maki, A.W., E.J. Brannon, L.G. Gilbertson, L.L. Moulton, and J.R. Skalski. 1995. An assessment of oil spill effects on pink salmon populations following the *Exxon Valdez* oil spill-Part 2: Adults and escapement. In: Wells, P.G., J.N. Butler, J.S. Hughes, eds. *Exxon Valdez* oil spill: Fate and effects in Alaskan waters. Philadelphia, PA: American Society for Testing and Materials. ASTM STP 1219. Pp. 585-625.

Malins, D.C., S. Chan, H.O. Hodgins, U. Varanasi, D.D. Weber, and D.W. Brown. 1982. The nature and biological effects of weathered petroleum. Environmental Conservation Division, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, Seattle, WA. 43 pp.

Manzella, S., J. Williams, B. Schroeder, and W. Teas. 1991. Juvenile head-started Kemp's ridleys found in floating grass mats. Marine Turtle Newsletter, No. 52:5-6.

Marine Mammal Commission (MMC). 1998. Annual report to Congress, 1997.

Marquez-M., R. 1990. FAO Species Catalogue. Volume 11: sea turtles of the world. An annotated and illustrated catalogue of sea turtle species known to date. FAO Fisheries Synopsis. FAO, Rome.

Marquez-M., R. 1994. Synopsis of biological data on the Kemp's ridley turtle, *Lepidochelys kempi*, (Garman, 1880). U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 94-0023. 91 pp.

Martin, R.P. 1991. Regional overview of wading birds in Louisiana, Mississippi, and Alabama. In: Proceedings of the coastal nongame workshop. U.S. Dept. of the Interior, Fish and Wildlife Service, Region 4, and Florida Game and Fresh Water Fish Commission. Pp. 22-33.

Martin, R.P., and G.D. Lester. 1991. Atlas and census of wading bird and seabird nesting colonies in Louisiana: 1990. Special Publication No. 3, Louisiana Dept. of Wildlife and Fisheries, Louisiana Natural Heritage Program.

Matkin, C.O. and D. Sheel. 1996. Comprehensive killer whale investigation in Prince William Sound. Abstract, Draft 1996 Restoration Workshop, *Exxon Valdez* Oil Spill Trustee Council, January 16-18, Anchorage, AK.

Matkin, C.O., G.M. Ellis, M.E. Dahlheim, and J. Zeh. 1994. Status of killer whales in Prince William Sound, 1985-1992. In: Loughlin, T.R., ed. Marine mammals and the *Exxon Valdez*. San Diego, CA: Academic Press. Pp. 141-162.

McCauley, R.D., J. Fewtrell, A.J. Duncan, C. Jenner, M-N. Jenner, J.D. Penrose, R.I.T. Prince, A. Adhitya, J. Murdoch, and K. McCabe. 2000. Marine seismic surveys – a study of environmental implications. APPEA Journal 2000:692-708.

McRoy, C.P. and C. Helfferich. 1980. Applied aspects of seagrasses. In: Phillips, R.C. and C.P. McRoy, eds. Handbook of seagrass biology—an ecosystem approach. New York: Garland Publications, Inc. Pp. 297-342.

Mead, J.G. 1989. Beaked whales of the genus - *Mesoplodon*. In: Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Vol. 4: River dolphins and the larger toothed whales. London: Academic Press. Pp. 349-430.

Mead, J.G. and C.W. Potter. 1990. Natural history of bottlenose dolphins along the Central Atlantic coast of the United States. In: Leatherwood, S. and R.R. Reeves, eds. The bottlenose dolphin. San Diego: Academic Press. Pp. 165-195.

Miller, J.E., S.W. Baker, and D.L. Echols. 1995. Marine debris point source investigation 1994-1995, Padre Island National Seashore. U.S. Dept. of the Interior, National Park Service, Corpus Christi. June 1995. 40 pp.

Mills, L.R. and K.R. Rademacher. 1996. Atlantic spotted dolphins (*Stenella frontalis*) in the Gulf of Mexico. Gulf of Mexico Science 1996:114-120.

Mitchell, E.D. 1991. Winter records of the minke whale *Balaenoptera acutorostrata* (Lacepede 1804) in the southern North Atlantic. Rep. Int. Whal. Commn. 41:455-457.

Miyazaki, N. and W.F. Perrin. 1994. Rough-toothed dolphin - *Steno bredanensis* (Lesson, 1828). In: Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Vol. 5: First book of dolphins. San Diego, CA: Academic Press. Pp. 1-21.

Mobile Register. 1996. Article providing information on the economic value of tourism to coastal Alabama. November 16, 1996. Mobile, AL.

Moein Bartol, S., J.A. Musick, and M.L. Lenhardt. 1993. Auditory evoked potentials of the loggerhead sea turtle (*Caretta caretta*). Copeia 1999:836-840.

Mooney, T. 1996. Fishermen ask state: Put us back in water. Providence Journal Bulletin. March 12.

Moore, D.R. and H.R. Bullis, Jr. 1960. A deep-water coral reef in the Gulf of Mexico. Bull. Mar. Sci. 10(1):125-128.

Moore, J.C. and E. Clark. 1963. Discovery of right whales in the Gulf of Mexico. Science 141:269.

Morreale, S.J., E.A. Standora, J.R. Spotila, and F.V. Paladino. 1996. Migration corridor for sea turtles. Nature 384:319-320.

Mullin, K. 1998. Personal communication. U.S. Dept. of Commerce, National Marine Fisheries Service, Pascagoula, MS.

Mullin, K.D. and L.J. Hansen. 1999. Marine mammals of the northern Gulf of Mexico. In: H. Kumph, K. Steidinger, and K. Sherman, eds. Gulf of Mexico: A large marine ecosystem. Blackwell Science. Pp. 269-277.

Mullin, K., W. Hoggard, C. Roden, R. Lohoefener, C. Rogers, and B. Taggart. 1991. Cetaceans on the upper continental slope in the north-central Gulf of Mexico. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 91-0027. 108 pp.

Mullin, K.D., W. Hoggard, C.L. Roden, R.R. Lohoefener, C.M. Rogers, and B. Taggart. 1994a. Cetaceans on the upper continental slope in the north-central Gulf of Mexico. U.S. Fish. Bull. 92:773-786.

Mullin, K.D., T.A. Jefferson, L.J. Hansen, and W. Hoggard. 1994b. First sightings of melon-headed whales (*Peponocephala electra*) in the Gulf of Mexico. Mar. Mamm. Sci. 10:342-348.

Mullin, K.D., L.V. Higgins, T.A. Jefferson, and L.J. Hansen. 1994c. Sightings of the Clymene dolphin (*Stenella clymene*) in the Gulf of Mexico. Mar. Mamm. Sci. 10:464-470.

Murray, S.P. 1998. An observational study of the Mississippi-Atchafalaya coastal plume: Final report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 98-0040. 513 pp.

Myrick, A.C., Jr. and P.C. Perkins. 1995. Adrenocortical color darkness and correlaes as indicators of continuous acute premortem stress in chased and purse-seine captured male dolphins. Pathophysiology 2:191-204.

National Research Council (NRC). 1983. Drilling discharges in the marine environment. Panel on Assessment of Fates and Effects of Drilling Fluids and Cuttings in the Marine Environment. Marine Board; Commission on Engineering and Technical Systems; National Research Council. Washington, DC: National Academy Press.

National Research Council (NRC). 1985. Oil in the sea: inputs, fates, and effects. Washington, DC: National Academy Press. 601 pp.

National Research Council (NRC). 1990. The decline of sea turtles: causes and prevention. Washington, DC: National Academy Press. 183 pp.

National Research Council (NRC). 1994. Low-frequency sound and marine mammals: current knowledge and research needs. Washington, DC: National Academy Press. 75 pp.

National Reseach Council (NRC). 2002. Oil in the sea III: Inputs, fates, and effects. Committee on Oil in the Sea, National Academy Press, Washington, DC (prepublication version http://www.nap.edu/catalog/10388.html).

Neff, J.M. 1981. Fate and biological effects of oil well drilling fluids in the marine environment: a literature review. Final technical report no. 15077 to the U.S. Environmental Protection Agency. Gulf Breeze, FL: U.S. Environmental Protection Agency, Environmental Research Laboratory.

Neff, J.M. 1987. Biological effects of drilling fluids, drill cuttings and produced waters. In: Boesch, D.F. and N.N. Rabalais, eds. Long-term Environmental Effects of Offshore Oil and Gas Development. London: Elsevier Applied Science. Pp. 469-538.

Neff, J.M. 1990. Composition and fate of petroleum and spill-treating agents in the marine environment. In: Geraci, J.R. and D.J. St. Aubin, eds. Sea mammals and oil: confronting the risks. San Diego, CA: Academic Press, Inc. Pp. 1-33.

Neff, J.M. 1997. Metals and organic chemicals associated with oil and gas well produced water: bioaccumulation, fates, and effects in the marine environment (Gulf of Mexico produced water bioaccumulation study). Prepared for Continental Shelf Associates, Inc., Jupiter, FL. 357 pp.

Neff, J.M. 2002. Bioaccumulation in Marine Organisms. Elsevier Science. NY, NY.

Neff, J.M., T.C. Sauer, and N. Maciolek. 1989. Fate and effects of produced water discharges in nearshore marine waters. Prepared for the American Petroleum Institute, Washington, DC.

Neff, J.M., S. McKelvie, and R.C. Ayers, Jr. 2000. Environmental impacts of synthetic-based drilling fluids. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2000-064. 120 pp.

NERBC (New England River Basins Commission). 1976. Factbook. In: Onshore facilities related to offshore oil and gas development. Boston, MA.

Nelson, H.F. and E.E. Bray. 1970. Stratigraphy and History of the Holocene Sediments in the Sabine-High Island Area, Gulf of Mexico. In: Morgam, J.P., ed. Deltaic Sedimentation; Modern and Ancient. Special Publn. No. 15. Tulsa, OK: SEPM.

Newman, J.R. 1977. Sensitivity of the hose martin (*Delichon urbica*) to fluoride emissions. Fluoride 10:73-76.

Newman, J.R. 1979. Effects of industrial air pollution on wildlife Biol. Conserv. 15:181-190.

Newman, J.R. 1980. Effects of air emissions on wildlife resources. U.S. Dept. of the Interior, Fish and Wildlife Service, Biological Services Program, National Power Plant Team. FWS/OBS-80/40.1. 32 pp.

Newman, J.R. 1981. Effects of air pollutants on animals at concentrations at or below ambient air quality standards. Final report to the U.S. Dept. of the Interior, National Park Service, Denver Air Quality Office. 26 pp.

Nicholls, J.L. and G.A. Baldassarre. 1990. Habitat associations of piping plovers wintering in the United States. Wilson Bulletin 102:581-590.

NOSAC (National Offshore Safety Advisory Committee). 1999. Deepwater facilities in the Gulf of Mexico, final report. NOSAC Subcommittee on Collision Avoidance. 42 pp.

Nowlin, W.D., Jr. 1972. Winter Circulation Patterns and Property Distributions. In: Capurra, L.R.A. and J.L. Reid, eds. Contributions on the Physical Oceanography of the Gulf of Mexico. Houston, TX: Gulf Publishing Company. Pp. 3-51.

Nowlin, W.D., Jr., A.E. Jochens, R.O. Reid, and S.F. DiMarco. 1998. Texas-Louisiana shelf circulation and transport processes study: Synthesis report. Volume II: Appendices. U.S. Dept. of the Interior, Minerals Management Services, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 98-0036. 288 pp.

Oceaneering International, Inc. 1990. Oryx Energy ROV chemosynthetic survey, Viosca Knoll Block 826. Report to Oryx Energy Company. 6 pp. + appendices and map.

Oceaneering and LGL. 1991. Composite map series for Oryx Energy Company. Set of 5 composite maps interpreted and color coded from original ROV data by Oceaneering International (1990).

Odell, D.K. and C. MacMurray. 1986. Behavioral response to oil. In: Vargo, S., P.L. Lutz, D.K. Odell, T. Van Vleet, and G. Bossart, eds. Study of the effects of oil on marine turtles, final report. U.S. Dept. of the Interior, Minerals Management Service, Atlantic OCS Region.

Odell, D.K. and K.M. McClune. 1999. False killer whale *Pseudorca crassidens* (Owen, 1846). In: Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Vol. 6: Second book of dolphins. San Diego, CA: Academic Press. Pp. 213-243.

Offshore Technology. (2002). Delmar, Shell reach record mooring water depth. Internet Website. Industry News, March 12, 2002. http://www.offshore-technology.com.

Ogren, L.H. 1989. Distribution of juvenile and subadult Kemp's ridley turtles: Preliminary result from the 1984-1987 surveys. In: Proceedings of the First International Symposium on Kemp's Ridley Sea Turtle Biology, Conservation and Management, October 1-4, 1985, Galveston, TX. TAMU-SG-89-105. Sea Grant College Program, Texas A&M University. Pp. 116-123.

O'Hara, J. and J.R. Wilcox. 1990. Avoidance responses of loggerhead turtles, *Caretta caretta*, to low frequency sounds. Copeia 1990(2):564-567.

OILNERGY. 2002. Internet site (December 13, 2002). Energy Statistics. http://www.oilnergy.com.

Okuyama, H., Y. Majima, A.M. Dannenberg, Jr., M. Suga, B.G. Bang, and F.B. Bang. 1979. Quantitative histological changes produced in the tracheal mucosa of young chickens by the inhalation of sulfur dioxide in low concentrations. J. Environ. Sci. Health C13(4):267-700.

Olds, W.T., Jr. 1984. In: U.S. Congress, House Committee on Merchant Marine Fisheries, Offshore Oil and Gas Activity and Its Socioeconomic and Environmental Influences, 98th Cong., 2d session., 1984. Pp. 54-55.

Orlando, S. P. J., L. P. Rozas, G. H. Ward, and C. J. Klein. 1993. Salinity characteristics of Gulf of Mexico estuaries. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Silver Spring, MD. P. 209.

Ortega, J. 1998. Personal communication. Marine Mammal Research Program, Texas A&M University at Galveston, Galveston, TX.

O'Shea, B.B. Ackerman, and H.F. Percival, eds. 1995. Population biology of the Florida manatee. National Biological Service, Information and Technology Report 1.

O'Sullivan, S. and K.D. Mullin. 1997. Killer whales (*Orcinus orca*) in the northern Gulf of Mexico. Mar. Mamm. Sci. 13:141-147.

Otvos, E.G. 1979. Barrier island evolution and history of migration: north central Gulf coast. In: Leatherman, S., ed. Barrier islands from the Gulf of St. Lawrence to the Gulf of Mexico. New York, NY: Academic Press. Pp. 219-319.

Overton, E.B., C.J. Byrne, J.A. McFall, S.R. Antoine, and J.L. Laseter. 1983. Results from the chemical analyses of oily residue samples from stranded juvenile sea turtles collected from Padre and Mustang Islands, Texas. Prepared by the Center for Bio-Organic Studies, University of New Orleans for the U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA.

Owens, D. 1983. Oil and sea turtles in the Gulf of Mexico: a proposal to study the problem. In: Keller, C.E. and J.K. Adams, eds. Proceedings, Workshop on cetaceans and sea turtles in the Gulf of Mexico: study planning for effects of outer continental shelf development. Prepared by the U.S. Dept. of the Interior, Fish and Wildlife Service, for the U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. Pp. 34-39.

Paladino, F.V., M.P. O'Connor, and J.R. Spotila. 1990. Metabolism of leatherback turtles, gigantothermy, and thermoregulation of dinosaurs. Nature 344:859-860.

Parnell, J.F., D.G. Ainley, H. Blokpoel, B. Cain, T.W. Custer, J.L. Dusi, S. Kress, J.A. Kushlan, W.E. Southern, L.E. Stenzel, and B.C. Thompson. 1988. Colonial waterbird management in North America. Colonial Waterbirds 11:129-345.

Pashley, D.N. 1991. Shorebirds, gulls, and terns: Louisiana, Mississippi, Alabama. In: Proceedings of the coastal nongame workshop. U.S. Dept. of the Interior, Fish and Wildlife Service, Region 4, and Florida Game and Fresh Water Fish Commission. Pp. 79-83.

Patrick, L. 1996. Personal communication. U.S. Dept. of the Interior, Fish and Wildlife Service, Panama City, FL.

Patrick, L. 1997. Personal communication. U.S. Dept. of the Interior, Fish and Wildlife Service, Panama City, FL.

Payne, J.F., J. Kiceniuk, L.L. Fancey, U. Williams, G.L. Fletcher, A. Rahimtula, and B. Fowler. 1988. What is a safe level of polycyclic aromatic hydrocarbons for fish: subchronic toxicity study on winter flounder (*Pseudopleuronectes americanus*). Can. J. Fish. Aquat. Sci. 45:1983-1993.

Pearson, W.H., E. Moksness, and J.R. Skalski. 1995. A field and laboratory assessment of oil spill effects on survival and reproduction of Pacific herring following the *Exxon Valdez* spill. In: Wells, P.G., J.N. Butler, and J.S. Hughes, eds. *Exxon Valdez* oil spill: Fate and effects in Alaskan waters. Philadelphia, PA: American Society for Testing and Materials. ASTM STP 1219. Pp. 626-661.

Pearson, C.E., S.R. James, Jr., S.D. El Darragi, and M.C. Krivor. 2002. Refining and revising the Gulf of Mexico Outer Continental Shelf Region high probability model for historic shipwrecks. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico Region, New Orleans, LA. MS Contract Number 31054.

Penland, S. 1995. Consequences of Mississippi River control in Louisiana: the worst coastal land loss conditions in the United States. Geological Society of America, Abstracts with Programs 28, p. A-85.

Penland, S. and J.R. Suter. 1988. Barrier island erosion and protection in Louisiana: a coastal geomorphological perspective. Transactions Gulf Coast Associations of Geological Societies. 38:331-342.

Pequegnat, W.E. 1983. The ecological communities of the continental slope and adjacent regimes of the northern Gulf of Mexico. Prepared by TerEco Corp. for the U.S. Dept. of the Interior, Minerals Management Service, New Orleans, LA. Contract no. AA851-CT1-12. 398 pp.

Perrin, W.F. and J.W. Gilpatrick, Jr. 1994. Spinner dolphin - *Stenella longirostris* (Gray, 1828). In: Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Vol. 5: First book of dolphins. London: Academic Press. Pp. 99-128.

Perrin, W.F. and A.A. Hohn. 1994. Pantropical spotted dolphin - *Stenella attenuata*. In: Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Vol. 5: The first book of dolphins. London: Academic Press. Pp. 71-98.

Perrin, W.F. and J.G. Mead. 1994. Clymene dolphin *Stenella clymene* (Gray, 1846). In: Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Vol. 5: The first book of dolphins. London: Academic Press. Pp. 161-171.

Perrin, W.F., E.D. Mitchell, J.G. Mead, D.K. Caldwell, and P.J.H. van Bree. 1981. *Stenella clymene*, a rediscovered tropical dolphin of the Atlantic. J. Mammal. 62:583-598.

Perrin, W.F., D.K. Caldwell, and M.C. Caldwell. 1994a. Atlantic spotted dolphin *Stenella frontalis* (G. Cuvier, 1829). In: Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Vol. 5: The first book of dolphins. London: Academic Press. Pp. 173-190.

Perrin, W.F., C.E. Wilson, and F.I. Archer II. 1994b. Striped dolphin - *Stenella coeruleoalba* (Meyen, 1833). In: Ridgway, S.H. and R. H arrison, eds. Handbook of marine mammals. Vol. 5: The first book of dolphins. London: Academic Press. Pp. 129-159.

Perrin, W.F., S. Leatherwood, and A. Collet. 1994c. Fraser's dolphin - *Lagenodelphis hosei* (Fraser, 1956). In: Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Vol. 5: The first book of dolphins. London: Academic Press. Pp. 225-240.

Perryman, W.L., D.W.K. Au, S. Leatherwood, and T.A. Jefferson. 1994. Melon-headed whale - *Peponocephala electra* (Gray, 1846). In: Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Vol. 5: The first book of dolphins. London: Academic Press. Pp. 363-386.

Petrazzuolo, G. 1981. Preliminary report: an environmental assessment of drilling fluids and cuttings releases onto the outer continental shelf. Washington, DC: U.S. Environmental Protection Agency.

Piatt, J.F., C.J. Lensink, W. Butler, M. Kendziorek, and D.R. Nysewander. 1990. Immediate impact of the *Exxon Valdez* oil spill on marine birds. The Auk 107(2):387-397.

Plön, S. and R. Bernard. 1999. The fast lane revisited: Life history strategies of *Kogia* from southern Africa. Abstracts, 13th Biennial Conference on the Biology of Marine Mammals, Wailea, Maui, 28 November - 3 December.

Plotkin, P. and A.F. Amos. 1988. Entanglement in and ingestion of marine debris by sea turtles stranded along the South Texas coast. In: Proceedings, 8th Annual Workshop on sea turtle conservation and biology. NOAA Tech. Memo. NMFS-SEFSC-214.

Plotkin, P.T., M.K. Wicksten, and A.F. Amos. 1993. Feeding ecology of the loggerhead sea turtle *Caretta caretta* in the northwestern Gulf of Mexico. Mar. Biol. 115: 1-15.

Powell, E.N. 1995. Evidence for temporal change at seeps. In: MacDonald, I.R., W.W. Schroeder, and J.M. Brooks, eds. Chemosynthetic ecosystems study: final report. Volume 2: Technical report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 95-0022. Pp. 8.1-8.65.

Powell, J.A. and G.B. Rathbun. 1984. Distribution and abundance of manatees along the northern coast of the Gulf of Mexico. Northeast Gulf Sci. 7:1-28.

Power, J.H. and L. N. May, Jr. 1991. Satellite observed sea-surface temperatures and yellowfin tuna catch and effort in the Gulf of Mexico. Fish. Bull. 89:429-439.

Preen, A. 1991. Report on the die-off of marine mammals associated with the Gulf War oil spill. Report prepared for The National Commission for Wildlife Conservation and Development. 8 pp.

Price, J.M., C.F.Marshall, G.B. Rainey, and E.M. Lear, eds. 2001. Oil-spill risk analysis: Gulf of Mexico outer continental shelf (OCS), in support of the environmental impact statement (EIS) for proposed Lease Sale 181. U.S. Dept. of the Interior, Minerals Management Service, Branch of Environmental Operations and Analysis, Washington, DC. OCS Report MMS 2001-007.

Pristas, P.H., A.M. Avrigian, and M.I. Farber. 1992. Big game fishing in the northern Gulf of Mexico during 1991. NOAA Tech. Mem. NMFS-SEFC-312. 16 pp.

Quigley, D., J.S. Hornafius, B.P. Luyendyk, R.D. Francis, and E. Bartsch. 1996. Temporal variation in the spatial distribution of natural marine hydrocarbon seeps in the northern Santa Barbara Channel, California. Proceedings of the Annual Meeting of the American Geophysical Union.

Rathbun, G.B., J.P. Reid, and G. Carowan. 1990. Distribution and movement patterns of manatees (*Trichechus manatus*) in northwestern peninsular Florida. FL Mar. Res. Publ., No. 48. 33 pp.

Raymond, P.W. 1984. Sea turtle hatchling disorientation and artificial beachfront lighting, a review of the problem and potential solutions. Washington, DC: Center for Environmental Education. 72 pp.

Reeves, R.R., B.S. Stewart, and S. Leatherwood. 1992. The Sierra Club handbook of seals and Sirenians. San Francisco, CA: Sierra Club Books, 359 pp.

Rester, J. and R. Condrey. 1996. The occurrence of the hawksbill turtle, *Eretmochelys imbricata*, along the Louisiana coast. Gulf Mex. Sci. 1996:112-114.

Restrepo and Associates. 1982. *Ixtoc 1* oil spill economic impact study. Final report prepared for the U.S. Dept. of the Interior, Bureau of Land Management. Contract No. AA851-CTO-65. El Paso, TX. 3 vols.

Reuters. 1997. Japan oil spill forces dolphin evacuation. News clip from Reuters in January.

Rhinehart, H.L., C.A. Manire, J.D. Buck, P. Cunningham-Smith, and D.R. Smith. 1999. Observations and rehabilitation of rough-toothed dolphins, *Steno bredanensis*, treated at Mote Marine Laboratory from two separate stranding events. Abstracts, 13th Biennial Conference on the Biology of Marine Mammals, Wailea, Maui, 28 November - 3 December.

Richards, W.J., T. Leming, M.F. McGowan, J.T. Lamkin, and S. Kelley-Farga. 1989. Distribution of fish larvae in relation to hydrographic features of the Loop Current boundary in the Gulf of Mexico. Rapp. P.-v. Reun. Cons. Int. Explor. Mer. 191:169-176.

Richards, W.J., M.F. McGowan, T. Leming, J.T. Lamkin, and S. Kelley. 1993. Larval fish assemblages at the Loop Current boundary in the Gulf of Mexico. Bull. Mar. Sci. 53(2):475-537.

Richardson, W.J. and B. Würsig. 1997. Influences of man-made noise and other human actions on cetacean behaviour. Mar. Fresh. Behav. Physiol. 29:183-209.

Richardson, W.J., C.R. Greene, C.I. Malme, and D.H. Thomson. 1995. Marine mammals and noise. San Diego, CA: Academic Press.

Richie, W. and S. Penland. 1985. Overwash process-response characteristics of landforms along the Caminada-Moreau coast, Louisiana. In: Penland, S. and R. Boyd, eds. Transgressive Depositional Environments of the Mississippi River Delta Plain: A Guide to the Barrier Islands, Beaches, and Shoals of Louisiana. Louisiana Geological Survey, Guidebook Series, No. 3.

Ridgway, S.H., E.G. Wever, J.G. McCormick, J. Palin, and J.H. Anderson. 1969. Hearing in the giant sea turtle, *Chelonia mydas*. In: Proceedings of the National Academy of Sciences 64(3):884-890.

Rigzone. 2002. Internet website (October 23, 2002) Advanced Rig Search. http://www.rigzone.com/data/results.

Rike, J.L. 2000. Downsizing the operation instead of the company. In: McKay, M. and J. Nides, eds. Proceedings, Eighteenth Annual Gulf of Mexico Information Transfer Meeting, December 1998. U.S. Dept. of the Interior, Minerals, Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2000-030. Pp. 469-475.

Ripley, S.D., and B.M. Beechler. 1985. Rails of the world, a compilation of new information, 1975-1983, (Aves: Rallidae). Smithsonian Contributions to Zoology, No. 417. Washington, DC: Smithsonian Institute Press.

Roberts, H.H. In preparation. Improved geohazards and benthic habitat evaluations: Digital acoustic data with ground truth calibrations. Draft final report prepared under MMS Contract No. 14-35-0001-30660-19910 (February 2000). U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, Louisiana.

Roberts, H.H. and R. Carney. 1997. Evidence of episodic fluid, gas and sediment venting on the northern Gulf of Mexico continental slope. Economic Geology 92:863-879.

Robineau, D. and P. Fiquet. 1994. Cetaceans of Dawhat ad-Dafi and Dawhat al-Musallamiya (Saudi Arabia) one year after the Gulf War oil spill. Courier Forsch.-Inst. Senckenberg 166:76-80.

Rosman, I., G.S Boland, L.R. Martin, and C.R. Chandler. 1987. Underwater sightings of sea turtles in the northern Gulf of Mexico. U.S. Dept of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 87-0107. 37 pp.

Ross, G.J.B. and S. Leatherwood. 1994. Pygmy killer whale - *Feresa attenuata* Gray, 1874. In: Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Vol. 5: The first book of dolphins. London: Academic Press. Pp. 387-404.

Rudloe, J., A. Rudloe, and L. Ogren. 1991. Occurrence of immature Kemp's ridley turtles, *Lepidochelys kempi*, in coastal waters of northwest Florida. Short Papers and Notes. Northeast Gulf Sci. 12:49-53.

Ryan, P.G. 1988. Effecs of ingested plastic on seabird feeding: evidence from chickens. Mar. Poll. Bull. 19(3):125-128.

Ryan, P.G. 1990. The effects of ingested plastic and other marine debris on seabirds. In: Shomura, R.S. and M.L. Godfrey, eds. Proceedings of the Second International Conference on Marine Debris, April 2-7, 1989, Honolulu, HI. U.S. Dept. of Commerce, NOAA Tech. Memo. NMFS-NOAA-TM-NMFS-SWFSC-154. Pp. 623-634.

Rye, H. and P.J. Brandvik. 1997. Verification of subsurface oil spill models. In: Proceedings, 1997 International Oil Spill Conference, April 7-10, 1997, Fort Lauderdale, FL. American Petroleum Institute Publication No. 4651. Pp. 551-557.

Salata, G.G., T.L. Wade, J.L. Sericano, J.W. Davis, and J.M. Brooks. 1995. Analysis of Gulf of Mexico bottlenose dolphins for organochlorine pesticides and PCBs. Environ. Poll. 88:167-175.

Samuels, W.B. and A. Ladino. 1983/1984. Calculations of seabird population recovery from potential oilspills in the mid-Atlantic region of the United States. Ecological Modellling, 21. Pp. 63-84.

Sargent, F.J., T.J. Leary, D.W. Crewz, and C.R. Kruer. 1995. Scaring of Florida's seagrasses: assessment and management options. FRMI TR-1, Florida Marine Research Institute, St. Petersburg, FL. 37 pp. + app.

Sassen, R., J.M. Brooks, M.C. Kennucutt, II, I.R. MacDonald, and N.L. Guinasso, Jr. 1993. How oil seeps, discoveries relate in deepwater Gulf of Mexico. Oil & Gas Journal 91(16):64-69.

Schales, S. and D. Soileau. 2001. Personal communication with Samuel Holder: Shell Key, Point au Fer and their surrounding shell reefs, June 15. Both gentlemen were employed by the Louisiana Dept. of Wildlife and Fisheries at the time.

Schiro, A.J., D. Fertl, L.P. May, G.T. Regan, and A. Amos. 1998. West Indian *manatee (Trichechus manatus*) occurrence in U.S. waters west of Florida. Presentation, World Marine Mammal Conference, 20-24 January, Monaco.

Schmidly, D.J. 1981. Marine mammals of the southeastern United States coast and the Gulf of Mexico. FWS/OBS-80/41. U.S. Dept. of the Interior, Fish and Wildlife Service, Office of Biological Services, Washington, DC. 163 pp.

Schmidly, D.J., C.O. Martin, and G.F. Collins. 1972. First occurrence of a black right whale (*Balaena glacialis*) along the Texas coast. Southw. Natural. 17:214-215.

Science Applications International Corporation (SAIC). 1997. Northeastern Gulf of Mexico coastal and marine ecosystem program: Data search and synthesis; synthesis report. U.S. Dept. of the Interior, U.S. Geological Survey, Biological Resources Division, USGS/BRD/CR—1997-0005 and Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 96-0014. 304 pp.

Sharp, B.E. 1995. Does the cleaning and treatment of oiled seabirds mean that they are rehabilitated – what about post-release survival? In: Proceedings, The Effects of Oil on Wildlife, 4th International Conference, April 1995, Seattle, WA.

Sharp, B.E. 1996. Post-release survival of oiled, cleaned seabirds in North America. Ibis 138:222-228.

Sherman, K., R. Lasker, W.J. Richards, and A.W. Kendall, Jr. 1983. Ichthyoplankton and fishes recruitment studies in large marine ecosystems. Mar. Fish. Rev. 45(10-11-12):1-25.

Shiveley, D. 2000. Personal communication. Louisiana Dept. of Wildlife and Fisheries, Baton Rouge, LA.

Shomura, R.S. and M.L. Godfrey, eds. 1990. Proceedings of the Second International Conference on Marine Debris, 2-7 April 1989, Honolulu, HI. U.S. Dept. of Commerce, NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFSC-154.

Shoop, C.R. and R.D. Kenney. 1992. Seasonal distributions and abundance of loggerhead and leatherback sea turtles in waters of the northeastern United States. Herpetological Monographs No. 6.

Shoop, C., T. Doty, and N. Bray. 1981. Sea turtles in the region between Cape Hatteras and Nova Scotia in 1979. In: Shoop, C., T. Doty, and N. Bray. A characterization of marine mammals and turtles in the mid- and north-Atlantic areas of the U.S. outer continental shelf: annual report for 1979: Chapter IX. Kingston: University of Rhode Island. Pp. 1-85.

Sileo, L., P.R. Sievert, and M.D. Samuel. 1990a. Causes of mortality of albatross chicks at Midway Atoll. Jour. Wildl. Diseases. 26(3):329-338.

Sileo, L., P.R. Sievert, M.D. Samuel, and S.I. Fefer. 1990b. Prevalence and characteristics of plastic ingested by Hawaiian seabirds. In: Shomura, R.S. and M.L. Godfrey, eds. Proceedings of the Second International Conference on Marine Debris, April 2-7, 1989, Honolulu, HI. U.S. Dept. of Commerce, NOAA Tech. Memo. NMFS-NOAA-TM-NMFS-SWFCS-154. Pp. 665-681.

Schiro, A.J., D. Fertl, L.P. May, G.T. Regan, and A. Amos. 1998. West Indian manatee *(Trichechus manatus)* occurrence in U.S. waters west of Florida. Presentation, World Marine Mammal Conference, 20-24 January, Monaco.

Simpfendorfer, C.A. 2000. Letter to Charles A. Oravetz regarding information solicitation for sawfish listing process and attached response to request for information.

Sis, R.F., A.M. Landry, and G.R. Bratton. 1993. Toxicology of stranded sea turtles. In: Proceedings, 24th Annual International Association of Aquatic Animal Medicine Conference, Chicago, IL.

Smith, T.G., J.R. Geraci, and D.J. St. Aubin. 1983. The reaction of bottlenose dolphins, *Tursiops truncatus*, to a controlled oil spill. Can. J. Fish. Aquat. Sci. 40(9):1522-1527.

Smith, M.F., ed. 1984. Ecological characterization atlas of coastal Alabama: Map narrative. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS84-0052. 189 pp.

Smultea, M.A. and B. Würsig. 1991. Bottlenose dolphin reactions to the *Mega Borg* oil spill, Gulf of Mexico, 1990. Final report no. RF-90-1113. U.S. Dept. of Commerce, National Marine Fisheries Service, Southeast Fisheries Center, Miami, FL.

Smultea, M.A. and B. Würsig. 1995. Behavioral reactions of bottlenose dolphins to the *Mega Borg* oil spill, Gulf of Mexico 1990. Aquatic. Mamm. 21(3):171-181.

Sorensen, P.E. 1990. Socioeconomic effects of OCS oil and gas development. In: Synthesis of available biological, geological, chemical, socioeconomic, and cultural resource information for the South Florida area. Jupiter, FL: Continental Shelf Associates, Inc. Pp. 609-629.

Spies, R.B., J.S. Felton, and L. Dillard. 1982. Hepatic mixed-function oxidases in California flatfishes are increased in contaminated environments and by oil and PCB ingestion. Mar. Biol. 70:117-127.

Spraker, T.R., L.F. Lowry, and K.J. Frost. 1994. Gross necropsy and histopathological lesions found in harbor seals. In: Loughlin, T.R., ed. Marine mammals and the *Exxon Valdez*. San Diego, CA: Academic Press. Pp. 281-311.

St. Aubin, D.J. and V. Lounsbury. 1990. Oil effects on manatees: evaluating the risks. In: Geraci, J.R. and D.J. St. Aubin, eds. Sea mammals and oil: confronting the risk. San Diego, CA: Academic Press. Pp. 241-251.

Steiner, C.K., M.C. Causley, and M.A. Yocke. 1994. User's guide: Minerals Management Service outer continental shelf activity database (MOAD). U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 94-0018. 22 pp.

Stewart, B.S. and S. Leatherwood. 1985. Minke whale - *Balaenoptera acutorostrata*. In: Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Vol. 3: The Sirenians and baleen whales. London: Academic Press. Pp. 91-136.

Stout, J.P, M.G. Lelong, J.L. Borom, and M.T. Powers. 1981. Wetland habitat of the Alabama coastal area. Part II: An inventory of wetland habitats south of the battleship Parkway. Alabama Coastal Area Board, Technical Publication CAB-81-01.

Stroud, R.H. 1992. Stemming the tide of coastal fish habitat loss. In: Proceedings of a Symposium on Coastal Fish Habitat, March 7-9, 1991, Baltimore, MD. National Coalition for Marine Conservation, Inc., Savannah, GA. Pp. 73-79.

Sulak, K.L. 2002. Personal communication. Research Fishery Biologist, U.S. Geological Survey, Biological Resources Division, Gainesville, FL.

SUSIO (State University System of Florida Institute of Oceanography). 1975. Compilation and summation of historical and existing physical oceanographic data from the Eastern Gulf of Mexico. In: Molinari, R.L., ed. SUSIO report submitted to the U.S. Dept. of the Interior, Bureau of Land Management. Contract 08550-CT4-16. 275 pp.

SUSIO (State University System of Florida Institute of Oceanography). 1977. Baseline monitoring studies, Mississippi, Alabama, Florida Outer Continental Shelf, 1975-1976. Volume : Executive summary. U.S. Dept. of the Interior, Bureau of Land Management. Contract 08550-CT5-30. St. Petersburg, FL: SUSIO. 55 pp.

Systems Applications International, Sonoma Technology, Inc., Earth Tech., Alpine Geophysics, and A.T. Kearney. 1995. Gulf of Mexico air quality study, final report: Volumes I-III. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 95-0038, 95-0039, and 95-0040.

Tarpley, R.J. and S. Marwitz. 1993. Plastic debris ingestion by cetaceans along the Texas coast: two case reports. Aquat. Mamm. 19(2):93-98.

Teas, W.G. 1994. Annual report of the sea turtle stranding and salvage network: Atlantic and Gulf Coasts of the United States, January-December 1993.

Teas, W.G. and A. Martinez. 1992. Annual report of the sea turtle stranding and salvage network Atlantic and Gulf Coasts of the United States, January-December 1989.

Terres, J.K. 1991. The Audubon Society Encyclopedia of North American Birds. New York: Wing Books. 1,109 pp.

Thompson, N.B. 1988. The status of loggerhead, *Caretta caretta*; Kemp's ridley, *Lepidochelys kempi*; and green, *Chelonia mydas* sea turtles in U.S. waters. Mar. Fish. Rev. 50:16-23.

Trefry, J.H. 1981. A review of existing knowledge on trace metals in the Gulf of Mexico. In: Proceedings of a symposium on environmental research needs in the Gulf of Mexico (GOMEX): Vol. II B. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Environmental Research Lab. Pp. 225-259.

Trefrey, John. 1998. Forms of Mercury and Cadmium in Barite and their Fate in the Marine Environment: A Review and Synthesis. Report Prepared for Exxon Production Research Company. Unpublished.

Trivelpiece, W.Z., R.G. Butler, D.S. Miller, and D.B. Peakall. 1986. Reduced survival of chicks of oil-dosed adult Leach's storm-petrels. The Condor 86:81-82.

Tucker & Associates, Inc. 1990. Sea turtles and marine mammals of the Gulf of Mexico, proceedings of a workshop held in New Orleans, August 1-3, 1989. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 90-0009. 211 pp.

Turner, R.E. and D.R. Cahoon. 1988. Causes of wetland loss in the coastal Central Gulf of Mexico. Prepared under MMS Contract 14-12-0001-30252. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 87-0119 (Volume I: Executive Summary), 87-0120 (Volume II: Technical Narrative), and 87-0121 (Volume III: Appendices).

Underwood, A.J. and P.G. Fairweather. 1989. Supply side ecology and benthic marine assemblages. Trends Ecol. Evol. 4(1):16-20.

UCSUSA. Union of Concerned Scientists United States of America. 2002a. Internet site. Mississippi delta, controlling a river: the Mississippi River deltaic plain. (August 23, 2002). http://www.ucsusa.org/gulf/gcplacesmis.html.

UCSUSA. Union of Concerned Scientists United States of America. 2002b. Internet site. Explore the Impacts. Sea level change. http://www.ucsusa.org/gulf/gcimpactsea.html. August 23, 2002.

U.S. Congress. Office of Technology Assessment. 1990. Coping with an oiled sea: An analysis of oil spill response technologies. OTA-BP-O-63. Washington DC: U.S. Government Printing Office.

U.S. Dept. of the Army. Corp of Engineers. 2002. Ocean Disposal Database. Internet website (June 13, 2002) http://www.wes.army.mil/el/odd/odd.html.

U.S. Dept. of Commerce. Bureau of Economic Analysis. 1997. CD-ROM regional economic information system. U.S. Dept. of Commerce, Washington, DC.

U.S. Dept. of Commerce. National Marine Fisheries Service. 1984. Endangered; Species Act, Section 7 Consultation – Biological Opinion. Attachment C. In: Science Application, Inc., Revised Draft Environmental Impact Statement/Report, Technical Appendix 8, Marine Biology for Santa Ynez Unit/Las Flores Canyon Development and Production Plan. 34 pp.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 1988. Interagency task force on persistent marine debris. Office of the Chief Scientist, Ecology and Conservation Division.

U.S. Dept. of Commerce. National Marine Fisheries Service. 1990. Recovery plan for U.S. population of Atlantic green turtle (*Chelonia mydas*). U.S. Dept. of Commerce, National Marine Fisheries Service, St. Petersburg, FL.

U.S. Dept. of Commerce. National Marine Fisheries Service. 1991a. Recovery plan for the northern right whale (*Eubalaena glacialis*). Prepared by the Right Whale Recovery Team for the U.S. Dept. of Commerce, National Marine Fisheries Service, Silver Springs, MD. 86 pp.

U.S. Dept. of Commerce. National Marine Fisheries Service. 1992. Recovery plan for leatherback turtles in the U.S. Caribbean, Atlantic and Gulf of Mexico. U.S. Dept. of Commerce, National Marine Fisheries Service, Washington, DC.

U.S. Dept. of Commerce. National Marine Fisheries Service. 1993. Recovery plan for hawksbill turtles in the U.S. Caribbean Sea, Atlantic Ocean, and Gulf of Mexico. U.S. Dept. of Commerce, National Marine Fisheries Service, St. Petersburg, FL.

U.S. Dept. of Commerce. National Marine Fisheries Service. 1997. Report to Congress. Status of fisheries of the United States. Prepared by the National Marine Fisheries Service. 50+ pp. plus app. Internet site: http://www.nmfs.gov/sfa/Fstatus.html.

U.S. Dept. of Commerce. National Marine Fisheries Service. 1998a. Recovery plan for the blue whale (*Balaenoptera musculus*). Prepared by Reeves, R.R., P.J. Clapham, R.L. Brownell, Jr., and G.K. Silber for the U.S. Dept. of Commerce, National Marine Fisheries Service, Silver Spring, MD. 42 pp.

U.S. Dept. of Commerce. National Marine Fisheries Service. 1998b. Draft Amendment 1 to the Atlantic billfish fishery management plan. U.S. Dept. of Commerce, National Marine Fisheries Service, Highly Migratory Species Division. October 1998.

U.S. Dept. of Commerce. National Marine Fisheries Service. 1999. Personal communication. U.S. Dept. of Commerce, National Marine Fisheries Service, Fisheries Statistics and Economics Division. Internet site: http://www.st.nmfs.gov/recreational/ database/queries/index.html.

U.S. Dept. of Commerce. National Oceanographic and Atmospheric Administration Fisheries. (2002). Proposed Endangered Species (August 20, 2002) Internet site. http://www.nmfs.noaa.gov/prot_res/species/fish/Smalltooth_sawfish.html.

U.S. Dept. of Commerce. National Oceanographic and Atmospheric Administration Fisheries. 2002a. Information and databases on fisheries landings. Internet site: http://www.st.nmfs.gov/st1/commercial/landings/annual_landings.html.

U.S. Dept. of Commerce, National Oceanic Atmospheric Administration and U.S. Dept. of the Interior, Minerals Management Service. 2002b. Jointly Sponsored NOAA/MMS Workshop on Longer-term Weathering, held at OHMSETT, Naval Weapons Center, New Jersey, on April 17-18, 2002.

U.S. Dept. of Energy. Office of Fossil Energy. 1999. Environmental benefits of advanced oil and gas exploration and production technology. U.S. Dept. of Energy, Office of Fossil Energy, Washington, DC.

U.S. Dept. of the Interior. Fish and Wildlife Service. 1984. Southeastern states bald eagle recovery plan. U.S. Dept. of the Interior, Fish and Wildlife Service, Southeast Region, Atlanta, GA.

U.S. Dept. of the Interior. Fish and Wildlife Service. 1987. Recovery plan for the Choctawhatchee, Perdido Key, and Alabama Beach Mouse. U.S. Dept. of the Interior, Fish and Wildlife Service, Atlanta, GA. 45 pp.

U.S. Dept. of the Interior. Fish and Wildlife Service. 1997. Biological opinion on outer continental shelf oil and gas leasing, exploration, development, production, and abandonment in the central Gulf of Mexico, multi-lease sales 169, 172, 178, and 182. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. 211 pp.

U.S. Dept. of the Interior, Fish and Wildlife Service. 1999. National wetlands inventory: 1996 coastal Mississippi habitat data. National Wetlands Center, Lafayette, LA.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2001a. Share the beach. Newsletter of the U.S. Dept. of the Interior, Fish and Wildlife Service, Ecological Services Field Office, Daphne, AL. October 9, 2001.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2001b. Technical Agency Draft, Florida manatee recovery plan (*Trichechus manatus latirostris*), third revision. U.S. Dept. of the Interior, Fish and Wildlife Service, Atlanta, GA. 138 pp.

U.S. Dept. of the Interior. Geological Survey. 1988. Map of coastal erosion and accretion. In: National Atlas of the U.S.A. U.S. Dept. of the Interior, Geological Survey, Reston, VA.

U.S. Dept. of the Interior. Geological Survey. 1998. Chandeleur Islands, La. - 1992 Submerged Aquatic Vegetation. Geospatial Data Presentation Form: Map. Maintained by the U.S. Dept. of the Interior, Geological Survey, National Wetlands Research Center.

U.S. Dept. of the Interior. Minerals Management Service. 1983. Final regional environmental impact statement: Volumes I and II. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. 527 pp.

U.S. Dept. of the Interior. Minerals Management Service. 1987. Programmatic environmental assessment: structure removal activities, Central and Western Gulf of Mexico Planning Areas. U.S.

Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS EIS/EA MMS 87-0002. 84 pp.

U.S. Dept. of Interior. Minerals Management Service. 1988. Meteorological database and synthesis for the Gulf of Mexico. Prepared by Florida A&M University for the U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 89-0064. 430 pp.

U.S. Dept. of the Interior. Minerals Management Service. 1990. Gulf of Mexico Sales 131, 135, and 137: Central, Western, and Eastern Planning Areas--final environmental impact statement. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS EIS/EA MMS 90-0042. Available from NTIS, Springfield, VA: PB90-273590.

U.S. Dept. of the Interior. Minerals Management Service. 1999. Destin Dome 56 Unit: Development and production plan and right-of-way pipeline application; draft environmental impact statement. Volume I: Sections I-IX. U.S. Dept. of the Interior. Minerals Management Service, Gulf of Mexico OCS Region. New Orleans, LA. OCS EIS/EA MMS 99-0040. Available from NTIS, Springfield, VA: PB99-167397 (Volume I) and PB99-167405 (Volume II). 742 and 204 pp., respectively.

U.S. Dept. of the Interior. Minerals Management Service. 2000. Gulf of Mexico deepwater operations and activities – environmental assessment. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS EIS/EA MMS 2000-001.

U.S. Dept. of the Interior. Minerals Management Service. 2001a. Gulf of Mexico OCS Oil and Gas lease Sale 181: Eastern Planning Area—final environmental impact statement. 2 vols. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS EIS/EA MMS 2001-051.

U.S. Dept. of the Interior. Minerals Management Service. 2001b. Revised Proposal for Gulf of Mexico OCS Oil and Gas Lease Sale 181, Eastern Planning Area, environmental assessment. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS EIS/EA MMS 2001-083.

U.S. Dept. of the Interior. Minerals Management Service. 2001c. Site specific environmental assessment for new and unusual technology dual density drilling/subsea mudlift drilling technology, Green Canyon Block 137. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. SEA 5409, 7 pp.

U.S. Dept. of the Interior. Minerals Management Service. 2001d. Site specific environmental assessment for new and unusual technology dual density drilling/subsea mudlift drilling technology, Green Canyon Block 136. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. SEA 5499, 6 pp.

U.S. Dept of the Interior. Minerals Management Service. 2001e. Proposed Use of Floating Production, Storage and Offloading Systems on the Gulf of Mexico Outer Continental Shelf – Western and Central Planning Areas - final environmental impact statement, January 2001. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS EIS/EA MMS 2000-090.

U.S. Dept. of the Interior. Minerals Management Service. 2002a. Gulf of Mexico OCS Oil and Gas Leasing Program: 2003-2007, Central and Western Planning Areas - final environmental impact statement, November 2002. 2 vols. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS EIS/EA MMS 2002-052.

U.S. Dept. of the Interior. Minerals Management Service. 2002b. Deepwater Gulf of Mexico 2002: America's expanding frontier. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Report MMS 2002-021. 130 pp.

U.S. Dept. of the Interior. Minerals Management Service. 2002c. Gulf of Mexico OCS Oil and Gas Lease Sales: 2003 and 2005; Eastern Planning Area Sales 189 and 197 - draft environmental impact statement. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS EIS/EA 2002-056.

U.S. Dept. of the Interior. Minerals Management Service. 2002d. Oil Spill Risk Analysis: Gulf of Mexico Outer Continental Shelf (OCS) Lease Sales, Eastern Planning Area, 2003-2007 and Gulfwide OCS Program 2003-2042. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Report MMS 2002-069. 59 pp.

U.S. Dept. of Transportation. Coast Guard. 1997. Pollution incidents in and around U.S. waters; a 25-year compendium: 1969-1993. 22 pp. Internet site: http://www.uscg.mil/hq/g-m/nmc/response/stats/aa.htm.

U.S. Environmental Protection Agency. 1990. Draft environmental impact statement for the designation of a new ocean dredged material disposal site located offshore Pascagoula, Mississippi. 72 pp. + app.

U.S. Environmental Protection Agency. 1993a. Development document for effluent limitation guidelines and standards for the offshore subcategory of the oil and gas extraction point source category, EPA 821-R-93-003.

U.S. Environmental Protection Agency. 1993b. Office of Water, Washington, DC. Supplemental information for effluent limitation guidelines and new source performance standards for the offshore subcategory of the oil and gas extraction point source category (40 CFR 435). Also supportive documents produced by the Office of Water Regulations and Standards, Washington, DC. Economic impact analysis of proposed effluent limitation guidelines and standards for the offshore oil and gas industry. Prepared by Eastern Research Group, Inc. EPA 440/2-91-001. Regulation published in the *Federal Register*, 58 FR 41, pp. 12453-12512 (March 4, 1993).

U.S. Environmental Protection Agency. 1997. Mercury Study Report to Congress. Office of Air Quality Planning and Standards and Office of Research and Development. EPA-452-/R-97-006.

U.S. Environmental Protection Agency. 1999a. The ecological conditions of estuaries in the Gulf of Mexico. U.S. Environmental Protection Agency, Gulf Breeze, FL. 71 pp.

U.S. Environmental Protection Agency. 1999b. Development document for proposed effluent limitations guidelines and standards for synthetic-based drilling fluids and other non-aqueous drilling fluids in the oil and gas extraction point source category. Office of Water, Office of Science and Technology. EPA-821-B-98-021.

U.S. Environmental Protection Agency. 2001. National Coastal Condition Report, Office of Research and Development, Office of Water, Washington DC EPA-620-R-01-005. 204 pp.

Valade, J. 2001. Written communication. U.S. Fish and Wildlife Service, Jacksonville, FL. e-mail to B. Lang, MMS, dated October 22, 2001. Manatee sighting in Mississippi Canyon Block 85.

van Beek, J.L. and K.J. Meyer-Arendt, eds. 1982. Louisiana's eroding coastline: recommendations for protection. Prepared for Coastal Management Section, Louisiana Dept. of Natural Resources, Baton Rouge, LA.

Van Buuren, J.T. 1984. Ecological survey of a North Sea gas leak. Great Britain: Pergamon Press Ltd. Mar. Poll. Bull. 15(8):305-307.

Van Vleet, E.S. and G. Pauly. 1987. Characterization of oil residues scraped from stranded sea turtles from the Gulf of Mexico. Carib. J. Sci. 23:77-83.

Vargo, S., P. Lutz, D. Odell, E. Van Vleet, and G. Bossart. 1986. Study of the effects of oil on marine turtles, a final report. Prepared by the Florida Institute of Oceanography. U.S. Dept. of the Interior, Minerals Management Service, Atlantic OCS Region. OCS Study MMS 86-0070. 3 vols. 360 pp.

Vauk, G., E. Hartwig, B. Reineking, and E. Vauk-Hentzelt. 1989. Losses of seabirds by oil pollution at the German North Sea coast. In: Ros, J.D., ed. Topics in Marine Biology. Scient. Mar. 53(2-3):749-754.

Vermeer, K. and R. Vemeer. 1975. Oil threat to birds on the Canadian west coast. The Canadian Field-Naturalist 89:278-298.

Wallace, R.K. 1996. Coastal Wetlands in Alabama. Auburn University, Marine Extension and Research Center, Mobile AL. Circular ANR-831 MASGP-96-018.

Walls, J.G. 1975. Fishes of the northern Gulf of Mexico. Neptune City, NJ: T.F.H. Publications, Inc. 432 pp.

Waring, G.T., D.L. Palka, K.D. Mullin, J.H.W. Hain, L.J. Hansen, and K.D. Bisack. 1997. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments -- 1996. NOAA Tech. Memo. NMFS-NE-114.

Waring, G.T., D.L. Palka, P.J. Clapham, S. Swartz, M.C. Rossman, T.V.N. Cole, L.J. Hansen, K.D. Bisack, K.D. Mullin, R.S. Wells, D.K. Odell, and N.B. Barros. 1999. U.S. Atlantic marine mammal stock assessments - 1999. U.S. Dept. of Commerce, NOAA Tech. Memo. NMFS-NE-153.

Webb, J.W., G.T. Tanner, and B.H. Koerth. 1981. Oil spill effects on smooth cordgrass in Galveston Bay, Texas. Contributions in Marine Science 24:107-114.

Webb, J.W., S.K. Alexander, and J.K. Winters. 1985. Effects of autumn application of oil on *Spartina alterniflora* in a Texas salt marsh. Environ. Poll., Series A. 38(4):321-337.

Weller, D.W., A.J. Schiro, V.G. Cockcroft, and W. Ding. 1996. First account of a humpback whale (*Megaptera novaeangliae*) in Texas waters, with a re-evaluation of historic records from the Gulf of Mexico. Mar. Mamm. Sci. 12:133-137.

Weller, D.W., B. Würsig, S.K. Lynn, and A.J. Schiro. 2000. Preliminary findings on the occurrence and site fidelity of photo-identified sperm whales (*Physeter macrocephalus*) in the northern Gulf of Mexico. Gulf of Mexico Science.

Wells, P.G. 1989. Using oil spill dispersants on the sea - issues and answers. Workshop on Technical Specifications for Oil and Dispersants Toxicity, January 17-19, 1989, New Orleans, LA. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. Pp. 1-4.

Wells, R.S. and M.D. Scott. 1999. Bottlenose dolphin - *Tursiops truncatus* (Montagu, 1821). In: Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Vol. 6: Second book of dolphins. San Diego, CA: Academic Press. Pp. 137-182.

Wells, R.S., H.L. Rhinehart, P. Cunningham, J. Whaley, M. Baran, C. Koberna, and D.P. Costa. 1999a. Long distance offshore movements of bottlenose dolphins. Mar. Mamm. Sci. 15:1098-1114.

Wells, R., C. Mainire, H. Rhinehart, D. Smith, A. Westgate, F. Townsend, T. Rowles, A. Hohn, and L. Hansen. 1999b. Ranging patterns of rehabilitated rough-toothed dolphins, *Steno bredanensis*, released in the northeastern Gulf of Mexico. Abstracts, 13th Biennial Conference on the Biology of Marine Mammals, Wailea, Maui, 28 November - 3 December.

Wetherell, V. 1992. St. Joseph Bay Aquatic Preserve Management Plan: Adopted January 22, 1992; Florida Dept. of Natural Resources, and Bureau of Submerged Lands and Preserves Division of State Lands.

Williams, T.M. and R.W. Davis, eds. 1995. Emergency care and rehabilitation of oiled sea otters: a guide for oil spills involving fur-bearing marine mammals. Fairbanks, AK: University of Alaska Press.

Williams, S.J., S. Penland, and A.H. Sallenger, Jr., eds. 1992. Louisiana barrier island study: atlas of shoreline changes in Louisiana from 1853 to 1989. U.S. Dept. of the Interior, Geological Survey, Miscellaneous Investigations Series I-2150-A.

Winn, H.E. and N.E. Reichley. 1985. Humpback whale - *Megaptera novaeangliae*. In: Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Vol. 3: The sirenians and baleen whales. London: Academic Press, Inc. Pp. 241-274.

Witham, R. 1978. Does a problem exist relative to small sea turtles and oil spills? In: Proceedings, Conference on Assessment of Ecological Impacts of Oil Spills, June 14-17, Keystone, CO. Washington, DC: American Institute of Biological Sciences. Pp. 630-632.

Witherington, B.E. 1994. Flotsam, jetsam, post-hatchling loggerheads, and the advecting surface smorgasbord. In: Proceedings, 14th Annual Symposium on Sea Turtle Biology and Conservation. NOAA Tech. Memo. NMFS-SEFSC-351.

Witherington, B.E. 1997. The problem of photopollution for sea turtles and other nocturnal animals. In: Clemmons, J.R. and R. Buchholz, eds. Behavioral approaches to conservation in the wild. Cambridge University Press. Pp. 303-328.

Witherington, B.E. and R.E. Martin. 1996. Understanding, assessing, and resolving light-pollution problems on sea turtle nesting beaches. Florida Marine Research Institute Technical Report TR-2, Florida Dept. of Environmental Protection. 73 pp.

Witzell, W.N. and W.G. Teas. 1994. The impacts of anthropogenic debris on marine turtles in the western North Atlantic Ocan. NOAA Tech. Memo. NOAA-TM-NMFS-SEFCS-355.

Wolfe, S.H., J.A. Reidenauer, and D.B. Means. 1988. An ecological characterization of the Florida Panhandle. U.S. Dept. of the Interior, Fish and Wildlife Service Biological Report 88(12) and Minerals Management Service OCS Study MMS 88-0063. 278 pp.

Wooley, C.M., and E.J. Crateau. 1985. Movement, microhabitat, exploitation, and management of Gulf of Mexico sturgeon, Apalachicola River, Florida. North American Journal of Fishery Management. Pp. 590-605.

WorkBoat. 1998. WorkBoat's 1997 construction survey: supply side. January:64-78.

Wright, S.D., B.B. Ackerman, R.K. Bonde, C.A. Beck, and D.J. Banowetz. 1995. Analysis of watercraft-related mortality of manatees in Florida, 1979-1991. In: O'Shea, T.J., B.B. Ackerman, and H.F. Percival, eds. Population biology of the Florida manatee. National Biological Service Information and Technology Report 1. Pp. 259-268.

Würsig, B. 1990. Cetaceans and oil: ecologic perspectives. In: Geraci, J.R. and D.J. St. Aubin, eds. Sea mammals and oil: confronting the risks. San Diego: Academic Press. Pp. 129-165.

Würsig, B., S.K. Lynn, T.A. Jefferson, and K.D. Mullin. 1998. Behavior of cetaceans in the northern Gulf of Mexico relative to survey ships and aircraft. Aquatic Mammals 24:41-50.

Würsig, B., T. Jefferson, and D. Schmidly. 2000. The marine mammals of the Gulf of Mexico. College Station, TX: Texas A&M University Press.

Yochem, P.K. and S. Leatherwood. 1985. Blue whale - Balaenoptera musculus. In: Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Vol. 3: the sirenians and baleen whales. London: Academic Press, Inc. Pp. 193-240.

Zieman, J.C., R. Orth, R.C. Phillips, G. Thayer, and A. Thornhaug. 1984. The effects of oil on seagrass ecosystems. In: Cairns, J. and A. Buikema, eds. Recovery and restoration of marine ecosystems. Stoneham, MA: Butterworth Publications. Pp. 37-64.

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8. APPENDIX

Appendix A Physical Setting of the EPA Sale Area

Appendix A
Physical Setting of the EPA Sale Area

GEOLOGIC AND GEOGRAPHIC SETTING

The present day GOM is a small ocean basin with a water-surface area of more than one and half million square kilometers. The greatest water depth is approximately 3,700 m (12,100 ft). It is bordered by land on three sides, opening to the Atlantic Ocean through the Straits of Florida and to the Caribbean Sea through the Yucatan Channel. Underlying the present GOM and the adjacent coast is a large geologic basin. This basin received a thick wedge of carbonate and clastic sediment during its long depositional history. The continental shelf extends seaward from the shoreline to about 200 m water depth and is characterized by a gentle slope of a few meters per kilometer (less than 1 degree). The shelf is wide off Florida and Texas, but it is narrower where the Mississippi River Delta has extended seawards to near the shelf edge. The continental slope extends from the shelf edge to the Sigsbee and Florida Escarpments, in about 2,000-3,000 m water. The topography of the slope is irregular, and characterized by canyons, troughs, and salt structures. The gradient on the slope is normally 1-2 degrees.

The geology of the GOM has been studied in detail for the exploration and development of oil and natural gas resources for over 50 years. There are two major sedimentary provinces in the Gulf Coast Region: Cenozoic (the western and central part of the Gulf) and Mesozoic (the eastern Gulf). The Mesozoic Province is mostly a carbonate terrane of limestone and reefs from Jurassic to Cretaceous age (205-65 Mya), with fewer than 350 exploration wells. The Cenozoic Province is a clastic terrane characterized by thick deposits of sand and shale from Paleocene to Recent age (65 Mya to present) underlain by Jurassic and Cretaceous carbonate rocks. The Cenozoic Province has been extensively explored by approximately 40,000 wells. The EPA sale area is thought to lie in an area underlain by some of the deeper Mesozoic carbonate plays and also the shallower Cenozoic clastic plays (Lore et al., 2001).

To produce economically viable accumulations of oil and gas, 4 conditions must occur in the proper sequence. First, a rock containing an enriched supply of organic material capable of forming oil and gas by the chemical and physical changes that occur during burial (the source). Second, a rock with pores and openings sufficient to hold and transmit oil or gas after it is generated (typical reservoir rocks in the Gulf are sandstone) (the reservoir). Third, the layers of rock must be structurally configured so as to capture a large accumulation of hydrocarbon resource (the trap). And fourth, the trapping structure and the reservoir rock must be overlain by impermeable rocks or configured so that the trap is sealed to prevent the escape of oil or gas (the seal).

REGIONAL GEOLOGY

The continental shelf landward of the EPA sale area was the site of significant deposition during the Mesozoic. Upper Jurassic marine sediments initially filled the basin and Lower Cretaceous reefs and patch reefs developed along the shelf edge boundary. The last major depositional event took place during the Miocene when deltas built seaward from the east and north providing reservoir quality sediments in stream channels, barrier bar deposits on the shelf, and fan deposits in the EPA sale area. Beyond the Lower Cretaceous shelf edge, in water depths greater than 900 m, deepwater fans developed in delta systems that had their thickest accumulation of sediments during the Miocene.

Mesozoic Province (Eastern Gulf)

The Mesozoic Province in the OCS extends eastward from the Cretaceous shelf edge off the coast of Mississippi, Alabama, and Florida towards the coastline of Florida. The Cretaceous shelf edge lies northeast of the EPA sale area and intersects it only in the northeast corner of the EPA sale area. Although this Mesozoic Province has experienced limited drilling and most control points are on the shelf, some general statements can be made concerning resources. This province is dominated by carbonate rocks with some Cenozoic clastic rocks. The deepest prospective rocks are Jurassic in age. The hydrocarbon potential has been realized throughout the entire geologic interval – from the very shallow, young portion of the Tertiary Pleistocene (1,500-4,000 ft; 450-1200 m)), to the intermediate Cretaceous James Formation (14,000-16,000 ft; 4250-4900 m) and the deep, older Jurassic Norphlet Formation (15,000-24,000 ft; 4,575-7300 m). Approximately two dozen fields in the Mesozoic Province produce gas from the shallow Cenozoic. In the area offshore of the Florida Panhandle (Pensacola and Destin Dome), a total of 31 wells have been drilled, with 18 of the wells penetrating the Norphlet Formation. The depths at which the Norphlet Formation is found in the Gulf coast region varies from less than 5,000 ft (1,525 m) onshore to more than 24,000 ft (7,300 m) subsea offshore Mississippi and 15,000 ft (4,575 m) subsea in Apalachicola Embayment and Destin Dome OCS area.

This province has several potential Mesozoic hydrocarbon plays that are downdip equivalents of onshore productive fields. Carbonate rocks often require favorable diagenesis (physical and chemical alterations to the sediments after deposition), faulting, fracturing, and stratigraphy to enhance the low porosity and permeability. The variability of porosity and permeability within carbonate rocks increases the play risk in factors such as the potential drainage area, production rates, and resource volume.

Lore et al. (2001) identified twenty-three plays in the Mesozoic Province: two proven, five frontier, and sixteen conceptual. The mean total endowment for these plays as of January 1999 is estimated by MMS to be 11.006 BBOE. To date, the only Mesozoic fields in the OCS are the Jurassic Norphlet (13 fields), the Cretaceous James (4), and the Cretaceous Andrews (1). Most of these fields are located in the northeastern portion of the CPA.

Cenozoic Province (Western Gulf)

The Cenozoic Province extends from offshore Texas eastward across the north-central GOM to the edge of the Cretaceous Shelf Edge (commonly called the Florida Escarpment) offshore Mississippi, Alabama and Florida. It incorporates all of the WPA, a large portion of the CPA, and the southwestern portion of the EPA sale area. To date, all of the hydrocarbon production on the OCS in the Cenozoic Province is from sands ranging in age from Oligocene to Pleistocene (approximately 34-0.2 Mya).

Two major events laid the template for the structural tectonics and stratigraphy of the Cenozoic Province and still influence the depositional patterns in the Gulf today. First, breakup and drifting of the North American Plate formed the GOM basin. Second, the isolated basins that resulted were periodically breached to the west, allowing marine waters into the young basin. The arid climate during the Jurassic inhibited the transport of most clastic materials to the Gulf basin, allowing for the predominance of carbonate deposition.

Major faulting during the ocean spreading stage created a horst (high block) and graben (low block) system in the Gulf basin that was surrounded by higher more stable land mass. During the Upper Jurassic emergent highs were exposed and subjected to erosion, while adjacent lows filled with sediment. Due to the arid conditions, shallow waters, and the isolated lows formed within the horst and graben system, the eroded sediments were transported only a short distance to the adjacent lows. Repeated flooding and evaporation of the shallow saline waters that filled the basin resulted in a thick, widespread, salt bed (Louann Salt) that was often deposited directly onto basement rocks. Through time the basin cooled, subsided, and was gradually filled with deeper water in which more carbonates (limestone, chalk, reefs) were deposited. At the end of the Mesozoic era, the climate became more temperate which facilitated the erosion of the surrounding mountains. During the last 65 million years (Cenozoic era), several river systems brought the eroded material (clastic) into the GOM.

Because salt is less dense than sand, silt, or clay, it tends to become mobilized as denser sediments are deposited on it. The movement of salt upward pierces overlying rocks and sediment forming structures that have trapped the prolific hydrocarbon resources in the GOM. The updip sediment loading on the shelf and the upward movement of salt during the Tertiary has formed a vast canopy of mobilized salt over most of the outer continental shelf and slope. Individual, isolated salt bodies are called diapirs. Sands in proximity to salt structures have the greatest potential for hydrocarbon accumulation because it is a favorable place for the successful cross strata migration and accumulation of oil and gas. First, salt structures create pathways for migration of hydrocarbon from Upper Jurassic, Lower Cretaceous, and/or Lower Tertiary source beds to the reservoir sands. Second, thick sands deposited in deltas or in deep sea fans with good porosity and permeability provide reservoir space. Third, impermeable shales, salt, and/or faults serve as seals for trapping of oil and gas in the pore spaces of the reservoir rocks.

The hydrocarbon-producing horizons on the continental shelf and slope of the Cenozoic Province are mainly Miocene, Pliocene, and Pleistocene, and production generally comes from progressively younger sands in the seaward direction. These Cenozoic productive intervals become thinner and younger with less hydrocarbon potential eastward in the direction of the Cretaceous shelf edge (Mesozoic Province). Deeply buried Mesozoic rocks have been penetrated by only a few wells in the Cenozoic Province with no commercial hydrocarbons being reported to date.

REGIONAL EXPLORATION

The inventory of exploration wells by water depth for the GOM OCS Region in July 2000 was 917 wells in water depths <60 m; 1,125 wells in 61-200 m; 803 wells in 201-900 m; and 394 wells in >900 m. Exploration wells in the EPA are few and date from the early 1980's. These wells were mostly on the continental shelf and targeted five carbonate or clastic hydrocarbon plays in the Central or Mesozoic Provinces.

The first well drilled by Chevron in 1977 targeted lower Cretaceous carbonates on Destin Dome Block 617. A second lower Cretaceous carbonate well was drilled by Shell in 1980 on Destin Dome Block 529. Mobil drilled the third well in Pensacola Block 973 in 1981. Mobil's well was the deepest on the shelf until 1986. The intended targets of the well were the Norphlet and Smackover Formations in the Upper Jurassic clastics and carbonate targets. On the continental shelf, both the Norphlet and Smackover Formations are considered minor hydrocarbon plays. The reservoir-quality rock in the dune facies (facies is a term used by geologists to characterize different depositional environments) of the Norphlet Formation was not present in the Pensacola Block 973 well, nor were any porous zones identified in the Smackover Formation. A well drilled in Mobile Block 1006 encountered only poor porosity in a sand sheet facies of the Norphlet Formation and a thick carbonate section in the Smackover Formation. The nearest Norphlet discovery in the Eastern GOM is in the Destin Dome 56 field, approximately 30 km (19 mi) from shore. This field is one of the largest Norphlet fields identified to date, but opposition has blocked production in this area thus far.

The fourth well drilled by Shell in 1986 targeted lower Cretaceous carbonates on DeSoto Canyon Block 512. This well established the occurrence of zones with porosities as high as 18 percent and permeability of 0.25 darcy. The first field in the Lower Cretaceous carbonates was declared in 1972 in Main Pass Block 253.

Two wells drilled on Destin Dome Blocks 1 and 2 by Apache in 1989 targeted shallow Miocene "bright spots" (strong reflections on seismic survey data). Although Apache's wells have not produced to date, the first production in the EPA was established by Unocal in 1999 in reservoirs of similar age on Pensacola Block 881.

In the shallow sedimentary deposits of Miocene age found on the shelf offshore Alabama, more than 30 fields have been declared. All of these discoveries are natural gas fields. In addition, on the shelf offshore Alabama in water depths of less than 100 m, the four field discoveries in the Lower Cretaceous James Limestone are natural gas fields. In the EPA sale area, the deep deposits of the Jurassic Norphlet Formation are found at greater than 20,000 ft BML. Due to high temperatures and pressures, any hydrocarbons at or below this depth will be natural gas.

One field underlying three OCS blocks is recognized in the EPA sale area. A field was announced by Amoco on DeSoto Canyon Block 133 in 1993 based on data from a well drilled in Miocene fan deposits beyond the shelf-edge reef trend. Two more lease blocks were added to this field by Amoco in 1997 with the drilling of DeSoto Canyon Block 177 and adjacent Mississippi Canyon block 217. Table A-1 identifies fields that have been found in the fan deposits on blocks near or adjacent to the EPA sale area. Other blocks with hydrocarbon significance include Mississippi Canyon Blocks 260/261, Mississippi Canyon Block 305, and Viosca Knoll Block 1003.

Table A-1

Oil or Gas Fields In or Adjacent to the EPA Sale Area

Field Name	Effective Date	Operator	Target	Status
DeSoto Canyon 133	1993	Amoco	Miocene delta fans	Active
Mississippi Canyon 84	1993	Amoco	Miocene delta fans	Active
Mississippi Canyon 657	1988	Shell	Miocene delta fans	Active
Viosca Knoll 786	1995	Texaco	Miocene delta fans	Producing
DeSoto Canyon 177	1997	Amoco	Miocene delta fans	Producing
Mississippi Canyon 217	1997	Amoco	Miocene delta fans	Producing

RECOVERABLE ESTIMATES

DeSoto Canyon Blocks 133 and 177 have approved DOCD's and production from the EPA sale area in water depths of about 2,000 m (6,560 ft) has begun. Table A-2 shows the estimated recoverable resources for the EPA sale area for the period 2003-2043.

Table A-2

Estimated Mean Recoverable Resources in the EPA Sale Area

Water Depth	Oil (Bbbl)	Gas (tcf)	Bbbl of oil equivalent (Bbbl)
1,600-2,400 m	0.021-0.026	0.100-0.129	0.038-0.049
>2,400 m	0.044-0.059	0.164-0.211	0.074-0.097
Total	0.065-0.085	0.265-0.340	0.112-0.145

SEA BOTTOM DRILLING HAZARDS

The drilling hazards expected in the EPA sale area are similar to those encountered in deepwater environments in the CPA and WPA areas of the GOM. Among the sea bottom geohazards in the deepwater environment that can threaten the stability of drilling rig anchors, well bores, and rig worker safety are (1) H_2S gas, (2) high rates of sedimentation, (3) movement of underlying salt or shale masses, (4) faulting, (5) slope instability and landsliding, (6) hydrocarbon seeps, (7) gas hydrates, (8) shallow biogenic gas, and (9) shallow overpressured channel sands (Campbell, 1999).

Shallow faulting may cause lost circulation of the drilling mud, which can be offset by an increase in mud weight. Shallow biogenic gas pockets, which are usually identified prior to drilling by seismic surveys, can be accommodated with an appropriate mud weight and drilling program. Shallow biogenic gas can be safely drilled by reducing the drilling rate through the charged section.

Shallow geopressured zones and shallow water flow zones (SWF) are caused by stringers and pods of sandy sediment deposited in buried channels. These sandy zones are more permeable than the surrounding shales in which they are encased and can be intervals of anomalous formation pressure. If penetrated during drilling these zones can cause complications because of unpredictable downhole pressure changes that an operator's drilling mud program may not be prepared to accommodate. Such an event can precipitate a well blowout. A shallow geohazards analysis for each exploration well location is required in an operator's EP. There are no known geopressured zones in the EPA sale area.

From drilling experience in the GOM, the MMS and operators have identified the typical drilling hazards as faults that could cause lost circulation of drilling mud and geopressure zones requiring more than 12.5 ppg mud weights to prevent flows into the borehole. Detection and avoidance of potential overpressured SWF zones remains the best mitigation to minimize risks for a drill site. A SWF may washout sediments around the drill site and destabilize the well. The consequences of encountering shallow-water flow conditions, without preparation, range from drilling delays to loss of the well site.

Hydrogen sulfide (H_2S) gas is a threat to worker safety. The presence of H_2S in the deeper carbonate section (>20,000 ft BML) may be an issue in the EPA sale area due to the carbonate source rock and the higher temperature. H_2S in low concentrations is known from Jurassic rocks that are penetrated at shallower depths closer to the shorelines of Mississippi and Alabama.

PHYSICAL OCEANOGRAPHY

The northeastern GOM encompasses a variety of geomorphic features including a continental shelf, DeSoto Canyon, a continental slope and rise, and an abyssal plain. The most prominent source of mesoscale variability in the Eastern GOM is the Loop Current. Caribbean waters entering the Gulf through the Yucatan Channel are constrained by its 1,820-m effective sill depth. Once free of the Yucatan Channel, flow from the Yucatan Current proceeds northward into the GOM becoming the Loop Current. This current, which transports an estimated volume of 30 million m^3/s seawater, gradually turns clockwise through the eastern GOM and eventually loops back to the south and east. The Loop Current exits the Gulf via the Straits of Florida, where the effective sill depth is 820 m, and proceeds into the Atlantic where it continues as the Gulf Stream (Sturges et al., 1993). Loop Current waters are relatively salty and warm, having core salinity at or above 36.65 ppm and temperature of around 22.5°C at 125-150 m depth.

The Loop Current varies seasonally and annually in areal extent, which is on the order of 200,000 km^2, and the frequency of occurrence of Loop Current water varies from about 20 percent in along the continental slope to less than 5 percent on the shelf. The Loop Current influences the northeastern GOM both directly due to intrusion of the Loop Current itself and indirectly by means of elongated filaments of Loop Current water that extend outward from the Loop Current front, as well as by clockwise-rotating closed rings called Loop Current eddies (LCE's) that the Loop Current spawns. Intrusion of Loop Current waters is chaotic in occurrence, but intrusions are an important physical oceanographic influence in the region because of the frequency of occurrence, the marked contrast in water mass properties, and the large areas affected.

Loop Current filaments have been observed on the shelf and intruding into the DeSoto Canyon. Thirty percent of Mississippi River water moves eastward from the river mouth. Eddies and filaments generated by the Loop Current, which subsequently spin eastward along the Mississippi/Alabama outer shelf, can entrap parcels of Mississippi River water (Brooks, 1991). The Loop Current extends vertically to approximately 1,000 m depth, below which there is evidence of opposing currents and vortex-like features of weaker velocity. The Loop Current and LCE's may have surface speeds as high as 150-200 cm/s or more, which decrease with depth. Speeds at 500 m depth are commonly around 10 cm/s (Cooper et al., 1990). Near the bottom of the Loop Current, velocities are low and fairly uniform in the vertical although with bottom intensification, a characteristic of topographic Rossby waves (TRW's). This indicates that the Loop Current is in fact a source of the TRW's, which are a major component of deep circulation below 1,000 m in this part of the Gulf (Sturges et al., 1993; SAIC, 1989; Hamilton, 1990).

Large anticyclonic (clockwise rotating) eddies pinch off and gradually separate from the Loop Current at irregular intervals of roughly 6-18 months. These LCE's are also called warm core eddies since they surround a central core of warm Loop Current water. The average diameter of warm core eddies is about 200 km, and they may be as large as 400 km in diameter. After separation from the Loop Current, these eddies often translate westward across the GOM at a speed of about 5 km/day. Some LCE's move into the northeastern Gulf as well, contributing energetic anticyclonic flow to circulation in this region. GOM warm core eddies can have a life span of a year or more (Elliott, 1982), and their effects can persist at one location for weeks or even months (Nowlin et al., 1998). Small LCE's have been observed to move northward into the DeSoto Canyon, where they eventually dissipate (Muller-Karger et al., 1998).

Cold core cyclonic (counter-clockwise rotating) eddies have been observed in the study region as well, and surface waters within these cyclones are cooler and fresher than adjacent waters. Cyclonic circulation is associated with upwelling, which brings cooler, deeper water towards the surface. Small cyclonic eddies around 50-100 km in diameter have been observed over the continental slope off both Louisiana (Hamilton, 1992) and the Florida Panhandle (Jochens and Nowlin, 1998). These eddies can persist for six months or longer and are relatively stationary.

Cold core and warm core eddies have been observed to dominate the deepwater circulation patterns of the continental slope and rise, abyssal plain, and DeSoto Canyon. The Sturges et al. (1993) model suggests a surprisingly complex circulation pattern beneath the anticyclone, with vortex-like and wavelike features that interact with the bottom topography. These model findings are consistent with Hamilton's (1990) interpretation of observations.

Abyssal currents in the GOM have been directly measured by current meters at instrument depths of up to 3,175 m. The major low-frequency velocity fluctuations in the bottom 1,000-2,000 m of the water column have the characteristics of TRW's. These are long waves of wavelength 150-250 km having periods greater than 10 days and group velocity estimated at 9 km/day, and they are characterized by columnar motions that are bottom intensified. They move westward at higher group velocities than the typical anticyclonic eddy translation velocity of 3-6 km/day. The Loop Current and LCE's are thought to be major sources of these westward propagating TRW's (Hamilton, 1990).

In general, past current observations in the deep water GOM have revealed decreases in current speed with depth. During late 1999, a limited number of high-speed current events, at times approaching 2 kn (3.7 km/hour) were observed at depths exceeding 1,500 m in the northern GOM (MMS unpublished data). Furrows on the seafloor apparently resulting from the erosional effects of high-speed currents have also been discovered in the northern Gulf and near the edge of the Sigsbee Escarpment in Walker Ridge and Keathley Canyon.

Low salinity waters have been observed at the head of DeSoto Canyon, and these are thought to originate either from Mississippi River waters transported there by deeper cyclonic flow or else from various Alabama or Florida rivers. Downwelling and upwelling are both known to occur in the DeSoto Canyon region. Summer upwelling of cold water into regions having a seafloor depth of less than 100 m at the head of the canyon has been observed and is enhanced by canyon topography.

Circulation on the continental shelf in the northeastern GOM has been observed to follow a cyclonic pattern, with westward alongshore currents prevailing on the inner and middle shelf and opposing alongshore flow over the outer shelf and slope (Dinnell, 1988; Brooks, 1991). Inner shelf currents are primarily wind forced and are also influenced by river outflow and buoyancy forcing from water discharged by the Mississippi, Apalachicola, Tombigbee, Alabama, and other rivers in the region. Preliminary ADCP results from the ongoing Northeastern GOM Chemical Oceanography and Hydrography Study (NEGOM) appear to confirm these findings. Midshelf and inner shelf flow was weakly cyclonic except for the summer of 1999. Circulation over the slope and shelf edge appeared to be driven by offshore eddies and the Loop Current. Continental shelf waves may propagate westward along the slope in this region. Cold water from deeper offshelf regions moves onto and off the continental shelf by cross-shelf flow associated with upwelling and downwelling processes. Upwelling of nutrient rich, cold water onto the shelf in 1998 was correlated with hypoxia, anoxia, and mass mortalities of fishes and invertebrates in the region, although causation has not been established (Collard and Lugo-Fernandez, 1999). A more extensive discussion of the physical oceanography of the continental shelf in this region is available in the Destin Dome EIS (USDOI, MMS, 1999). Table A-4 in the Final EIS for Lease Sale 181 (USDOI, MMS, 2001) gives the names, depth ranges, densities, and identifying features of the remnants of the principal watermasses in the Eastern GOM, excluding the highly variable surface waters, as observed by Morrison and Nowlin (1977) and Nowlin and McLellan (1967).

Eastward and shoreward winds that could force upwelling in this region and that were related to the 1997-1998 El Niño climatic conditions were associated with the upwelling event that occurred in 1998 on the Florida continental shelf in the northeastern GOM. This event was documented by Advanced Very High Resolution Radiometer (AVHRR, an instrument by which infrared radiation can be detected over large areas via satellite), wind, bottom-water temperature, sea-surface height fields, and ADCP observations and has been attributed not directly to the prevailing winds but to a persistent anticyclone located over DeSoto Canyon during 1998 (Collard and Lugo-Fernandez, 1999).

Cold fronts, as well as diurnal and seasonal cycles of heat flux at the air/sea interface, affect near-surface water temperatures, although water at depths greater than about 100 m remains unaffected by surface boundary heat flux. Water temperature is greater than air temperature at the air/sea interface during all seasons. Frontal passages over the region can cause changes in temperature and velocity structure in the upper layers, specifically increasing current speeds and variability. These fronts tend to occur with frequencies from 3-10 days (weatherband frequency). In the winter, the shelf water is nearly homogeneous due to wind stirring and cooling by fronts and winter storms. Storms and hurricanes as far away as the Yucatan Peninsula can induce strong currents in this part of the northeastern GOM (Brooks, 1991; page 13). Hurricanes increase surface current speeds and cool the surface waters in much the same way as do cold fronts, but may stir the mixed layer to an even greater depth (Molinari, 1979). Surface waves and sea state may limit normal oil and gas operations as well as oil-spill response activities (Brower et al., 1972). During passage of a cold front, the cold air mass is warmed as it travels over surface waters. In deeper waters, the mixed layer deepens. In the summer, vertical density stratification increases with the development of a seasonal thermocline. In deeper waters, the mixed layer is diminished. The transition between summer and winter is believed to occur with passage of the first cold front, and the transition from winter to summer coincides with the last cold front (Molinari and Festa, 1978).

METEOROLOGICAL CONDITIONS

The maritime subtropical climate of the GOM is controlled mainly by the clockwise circulation around the semipermanent area of high barometric pressure commonly known as the Bermuda High. The center of the high-pressure cell is usually located at the Atlantic Ocean or sometimes near the Azores Islands off the coast of Spain (Henry et al., 1994). The GOM is located to the southwest of this center of circulation. This proximity to the high-pressure system results in a predominantly east to southeasterly air flow in the GOM region. Two important classes of cyclonic storms are occasionally superimposed on this circulation pattern. During the winter months of December through March, cold fronts associated with cold continental air masses influence mainly the northern coastal areas of the GOM. Behind the fronts, strong north winds bring drier air into the region. During the summer and fall months of June through October, tropical cyclones may develop or migrate into the GOM. These storms may affect any area of the GOM and substantially alter the local wind circulation around them. In coastal areas, the sea breeze effect may become the primary circulation feature during the summer months of May through October. In general the subtropical maritime climate is the dominant feature in driving all aspects of the weather in this region; as a result, the climate shows relatively small diurnal variation in summer.

The climatology of the GOM region is primarily governed by two types of air masses. One type of air mass is the warm and moist, maritime tropical air; the other type is very cold and dry, continental polar air. During summer months, the mid-latitude polar jet retreats northward, allowing maritime air to dominate through the GOM. In the southeastern region of the GOM, the climate is dominated by the warm and moist, maritime tropical air year round.

Winds are more variable near the coast than over open waters because coastal winds are more directly influenced by the moving cyclonic storms that are characteristic of the continent and because of the land and sea breeze regime. During the relatively constant summer conditions, the southerly position of the Bermuda High generates predominantly southeasterly winds in the northern Gulf and easterly winds in the southern parts of the Gulf. Winter winds usually blow from northeasterly directions and become more easterly in the southern parts of the Gulf.

Precipitation is frequent and abundant throughout the year but does show distinct seasonal variation. The highest precipitation rates occur during the warmer months of the year. The warmer months usually have convective cloud systems that produce showers and thunderstorms; however, these thunderstorms rarely cause any damage or have attendant hail (USDOC, 1967; Brower et al., 1972). Winter rains are associated with the frequent passage of frontal systems through the area. Rainfalls are generally slow, steady, and relatively continuous, often lasting several days. Frozen precipitation is unlikely to occur in the EPA sale area.

Warm, moist Gulf air blowing slowly over chilled land or water surfaces brings about the formation of fog. Fog occurrence decreases seaward. Coastal fogs generally last 3 or 4 hours, although particularly dense sea fogs may persist for several days. The poorest visibility conditions occur during winter and early spring. Industrial pollution and agricultural burning also impact visibility.

Mixing height is very important because it determines the volume of air available for dispersing pollutants. Mixing height is directly related to vertical mixing in the atmosphere. A mixed layer is expected to occur under neutral and unstable atmospheric conditions. Vertical mixing is most vigorous during unstable conditions. Vertical motion is suppressed during stable conditions. The mixing height tends to be lower in winter and daily variations are smaller than in summer.

Not all of the Pasquill-Gifford stability classes are found offshore in the GOM. Specifically, the F stability class seldom occurs and the G stability is markedly absent; the G stability class is the extremely stable condition that only develops at night over land with rapid radiative cooling. This large body of water is simply incapable of losing enough heat overnight to set up a strong radiative inversion. Likewise, A stability class is rarely present but could be encountered during cold air outbreaks in the wintertime, particularly over warmer waters. Category A is the extremely unstable condition that requires a very rapid warming of the lower layer of the atmosphere, along with cold air aloft. This is normally brought about when cold air is advected aloft, and in strong insolation rapidly warms the earth's surface, which, in turn, warms the lowest layer of the atmosphere. Once again, the ocean surface is incapable of warming rapidly; therefore, you would not expect to find stability class A over the ocean. For the most part, the stability is neutral to slightly unstable.

In this area, the over-water stability is predominantly unstable, with neutral conditions making up the bulk of the remainder of the time (Hsu, 1996; Marks, written communication, 1996 and 1997; Nowlin et al., 1998). Stable conditions do occur, although infrequently.

The mixing heights offshore are quite shallow, 900 m or less (Hsu, 1996; Nowlin et al., 1998). Transient cold fronts also have an impact on the mixing heights; some of the lowest heights can be expected to occur with frontal passages and on the cold-air side of the fronts. This effect is caused by the frontal inversion.

The GOM is part of the Atlantic tropical cyclone basin. Tropical cyclones generally occur in summer and fall seasons; however, the Gulf also experiences winter storms or extratropical storms. These winter storms generally originate in middle and high latitudes and have winds that can attain speeds of 15-26 m/sec (33.5-58.2 mph). The Gulf is an area of cyclone development during cooler months due to the contrast of the warm air over the Gulf and the cold continental air over North America. The most severe extratropical storms in the Gulf originate when a cold front encounters the subtropical jetstream over the warm waters of the Gulf. Statistics of 100-year data of extratropical cyclones reveal that most activity occurs above 25°N in the Western GOM. The mean number of these storms ranges from 0.9 storms per year near the southern tip of Florida to 4.2 over central Louisiana and average 2.9 in the region of the EPA sale area (USDOI, MMS, 1988).

The frequency of cold fronts in the Gulf exhibits similar synoptic weather patterns during the four-month period of December through March. During this time the area of frontal influence reaches south to 10°N. Frontal frequency is about nine fronts per month in February (1 front every 3 days on the average) and about seven fronts per month in March (1 front every 4-5 days on the average). By May, the frequency decreases to about four fronts per month (1 front every 7-8 days), and the region of frontal influence retreats to about 15°N. During June-August frontal activity decreases to almost zero and fronts seldom reach below 25°N. latitude (USDOI, MMS, 1988).

Tropical cyclones affecting the Gulf originate over the equatorial portions of the Atlantic Ocean, the Caribbean Sea, and the GOM. Tropical cyclones occur most frequently between June and November. Based on 42 years of data, there are about 9.9 storms per year with about 5.5 of those becoming major hurricanes in the Atlantic Ocean (Gray, written communication, 1992). Data from 1886 to 1986 show that 44.5 percent of these storms, or 3.7 storms per year, will affect the GOM (USDOI, MMS, 1988). The Yucatan Channel is the main entrance of Atlantic storms into the GOM, and a reduced translation speed over Gulf waters leads to longer residence times in this basin. The probability of a tropical storm or hurricane crossing the Escambia and Santa Rosa County coastlines is approximately 20 percent for any year; or they should experience one about once every five years. The probability of occurrence for a tropical storm in Louisiana and Mississippi is on average about 15 percent; it is approximately 20 percent in Alabama. Records from 1886 to 1992 show that 85 hurricanes hit the State of Florida, about one tropical storm per year.

Tropical storms can affect OCS operations and activities through storm surge, waves, and currents generated by tropical storms. Most of the damage is caused by storm surge, waves, and high winds. Storm surge depends on local factors, such as bottom topography and storm intensity. Water depth and storm intensity control wave height during hurricane conditions. Sustained winds for major hurricanes (Saffir-Simpson Category 3 and above) are greater than 49 m/sec (109.6 mph).

BIBLIOGRAPHY

Brooks, J.M., ed. 1991. Mississippi-Alabama continental shelf ecosystem study: Data summary and synthesis. Volume II: Technical narrative. U.S. Dept of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 91-0063. 862 pp.

Brower, W.A., J.M. Meserve, and R.G. Quayle. 1972. Environmental guide for the U.S. Gulf Coast. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Environmental Data Service, National Climatic Center, Asheville, NC.

Campbell, K.J. 1999. Deepwater geohazards: how significant are they? The Leading Edge 18(4):514-519.

Collard, S.B. and A. Lugo-Fernandez. 1999. Coastal upwelling and mass mortalities of fishes and invertebrates in the northeastern Gulf of Mexico during spring and summer 1998. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 99-0049. 20 pp.

Cooper, C.A., G.Z. Forristall, and T.M. Joyce. 1990. Velocity and hydrographic structure of two Gulf of Mexico warm-core rings. J. Geophys. Res. 95:1663-1679.

Dinnell, S.P. 1988. Circulation and sediment dispersal on the Louisiana-Mississippi-Alabama continental shelf. Ph.D. Dissertation, Louisiana State University. xii + 173 pp.

Elliot, B.A. 1982. Anticyclonic rings in the Gulf of Mexico. J. Phys. Oceanography 12:1292-1309.

Gray, W.M. 1992. Written communication. Updated forecast of Atlantic seasonal activity for 1992.

Hamilton, P. 1990. Deep currents in the Gulf of Mexico. J. Phys. Oceanography 20:1087-1104.

Hamilton, P. 1992. Lower continental slope cyclonic eddies in the Central Gulf of Mexico. J. Geophys. Res. 97:2185-2200.

Henry, J.A., K.M. Portier, and J. Coyne. 1994. The climate and weather of Florida. Sarasota, FL: Pineapple Press, Inc.

Hsu, S.A. 1996. Analysis of ambient pollutant concentrations and meteorological conditions affecting EPA Class I and II areas in southeastern Louisiana. Volume II: Appendices. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 96-0063. 364 pp.

Jochens, A.E. and W.D. Nowlin, Jr., eds. 1998. Northeastern Gulf of Mexico chemical oceanography and hydrography study between the Mississippi Delta and Tampa Bay; Annual Report: Year 1. U.S. Dept of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 98-0060. 126 pp.

Lore, G.L., D.A Marin, E.C. Batchelder, W.C. Courtwright, R.P. Desselles, and R.J. Klazynski. 2001. 2000 Assessment of Conventionally Recoverable Hydrocarbon Resources in the Gulf of Mexico Outer Continental Shelf as of January 1, 1999. U.S. Dept of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Report MMS 2001-087. 652 pp.

Marks, S. 1996. Written communication. Meteorological file. Observations from rig during drilling of Destin Dome 57 #1 well. DD 57 drilling rigs. 300 pp.

Marks, S. 1997. Written communication. Compilation of meteorological data from actual observations in the Destin Dome Unit. 271 pp.

Molinari, R.L. and J.F. Festa. 1978. Ocean thermal and velocity characteristics of the Gulf of Mexico relative to the placement of a moored OTEC plant. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Environmental Research Laboratories, Miami, FL. NOAA Technical Memorandum ERL AOML-33. 106 pp.

Molinari, R.L. 1979. Physical oceanographic conditions at a potential OTEC site in the Gulf of Mexico; 88°W, 29°N. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Environmental Research Laboratories, Miami, FL. NOAA Technical Memorandum ERL AOML-41. 105 pp.

Morrison, J.M. and W.D. Nowlin, Jr. 1977. Repeated nutrient, oxygen, and density sections through the Loop Current. J. Mar. Res. 35:105-128.

Muller-Karger, F.E., F. Vukovich, R. Leben, B. Nababan, and D. Myhre. 1998. Northeastern Gulf of Mexico physical oceanography program: Eddy monitoring and remote sensing: First annual report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 98-0051. 41 pp.

Nowlin, W.D. Jr., A.E. Jochens, R.O. Reid, and S.F. DiMarco. 1998. Texas-Louisiana shelf circulation and transport processes study: Synthesis report. Volume I: Technical report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 98-0035. 502 pp.

Nowlin, W.D. Jr. and H.J. McLellan. 1967. A characterization of the Gulf of Mexico waters in winter. J. Mar. Res. 25:29-59.

Science Applications International Corporation (SAIC). 1989. Gulf of Mexico physical oceanography program; Final report: Year 5. Volume II: Technical report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Report MMS 89-0068. 333 pp.

Sturges, W., J.C. Evans, S. Welsh, and W. Holland. 1993. Separation of warm-core rings in the Gulf of Mexico. J. Phys. Oceanography 23:250-268.

U.S. Dept. of Commerce. 1967. United States coast pilot 5. Atlantic Coast, Gulf of Mexico, Puerto Rico and Virgin Islands, 6th ed. Washington, DC: U.S. Coast and Geodetic Survey, Environmental Science Services Administration. 301 pp.

U.S. Dept. of the Interior. Minerals Management Service. 1988. Meteorological database and synthesis for the Gulf of Mexico. Prepared by Florida A&M University for the U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 89-0064. 430 pp.

U.S. Dept. of the Interior. Minerals Management Service. 1999. Destin Dome 56 Unit: Development and production plan and right-of-way pipeline application; draft environmental impact statement. Volume I: Sections I-IX. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS EIS/EA MMS 99-0040. Available from NTIS, Springfield, VA: PB99-167397 (Volume I) and PB99-167405 (Volume II). 742 and 204 pp., respectively.

U.S. Dept. of the Interior. Minerals Management Service. 2001. Gulf of Mexico OCS oil and gas lease Sale 181: Eastern Planning Area—final environmental impact statement. 2 vols. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS EIS/EA MMS 2001-051.

The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Minerals Revenue Management** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.