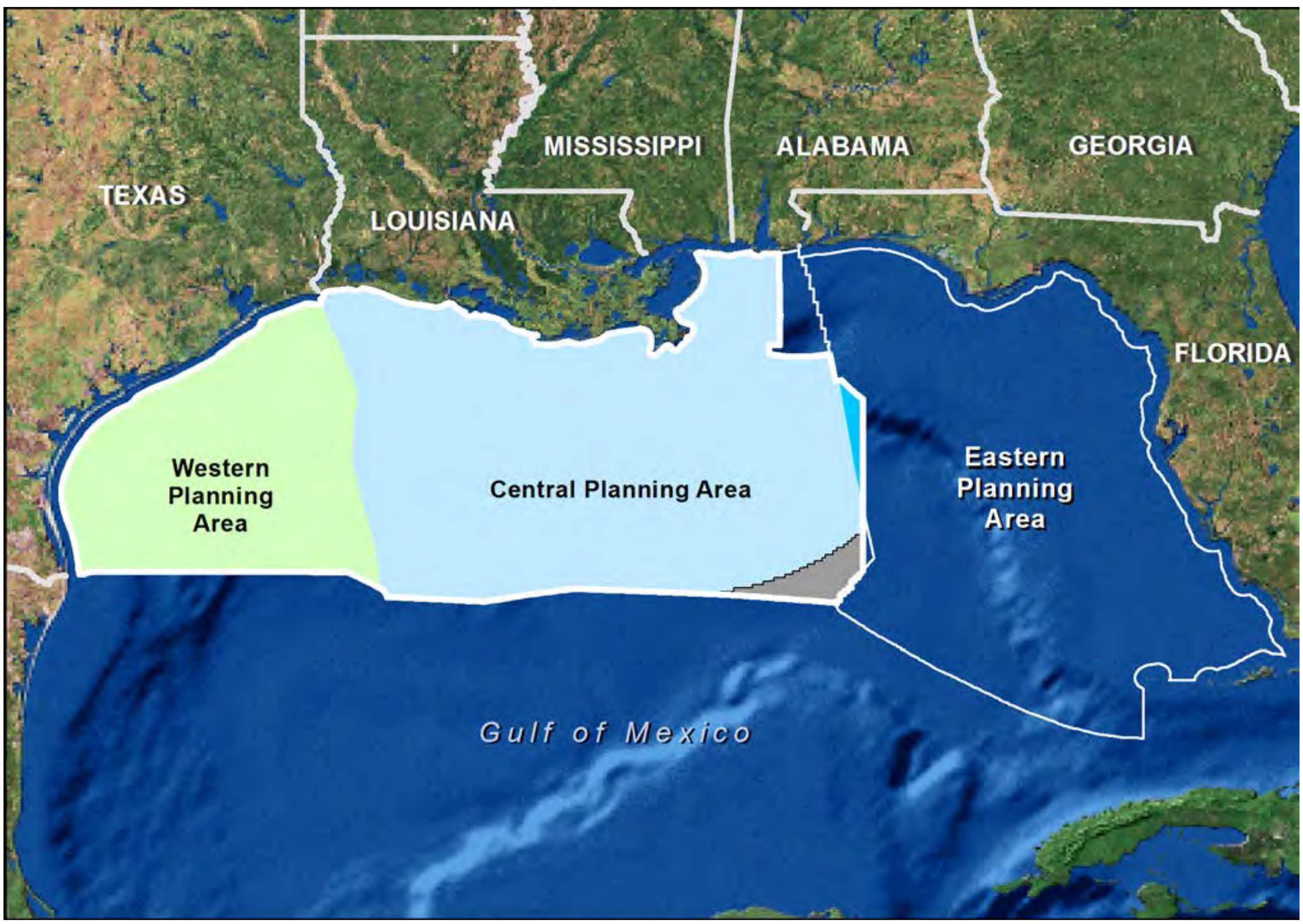
OCS EIS/EA
BOEM 2017-009

Gulf of Mexico OCS Oil and Gas Lease Sales: 2017-2022

Gulf of Mexico Lease Sales 249, 250, 251, 252, 253, 254, 256, 257, 259, and 261

Final Multisale Environmental Impact Statement

Volume II: Chapters 4-8



U.S. Department of the Interior
Bureau of Ocean Energy Management
Gulf of Mexico OCS Region

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Chapter 4

Description of the Environment and Impact Analysis

What's in This Chapter?

- **Chapter 4** describes the affected environment and potential environmental consequences of a single proposed lease sale.
- Resources analyzed are as follows:
  – Air Quality
  – Water Quality
  – Coastal Habitats (Estuarine Systems, and Coastal Barrier Beaches and Associated Dunes)
  – Deepwater Benthic Communities
  – *Sargassum* and Associated Communities
  – Live Bottom Habitats (Topographic Features, and Pinnacles and Low-Relief Features)
  – Fishes and Invertebrate Resources
  – Birds
  – Protected Species (Marine Mammals, Sea Turtles, Beach Mice, Protected Birds, and Protected Corals)
  – Commercial Fisheries
  – Recreational Fishing
  – Recreational Resources
  – Archaeological Resources
  – Socioeconomic Issues (Land Use and Coastal Infrastructure, Economic Factors, and Social Factors, Including Environmental Justice)
- Impact-producing factors and impact-level definitions are identified for each resource.
- The analyses of environmental consequences consider the potential impacts from routine activities, accidental events, and cumulative impacts; and incomplete or unavailable information.
- Other analyses in this chapter include the following:
  – Unavoidable Adverse Impacts of a Proposed Action
  – Irreversible and Irretrievable Commitment of Resources
  – Relationship Between the Short-term Use of Man's Environment and the Maintenance and Enhancement of Long-term Productivity

4 DESCRIPTION OF THE AFFECTED ENVIRONMENT AND IMPACT ANALYSIS

4.0 OVERVIEW

As discussed in **Chapter 1.3**, BOEM makes individual decisions on whether and how to proceed with each lease sale pursuant to the OCSLA's staged leasing process. Therefore, the analysis presented here is for a single proposed lease sale. However, since this is a programmatic analysis, this Multisale EIS will be used to support all 10 lease sale decisions. Additional NEPA reviews (e.g., a Determination of NEPA Adequacy, an EA or, if determined necessary, a Supplemental EIS) will be conducted prior to subsequent lease sale decisions. This chapter describes the affected environment and the potential impacts of routine activities, reasonably foreseeable accidental events, and cumulative impacts caused by a proposed lease sale and the alternatives on these resources.

***Chapter 4** describes the affected environment and potential environmental consequences of a single proposed lease sale. This Multisale EIS tiers from and uses the information contained in the Five-Year Program EIS (USDOI, BOEM, 2016b).*

This chapter is organized by groups of resources. The chapter is divided into the physical factors (i.e., air and water quality), biological factors (i.e., habitat resources followed by the fauna that are found in or utilize these habitats), and finally the social environment, including environmental justice, commercial fisheries, recreational resources, and land use.

- Air Quality (**Chapter 4.1**)
- Water Quality (**Chapter 4.2**)
- Habitat Resources
  - Coastal Habitats (**Chapter 4.3**)
  - Deepwater Benthic Communities (**Chapter 4.4**)
  - *Sargassum* and Associated Communities (**Chapter 4.5**)
  - Live Bottom Habitats (**Chapter 4.6**)
- Faunal Resources
  - Fish and Invertebrate Resources (**Chapter 4.7**)
  - Birds (**Chapter 4.8**)
  - Protected Species (**Chapter 4.9**)
- Social Environment
  - Commercial Fisheries (**Chapter 4.10**)
  - Recreational Fishing (**Chapter 4.11**)
  - Recreational Resources (**Chapter 4.12**)
  - Archaeological Resources (**Chapter 4.13**)
  - Human Resources and Land Use (**Chapter 4.14**)

The habitat resource chapters focus on the impact-producing factors that would affect their environment while the other chapters concentrate on the biological effects of impact-producing factors on fauna and human resources. To decrease repetition, the habitat information is generally not restated in the fauna chapters and vice versa.

Analysts concentrated on providing a focused analysis, using illustrations to communicate key concepts, and including more detailed, technical information in supporting appendices. Furthermore, supporting technical information in previous NEPA reviews have been developed as white papers and are summarized and incorporated by reference as appropriate. These white papers include the *OCS Regulatory Framework* (Cameron and Matthews, and 2016), *Catastrophic Spill Event Analysis* (USDOI, BOEM, 2017), *Essential Fish Habitat Assessment* (USDOI, BOEM, 2016d), and *Potential Lifecycle Greenhouse Gas Emissions and Social Cost of Carbon* (Wolvovsky and Anderson, 2016). This Multisale EIS also tiers from and uses information contained in the *Outer Continental Shelf Oil and Gas Leasing Program: 2017-2022; Final Programmatic Environmental*

Impact Statement (Five-Year Program EIS; USDOI, BOEM, 2016b). Programmatic aspects of the potential impacts of climate change relative to the environmental baseline for the Gulf of Mexico OCS Program are discussed within each resource and in Chapter 4 of the Five-Year Program EIS.

This Multisale EIS was prepared with consideration of potential changes to or new information about the baseline conditions of the physical, biological, and socioeconomic resources. Current baselines (including past and present events) are described for all resources under their respective "Affected Environment" subchapters in this Multisale EIS. Past events such as Hurricanes Katrina and Rita and the *Deepwater Horizon* explosion, oil spill, and response have the potential to adversely affect multiple resources over a large area. Specific to the *Deepwater Horizon*, the Deepwater Horizon Natural Resource Trustees (Trustees) has completed the *Deepwater Horizon Oil Spill: Final Programmatic Damage Assessment and Restoration Plan and Final Programmatic Environmental Impact Statement* (PDARP/PEIS) (Deepwater Horizon Natural Resource Damage Assessment Trustees, 2016), which has the purpose and need of assessing and creating restoration plans to relieve injuries from the *Deepwater Horizon* explosion, oil spill, and response to natural resources and services. The injuries assessed within the PDARP/PEIS do not necessarily equate the baseline as defined in NEPA. The level of adverse effect depends on many factors, including the sensitivity of the resource as well as the sensitivity of the environment in which the resource is located. All effects may not currently be known and some could take years to fully develop (refer to the "Incomplete or Unavailable Information" for each resource). The analyses of impacts from the *Deepwater Horizon* explosion, oil spill, and response on the physical, biological, and socioeconomic resources in this Multisale EIS are based on credible scientific information that was publicly available at the time this document was prepared. This credible scientific information was applied using accepted methodologies, including numerical modeling of data and scientific writing methods to convey the information of BOEM's subject-matter experts' technical knowledge and experience. However, BOEM and the Deepwater Horizon NRDA Trustee Council continue to study, measure, and interpret impacts arising out of that spill. BOEM continues to analyze the *Deepwater Horizon* explosion, oil spill, and response as information becomes available, and it was evaluated as part of the baseline for resources in this Multisale EIS. Thus, there are instances in which BOEM is faced with incomplete or unavailable information (refer to **Chapter 4.0.2.4**) that may be relevant to evaluating reasonably foreseeable significant adverse impacts on the human environment. Further, a low-probability catastrophic event and the resulting analysis of potential effects are presented in the *Catastrophic Spill Event Analysis* white paper (USDOI, BOEM, 2017).

4.0.1 What Encompasses the Affected Environment for a Gulf of Mexico Lease Sale?

Each resource chapter includes a unique description of the affected environment and an analysis of the potential environmental consequences of the alternatives for that particular resource. The Federal and State waters of the Gulf of Mexico and the adjacent coastal states are generally the affected environment described in each resource chapter. Current baselines are described for all resources under their respective "Affected Environment" sections. Specific to the PDARP/PEIS (Deepwater Horizon Natural Resource Damage Assessment Trustees, 2016), the altered baseline includes individual protected species directly affected by this unexpected unique catastrophic event. BOEM understands that each oil-spill event is unique and that its outcome depends on several factors, including time of year and location of the release relative to winds, currents, land, and sensitive resources, as well as specifics of the well and response effort. BOEM also understands that the severity of impacts from an oil spill cannot be predicated on volume alone. BOEM has analyzed a low-probability catastrophic event (USDOI, BOEM, 2017) in conjunction with its analysis of potential effects, as requested by CEQ pursuant to its regulation at 40 CFR § 1502.22. A low-probability catastrophic spill is, by definition, not reasonably certain to occur. Other methods of analysis are neither significantly limited in their applicability and availability nor would they provide any meaningful or useful information to be used to assess the risk of catastrophic spill occurrence at this programmatic level of oil and gas activities in the GOM. The return period of a catastrophic oil spill in OCS areas is estimated to be 165 years, with a 95 percent confidence interval between 41 years and more than 500 years (Ji et al., 2014).

4.0.2 How are the Potential Environmental Consequences Determined?

The analyses of potential impacts to the wide variety of physical, environmental, and socioeconomic resources in the vast area of the GOM and adjacent coastal areas is very complex. For this Multisale EIS, a set of assumptions and a scenario were developed, along with descriptions of impact-producing factors that could occur from routine OCS oil- and gas-related activities, including accidental events. Analysis of the various alternatives considers these impact-producing factors (described in detail in **Chapter 3**) within a distinct framework that includes frequency, duration, and geographic extent. Frequency (whether rare, intermittent, or continuous) refers to how often the factor occurs over the entire analysis period of 50 years for routine activities and accidental events. Duration refers to how long the factor lasts from less than a year to many years. Geographic extent covers what areas are affected and, depending on the factor, how large of an area is affected.

An impact-producing factor is an activity or process, as a result of a proposed lease sale, that could cause impacts on the environmental or socioeconomic setting. ***Chapter 3*** *provides a description of all possible impact-producing factors considered in this analysis.*

Using this information, the interdisciplinary team of subject-matter experts applies knowledge and experience to conduct analyses of the potential effects of a proposed lease sale on assigned resources. Specialized education, experience, and technical knowledge are required of these subject-matter experts, as well as familiarity with the numerous impact-producing factors associated with OCS oil- and gas-related activities and other activities that can cause cumulative impacts in the area to conduct this analysis. Knowledge and practical working experience of major environmental laws and regulations such as NEPA, the Clean Water Act, Clean Air Act, Coastal Zone Management Act (CZMA), ESA, Marine Mammal Protection Act, Magnuson-Stevens Fishery Conservation and Management Act, and others are also required to conduct this analysis. In order to accomplish this task, BOEM has assembled an interdisciplinary team with many years of collective experience. The vast majority of this team has advanced degrees with a high level of knowledge related to the particular resources discussed in this chapter. This team prepares the input to BOEM's lease sale EISs and a variety of subsequent postlease NEPA reviews, and is also involved with ESA, EFH Assessment, and CZMA consultations. In addition, this same staff is also directly involved with the development of studies conducted by BOEM's Environmental Studies Program. The results of these studies feed directly into the Bureau of Ocean Energy Management's NEPA analyses.

How Were Impact Levels Defined?

The environmental consequences in each resource chapter include an analysis of applicable impact-producing factors from the categories of routine activities, accidental events, and cumulative impacts that would occur under any of the action alternatives (i.e, Alternatives A, B, C, and D).

It must be emphasized that, in arriving at the overall conclusions for certain environmental resources (e.g., birds, fisheries, and wetlands) for each alternative, the conclusions are based on potential impacts to the resources or species population as a whole, not to individuals, small groups of animals, or small areas of habitat. BOEM analyzes impacts on a finer geographic scale and mitigations that are appropriate for consideration through site-specific environmental reviews (refer to **Appendix A**). Each resource topic discussion includes a threshold effects determination and includes a resource-specific definition of impact level. Additionally, potential beneficial effects of a proposed action have also been considered and identified in individual resource chapters. For example, implementation of a proposed lease sale is anticipated to have beneficial impacts in the Area of Interest for economics due to the direct and indirect spending associated with the oil and gas industry. For this Multisale EIS, effects thresholds are defined using four categories of significance.

The potential magnitude of impact using these resource-specific definitions are provided in the introduction of most resource sections as a summary table to help the reader quickly identify the level of potential impacts for each impact-producing factor. The analysis supporting these conclusions are then discussed in detail in each resource chapter.

- **Negligible** – Impacts may or may not cause observable changes to natural conditions; regardless, they do not reduce the integrity of a resource.
- **Minor** – Impacts cause observable and short-term changes to natural conditions but they do not reduce the integrity of a resource.
- **Moderate** – Impacts cause observable and short-term changes to natural conditions and/or they reduce the integrity of a resource.
- **Major** – Impacts cause observable and long-term changes to natural conditions and they reduce the integrity of a resource.

The conclusions developed by BOEM's subject-matter experts regarding the potential effects of a proposed lease sale for most resources are necessarily qualitative in nature; however, they are based on the science-based judgment of the highly trained subject-matter experts. Staff approach this effort utilizing credible scientific information and apply it to the subject resources using accepted methodologies. It is important to note that, barring another catastrophic oil spill, which is a low-probability accidental event not expected to occur and therefore not part of a proposed action, the adverse impacts associated with a proposed lease sale are expected to be small, and beneficial impacts are projected as well for certain activities and species. This is because of BOEM's potential use of lease sale stipulations and mitigations, site-specific mitigations that may become conditions of plan or permit approval at the postlease stage, and mitigations required by other State and Federal agencies that help to reduce or minimize many of the impacts. Over the years, a suite of lease stipulations and mitigating measures has been developed to eliminate or ameliorate potential environmental effects, where implemented (refer to **Appendix B**, "Commonly Applied Mitigation Measures"). BOEM's primary mitigative method is the avoidance of impacts, which is primarily implemented during approval of postlease activities. In many instances, these were developed in coordination with other natural resource agencies such as NMFS and FWS. Informal and formal consultation with other Federal agencies and affected States, and commenting opportunities for the public are implemented to assist in the development of the information and analyses in this Multisale EIS. Specifically, information requests soliciting input on the proposed lease sales were issued during scoping for this Multisale EIS (refer to **Chapter 5**). The impact-level conclusions reached in each resource area consider the applicable impact-producing factors, the level of activity, and the geographic area of each alternative.

Lease sale stipulations considered for a proposed lease sale include the Topographic Features Stipulation; Live Bottom (Pinnacle Trend) Stipulation; Military Areas Stipulation; Evacuation Stipulation; Coordination Stipulation; Blocks South of Baldwin County, Alabama, Stipulation; Protected Species Stipulation; United Nations Convention on the Law of the Sea Royalty Payment Stipulation; Below Seabed Operations Stipulation; and the Stipulation on the Agreement between the United States of America and the United Mexican States Concerning Transboundary Hydrocarbon Reservoirs in the Gulf of Mexico (Transboundary Stipulation). The Topographic Features and Live Bottom (Pinnacle Trend) Stipulations have been applied as programmatic mitigation in the Five-Year Program EIS (USDOI, BOEM, 2016b) and, therefore, would apply to all leases issued under the Five-Year Program in designated lease blocks. Site-specific postlease mitigations may include buffer zones and avoidance criteria to protect sensitive resources such as areas of deepwater benthic communities, topographic features, and historic shipwrecks. Mitigations may also be required by other agencies (i.e., the U.S. Army Corps of Engineers and State CZM agencies) to avoid or reduce impacts from OCS oil- and gas-related activities, e.g., boring under beach shorelines and the rerouting of pipelines to reduce or eliminate impacts from OCS pipelines that make landfall. These mitigations and their potential effect on reducing or eliminating impacts from a proposed lease sale are analyzed in this chapter.

Under all four action alternatives, postlease activities would be reviewed on a case-by-case basis and the applicable commonly applied mitigating measures (refer to **Appendix B**) would be identified during site-specific reviews of plans and permits. This avoids excessive replication of discussion of similar if not identical impacts throughout the entire document, allowing the reader to focus on the differences between the alternatives.

4.0.2.1 Routine Activities

The types of routine activities that could occur from all operations as a result of a single lease sale are described in **Chapter 3.1**. The major types of routine activities include geological and geophysical surveys; exploration, development, and production drilling; infrastructure emplacement and presence; transportation, including pipelines, vessels, and helicopters; discharges and wastes; decommissioning and removal; coastal infrastructure; air emissions; noise; and safety issues. The time period for postlease activities related to a single lease sale is 50 years.

4.0.2.2 Accidental Events

A summary of the information on accidental events that are reasonably foreseeable from all operations conducted under the OCS Program, as well as information on the number and sizes of spills from non-OCS sources is provided in **Chapter 3.2**. The types of accidental events that could reasonably be expected as a result of postlease activities include oil spills, losses of well control, accidental air emissions, pipeline failures, vessel and helicopter collisions, chemical and drilling-fluid spills, and spill response as a result of a proposed lease sale.

4.0.2.3 Cumulative Impacts

The cumulative analysis considers impacts to physical, biological, and socioeconomic resources that may result from the incremental impact of a proposed lease sale when added to all past, present, and reasonably foreseeable future human activities. However, most resources consider the past and present cumulative impacts as part of the baseline environmental conditions, and they are covered where relevant in the affected resource description. It is reasonably foreseeable to assume that lease sales would continue to occur, as they have historically, for many years to come in the Gulf of Mexico region, based on resource availability, existing infrastructure, and projected time lapses required for any other major energy sources to come online. However, the level of activities (exploration wells, production wells, and pipelines) becomes more speculative as time is projected further into the future. The causes for this are uncertainty in long-term oil price forecasts, resource potential, cost of development, and drill rig availability versus the amount of acreage leased from a lease sale. Furthermore, OCSLA provides for phased decisionmaking, each of which is a decision subject to NEPA. The OCSLA stages include the Five-Year Program stage to identify a schedule of leases over the period; the lease sale stage; the exploration stage; the development and production stage; and ultimately decisions on how a lessee may proceed with decommissioning. These reviews require consideration of cumulative impacts that would factor in changing environmental baselines, oil and gas price forecasts, and technology advancements, among others. Additionally, even though continued consumer demand is likely, new advances in technology (both on upstream development and production ends and downstream user ends) can potentially change the level of projected activities and how they are conducted. These could further minimize environmental risks. Technology advancements and organizational effectiveness could also further reduce projected air emissions, wastewater quantities, and other impact producing factors such as helicopter and vessel trips and accidental events.

Therefore, cumulative impact assessment for this Multisale EIS considers existing environmental baseline conditions, past OCS and non-OCS activities in the GOM, projected future activities as a result of past lease sales, 50 years of incremental projected activities as a result of the proposed lease sales during the 2017-2022 Five-Year Program, and reasonably assumes projected activities for future lease sales based on current trends. Non-OCS oil- and gas-related activities include, but are not limited to, import tankering; marine transportation; State oil and gas activity; recreational, commercial, and military vessel traffic; offshore liquefied natural gas activity; recreational and commercial fishing; onshore development; and natural processes. The time period for reasonably foreseeable future actions are dependent upon the nature of each resource and are therefore defined in each resource chapter. The types of cumulative activities that could reasonably occur are described in **Chapter 3.3**.

4.0.2.4 Incomplete or Unavailable Information

Throughout this chapter, where information was incomplete or unavailable, BOEM complied with its obligations under NEPA to determine if the information was relevant to reasonably foreseeable significant adverse impacts; if so, whether it was essential to a reasoned choice among alternatives; and, if it was essential, whether it can be obtained and whether the cost of obtaining the information is exorbitant, as well as whether scientifically credible information using generally accepted scientific methodologies can be applied in its place (40 CFR § 1502.22).

The most notable incomplete or unavailable information relates to some aspects of the effects from the *Deepwater Horizon* explosion, oil spill, and response. Credible scientific data regarding the potential short-term and long-term impacts from the *Deepwater Horizon* explosion, oil spill, and response on some GOM resources have become available. However, information relating to long-term effects continue to be studied and remain incomplete at this time, and it could be many years before this information becomes available. The Deepwater Horizon NRDA Trustees Council has released the PDARP/PEIS (Deepwater Horizon Natural Resource Damaage Assessment Trustees, 2016). However, the information collected during the NRDA process that the assessment, plan, and EIS used as a basis for their determinations are not yet publicly available (e.g., NRDA technical working group reports). There remains information being developed through the NRDA process, but it is not yet available as a final report. Nonetheless, BOEM's subject-matter experts acquired and used newly available, scientifically credible information; determined that other additional information was not available absent exorbitant expenditures or could not be obtained regardless of cost in a timely manner; and where gaps remained, exercised their best professional judgment to extrapolate baseline conditions and impact analyses using accepted methodologies based on credible information. While incomplete or unavailable information could conceivably result in potential future shifts in baseline conditions of habitats that could affect BOEM's decisionmaking, BOEM has determined that it can make an informed decision at this time without this incomplete or unavailable information. BOEM's subject-matter experts have applied other scientifically credible information using accepted theoretical approaches and research methods, such as information on related or surrogate species. Moreover, BOEM will continue to monitor these resources for effects caused by the *Deepwater Horizon* explosion, oil spill, and response, and will ensure that future BOEM environmental reviews take into account any new information that may emerge.

Furthermore, BOEM has considered the reasonably foreseeable impacts of a low-probability catastrophic oil spill in a white paper. These types of events, such as the one that resulted from the *Deepwater Horizon* explosion, are not reasonably expected to occur and therefore are not part of a proposed action. BOEM has prepared the *Catastrophic Spill Event Analysis* white paper, which provides a summary of existing credible scientific evidence related to this issue and BOEM's evaluation of the potential impacts to the physical, biological, and socioeconomic resources and conditions based upon theoretical approaches or research methods generally accepted in the scientific community (USDOI, BOEM, 2017). The white paper was included in previous lease sale EISs as an appendix. To avoid repetition and redundancies, the white paper is incorporated by reference and is publicly available on BOEM's website at http://www.boem.gov/nepaprocess/. BOEM updated the analysis in the white paper and will update it again should new information become available relevant to the reasonably foreseeable impacts of a catastrophic spill event.

Alternatives

Each resource chapter includes an analysis of the relevant impact-producing factors to that specific resource from the routine activities, accidental events, and cumulative impacts that are described in **Chapter 3**. After this general analysis, the scale and location of these activities, events, and impacts are considered for each alternative.

4.0.2.5 Alternative A

In general, Alternative A could potentially result in 1.2-4.2 percent of the forecasted cumulative OCS oil and gas activity in the Gulf of Mexico and would occur in the WPA, CPA, and EPA portions of the proposed lease sale area. Most of the activity (up to 83%) of a proposed lease sale under Alternative A is expected to occur in the CPA and EPA portions of the proposed lease sale area, while up to 19 percent of the activity could occur in the WPA portion of the proposed lease sale area. Approximately 75.4 million acres (82%) of the regionwide lease sale area would be available for lease under this alternative.

4.0.2.6 Alternative B

Alternative B could potentially result in 1.0-3.6 percent of the forecasted cumulative OCS oil and gas activity in the Gulf of Mexico, or a slightly smaller amount of activity than proposed for Alternative A, and would be located geographically in the CPA and EPA portions of the proposed lease sale area. Approximately 49.6 million acres (54%) of the regionwide lease sale area would be available for lease. While all of the leases issued under this alternative would occur in the CPA and EPA portions of the proposed lease sale area, activities such as vessel support and pipeline or coastal infrastructure could occur in the WPA portion of the proposed lease sale area.

4.0.2.7 Alternative C

Alternative C could potentially result in 0.2-0.6 percent of the forecasted cumulative OCS oil and gas activity in the Gulf of Mexico, which is much smaller than either Alternative A or B. Approximately 25.8 million acres (28%) of the regionwide lease sale area would be available for lease. While all of the leases issued under this alternative would occur in the WPA portion of the proposed lease sale area, activities such as vessel support and pipeline or coastal infrastructure could occur in the CPA/EPA portion of the proposed lease sale area.

4.0.2.8 Alternative D

Under Alternative D, the number of blocks that would become unavailable for lease represents only a small percentage of the total number of blocks to be offered under Alternative A, B, or C (<4%, even if blocks subject to all three stipulations were excluded). However, it is also possible (and BOEM believes more reasonable to expect) that Alternative D would only shift the location of offshore infrastructure and activities farther from these sensitive zones and not lead to a reduction in offshore infrastructure and activities.

4.0.2.9 Alternative E

Under Alternative E, there would be no routine activities or accidental events as a result of a proposed lease sale. Therefore, there would be no associated impacts resulting from a proposed lease sale. Cancellation of a proposed lease sale, however, would not stop all OCS oil- and gas-related activities. Activities related to previously issued leases and permits (as well as those that may be issued in the future under separate decision) related to the OCS oil and gas program would continue and could have impacts similar to those described in each resource chapter. However, no new activities related to a proposed lease sale would proceed and, therefore, those additional impacts would be avoided.

This chapter has thoroughly examined the existing credible scientific evidence that is relevant to evaluating the reasonably foreseeable significant impacts of a proposed lease sale and the alternatives on the environment. All reasonably foreseeable impacts, including beneficial ones, were considered. Impacts that could have catastrophic consequences, even if their probability of occurrence is low, not reasonably expected, and not part of a proposed action are considered in the *Catastrophic Spill Event Analysis* white paper (USDOI, BOEM, 2017). Throughout this chapter, where information was incomplete or unavailable, BOEM complied with its obligations under NEPA to determine if the information was relevant to reasonably foreseeable significant adverse impacts; if so, whether it was essential to a reasoned choice among alternatives; and, if it was essential, whether it can be obtained and whether the cost of obtaining the information is exorbitant, as well as whether credible scientific information applied using generally accepted scientific methodologies can be used in its place (40 CFR § 1502.22). BOEM has made conscientious efforts to comply with the spirit and intent of NEPA and to be comprehensive in its analyses of potential environmental impacts.

4.1 AIR QUALITY

The analyses of the potential impacts of routine activities and accidental events associated with a GOM proposed lease sale and its incremental contribution to the cumulative impacts to air quality are presented in this chapter. The approach of the analysis is to focus on the greatest reasonably foreseeable impact-producing factors from OCS oil- and gas-related routine activities (from exploration, development, and production), as well as accidental events and cumulative impacts, and to define the impact levels for each. The impact-producing factors considered and analyzed include (1) OCS oil- and gas-related emissions sources related to drilling and associated vessel support, production and the connected action of vessel support, flaring and venting, decommissioning, and oil spills; (2) other emissions not caused by OCS oil and gas development (i.e., non-OCS oil- and gas-related emissions such as State oil and gas programs, onshore industrial and transportation sources, and natural events); and (3) the incremental contribution of all postlease activities as a result of a single proposed lease sale. The impact-level definitions and the analyses supporting these conclusions are discussed in this chapter.

In order to assess the impacts from these oil- and gas-related activities, BOEM used an emissions inventory along with air dispersion and photochemical modeling. While an emissions inventory is an accounting of air emissions of criteria pollutants, precursors of criteria pollutants, and hazardous air pollutants from a variety of air emission sources, the comprehensive data from the inventory can be used to support air quality modeling. Typically, impacts are determined through modeling, and concentrations are reported. These impacts are then compared with reference measures, such as National Ambient Air Quality Standards (NAAQS), Significant Impact Levels, etc., to support impact conclusions. For this Multisale EIS analysis, BOEM used the following: (1) the results of the *Year 2011 Gulfwide Emissions Inventory* (GWEI) study, herein incorporated by reference (Wilson et al., 2014); (2) the changes in regulations as a result of the 2010 *Deepwater Horizon* explosion, oil spill, and response to determine the impact-producing factors (**Table 4-1**) that have the greatest impact potential in the GOM region; and (3) the results of the "Air Quality Modeling in the Gulf of Mexico Region" study to determine impacts. Pollutants included the emissions inventory support analysis of air quality impacts in terms of impacts on the attainment of the NAAQS and on air quality-related values (AQRVs), including acid deposition and visibility. The results of the emissions inventory study and air modeling study are discussed later in this chapter. The "Air Quality Modeling in the Gulf of Mexico Region" study includes technical support documents (**Appendices F-H**) that provide detailed descriptions of the emissions data, meteorological and photochemical grid, modeling parameters and methodology, and the results of the air quality impact analysis.

Table 4-1. Air Quality Impact-Producing Factors That Are Reasonably Foreseeable.

Air Quality	Magnitude of Potential Impact[1]				
Impact-Producing Factors	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
Routine Impacts					
Drilling	Minor	Minor	Minor	Minor	None
Production	Minor	Minor	Minor	Minor	None
Vessel Support during Drilling and Production	Minor	Minor	Minor	Minor	None
Routine Flaring and Venting	Minor	Minor	Minor	Minor	None
Decommissioning	Minor	Minor	Minor	Minor	None
Accidental Impacts					
Emergency Flaring and Venting	Minor	Minor	Minor	Minor	None
Oil Spills	Minor	Minor	Minor	Minor	None
Cumulative Impacts					
Incremental Contribution[2]	Minor	Minor	Minor	Minor	None
OCS Oil and Gas[3]	Moderate				
Non-OCS Oil and Gas[4]	Moderate				

[1] The analysis supporting these conclusions is discussed in detail in the environmental consequences "Environmental Consequences" chapter below.

[2] This includes all activities (i.e., routine activities projected to occur and accidental events that could occur) as a result of a single proposed lease sale in the Five-Year Program.

[3] This includes all activities (i.e., routine activities projected to occur and accidental events that could occur) from past, proposed, and future lease sales.

[4] This includes other past, present, and reasonably foreseeable future activities occurring within the same geographic range and within the same timeframes as a proposed action, but they are not related to the OCS Oil and Gas Program.

Impact-Level Definitions

The following impact categories and definitions are used:

- **Negligible** – No measurable impact(s).
- **Minor** – Most impacts on the affected resource could be avoided with proper mitigation; if impacts occur, the affected resource would recover completely without mitigation once the impacting stressor is eliminated.
- **Moderate** – Impacts on the affected resource are unavoidable. The viability of the affected resource is not threatened although some impacts may be irreversible, or the affected resource would recover completely if proper mitigation is applied or proper remedial action is taken once the impacting stressor is eliminated.

- **Major** – Impacts on the affected resource are unavoidable. The viability of the affected resource may be threatened although some impacts may be irreversible, and the affected resource would not fully recover even if proper mitigation is applied or remedial action is implemented once the impacting stressor is eliminated.

BOEM's Gulf of Mexico OCS Region manages the responsible development of oil, gas, and mineral resources for the 430 million ac in the WPA, CPA, and a small portion of the EPA on the OCS comprising the GOM region. The Gulf of Mexico OCS area of possible influence includes the States of Texas, Louisiana, Mississippi, Alabama, and Florida. However, the Clean Air Act Amendments of 1990 designated air quality authorities in the GOM, giving BOEM air quality jurisdiction westward of 87°30' W. longitude and USEPA air quality jurisdiction eastward of 87°30' W. longitude. The USEPA air quality jurisdiction includes part of the CPA and all of the EPA, while BOEM's air quality jurisdiction includes most of the CPA and all of the WPA. This separation of authority is depicted in **Figure 4-1**. In 2006, oil and gas leasing operations within 125 mi (201 km) of the Florida coastline were placed under moratorium until 2022 under the Gulf of Mexico Energy Security Act (GOMESA). The GOMESA moratoria area is depicted on **Figure 2-1**.

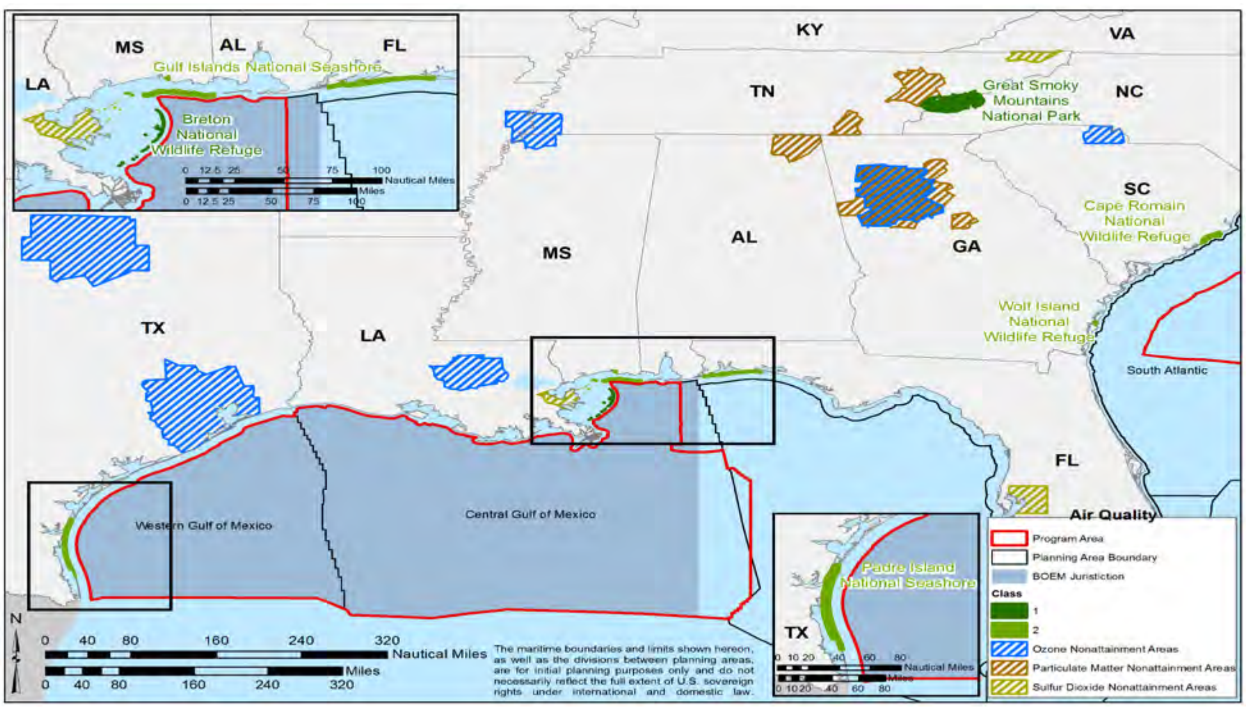

Figure 4-1. Gulf of Mexico Region with the Planning Areas, Nonattainment Areas, Air Quality Jurisdiction, and Class I and Sensitive Class II Areas. (Note: The South Atlantic Planning Area was removed from the Five-Year Program.)

BOEM is required under the OCSLA (43 U.S.C. § 1334(a)(8)) to develop regulations to ensure compliance with the NAAQS to the extent that OCS offshore oil and gas exploration, development, and production sources do not significantly affect the air quality of any state pursuant to the NAAQS. Since the primary NAAQS are designed to protect human health, BOEM focuses this Multisale EIS analysis on the impact of these activities on the States, where there are permanent human populations. However, the potential impacts for the whole Gulf of Mexico region were modeled, including the impacts at the State/seaward boundary of Gulf Coast States (3-9 nmi [3.45-10.36 mi; 5.56-16.67-km] from shore, depending on the State). Detailed potential impacts from the "Air Quality Modeling in the Gulf of Mexico Region" study are included in **Appendix H**.

4.1.1 Description of the Affected Environment

For this Multisale EIS analysis, the affected environment comprises the WPA, CPA, and EPA, including the States of Texas, Louisiana, Mississippi, Alabama, and Florida, and the respective State waters. This area also includes national parks and Federal wilderness areas where air quality and AQRVs (primarily visibility) are protected more stringently than under the NAAQS. These protected Class I areas in the GOM region include the following: the Breton Wilderness Area in Louisiana; and the Bradwell Bay Wilderness Area, Chassahowitza National Wilderness Area, Everglades National Park, and St. Marks Wilderness Area in Florida.

The Clean Air Act Amendments of 1977 designated 156 Class I areas, consisting of national parks and wilderness areas that are offered special protection for air quality and the AQRVs. The Class I areas, compared to the Class II areas, have lower PSD air quality increments that new sources may not exceed and are protected against excessive increases in several AQRVs, including visibility impairment, acid (sulfur and nitrogen) deposition, and nitrogen eutrophication. The Regional Haze Rule (40 CFR § 51.308) has a goal of natural visibility conditions by 2064 at Class I areas, and States must submit Regional Haze Rule State Implementation Plans that demonstrate progress towards that goal. **Figure 4-1** displays the locations of the mandatory Class I areas in the GOM region.

While not included in the Clean Air Act Amendments of 1977 as an area of special protection, Federal management agencies have designated certain other areas as sensitive Class II areas for tracking PSD increment consumption and AQRV impacts. The sensitive Class II areas, designated as such in the GOM region, include the Padre Island National Seashore and Gulf Islands National Seashore. Since Class I and sensitive Class II areas are of concern, the areas located in or nearby the GOM region are discussed in this Multisale EIS and are shown in **Figure 4-1**.

Clean Air Act and the Clean Air Act Amendments Overview

The Clean Air Act of 1970 established the NAAQS, which include the primary standards to protect public health and secondary standards to protect public welfare including visibility and vegetation. Under the Clean Air Act, USEPA is periodically required to review and, as appropriate, modify the criteria based on the latest scientific knowledge. Several revisions to the NAAQS have occurred in the past few years as more is understood about the effects of the pollutants. The current NAAQS, shown in **Table 4-2**, address six pollutants: carbon monoxide (CO); nitrogen dioxide (NO_2); particulate matter ($PM_{2.5}$ and PM_{10}); sulfur dioxide (SO_2); lead (Pb); and ozone (O_3).

Table 4-2. National Ambient Air Quality Standards.

Pollutant (Final Rule Citation)		Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide (CO) (*Federal Register*, 2011a)		Primary	8-hour	9 ppm	Not to be exceeded more than once per year
			1-hour	35 ppm	
Lead (Pb) (*Federal Register*, 2008b)		Primary and Secondary	Rolling 3-month average	0.15 μg/m^3 [(1)]	Not to be exceeded
Nitrogen Dioxide (NO_2) (*Federal Register*, 2010a) (*Federal Register*, 1996)		Primary	1-hour	100 ppb	98th percentile, averaged over 3 years
		Primary and Secondary	Annual	53 ppb [(2)]	Annual mean
Ozone (O_3) (*Federal Register*, 2015f)		Primary and Secondary	8-hour	0.070 ppm [(3)]	Annual 4th-highest daily maximum 8-hour concentration, averaged over 3 years
Particle Pollution (*Federal Register*, 2013) (*Federal Register*, 2006a)	$PM_{2.5}$	Primary	Annual	12 μg/m^3	Annual mean, averaged over 3 years
		Secondary	Annual	15 μg/m^3	Annual mean, averaged over 3 years
		Primary and Secondary	24-hour	35 μg/m^3	98th percentile, averaged over 3 years
	PM_{10}	Primary and Secondary	24-hour	150 μg/m^3	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide (SO_2) (*Federal Register*, 2010b) (*Federal Register*, 1973a)		Primary	1-hour	75 ppb [(4)]	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		Secondary	3-hour	0.5 ppm	Not to be exceeded more than once per year

(1) The Final Rule was signed on October 15, 2008. The 1978 lead standard (1.5 μg/m^3 as a quarterly average) remains in effect until 1 year after an area is designated for the 2008 standard. Areas designated nonattainment under the 1978 standard remain in effect until implementation plans are approved to attain or maintain the 2008 standard.

(2) The official level of the annual NO_2 standard is 0.053 ppm, equal to 53 ppb, which is shown here for the purpose of clearer comparison to the 1-hour standard.

(3) The final rule was signed on October 1, 2015, and became effective on December 28, 2015. The previous (2008) O_3 standards additionally remain in effect in some areas. Revocation of the previous (2008) O_3 standards and transitioning to the current (2015) standards will be addressed in the implementation rule for the current standards.

(4) The Final Rule was signed on June 2, 2010. The 1971 annual and 24-hour SO_2 standards were revoked in that same rulemaking. However, these standards remain in effect until 1 year after an area is designated for the 2010 standard, except in areas designated nonattainment for the 1971 standards, where the 1971 standards remain in effect until implementation plans to attain or maintain the 2010 standard are approved.

Notes: PM – particulate matter; ppb – parts per billion; ppm – parts per million.

Source: USEPA, 2015d.

The Clean Air Act establishes classification designations based on regional monitored levels of ambient air quality. These designations impose mandated timetables and other requirements necessary for attaining and maintaining healthful air quality in the U.S. based on the seriousness of the regional air quality problem. These designations are nonattainment, attainment, and unclassifiable. Nonattainment is any area that does not meet the national primary or secondary ambient air quality standard for the pollutant. When measured concentrations of these regulated pollutants exceed the standards established by the NAAQS, the number of exceedances and the concentrations determine the nonattainment classification of an area. The Clean Air Act Amendments of 1990 established these designations as marginal, moderate, serious, severe, and extreme. Attainment is any area that meets the national primary or secondary ambient air quality standard for the pollutant. Unclassifiable is any area that cannot be classified on the basis of available information as meeting or not meeting the national primary or secondary ambient air quality standard for the pollutant. **Figure 4-1** depicts all of the current nonattainment areas in the GOM region.

The Federal OCS waters are unclassifiable. The OCS areas are not classified because there is no regulatory provision for any classification in the Clean Air Act for waters outside of the boundaries of State waters. Only areas within State boundaries can be classified as either attainment or nonattainment.

Gulf of Mexico OCS Region Attainment Status

After promulgation of a NAAQS, USEPA designates areas that fail to achieve the NAAQS as nonattainment areas, and States are required to submit State Implementation Plans to USEPA; these plans contain emission control plans and a demonstration that the nonattainment area would achieve the NAAQS by the required date. After an area comes into attainment of the NAAQS, the area can be redesignated as a maintenance area and must continue to demonstrate compliance with the NAAQS. **Figure 4-1** depicts all the current nonattainment areas in the GOM region while **Table 4-3** summarizes the nonattainment and maintenance areas in the GOM region. Sulfur dioxide (SO_2) and lead (Pb) nonattainment areas are focused around specific large industrial sources of SO_2 or lead emissions, whereas ozone nonattainment areas are more regional in nature, reflecting the formation of ozone as a secondary pollutant from emissions of nitrogen oxides (NO_x) and volatile organic compound (VOC) precursors from a wide range of sources. (*Note: As November 1, 2016, USEPA proposed to redesignate the Baton Rouge, Louisiana, area as being in attainment of Federal health-based ozone standards. The State of Louisiana requested that the redesignation, based on 3 years of air quality data showing the metropolitan areas of Ascension, East Baton Rouge, Iberville, Livingston, and West Baton Rouge Parishes, meet the 2008 8-hour ozone standard of 0.075 parts per million [ppm*]. *The USEPA also proposes to approve the State's plan for maintaining the standard.*)

Table 4-3. Nonattainment and Maintenance Areas in the Gulf of Mexico Region.

State	Area	8-hr O_3 (1997)	8-hr O_3 (2008)	SO_2 (2010)	Lead (2008)
Alabama	Troy				NAA
Florida	Tampa				NAA
	Hillsborough County			NAA	
	Nassau County			NAA	
Louisiana	Baton Rouge	M	NAA		
	St. Bernard Parish			NAA	
Texas	Beaumont-Port Arthur	M			
	Houston-Galveston-Brazoria	NAA	NAA		
	Frisco				NAA

M = maintenance area; NAA = nonattainment area; O_3 = ozone; SO_2 = sulfur dioxide.
Blank cells indicate the area is in attainment of the National Ambient Air Quality Standards.

As previously mentioned, USEPA periodically modifies the NAAQS criteria based on new scientific knowledge. On October 1, 2015, USEPA strengthened the 8-hour NAAQS for ozone to 0.07 ppm (70 parts per billion [ppb]). Under this more stringent ozone NAAQS, there may be more areas in the southeastern U.S. designated as nonattainment. The USEPA plans to make attainment and nonattainment designations for the revised standards by October 2017, with the designations based on 2014-2016 air quality monitoring data.

In February 2010, USEPA issued a new 1-hour NO_2 NAAQS with a threshold of 100 ppb (98^{th} percentile daily maximum average over 3 years), and a new 1-hour SO_2 NAAQS was promulgated in June 2010 with a threshold of 75 ppb (99^{th} percentile averaged over 3 years). The USEPA has not yet designated the nonattainment areas for the 1-hour NO_2 and 1-hour SO_2 NAAQS.

A Pb NAAQS was issued in 2008; nonattainment areas for lead are associated with specific industrial sources. The USEPA has not yet designated the nonattainment areas for the Pb NAAQS.

The CO NAAQS has remained essentially unchanged since it was originally promulgated in 1971. As of September 27, 2010, all prior CO nonattainment areas throughout the country have been redesignated as maintenance areas.

Emissions Inventories

One of the most accurate methods for estimating air emissions is by developing a comprehensive emissions inventory. To develop a calendar year 2011 inventory of criteria pollutants, criteria precursors, and greenhouse gas emissions for all OCS oil and gas production-related sources in the GOM, BOEM collected activity data from platform operators during the year 2011. On September 15, 2010, NTL 2010-G06 was published to introduce the "2011 Gulfwide OCS Emissions Inventory (Western Gulf of Mexico)" and inform operators about the mandatory data collection. Affected operators are lessees and operators of Federal oil, gas, and sulfur leases in the

Gulf of Mexico OCS region west of latitude 87.5°. The USEPA jurisdiction has air quality jurisdiction east of latitude 87.5°.

BOEM updated and distributed a Microsoft® Visual Basic® program for platform operators to use to collect activity data on a monthly basis and submit to BOEM on an annual basis. The program, known as GOADS-2011, was used by operators to submit activity data for a number of production platform emission sources. Operators used the GOADS software to collect activity data for amine units, boilers/heaters/burners, diesel engines, drilling equipment, fugitives, combustion flares, glycol dehydrators, losses from flashing, mud degassing, natural gas engines, natural gas/diesel/dual-fuel turbines, pneumatic pumps, pressure/level controllers, storage tanks, and cold vents. These activity data were used to calculate CO, NO_x, SO_2, PM_{10}, $PM_{2.5}$, and VOC emissions estimates, as well as CO_2, CH_4, and N_2O. The Gulfwide Oracle® DBMS calculates and archives the activity data and the resulting emissions estimates. Database users can query by pollutant, month, equipment type, platform, etc. Emission estimates for non-platform sources on the Gulf of Mexico OCS include both oil and natural gas production-related sources, as well as non-oil and natural gas sources. Production sources consist of survey vessels, drilling rigs, pipe-laying operations, and support vessels and helicopters. Non-oil and natural gas sources include commercial marine vessels, the Louisiana Offshore Oil Platform (LOOP), and biogenic and geogenic sources. Ultimately, State agencies and Regional Planning Organizations will use these offshore oil and gas platform and non-platform inventories to perform modeling for ozone and regional haze for use in their State Implementation Plans, and BOEM will use the emission inventory for the cumulative impact analysis in NEPA documents.

2011 GWEI Pollutants

- *NAAQS: CO, NO_x, $PM_{2.5}$, PM_{10}, SO_2*
- *Criteria Precursors: VOC*
- *Greenhouse Gases: CO_2, CH_4, N_2O*

Emissions estimates calculated in the study were used to support analysis of air quality modeling impacts. In this inventory, emissions estimates are provided for directly emitted pollutants. While there are national air quality standards for six common air quality pollutants, only four of these pollutants (i.e., CO, Pb, NO_2, and SO_2) are directly emitted. Indirect emissions and the formation of other pollutants, as well as pollutants not included in the inventory, are analyzed below.

- *Greenhouse Gases*. Fluorinated gases, hydrofluorocarbons, and sulfur hexafluoride are not covered in this inventory because they are used in trace amounts and at no time are deliberately emitted into the atmosphere.
- *Lead*. Lead (Pb), a NAAQS criteria pollutant, is not covered in this inventory because oil and gas sources have negligible lead emissions. Since unleaded fuels have been phased out, lead remains a trace contaminant in other fuels (USEPA, 2016c).
- *Nitrogen Dioxide*. Nitrogen dioxide (NO_2), a NAAQS criteria pollutant, is one of a group of highly reactive gases known as nitrogen oxides (NO_x). Nitrogen oxides are stated as an equivalent mass of NO_2; consequently, NO_x is used instead of NO_2.

- *Particulate Matter*. Particulate matter (PM), a NAAQS criteria pollutant expressed as $PM_{2.5}$ and PM_{10}, can be emitted directly or it can be formed in the atmosphere when emissions of NO_x, sulfur oxides (SO_x), ammonia, organic compounds, and other gases react in the atmosphere. According to USEPA's "Particulate Matter Emissions Report," coarse PM (PM_{10}) is composed largely of primary particles, while a much greater portion of fine PM ($PM_{2.5}$) contains secondary particles. "Primary" particles are those released directly to the atmosphere whereas "secondary" particles are formed in the atmosphere from chemical reactions involving primary gaseous emissions. While both $PM_{2.5}$ and PM_{10} are included the inventory, the secondary formation is not included the inventory because secondary PM is not directly emitted. Since USEPA has not developed separate $PM_{2.5}$ and PM_{10} emissions factors per source, particulate-matter emission estimates of $PM_{2.5}$ and PM_{10} are similar. Therefore, PM_{10} values have been used in this chapter to represent particulate matter emission estimates.

- *Ozone*. Ozone (O_3), an NAAQS pollutant, is not directly emitted into the air but is formed by photochemical reactions of NO_x and VOCs in the presence of sunlight. Since NO_x and VOCs are directly emitted pollutants, they are included in the emissions inventory, and their resulting emission estimates are used in the air quality model to analyze the air quality impacts of O_3.

Summary of Results of the Year 2011 Gulfwide Emissions Inventory

The Year 2011 GWEI results indicate that OCS oil and gas production platform and non-platform sources emit the majority of NAAQS criteria pollutants, VOCs, and greenhouse gases on the Gulf of Mexico OCS, with the exception of SO_2 (primarily emitted from commercial marine vessels), and N_2O (from biological sources) (Wilson et al., 2014). The total platform and non-platform emission estimates for criteria pollutants and the total platform and non-platform emission estimates for greenhouse gases are depicted in **Figures 4-2 and 4-3**, respectively. In both figures, total emission estimates are subdivided into three main categories: total non-OCS oil/gas source emissions; total OCS oil/gas non-platform source emissions; and total OCS oil/gas platform source emissions.

Total emissions estimates include

- *total non-OCS oil and gas source emissions,*
- *total OCS oil and gas non-platform source emissions, and*
- *total OCS oil and gas platform production source emissions.*

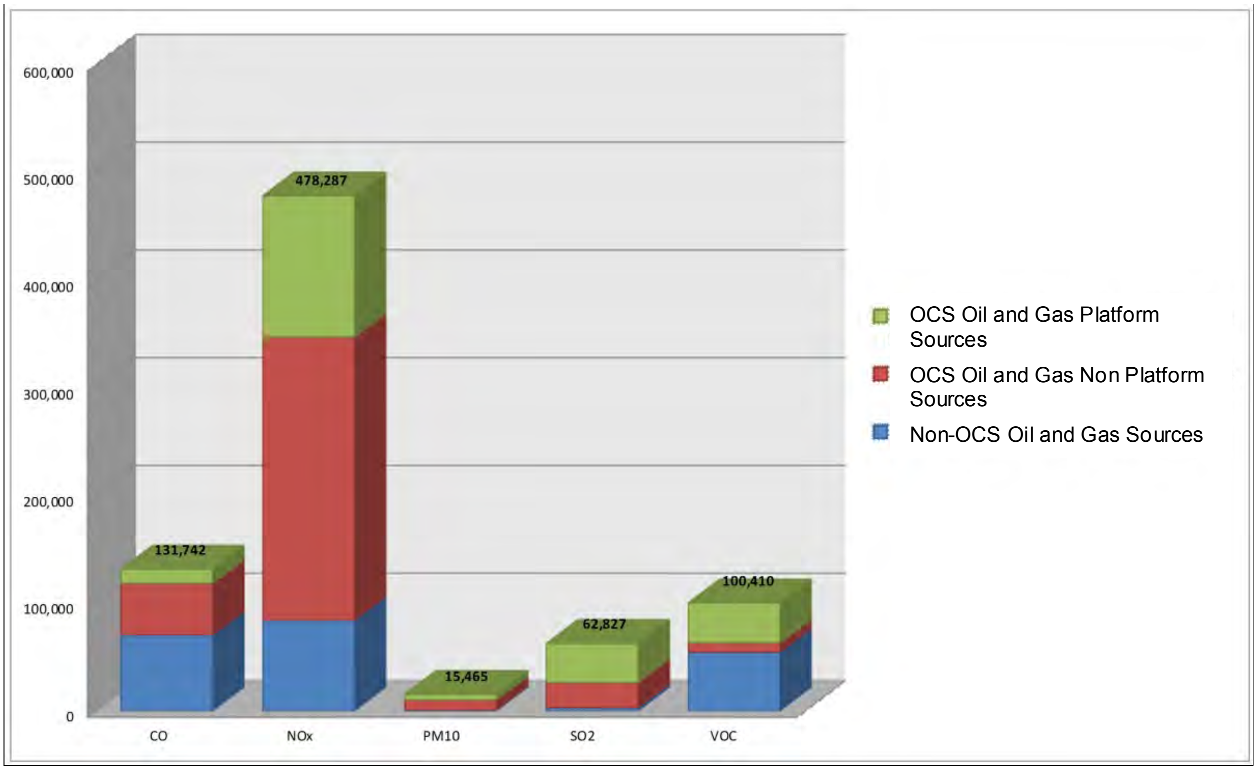

Figure 4-2. Year 2011 Gulfwide Emission Inventory Results for Total Platform and Non-Platform Criteria Pollutant Emissions (TPY).

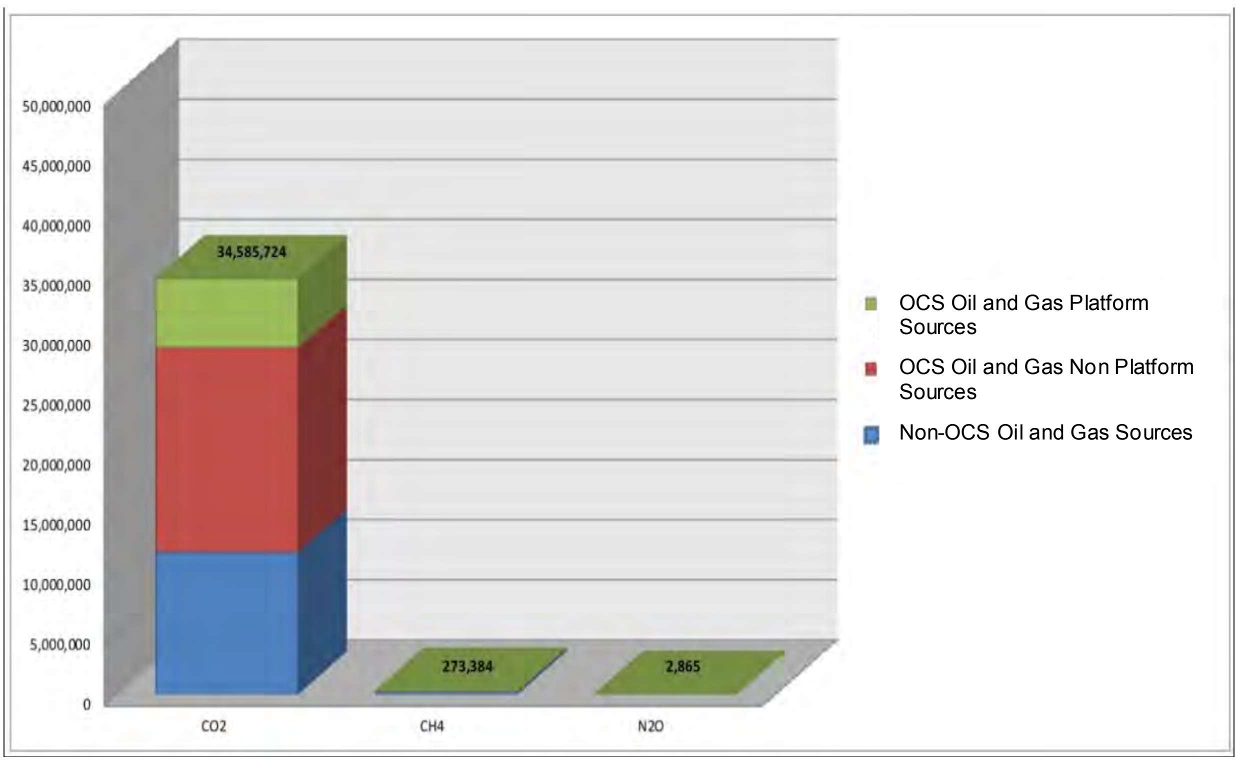

Figure 4-3. Year 2011 Gulfwide Emission Inventory Results for Total Platform and Non-Platform Greenhouse Gas Emissions (TPY).

Natural gas engines on platforms represented the largest CO emission source, and support vessels were the highest emitters of both NO_x and PM_{10}. Oil and natural gas production platform vents account for the highest percentage of the VOC emissions. Support vessels; production platform natural gas, diesel, and dual-fuel turbines; and commercial marine vessels emit the majority of the greenhouse gas emissions.

Platform sources include

- *criteria pollutants,*
- *emissions in (TPY),*
- *greenhouse gases, and*
- *emissions in (TPY).*

The Year 2011 GWEI results for criteria pollutant and greenhouse gas emissions (in tons/year) from platform sources are depicted in **Figures 4-4 and 4-5**, respectively. In both figures, each platform source emission type is represented per pollutant in tons/year.

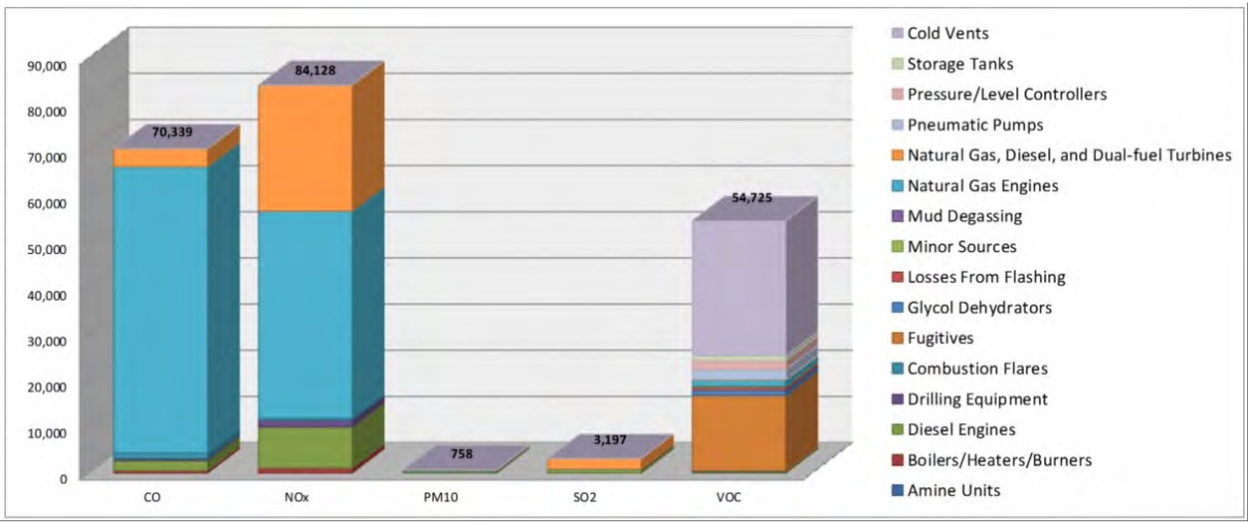

Figure 4-4. 2011 Criteria Pollutant Emissions (TPY) from Platform Sources.

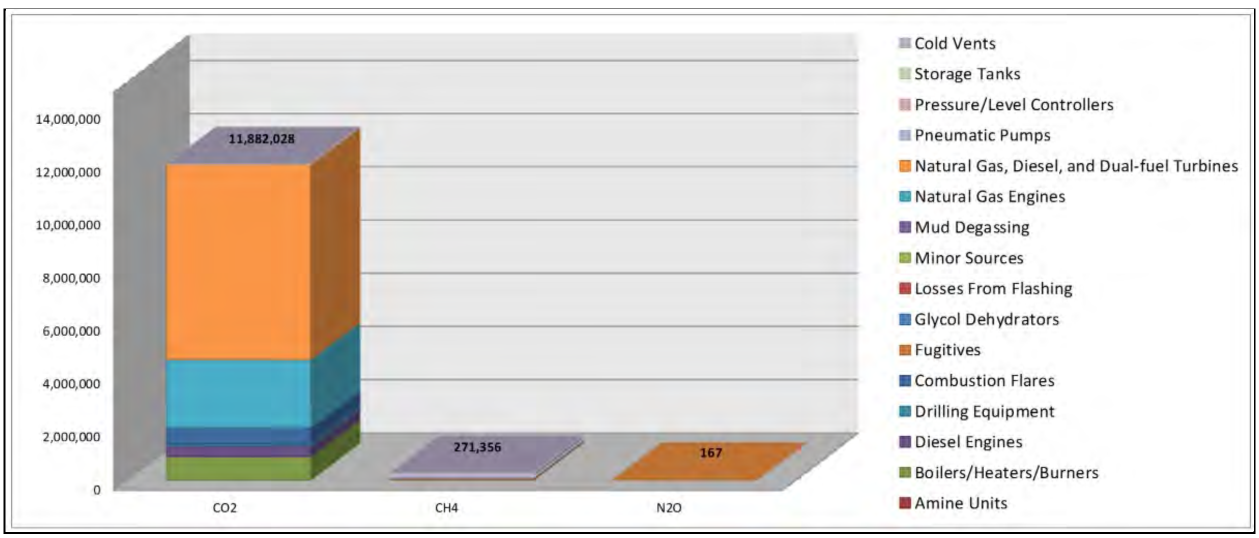

Figure 4-5. 2011 Greenhouse Gases (TPY) from Platform Sources.

The Year 2011 GWEI results for criteria pollutant and greenhouse gas emissions (in tons/year) from non-platform sources (not pictured) indicate that support vessels emit the majority of the greenhouse gas emissions, as well as the highest emitter of both NO_x and PM_{10} criteria pollutants.

4.1.2 Environmental Consequences

The impact-producing factors and their potential impacts identified for routine activities, accidental events, cumulative impacts, and incomplete or available information would apply, in general, to Alternatives A-D. These analyses are then applied to each alternative based on the varying degrees of forecasted levels of activities by geographical area and water depth. Following this environmental consequences discussion, there will be a summary of the potential impacts as they relate to the alternatives.

As discussed in the air quality introduction, the following list of impact-producing factors can occur in routine activities, accidental events, and cumulative impacts. The impact-producing factors include (1) OCS oil- and gas-related emissions sources related to drilling and associated vessel support, production, and the connected action of vessel support, flaring and venting, decommissioning, and oil spills; (2) non-OCS oil- and gas-related emissions such as State oil and gas programs, onshore industrial and transportation sources, and natural events; and (3) the incremental contribution of all postlease activities as a result of a single proposed lease sale. These impact-producing factors can produce greenhouse gas and fugitive emissions, which are discussed below.

Greenhouse Gases and Fugitive Emissions

Greenhouse Gases Including Downstream Gas

Chief among drivers of climate change are increasing atmospheric concentrations of carbon dioxide (CO_2) and other greenhouse gases, such as methane (CH_4) and nitrous oxide (N_2O). These greenhouse gases reduce the ability for solar radiation to re-radiate out of the Earth's atmosphere and into space. Although all three have natural sources, these three greenhouse gases comprise the majority of greenhouse gases released from anthropogenic sources; CO_2 and N_2O are released in association with combustion and CH_4 and N_2O are released as a byproduct of agriculture and also oil and gas production. Hydrofluorocarbons and sulfur hexafluoride are two fluorinated greenhouse gases that are used on the OCS, but they are used in trace amounts and are at no time deliberately emitted into the atmosphere.

The activities associated with a proposed action would increase global greenhouse gas emissions from the use of vessels, drilling equipment, and other activities that burn fossil fuels. In addition, CH_4, also known as natural gas, is removed from wells and brought onto OCS facilities along with oil being produced. Sometimes CH_4 is released as a fugitive gas that can escape unintentionally from leaks in equipment used by operators. Operators have the four following methods of managing natural gas removed from wells: (1) production – selling the natural gas, provided there is a sufficient quantity, favorable market conditions, and infrastructure (e.g., natural gas pipelines) to justify production; (2) reinjection – the natural gas is directed back into the reservoir to aid in oil extraction; (3)venting – the deliberate release of natural gas into the atmosphere; and (4) flaring – burning the natural gas, converting it to CO_2 and water, and in some cases, also releasing N_2O and black carbon. This practice is rare on the OCS.

Because each greenhouse gas impacts the atmosphere at a different strength and for a different period of time, for analytical purposes, they typically are converted to what the strength would be if emissions were exclusively CO_2; this is referred to as the CO_2-equivalent (CO_2e) to facilitate comparison. CH_4 and N_2O are much more effective climate forcers than CO_2, meaning 1 ton of CH_4 or N_2O has a greater impact on climate change than 1 ton of CO_2. However, CH_4 and N_2O are removed from the atmosphere through natural processes more efficiently than CO_2. Accounting for these factors, CO_2e conversion for CH_4 and N_2O are 25 and 298, respectively (Ecometrica, 2012). This means that 1 ton of CH_4 is estimated to have the same warming potential as 25 tons of CO_2, and 1 ton of N_2O would have the same impact as 298 tons of CO_2. Because black carbon is not a greenhouse gas and functions differently, it is not possible to convert it using the CO_2e method. However, because black carbon is a specific kind of $PM_{2.5}$, it is possible to use the $PM_{2.5}$ concentration to estimate the maximum amount of black carbon released. BOEM has regulatory authority on the OCS for $PM_{2.5}$, along with several other air quality pollutants.

As a result of exploration, development, and production of oil and gas on the OCS, the activities associated with a proposed action are expected to release greenhouse gases and black carbon from the use of combustion engines in vessels, construction, drilling, and other equipment, as well as through the deliberate or accidental release of CH_4. Emissions estimates for the activities associated with a proposed action, and for cumulative BOEM-related OCS emissions, were calculated using the Offshore Environmental Cost Model. These estimates are for the high-price scenario, which would likely result in the highest level of potential emissions for a proposed action. Cumulative numbers include current operations, the activities associated with a proposed action, and expected future development beyond a proposed action. Unlike the greenhouse gases, which warm the planet generally, black carbon's potential to contribute to climate change has a spatial component. Compared with the 2012-2017 Five-Year Program, the activities associated with a proposed action would result in an overall increase in the rate of CO_2e emissions from OCS oil- and gas-related activities.

In addition to the direct emissions from OCS oil- and gas-related operations presented above, BOEM has evaluated greenhouse gas emissions covering the lifecycle of OCS oil and gas production and consumption. This includes both the "downstream" consumption and onshore processing of oil and gas products, as well as the "upstream" emissions from offshore exploration, development, and production.

The expected greenhouse gas emissions for the low- and high-price scenarios include numerous assumptions (Wolvovsky and Anderson, 2016); therefore, while being a reasonable approximation, these numbers are an estimate and not a forecast. However, because the methodology used to compare the two price scenarios and the No Action Alternative are the same, the analysis can be assumed to provide a relative comparison. There is a significant degree of uncertainty in these numbers, and they do not take into account future Federal, State, and/or local economic, social, policy, regulatory, and legislative changes that could affect the amount of greenhouse gases released. In addition, this analysis is bounded by U.S. consumption and the upstream domestic and overseas production supporting American consumption. This means that the likely overseas reduction in consumption under the No Action Alternative is not calculated in this analysis.

On April 22, 2016, the United States joined the Paris Agreement, a United Nations-brokered agreement to keep global temperatures within 2 °C (36 °F) of the pre-industrial climate, and preferably within 1.5 °C (35 °F) (United Nations Framework Convention on Climate Change, 2016). A recent study (McGlade and Ekins, 2015) states that, to prevent the planet from warming beyond 2 °C (36 °F), emissions of greenhouse gases must be kept below 1,100 billion tons of CO_2e between 2011 and 2050. McGlade and Elkins (2015) also discuss the need to greatly reduce the amount of oil and gas extraction to stay under this threshold, with particular emphasis on not drilling in the Arctic. It should be noted that the 2 °C (36 °F) warming threshold would still result in significant impacts on the world's ecosystems and to humanity (Hansen et al., 2016).

The U.S. has pledged to reduce emissions by filing an Intended Nationally Determined Contributions with the United Nations. The American Intended Nationally Determined Contributions commitment is to reduce net greenhouse gas emissions by 17 percent below 2005 levels by 2020 and by 26-28 percent by 2025 (United Nations Framework Convention on Climate Change, 2016). In addition, the Obama Administration has set a target to reduce U.S. greenhouse gas emissions by at least 80 percent by 2050 (The White House, 2015). In 2005, the U.S. had net emissions of 6,680,300,000 metric tons of CO_2e (Ecometrica, 2012).

The activities associated with the proposed action's lifecycle emissions fluctuate over the course of the 2017-2022 Five-Year Program, with early emissions largely coming from OCS sources. The greenhouse gas emissions would peak in the 2030s and 2040s, at the same time as production peaks. Overall, the greenhouse gases from the activities associated with the proposed action would be similar to but slightly lower than the No Action Alternative in both low- and high-price scenarios. This similarity is due to the economic substitution effects from onshore and overseas sources expected under the No Action Alternative.

Additional sector-specific goals, such as the United States' commitment with Canada and Mexico to achieve 50 percent of electricity from noncarbon sources (The White House, 2016) and other yet-to-be determined measures, could significantly affect how oil and gas products are used and the emissions resulting from that consumption. Policies already determined and implemented have been included in the lifecycle analysis. The high- and low-price scenarios are intended to provide the upper and lower bounds of possible emissions scenarios. Overall, implementation of U.S. climate goals through future policies and regulations would be expected to reduce overall oil and gas demand, making it unlikely that the estimated emissions presented for the high-price scenario would be realized.

Fugitive Emissions

Fugitive emissions are not intentionally released through a stack, vent, or flare, but they are instead caused by leaks or intermittently escapes from pressurized equipment from sealed surfaces in various components of the facility. Fugitive emissions are mainly comprised of VOCs and methane (CH_4). Sources of fugitive emissions typically include valves, flanges, connectors, pumps, and compressor seals, but they may also include other platform components such as pneumatic controllers. Fugitive emissions can occur during all phases of OCS oil- and gas-related activity.

According to the Year 2011 GWEI study, fugitive emissions constitute one of the largest VOCs and CH_4 emissions sources from offshore oil and gas platforms, behind only cold vents. The BSEE personnel have indicated that the infrared camera surveys, performed to detect hydrocarbon leaks during inspections of offshore platforms, show very few, if any, hydrocarbon leaks. This could imply that the current emission factors may be overestimating VOC and methane emissions. Several State coastal areas have been designated nonattainment for ozone. Since ozone is formed by the combination of VOCs and NO_x, the OCS emissions inventory for VOCs needs to be as accurate as possible. In addition, the Government Accountability Office has published *Opportunities Exist to Capture Vented and Flared Natural Gas, Which Would Increase Royalty Payments and Reduce Greenhouse Gases* (U.S. Government Accountability Office, 2010) looking to reduce CH_4 emissions by the installation of control technology on platforms. Before control technology is required, the OCS emissions inventory for CH_4 also needs to be as accurate as possible.

Based on the results of the emission inventory study, as well as correspondence with BSEE, and the GAO report, BOEM wants to further assess emissions from fugitive equipment leaks on offshore oil and gas platforms operating on the Gulf of Mexico OCS. Under BOEM's Contract Number M16PC00010, "Fugitive Emissions Update in the Outer Continental Shelf," the objective is to visit offshore production platforms to identify and conduct the testing of fugitive equipment leaks in order to develop updated VOC, select hazardous air pollutant, and methane emission factors. These updated emission factors would be used by BOEM to develop improved and contemporary emissions inventories that will be used for a variety of purposes, including future photochemical grid modeling conducted by states in the Gulf of Mexico region for State Implementation Plan compliance demonstrations. However, if the OCS emissions inventories are overestimating VOC and methane emissions, then possibly control technologies would not be required. These study results are projected to be available by spring of 2019. Otherwise, BOEM would determine the appropriate use of control technologies on the platforms during postlease reviews.

4.1.2.1 Routine Activities

The primary routine impact-producing factors associated with the proposed action that could potentially affect air quality and that also could contribute to climate change include (1) drilling and production and the associated vessel support, (2) flaring and venting, and (3) decommissioning of facilities. These routine activities result in pollutant emissions. Emissions of air pollutants from these activities would occur during exploration, development, production, and decommissioning activities.

Drilling and Production with Associated Vessel Support

Since both drilling and production activities include associated vessel support, the activities are analyzed together in this section. Emissions during exploration are higher than emissions during development due to power requirements for drilling a deeper wellbore hole. During drilling, diesel engines are used to power the drilling (top drive) assembly, draw works, electrical generators, mud pumps, vessel propulsion (drillships and support vessels)), and dynamic positioning systems of the drilling rig (if a dynamic positioning semisubmersible or dynamic positioning drillship is used). Combustion of fuel to run the engines generates NAAQS criteria pollutants, VOCs, and greenhouse gases. More information about the pollutants that are generated by specific equipment and activities is available in the *Year 2011 Gulfwide Emission Inventory Study* (Wilson et al., 2014). As illustrated in **Figure 3-2**, during a 50-year analysis period, exploratory drilling mainly occurs during the first decade and development drilling extends throughout the first and second decade.

We know from **Chapter 3** that, during production, pollutants emitted during routine activities may be combustion products of burning fuel to power pumps, compressors, or generators, or they may consist of fugitive VOCs, which escape from the un-combusted hydrocarbons. The platform emission sources include boilers, turbines, pneumatic pumps, diesel engines, combustion flares, fugitives, glycol dehydrators, natural gas engines, pressure/level controllers, storage tanks, cold vents, and others. As illustrated in **Figure 3-2**, during a 50-year analysis, most production occurs during the second and third decade. Because the levels of activity in the 2011 GWEI are projected to be less than a proposed lease sale, these emission values are used to project potential impacts as described below.

The OCS emissions in tons per year for the criteria pollutants and for the greenhouse gases from platform sources are indicated in **Figures 4-4 and 4-5**. The distribution of emissions across various platforms sources would be expected to be similar. These figures show the following: criteria pollutants – the major pollutant emitted is NO_x, while PM_{10} is the least emitted pollutant; and greenhouse gases – the major pollutant emitted is CO_2, while N_2O is the least emitted pollutant. Combustion-intensive operations such as platform operations, well drilling, and service-vessel activities contribute mostly NO_x and CO_2; platform operations are also the major contributors of VOC emissions. As a result of a proposed lease sale, multiple platforms would be installed on the leases, and platform construction emissions would contribute appreciable amounts of all pollutants over the resulting lease sale's 50-year analysis period. Emissions from a singular platform construction are temporary in nature and generally occur for a period of 3-4 months. Typical construction emissions result from the derrick barge placing the jacket and various modular components and from various service vessels supporting this operation. Drilling operations contribute considerable amounts of all pollutants. These emissions are temporary in nature and typically occur over a 90-day per well drilling period. Support vessels for OCS oil- and gas-related activities, as described in **Chapter**

3.1.4.4, include emissions of NO_x, CO, and CO_2. These emissions are directly proportional to the number and type of OCS operations requiring support activities. Most emissions from these support activities occur during transit between the port and offshore facilities; a smaller percentage of the emissions occur during idling at the platform.

Currently, there are minor impacts occurring to air quality from drilling and production with associated vessel support impacts as shown in the model. Therefore, because the projected activities in this scenario for a proposed lease sale are less than the current 2011 GWEI activities, the impacts would be **minor**. The activities' impacts would vary in intensity based on the type and location of the activity.

Flaring and Venting

Reasonably foreseeable flaring and venting emissions operations occur intermittently for short periods of time over the life of the lease. Flaring systems are also used to vent natural gas during well testing or during repair/installation of production equipment. The BSEE operating regulations at 30 CFR § 250.1160 provide for some limited volume, short-duration flaring, or venting of some natural gas volumes upon approval by BSEE. These operations may occur for short periods of time (typically 2-14 days) as part of unloading/testing operations that are necessary to remove potentially damaging completion fluids from the wellbore, to provide sufficient reservoir data for the operator to evaluate a reservoir and development options, and in emergency situations. The potential impacts from these emergency operations are described in the "Accidental Events" chapter below and in **Chapter 3.2.3**.

Flaring may involve the disposal of sweet gas or sour gas. Sweet gas is natural gas that does not contain hydrogen sulfide (H_2S), while sour gas is natural gas that does contain H_2S. During the flaring of gas containing H_2S, the gas entering the flare would largely combust to SO_2. The contribution of flaring sour gas to SO_2 is regulated in 30 CFR part 250 subpart K. The SO_2 levels from reasonably foreseeable flaring are evaluated as part of the postlease plans review process.

Hydrogen sulfide released to the air can come from natural sources such as swamps, bogs, and volcanoes. Hydrogen sulfide can also be released from industrial sources such as petroleum refineries, natural gas plants, kraft paper mills, manure treatment facilities, waste-water treatment facilities, and tanneries. The concentration of H_2S occurring naturally in crude oil varies from formation to formation and even varies to some degree within the same reservoir. The natural gas in deepwater reservoirs has been mainly sweet (i.e., low in sulfur content), but the oil averages between 1 and 4 percent sulfur content by weight. By far, most of the documented production of sour gas (i.e., high sulfur content) lies within 150 km (93 mi) of the Breton Wilderness Area Class I area. The BSEE regulations at 30 CFR § 250.490(f) describe safety precautions for employees operating in an H_2S area. Hydrogen sulfide is a naturally occurring compound that is formed from the breakdown of organic matter in low oxygen environments. The effects of H_2S depend on the magnitude, duration, and frequency of exposure, as well as the susceptibility of the individual organism or environment. The human nose is very sensitive and can detect extremely low levels of H_2S. A rotten egg odor characterizes H_2S at very low concentrations. However, prolonged exposure to low levels of H_2S can cause skin irritation and olfactory paralysis. Therefore, relying on odor or sense of smell would not be a reliable warning signal to detect H_2S presence. Short-term exposure to high concentrations of H_2S can cause death. Portable monitors worn by workers, as well as visual and audible alarms and H_2S sensors on platforms to activate when the presence of H_2S is detected, can help to prevent loss of life. According to the NPS, Gulf Islands National Seashore visitors have complained about H_2S odors. BOEM expects that concentrations at the park, resulting from OCS sources of H_2S, to be at very low nuisance levels. The source of odors in the park may include releases from the local marsh muds or nearby State oil and gas activity. Therefore, several contributing factors could be responsible for the odors at Gulf Islands National Seashore.

Impacts to air quality from reasonably foreseeable flaring and venting would be **minor** because the activity is short in duration during a 50-year analysis period, and release likely dissipates before reaching coastal areas due to distance. The impacts would vary in intensity based on the type of flare and location of the activity.

Decommissioning

During a 50-year analysis period, most decommissioning occurs during years 20-40. Decommissioning emissions are due mainly to engines on vessels used in the decommissioning process for propulsion, electrical power, and ancillary mechanical equipment and activities. These emissions include the following pollutants: CO, NO_2, PM, $SO_{2,}$ CO_2, CH_4, N_2O, and VOCs. There are two primary methodologies used in the GOM for cutting decommissioning targets: nonexplosive and explosive severance. Nonexplosive methods include abrasive cutters, mechanical cutters, diamond wire cutting devices, and cutting facilitated by commercial divers using arc/gas torches. Though a relatively slow process and potentially dangerous for offshore workers, nonexplosive-severance activities have little to no impact on air quality. Explosive-severance activities use specialized charges to achieve target severance. Unlike most nonexplosive methods, severance charges can be deployed on multiple targets and detonated nearly simultaneously, effecting rapid severances. Though a relatively faster yet safer process for offshore workers with the omission of diver cutting, the detonation of cutting charges occurs mainly underwater and, therefore, would have little impact on air quality. For this reason, impacts to air quality from decommissioning would be **minor**. The impacts would vary in intensity based on the type and location of the activity. The main concern of air quality from decommissioning is the exhaust from support equipment. The less time that heavy equipment must be employed during decommissioning the less air quality will be negatively impacted.

4.1.2.2 Accidental Events

The greatest impact-producing factors associated with a proposed action that could potentially affect air quality from a reasonably foreseeable accidental event include (1) emergency flaring and venting, and (2) oil spills. Accidental air emissions are described in **Chapter 3.2.3**.

Emergency Flaring and Venting

Emergency flaring is distinguished from routine flaring by the magnitude, frequency, and duration of flaring events. Emergency flaring events are the result of operating conditions that are outside normal process and equipment operations. Emergency flaring is generally characterized by infrequent occurrence, high-emission rates, and short durations. Potential impacts to air quality are not expected to be significant, except in the rare case of a catastrophic event, which is not part of a proposed action and not reasonably foreseeable. Emergency flaring may be conducted to manage excess natural gas during an accidental event, such as damage to a pipeline that transports the gas to shore, or a process upset. In the absence of safety flares, plants would be at a higher risk for fires and explosions. The flare is operated temporarily until the emergency situation is resolved. Flaring would result in the release of NO_x emissions from the flare; SO_2 emissions would be dependent on the sulfur content of the crude oil; and particulate matter from the flare would affect visibility.

Venting would result in the release of mainly CH_4 emissions. Emergency venting may be necessary where flaring of the gas is not possible or in situations precluding the use of a flare gas system, such as insufficient hydrocarbon content in the gas stream to support combustion or a lack of sufficient gas pressure to allow it to enter the flare system. Therefore, the potential impacts of a reasonably foreseeable accidental gas release analyzed in this Multisale EIS would be localized and short term, and would have no impact to coastal areas, including the Bradwell Bay Wilderness Area, Breton Wilderness Area, Chassahowitza National Wilderness Area, Everglades National Park, and St. Marks Wilderness Area, or the Padre Island National Seashore and Gulf Islands National Seashore. The accidental event's impacts on air quality over the OCS and adjacent onshore areas on accidental gas releases are expected to be **minor**.

The accidental release of hydrocarbons related to a proposed lease sale would result in the emission of air pollutants. The OCS accidents would include the release of oil, condensate, or natural gas or chemicals used offshore or pollutants from the burning of these products. The air pollutants include criteria NAAQS pollutants, volatile and semi-volatile organic compounds, hydrogen sulfide, and methane. These pollutants are discussed in **Chapter 4.1.2** above. These accidental events may potentially affect the air quality at the Bradwell Bay Wilderness Area, Breton Wilderness Area, Chassahowitza National Wilderness Area, Everglades National Park, and St. Marks Wilderness Area, as well as the Padre Island National Seashore and Gulf Islands National Seashore, during a 50-year analysis period.

Emergency flaring may be conducted to manage excess natural gas during an accidental event such as damage to a pipeline that transports the gas to shore or a process upset. In the absence of safety flares, plants would be at a higher risk for fires and explosions. The flare is operated temporarily until the emergency situation is resolved. Flaring would result in the release of NO_x emissions from the flare; SO_2 emissions would be dependent on the sulfur content of the crude oil; and particulate matter from the flare would affect visibility.

Oil Spills

Accidental oil spills, though not considered a routine OCS oil- and gas-related activity, have the potential to occur during each phase of oil and gas operations. In April 2010, the *Deepwater Horizon* explosion and oil spill was a catastrophic event that occurred on the Gulf of Mexico OCS. The impacts on air quality from the *Deepwater Horizon* explosion and oil spill have been well documented. BOEM does not expect accidental events to resemble the *Deepwater Horizon* explosion and oil spill. BOEM is not analyzing the rare, catastrophic *Deepwater Horizon* explosion and oil spill as an accidental event in this chapter but rather is using the information to describe the potential impacts common to spills and accidental events regardless of size. Additionally, BOEM has assessed the potential impacts resulting from a low-probability catastrophic event, and the analysis is presented in the *Catastrophic Spill Event Analysis* white paper (USDOI, BOEM, 2017). To date, air monitoring conducted following the *Macondo* loss of well control and spill has not found any pollutants at levels expected to cause long-term harm (USEPA, 2010). The loss of well control and blowouts are rare events and of a short duration. Potential impacts to air quality are not expected to be significant, except in the rare case of a catastrophic event, which is not reasonably foreseeable and not part of a proposed action. Therefore, potential impacts as a result of the much smaller reasonably foreseeable accidental spills analyzed in this Multisale EIS would be localized and short term, and would have no impact to coastal areas, including the Bradwell Bay Wilderness Area, Breton Wilderness Area, Chassahowitza National Wilderness Area, Everglades National Park, and St. Marks Wilderness Area, as well as the Padre Island National Seashore and Gulf Islands National Seashore. The accidental event's impact on air quality over the OCS and adjacent onshore areas on oil spills is therefore expected to be **minor**.

In the Gulf of Mexico, evaporation from an oil spill would result in concentrations of VOCs in the atmosphere, including chemicals that are classified as being hazardous. Benzene, toluene, ethylbenzene and xylene (BTEX) are a category of VOCs that occur naturally in crude oil, as well as during the process of making of gasoline and other fuels from crude oil. The VOC concentrations would occur anywhere where there is an oil slick, but they would be highest at the source of the spill because the rate of evaporation depends on the volume of oil present at the surface. The VOC concentrations would decrease with distance as the layer of oil gets thinner. The lighter compounds of VOCs, such as BTEX, would be most abundant in the immediate vicinity of the spill site. The heavier compounds would be emitted over a longer period of time and over a larger area. Some of the compounds emitted could be hazardous to workers in close vicinity of the spill site. In hazardous conditions, the Occupational Safety and Health Administration and USCG regulations require workers to use breathing protection. The hazard to workers can also be reduced by limiting exposure through limited work shifts, rotating workers in close vicinity of the spill site, and pointing vessels into the wind. While the reasonably foreseeable spills analyzed as part of this Multisale EIS are significantly smaller than the catastrophic *Deepwater Horizon* explosion and oil spill, air samples collected during that event by individual offshore workers of British Petroleum (BP), the Occupational Safety and Health Administration (OSHA), and the USCG showed levels of BTEX that were mostly under detection levels. All samples had concentrations below the OSHA permissible exposure limits and the more stringent American Conference of Governmental Industrial Hygienists threshold limit values (U.S. Dept. of Labor, OSHA, 2010). Therefore, the reasonably foreseeable oil spills would be expected to be even smaller.

The VOC emissions that result from the evaporation of oil contribute to the formation of particulate matter ($PM_{2.5}$) in the atmosphere (Brock et al., 2012). In addition, VOCs could cause an increase in ozone levels, especially if the release were to occur on a hot, sunny day with sufficient concentrations of NO_x present in the lower atmosphere. Effects to ozone concentrations would depend on distance of the proposed lease sale area from shore and the accidental spill size. If there were any effects to onshore ozone concentrations to a state, they would likely be temporary in nature and last, at most, the length of time of the spill's duration.

Removal and containment efforts to respond to an ongoing offshore spill would likely require multiple technologies, including source containment, mechanical cleanup, in-situ burning of the slick, and chemical dispersants (**Chapter 3.2.7**). In-situ burning would result in ambient concentrations of CO, CO_2, NO_x, PM_{10}, $PM_{2.5}$, and SO_2 very near the site of the burn and would generate a plume of black smoke. The levels of $PM_{2.5}$ could be a hazard to personnel working in the area, but this could be effectively mitigated through monitoring and relocating vessels to avoid areas of highest concentrations.

4.1.2.3 Cumulative Impacts

An analysis of the cumulative impacts in the GOM region is described in this chapter. This cumulative analysis considers OCS oil- and gas-related and non-OCS oil- and gas-related activities that could occur and adversely affect air quality during the 50-year analysis period.

Under BOEM Contract Number M14PC00007, "Air Quality Modeling in the Gulf of Mexico Region" study, photochemical grid modeling was conducted to assess the impacts to nearby states of existing and proposed future OCS oil and gas exploration, development, and production. Preliminary results from the modeling conducted for this study have become available and are being included in this Multisale EIS to disclose potential cumulative and incremental air quality impacts of the proposed lease sales. These preliminary results represent the best available science at this time and are included in **Appendices F-H**. At the lease issuance stage, no activities beyond certain ancillary activities are actually authorized by the lease; therefore, there are few environmental impacts, including air quality, reasonably expected from a proposed lease sale itself (refer to **Chapter 1.3.1**). During postlease activities, BOEM has the authority to disapprove or require additional mitigation to reduce impacts from site-specific activities as additional information becomes available.

The air quality modeling study examines the potential impacts of the proposed lease sales with respect to (1) the NAAQS for the criteria pollutants O_3, NO_2, SO_2, CO, $PM_{2.5}$, PM_{10}; (2) the Class I and Class II PSD increments; and (3) the AQRVs, including visibility and acid deposition (sulfur and nitrogen) in the nearby Class I and sensitive Class II areas.

Results of each impact analysis are compared with applicable "thresholds of concern," which have typically been used in air quality impact evaluations by other Federal actions, including onshore oil and gas leasing programs. The applicable comparison thresholds for criteria pollutant impacts are the corresponding NAAQS. For acid (i.e., sulfur and nitrogen) deposition impacts, thresholds are based on (1) incremental impacts considered sufficiently small as to have no consequential effect on the receiving ecosystems, i.e., Deposition Analysis Thresholds, and (2) critical load levels above which cumulative ecosystem effects are likely to or have been observed. For visibility impacts, thresholds are based on incremental changes in light extinction below the level at which they would be noticeable to the average human observer. Additional information about these various thresholds is provided in relevant chapters in the remainder of this Multisale EIS.

Overview of Modeling Approach

The Comprehensive Air-quality Model with extensions (CAMx) and Community Multiscale Air Quality (CMAQ) photochemical grid models were used to simulate the dispersion and chemical transformation of pollutants over the study area. Similar to other air quality models, CAMx/CMAQ require several input datasets, including meteorology and an emissions inventory. **Figure 4-6** presents an overview of how these project datasets fit together for the "Air Quality Modeling in the Gulf of Mexico Region" study. Photochemical modeling was conducted for two emission scenarios:

- a Base Case scenario using the 2012 base year (BY) emissions inventory described in **Appendix G** to evaluate model performance and to define current baseline air quality conditions; and
- a Future Year development scenario (FY) using an emissions inventory that includes potential new sources associated with the lease sales analyzed in this Multisale EIS and the projections of emissions to 2017 for all other sources as described in **Appendix G** to estimate the cumulative and incremental air quality and AQRV impacts of the lease sales analyzed in this Multisale EIS.

NOTE: Both scenarios used the same 2012 meteorological dataset and the same photochemical model configuration. (*In determining the Base Case (base year) for the "Air Quality Modeling in the Gulf of Mexico Region" study emissions inventory, 2011 was initially selected based on data availability. Calendar year 2011 emissions data are readily available for most sources from USEPA's National Emissions Inventory (USEPA, 2015a) and BOEM's Year 2011 Gulfwide Emissions Inventory Study (Wilson et al., 2014). However, 2011 was an unusually hot and dry year in the Gulf of Mexico region, particularly in Texas, which experienced record heat and dry conditions during the summer of 2011 and which had a very high incidence of wildfires. Therefore, 2012 was selected as the base year as more representative of "typical" conditions in the Gulf of Mexico region.)*

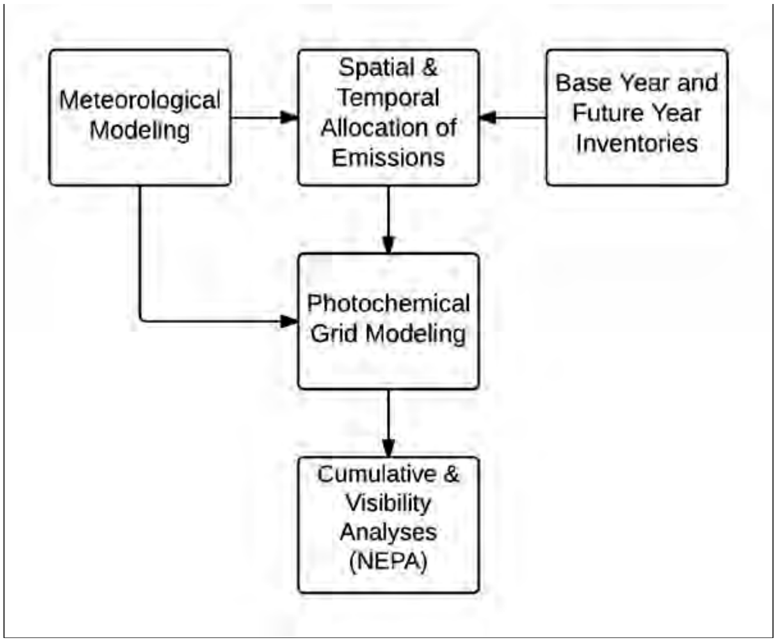

Figure 4-6. Overview of the Gulf of Mexico Region's Cumulative and Visibility Impacts Assessment.

Modeling Input – Meteorological Modeling

Meteorological datasets required to determine the rate that pollutants disperse and react in the atmosphere include spatially and temporally varying parameters such as wind speed, wind direction, air temperature, and humidity, among others. Sources of meteorological information include datasets of measurements gathered at various locations within the Gulf of Mexico region domain, i.e., the area of interest where geographic features influence transport patterns. Results of these meteorological models provide the inputs needed to exercise the photochemical grid air quality dispersion models used in the "Air Quality Modeling in the Gulf of Mexico Region" study. For this study, the Advanced Research version of the Weather and Research Forecasting (WRF) model, as described in **Appendix F**, was applied over a system of nested modeling grids. **Figure 4-8** shows the WRF modeling grids at horizontal resolutions of 36, 12, and 4 km. All WRF grids were defined on a Lambert Conformal Conic projection centered at 40° N. latitude, 97° W. longitude with true latitudes at 33° N. latitude and 45° N. latitude (the "standard RPO" projection). In **Figure 4-8**, the outermost domain (outer box) with 36-km resolution includes the entire continental U.S. and parts of Canada and Mexico, and captures synoptic-scale (storm system-scale) structures in the atmosphere. The inner 12-km regional grid (d02) covers the southeastern U.S. and is used to ensure that large-scale meteorological patterns across the region are adequately represented and to provide boundary conditions to the 4-km domain. The 4-km domain (d03) is centered on the coastal areas of the southeastern U.S. and over-water portions of the Gulf of Mexico. The 4-km domain area, which includes parts of Alabama, Georgia, Louisiana, Mississippi, and Texas, and all of Florida, as well as the WPA, CPA, and EPA, and part of the Atlantic Ocean, was the main focus of the emissions inventory efforts. However, the focus of this Multisale EIS analysis are the coastal areas adjacent to the WPA, CPA, and EPA, which include Texas, Louisiana, Mississippi, Alabama, and Florida.

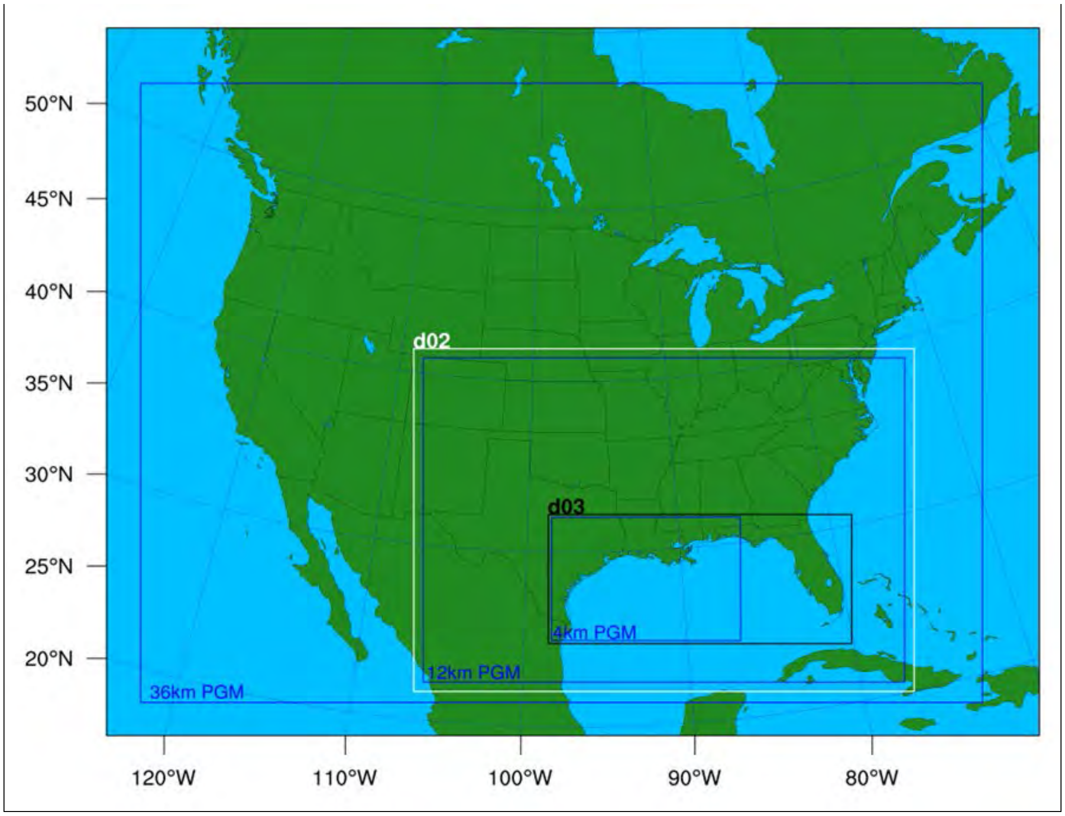

Figure 4-7. Geographic Domain of the "Air Quality Modeling in the Gulf of Mexico" Region Study.

Modeling Input – Emissions Inventories

Analysis of the cumulative air quality impacts of this Multisale EIS required the development of both a contemporary base year emissions inventory for the base case analysis and a projected future year inventory that includes emissions from all cumulative sources, as well as additional emissions anticipated to occur under this Multisale EIS' alternative in which additional exploratory drilling and construction of new shallow and deepwater platforms to support oil and gas production would occur. Both the base case and future year cumulative source inventories represent comprehensive compilations of pollutant emissions from all human activities as well as emissions from biogenic and geogenic sources. Specific details on the development of the emission inventory are presented in **Appendix G**. The scope of the air pollutant emissions inventory for the "Air Quality Modeling in the Gulf of Mexico Region" study is defined in terms of pollutants, representative time periods for the base case and future year analysis, geographical domain, and sources to be included.

Pollutants included in the inventories were selected to support analysis of air quality impacts in terms of impacts on attainment of the NAAQS and on AQRVs, including acid deposition and visibility. The selected pollutants are as follows: the NAAQS criteria pollutants – CO, NO_x (which includes NO and NO_2 and is stated in terms of equivalent mass of NO_2), $PM_{2.5}$, fine plus coarse PM (PM_{10}), and SO_2; criteria precursors – VOCs (which are precursors to the formation of ozone and organic particulates) and ammonia (NH_3) (which is a precursor to particulate matter formation). As previously mentioned in **Chapter 4.1.1**, lead (Pb) was not included in the inventory. While the cumulative air quality impact analysis did not focus specifically on air toxics, the compilation of VOC emissions by source type, together with VOC speciation profiles by source type, provides a mechanism for estimating emissions of individual air toxic species.

Overview of Modeling Results

The post-processed results for comparison to the NAAQS, PSD increments, and visibility and acid deposition thresholds are described below. The results in this section are still preliminary, but are being used to disclose the potential cumulative impacts to coastal areas.. Specific cumulative impact analysis results from the "Air Quality Modeling in the Gulf of Mexico Region" study are presented in **Appendix H**.

The CAMx future year scenario model and ozone and particulate matter source apportionment modeling outputs were post-processed for comparison against the NAAQS and PSD concentration increments, and other thresholds of concern as discussed below. For analyzing the NAAQS and AQRV impacts at Class I and sensitive Class II areas, the thresholds of concern used were as defined by the Federal Land Manager that manages each Class I/II area.

Source apportionment provides a means of assessing the contributions of specified sources or categories of sources to predicted ozone and PM concentrations and their precursors under the air quality conditions being simulated. Source contributions were calculated for ozone and PM using the Ozone and Particulate Source Apportionment Technology routines included in CAMx. Source apportionment analyses were applied to the future year scenario in order to analyze the pre- and postlease OCS oil- and gas-related impacts to short-term and annual NAAQS, AQRVs, and PSD increments. While BOEM selected nine source categories for the CAMx future year source apportionment simulation as listed in **Table 4-4**, only four are appropriate for this Multisale EIS analysis because they apply to the Gulf of Mexico region.

Table 4-4. Source Categories for Source Apportionment Calculations.

Category ID	Sources
SC3	Additional BOEM OCS oil and gas production platforms associated with this Multisale EIS (with Action)
SC4	Additional BOEM oil and gas production support vessels and helicopters associated with this Multisale EIS (with Action)
SC5	BOEM OCS oil and gas production platforms, support vessels, and helicopters under the base case (No Action)
SC6	All other marine vessel activity in the Gulf of Mexico not associated with OCS oil and gas development, exploration, or production

SC = source category.

4.1.2.3.1 Impacts Assessment

NAAQS Impacts

The impacts for the NAAQS criteria pollutants ozone (O_3), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), fine particulate matter with aerodynamic diameter less than 2.5 µm ($PM_{2.5}$), and fine plus coarse particulate matter with aerodynamic diameters less than 10 µm (PM_{10}) are discussed below.

Comparison to the NAAQS

Results of each impact analysis are compared with applicable "thresholds of concern," which have typically been used in air quality impact evaluations by other Federal actions, including onshore oil and gas leasing programs. The applicable comparison thresholds for criteria pollutant impacts are the corresponding NAAQS (**Table 4-5**).

The CAMx future year scenario predicted that the total concentrations from all emission sources were post-processed for comparison to the applicable NAAQS in two different ways. First, the CAMx predictions were compared directly against each NAAQS. This is referred to as the "absolute" prediction comparison. These absolute prediction comparisons may be misleading in cases in which the model exhibits significant prediction bias. In recognition of this, USEPA modeling guidance (USEPA, 2007 and 2014) recommends using the model in a relative sense when projecting future year ozone, $PM_{2.5}$, and regional haze levels, and USEPA has developed the Modeled Attainment Test Software (MATS; Abt., 2014) for making such future year projections. This approach uses the ratio of future year to current year modeling results to develop Relative Response Factors (RRFs) that are applied to observed current year Design Values (abbreviated as either DVC or DVB) to make future year Design Value (DVF) projections (i.e., DVF = DVC x RRF). The MATS was applied to the prediction of both ozone and $PM_{2.5}$ DVFs.

Table 4-5. NAAQS and PSD Increments.

Pollutant	Pollutant/Averaging Time	NAAQS	PSD Class I Increment[1]	PSD Class II Increment[1]
CO	1-hour[2]	**35 ppm** 40,000 µg/m^3	--	--
CO	8-hour[2]	**9 ppm** 10,000 µg/m^3	--	--
NO_2	1-hour[3]	**100 ppb** 188 µg/m^3	--	--
NO_2	Annual[4]	**53 ppb** 100 µg/m^3	2.5 µg/m^3	25 µg/m^3
O_3	8-hour[5]	**0.070 ppm** 137 µg/m^3	--	--
PM_{10}	24-hour[6]	**150 µg/m^3**	8 µg/m^3	30 µg/m^3
PM_{10}	Annual[7]	--	4 µg/m^3	17 µg/m^3
$PM_{2.5}$	24-hour[8]	**35 µg/m^3**	2 µg/m^3	9 µg/m^3
$PM_{2.5}$	Annual[9]	**12 µg/m^3**	1 µg/m^3	4 µg/m^3

Pollutant	Pollutant/Averaging Time	NAAQS	PSD Class I Increment[1]	PSD Class II Increment[1]
SO_2	1-hour[10]	**75 ppb** 196 µg/m^3		
SO_2	3-hour[11]	**0.5 ppm** 1,300 µg/m^3	25 µg/m^3	512 µg/m^3
SO_2	24-hour	--	5 µg/m^3	91 µg/m^3
SO_2	Annual[4]	--	2 µg/m^3	20 µg/m^3

[1] The PSD demonstrations serve information purposes only and do not constitute a regulatory PSD increment consumption analysis.
[2] No more than one exceedance per calendar year.
[3] 98th percentile, averaged over 3 years.
[4] Annual mean not to be exceeded.
[5] Fourth-highest daily maximum 8-hour ozone concentrations in a year, averaged over 3 years, NAAQS promulgated December 28, 2015.
[6] Not to be exceeded more than once per calendar year on average over 3 years.
[7] 3 year average of the arithmetic means over a calendar year.
[8] 98th percentile, averaged over 3 years.
[9] Annual mean, averaged over 3 years, NAAQS promulgated December 14, 2012.
[10] 99th percentile of daily maximum 1-hour concentrations in a year, averaged over 3 years.
[11] No more than one exceedance per calendar year (secondary NAAQS).

Ozone

The ozone NAAQS is defined as an 8-hour averaging time that is expressed as a 3-year average of the 4th highest maximum daily average. Since only one calendar year of modeling results are available for the base year and future year outcome, the future year 4th highest maximum daily average 8-hour ozone concentration is used as a pseudo-NAAQS comparison metric. The USEPA's Modeled Attainment Test Software was used to make future year ozone future design values projections using the CAMx 2012 Base Case and Future Year Scenario modeling results.

The impacts to air quality from O_3 for of all proposed and existing oil and gas emissions from Gulf of Mexico OCS sources and their support vessels/aircraft (Source Group C) are **moderate** because the future year design values were above the current year design value (which was already above the NAAQS). The modeling suggests that the maximum contribution of all proposed and existing oil and gas emissions from Gulf of Mexico OCS sources and their support vessels/aircraft (Source Group C) occur in Galveston, Texas (a nonattainment area).

The impacts to air quality from O_3 for Source Group B (new platforms and associated support vessels and aircraft under this Multisale EIS) are **minor** because the future year design values were lower than the current year design values. The modeling suggests that the maximum contribution of Source Group B is centered in the GOM offshore of Louisiana; maximum impacts from the State seaward boundaries inland along the coast of Cameron Parish, Louisiana. Source Group A (new platforms under this Multisale EIS) maximum contributions occur in the same location, but the support vessel and helicopter activities (from Source Group B) are responsible for the greater impacts landward of the State seaward boundary.

NOTE: *For the ozone impacts assessment, please note that the States will not designate under the 2015 ozone standard of 70 ppb until 2017, with the earliest attainment date of March 2021 for marginal areas. For this impacts assessment, the non-OCS source emissions were based on USEPA's 2017 emission projections, with a future modeled year of 2017 and compared with the 70-ppb standard. This assessment is assuming the standard will be attained in advance of the actual attainment date but wanted to give maximum OCS oil and gas impacts under the new 70-ppb ozone standard.*

Particulate Matter (PM)

$PM_{2.5}$

There are two $PM_{2.5}$ NAAQS: one for the 24-hour averaging time that is expressed as a 3-year average of the annual 98^{th} percentile in a year and an annual average over 3 years. With 1 year of photochemical grid modeling, the annual 98^{th} percentile would correspond to the 8^{th} highest 24-hour $PM_{2.5}$ concentration in a year. As described for the ozone NAAQS analysis, the MATS was used to calculate DVFs for the 24-hour and annual $PM_{2.5}$ NAAQS.

All future year modeled concentrations for 24-hour and annual $PM_{2.5}$ are below the NAAQS. The impacts to air quality from 24-hour $PM_{2.5}$ and annual $PM_{2.5}$ are **minor** because the future year design values were lower than the current year design values at all sites except one. While the annual $PM_{2.5}$ current year modeled concentration exceeded the NAAQS in Harris County, Texas, the projected future year design value at this location is below the NAAQS.

24-hour $PM_{2.5}$: All current and future year design values are below the NAAQS, and the future year design values are projected to be lower than the current year design values at all sites. The modeling suggests that the highest 24-hour $PM_{2.5}$ impacts occur at the State seaward boundary off the coast of Louisiana. There were no monitoring sites with the 24-hour $PM_{2.5}$ in excess of the NAAQS, with future year modeling projecting no design value exceedances. The maximum contributions due to emissions from all existing and proposed GOM platform and support equipment to the 8^{th} highest 24-hour $PM_{2.5}$ concentrations occurs right on the State seaward boundary off the coast of Houma, Louisiana.

Annual Average $PM_{2.5}$: The modeling suggests that the highest annual $PM_{2.5}$ impacts occur right at the State seaward boundary off the coast of Louisiana. There was one monitoring site with annual $PM_{2.5}$ design value concentrations above the NAAQS (in Harris County (Houston), Texas) but reduced to below the NAAQS in the future year. The maximum contribution to annual $PM_{2.5}$ future design values due to emissions from all existing and proposed GOM platform and support equipment occurs at the State seaward boundary off the coast of Louisiana.

PM_{10}

There is only one PM_{10} NAAQS: one for the 24-hour averaging time that is expressed as a 3-year average not to be exceeded more than once per calendar year. With 1 year of photochemical grid modeling, the annual 98th percentile will correspond to the 8th highest 24-hour $PM_{2.5}$ concentration in a year. The impacts to air quality from PM_{10} are **minor** because, while there are concentrations increases in water farther offshore, no overall standards were exceeded.

24-Hour PM_{10}: The OCS oil- and gas-related impacts for the 24-hour PM_{10} are similar to the 24-hour $PM_{2.5}$ future year modeling, projecting no future design value exceedances. The modeled 2nd highest daily average PM_{10} concentrations can be compared with the 24-hour average PM_{10} NAAQS for the base and future scenarios and the base-future differences. The modeling suggests areas of elevated PM_{10} are evident in urban and port areas and in fire zones along the Gulf Coast of Texas and Louisiana (impacts of fires on PM_{10} are also seen). The PM_{10} decreases between the current and future year are modeled along the Louisiana coast, with increases in waters farther offshore associated with new emissions from proposed action sources. The maximum contribution of all oil and gas platforms and support vessels and helicopters (Source Group C) are below the NAAQS, and the maximum contribution of the new platforms and associated support vessels and aircraft under this Multisale EIS (Source Group B) are below the NAAQS.

Nitrogen Dioxide (NO_2)

There are two NO_2 NAAQS: one for the 1-hour averaging time that is expressed as a 3-year average of the annual 98th percentile in a year and an annual average over 3 years. With 1 year of photochemical grid modeling, the annual 98th percentile would correspond to the 8th highest 24-hour NO_2 concentration in a year. Results are included below for both the 1-hour NO_2 and the annual NO_2 averaging times. All modeled concentrations for NO_2 are below the NAAQS. The impacts to air quality from 1-hour NO_2 and annual NO_2 are **minor** because overall, concentrations decrease between the base and future year scenarios at most locations. While there was in increase between the base and future year scenarios for annual NO_2 in Vermilion Parish, Louisiana, the no standards were exceeded.

1-hour NO_2: All modeled 1-hour NO_2 concentrations are below the NAAQS. The overall, concentrations decrease between the base and future year scenarios at most locations. The modeling suggests that the maximum contributions from new platforms and support vessels and helicopters associated with this Multisale EIS (Source Group B) are dominated by vessel and possibly helicopter traffic in the port areas, most notably in Vermilion Parish, Louisiana; and the maximum combined contributions from new and existing platforms and support vessels and helicopters (Source Group C) are dominant in the area of the LOOP.

Annual NO_2: These results are similar to those for 1-hour NO_2. The maximum impacts of new and existing platforms and support vessels and helicopters associated with this Multisale EIS (Source Group C) showed increases between the base and future year scenarios to occur near the entrance to the Freshwater Bayou Canal in Vermilion Parish, Louisiana, and somewhat larger increases modeled in the Permian Basin of west Texas. However, overall no standards were exceeded.

Sulfur Dioxide (SO_2)

There are two SO_2 NAAQS: one for a 1-hour averaging time that is expressed as a 3-year average of the annual 99^{th} percentile in a year and a 3-hour average not to be exceeded more than once per year. All modeled concentrations for SO_2 are below the NAAQS. The impacts to air quality from 1-hour SO_2 and 3-hour SO_2 are **minor** because overall, concentrations decrease between the base and future year scenarios at most locations as sources retire or apply control equipment.

1-hour SO_2: All modeled values are below the NAAQS. While maximum contributions are located from sources in areas with deepwater platforms, concentrations decrease in most locations in the future year scenario as sources are retired or apply control equipment with projected maximum impacts all below the NAAQS.

3-hour SO_2: All modeled values are below the NAAQS. These results are similar to those for the 1-hour SO_2 described above.

Carbon Monoxide (CO)

There are two CO NAAQS: a 1-hour averaging time and an 8-hour average not to be exceeded more than once per year. All modeled concentrations for SO_2 are below the NAAQS. The impacts to air quality from 1-hour CO_2 and 8-hour CO are **minor** because overall, concentrations decrease between the base and future year scenarios at all locations.

1-hour CO: The modeled 1-hour CO design values (based on the annual 2^{nd} highest daily maximum 1-hour average) for the base, future, and future-base scenarios show all values are below the NAAQS.

8-hour CO: The modeled 8-hour CO design values (based on the annual 2^{nd} highest non-overlapping running 8-hour average) for the base, future, and future-base scenarios show the maximum predicted 8-hour design value in the future year occurs at the entrance to the Freshwater Bayou Canal in Vermilion Parish, Louisiana, but no over standard was exceeded.

Incremental Impacts of PSD Pollutants with Respect to PSD Class I and Class II Increments

As mentioned in **Chapter 4.1.1**, the WPA, CPA, and EPA include national parks and Federal wilderness areas where air quality and AQRVs (primarily visibility) are protected more stringently than under the NAAQS. The Class I areas, compared with Class II areas, have lower PSD increments that new sources may not exceed and that are protected against excessive increases in several AQRVs, including visibility impairment. **Table 4-6** lists those areas that are located along the Gulf Coast and, thus, are of greatest interest to this analysis.

The incremental AQ/AQRV contributions associated with emissions from each source group listed in **Table 4-4** were calculated for the Class I and sensitive Class II areas listed in **Table 4-6**. The selected areas include all Class I and sensitive Class II areas within the 4-km modeling domain plus additional Class I areas within the 12-km modeling domain (Bradwell Bay).

The Class I and sensitive Class II increments analyses results are expressed in terms of the maximum increment consumption over all Class I and sensitive Class II areas within the 4-km modeling domain. Incremental impacts of each Source Group at Class I and sensitive Class II areas were calculated for all pollutants for which PSD increments have been set (NO_2, SO_2, PM_{10}, and $PM_{2.5}$) and are discussed below.

Table 4-6. Class I and Sensitive Class II Areas in Gulf Coast and Nearby States.

Type	Name	Agency	State	Modeling Domain
Class I	Breton Wilderness Area	FWS	LA	4 km
Class II	Breton National Wildlife Refuge	FWS	LA	4 km
Class II	Gulf Islands National Seashore	NPS	MS, FL	4 km
Class II	Padre Island National Seashore	NPS	TX	4 km
Class I	Bradwell Bay Wilderness Area	FS	FL	12 km

FS = Forest Service; FWS = Fish and Wildlife Service; NPS = National Park Service.

Comparison at the Class I and Sensitive Class II Areas

The maximum contribution of new oil and gas production sources under this Multisale EIS were reported for each Class I and sensitive Class II area and were compared against the PSD increments given in **Table 4-5**. Comparisons of impacts from a proposed action with maximum allowed PSD increments are presented here as an evaluation of a "threshold of concern" for potentially significant adverse impacts, but they do not represent a regulatory PSD increment consumption analysis. (*Note: This analysis does not constitute a regulatory PSD increment consumption analysis as would be required for major sources subject to the New Source Review program requirements of the Clean Air Act. Under the Clean Air Act, a PSD increment consumption analysis requires major stationary sources subject to PSD review to demonstrate that emission* *increases from the proposed source, in conjunction with all other emissions increases or reductions in the impacted area (typically within 50 km [31 mi]), will not cause or contribute to concentrations of air pollutants that exceed PSD increments. The PSD increments have been established for* NO_x*,* SO_2*, and PM in Class I and* sensitive *Class II areas. Actions to be authorized by BOEM under this Multisale EIS do not typically constitute major stationary sources and do not typically trigger PSD permits or review. However, a comparison of ambient concentrations from an accumulation of new oil and gas sources within the entire study area to PSD increments at specific Class I and* sensitive *Class II areas is included in this analysis for information purposes. This information is presented to aid State agencies in tracking potential minor source increment consumption and to aid Federal Land Managers or Tribal governments responsible for protecting air resources in Class I areas).*

The CAMx source apportionment results for individual source categories were used to evaluate the incremental impacts of each of a set of hierarchical source groups as defined in **Table** 4-6. Note that Source Group B represents all new direct emissions associated with this Multisale EIS, and Source Group C represents these sources in addition to all existing OCS platforms and associated support vessel and aircraft activity.

The impacts to Class I areas from contributions of new platforms and its associated support vessels and aircraft are **minor** because proposed activities exceed the 24-hour $PM_{2.5}$ Class I PSD increments by 10 percent at the Breton Wilderness Area, which are a result of support vessels and helicopter traffic associated with the activities. The impacts to Class I areas from contributions of all activities from past, present, and future lease sales are **moderate** because proposed activities exceed the annual and 24-hour $PM_{2.5}$, 24-hour PM_{10}, and annual NO_2 Class I PSD increments at the Breton Wilderness Area.

The impacts to sensitive Class II areas from contributions of all activities as a result of a single proposed lease sale are **minor** because, while maximum increases occur at the Gulf Islands National Seashore for all PSD pollutants and averaging times and increases occur for annual NO_2 at the Breton Wilderness Area, there are no exceedances of the PSD Class II increment. The impacts to sensitive Class II areas from contributions of all activities from past, present, and future lease sales are **moderate** because proposed activities exceed the annual 24-hour $PM_{2.5}$ Class II PSD increments at the Gulf Islands National Seashore.

Class I Areas

For all source groups described in **Table 4-7**, the maximum contributions for all PSD pollutants and averaging times occur at the Breton Wilderness Area Class I area. Concentration increments from Source Groups A and B are less than the maximum allowed PSD increments for all pollutants and averaging times, except for the 24-hour $PM_{2.5}$ increment from Source Group B at the Breton Wilderness Class I area where the maximum impact exceeds the Class I PSD increment. The difference in the maximum Source Group A 24-hour average $PM_{2.5}$ increment and the maximum Source Group B 24-hour average $PM_{2.5}$ indicates that support vessels or helicopter traffic associated with new offshore platforms, rather than emissions from the platforms themselves, are largely responsible for pushing the maximum impact above the Class I PSD increment at Breton Wilderness Area. However, when the 24-hour $PM_{2.5}$ impact from Source Group B is averaged over all grid cells covering the Breton Wilderness Class I area, the impact is below the Class PSD increment. The maximum impacts from Source Group C exceeds the annual and 24-hour $PM_{2.5}$, 24-hour PM_{10}, and annual NO_2 Class I PSD increments at the Breton Wilderness Area..

Sensitive Class II Areas

For all source groups described in **Table 4-7**, the maximum contributions occur at the Gulf Islands National Seashore for all PSD pollutants and averaging times except annual NO_2, which occurs at the Breton Wilderness Area. The cumulative impacts (Source Group C) exceed the annual 24-hour $PM_{2.5}$ Class II PSD increments at the Gulf Islands National Seashore.

Table 4-7. Source Group for Incremental Impacts Analysis.

Source Group	Included Source Categories	Comment
A	SC3	New oil and gas platform sources under this Multisale EIS
B	SC3, SC4	Add support vessels and aircraft associated with new platform sources
C	SC3, SC4, SC5	Add oil and gas platforms and associated support vessels and aircraft under the No Action Alternative
D	SC3, SC4, SC5, SC6	Add all other marine vessel activity in the GOM

AQRV Impacts – Including Visibility and Acid Deposition

While visibility and acid deposition are not directly regulated by BOEM, an analysis of the potential impacts is provided below.

Results of each impact analysis are compared with applicable “thresholds of concern,” which have typically been used in air quality impact evaluations by other Federal actions, including onshore oil and gas leasing programs. The applicable comparison thresholds for visibility impacts are based on incremental changes in light extinction below the level at which they would be noticeable to the average human observer. The applicable comparison thresholds for acid (i.e., sulfur and nitrogen) deposition impacts are based on (1) incremental impacts considered sufficiently small as to have no consequential effect on the receiving ecosystems, i.e., Deposition Analysis Thresholds, and (2) critical load levels above which cumulative ecosystem effects are likely to or have been observed.

Comparison to Visibility and Acid Deposition

Visibility impacts were calculated for each source group using incremental concentrations as quantified by the CAMx Particulate Source Apportionment Technology tool. For each source group, the estimated visibility degradation at the Class I areas and sensitive Class II areas due to the source group are presented in terms of the number of days that exceed a threshold change in deciview (Δdv) relative to background conditions. The number of days with a Δdv greater than 0.5 and 1.0 are reported.

The preliminary results of impacts of all activities as a result of a single proposed lease sale to visibility impairment from a proposed lease sale is expected to be **minor** to **moderate** as modeled results show exceedances of the visibility thresholds at several of the Class I and sensitive Class II areas in the Gulf of Mexico region. The preliminary results of impacts of all activities as a result of all contributions of all activities from past, present, and future lease sales to visibility impairment from a proposed lease sale is expected to be **minor** to **moderate** as modeled results show exceedances of the visibility thresholds at several of the Class I and sensitive Class II areas in the Gulf of Mexico region.

The preliminary results of impacts of all activities as a result of a single proposed lease sale to acid deposition is expected to be **minor** to **moderate** as modeled results show incremental nitrogen deposition exceeds the western and eastern Deposition Analysis Thresholds at all three locations (i.e., the Breton Wilderness Area, Gulf Islands National Seashore, and Padre Island National Seashore). Additionally, incremental sulfur deposition is below the Deposition Analysis Thresholds in all cases except the sulfur deposition at the Breton Wilderness Area and Gulf Islands National Seashore, which exceed the western Deposition Analysis Thresholds but not the eastern Deposition Analysis Thresholds.

The preliminary results of impacts of all from contributions of all activities from past, present, and future lease sales to acid deposition is expected to be **minor** to **moderate** as modeled results show cumulative maximum nitrogen deposition to continue exceeding the critical load thresholds under the future year scenario for all areas except the Padre Island National Seashore. Additionally, cumulative sulfur deposition values are lower, and larger sulfur emission reductions help to reduce sulfur deposition from above the critical load to below the critical load at the Breton Wilderness Area and Breton National Wildlife Refuge (based on maximum grid cell values). Nevertheless, the maximum grid cell sulfur deposition still exceeds the critical load at the Gulf Islands National Seashore by a small margin.

Visibility

For visibility impacts, thresholds are based on incremental changes in light extinction below the level at which they would be noticeable to the average human observer. Incremental visibility impacts were calculated for each source group, as well as the cumulative impact of all sources combined. The changes in light extinction from CAMx model concentration increments due to emissions from each source group were calculated for each day at grid cells that intersect Class I and sensitive Class II areas within the 12/4km modeling domain-km (7/2-mi) modeling domain. For Source Group A, the annual 8th highest change in deciview (Δdv) exceed the 1.0 threshold at the Breton Wilderness Area, Breton National Wildlife Refuge, and Gulf Islands National Seashore. Incremental impacts for Source Group B are larger and include days with the 8th highest change in deciview greater than 1.0 at the Padre Island National Seashore in addition to the areas mentioned above, as well as values greater than 0.5 at the Chassahowitzka Wilderness Area and St. Marks National Wildlife Refuge. For Source Group A, the annual 8th highest deciview exceed the 1.0 threshold at the Breton Wilderness Area, Breton National Wildlife Refuge, and Gulf Islands National Seashore. Incremental impacts for Source Group B are larger and include days with 8th highest deciview greater than 1.0 at Padre Island National Seashore in addition to the areas mentioned above as well as values greater than 0.5 at Chassahowitzka Wilderness Area and St. Marks National Wildlife Refuge.

Acid Deposition

The CAMx-predicted that wet and dry fluxes of sulfur- and nitrogen-containing species were processed to estimate total annual sulfur (S) and nitrogen (N) deposition values at each Class I and sensitive Class II area. The maximum annual S and N deposition values from any grid cell that intersects a Class I receptor area was used to represent deposition for that area, in addition to the average annual deposition values of all grid cells that represent a Class I receptor area. Although the convention in the past has been to report just the maximum deposition in any receptor in a Class I/II area, since deposition relates to the total amount deposited across an entire watershed, the average metric may be considered a more relevant parameter for evaluating potential environmental effects. Maximum and average predicted S and N deposition impacts are reported separately for each source group.

As a screening analysis, incremental deposition values in Class I and II areas for combined Source Groups A (new platforms associated with the highest emissions year of the 10 proposed lease sales) and B (new platforms and associated support vessels and helicopters associated with the 10 proposed lease sales) were compared to the eastern and western U.S. Deposition Analysis Thresholds. Comparison of deposition impacts from cumulative sources to the Deposition Analysis Thresholds is not appropriate. Deposition results were also obtained for all other sensitive areas throughout the 12-km (7-mi) modeling domain, but the highest deposition values all occurred within the 4-km (2-mi) domain. The dividing line between the eastern and western Deposition Analysis Thresholds specified in the FLAG guidance is the Mississippi River, which makes sense for most locations in the U.S.; however, it is not necessarily clear which Deposition Analysis Threshold would be most appropriate for coastal locations along the Gulf Coast, so results are compared here against both Deposition Analysis Thresholds.

Incremental nitrogen deposition exceeds the western and eastern Deposition Analysis Thresholds at all three locations (i.e., the Breton Wilderness Area, Gulf Islands National Seashore, and Padre Island National Seashore). Incremental sulfur deposition is below the Deposition Analysis Thresholds in all cases except the sulfur deposition from Source Group B at the Breton Wilderness Area and Gulf Islands National Seashore, which exceeds the western Deposition Analysis Thresholds but not the eastern Deposition Analysis Thresholds.

Cumulative nitrogen deposition from all sources combined for the base case and future year scenarios were compared against applicable critical load levels in each Class I and II area for which critical loads were identified. Cumulative nitrogen deposition is projected to decrease in all areas between the 2012 base case and the 2017 future year, which is consistent with an overall reduction in NO_x emissions. Nevertheless, maximum nitrogen deposition is modeled to continue exceeding the critical load thresholds under the future year scenario for all areas except the Padre Island National Seashore. Sulfur deposition values are lower, and larger sulfur emission reductions help to reduce sulfur deposition from above the critical load to below the critical load at the Breton Wilderness Area and Breton National Wildlife Refuge (based on maximum grid cell values). Nevertheless, the maximum grid cell sulfur deposition still exceeds the critical load at the Gulf Islands National Seashore by a small margin.

OCS Oil- and Gas-Related Impacts

This section includes all activities (i.e., routine activities projected to occur and accidental events that could occur) from past, proposed, and future lease sales. Emissions contributing to air quality degradation come from many sources. Air pollutants on the NAAQS list are commonly referred to as criteria pollutants because they are ubiquitous. Although these pollutants occur naturally, elevated levels are usually the result of anthropogenic activities. The OCS oil- and gas-related activities that could impact air quality include the following: platform construction and emplacement; platform operations; drilling activities; flaring; service-vessel trips; fugitive emissions; the release of oil, condensate, natural gas, and chemicals used offshore, or pollutants from the burning of these products; and a low-probability catastrophic spill, which is not part of the proposed action and not likely expected to occur. Based on the air quality modeling results from the "Air Quality Modeling in the Gulf of Mexico Region" study, cumulative impacts would be **moderate** because, while there are exceedances to the thresholds of concern, the impacts are just enough to push over the standard.

In the air quality modeling study, Source Group C represents all proposed (new) and existing oil- and gas-related emissions from Gulf of Mexico OCS sources and their support vessels/aircraft. According to the modeling results, the impacts of criteria pollutants from Source Group C to air quality are below the NAAQS for all pollutants, except ozone which shows an increase in the future year design values occurring in Galveston, Texas, which is a nonattainment area. At the Galveston, Texas, monitor, the contribution of Source Group A (new platforms) alone was sufficient to bump the future year design value from just below the NAAQS to just above the NAAQS (recall comparisons to the 70-ppb NAAQS are made after truncating design values to the nearest ppb).

According to the modeling results, the incremental impacts of PSD pollutants from Source Group C to the Class I area exceed the annual and 24-hour $PM_{2.5}$, 24-hour PM_{10}, and annual NO_2 Class I PSD increments at the Breton Wilderness Area. The incremental impacts of PSD pollutants from Source Group C to the sensitive Class II area exceed the annual 24-hour $PM_{2.5}$ Class II PSD increments at the Gulf Islands National Seashore.

Non-OCS Oil- and Gas-Related Impacts

Non-OCS oil- and gas-related impacts include other past, present, and reasonably foreseeable future activities occurring within the same geographic range and within the same timeframes as a proposed action, but they are not related to the OCS Oil and Gas Program. Onshore emission sources from non-OCS oil- and gas-related activities include power generation, industrial processing, manufacturing, refineries, commercial and home heating, and motor vehicles (**Chapter 3.3.2.6**). The total impact from the combined onshore and offshore emissions would have an effect on the ozone nonattainment areas in southeast Texas and the parishes near Baton Rouge, Louisiana.

State oil and gas programs (**Chapter 3.3.2.1**) onshore, in territorial seas, and in coastal waters also generate emissions that affect the air quality of any state. These emissions are regulated by State agencies and/or the USEPA. Reductions in emissions have been achieved through the use of low sulfur fuels, catalytic reduction, and other efforts and, as a result, constitute minor impacts to the air quality of any state.

Other major factors influencing offshore environments, such as sand borrowing (**Chapter 3.3.2.7.6**), commercial transportation (**Chapter 3.3.2.3**), military vessels, and recreational vessels also generate emissions that can affect air quality. These emissions are regulated by State agencies and/or the USEPA. Reductions have been achieved through the use of low sulfur fuels and catalytic reduction and, as a result, constitute slight impacts to onshore air quality.

Hurricanes (**Chapter 3.3.2.10.2**) mainly cause damage to offshore infrastructures and pipelines, which may result in an oil spill. A hurricane would cause minor effects on the onshore air quality since air emissions in the event of a hurricane are temporary sources. For the cumulative scenario, the emissions from oil spill and the associated response activities and infrastructure repair activities are expected to be the same as a proposed lease sale and to have lesser effects on the onshore air quality.

Additionally, recent information shows that intercontinental dust transport may have impacts on the GOM's air quality. For example, dust from Central America and North Africa has been found in the Texas atmosphere. Fine particulates ($PM_{2.5}$), such as ammonium sulfate, can be suspended in the atmosphere and can impair visibility and adversely affect human health. Once in the atmosphere, these fine particulates can be transported for long distances. It has been observed that a substantial amount of the fine particulates observed in Texas comes from Mexico and Central America, and enters into the United States across Texas' southern border. As a result, it reduces the visibility at Big Bend and Guadalupe Mountains National Parks, both Class I (pristine with respect to visibility) areas. The results of air dispersion modeling indicate that as much as half of the visibility impairment (occurring on 20% of the most visibility impaired days) at Big Bend comes from international transport (State of Texas, Commission on Environmental Quality, 2014). The trans-Atlantic transport of North African dust by summertime trade winds occasionally increases ambient particulate matter (PM) concentrations in Texas above air quality standards (Bozlaker et al., 2013).

These results indicate that an increase in visibility impairment in Texas is likely due to transport of dust rather than OCS oil- and gas-related emission sources.

The activities associated with a proposed action would increase global greenhouse gas (GHG) emissions from the use of vessels, drilling equipment, and other activities that burn fossil fuels. In addition, methane (CH_4,) also known as natural gas, is removed from wells and brought onto OCS oil- and gas-related facilities along with oil being produced. Sometimes CH4 is released as a fugitive gas that can escape unintentionally from leaks in equipment used by operators. As a result of exploration, development, and production of oil and gas on the OCS, the activities associated with a proposed action are expected to release GHGs and black carbon from the use of combustion engines in vessels, construction, drilling, and other equipment, as well as through deliberate or accidental release of CH_4. In addition to the direct emissions from OCS oil and gas operations presented above, BOEM has evaluated GHG emissions covering the lifecycle of OCS oil and gas production and consumption. This includes both the "downstream" consumption and onshore processing of oil and gas products, as well as the "upstream" emissions from offshore exploration, development, and production. This Multisale EIS tiers from the Five-Year Program EIS. In the Five-Year Program EIS, the potential impacts of the Program's activities on climate change were assessed in Chapter 4.2.1 (Climate Change) and specifically addressed the GOM proposed lease sales in that analysis (Five-Year Program EIS) (USDOI, BOEM, 2016b).

Incremental Contribution of a Single Proposed Lease Sale to Overall Cumulative Impacts

In the air quality modeling study, incremental contributions are categorized as the impacts of pollutants from new platforms and their associated support vessels and aircraft. The forecasted data used to support modeling analyses include emissions resulting from the 10 proposed lease sales annualized by using BOEM's Resource Evaluation's mid-case scenario. To understand how these results would apply to a single proposed lease sale, the level of projected activity was compared between the modeled highest year of the 10 proposed lease sales to a single proposed lease sale. A regionwide lease sale has not previously been analyzed, and historic trend data are limited. In the scenario in **Chapter 3.1**, the projected activities of a single regionwide lease sale is based on a range of historic observations and provides a reasonable expectation of oil and gas production anticipated from a single proposed lease sale. The projected activities of 10 proposed regionwide lease sales' mid-case scenario, which was used in the model, falls within the range of a single proposed lease sale. This is conservative because the current price of oil equals the low range of the scenario. Using these assumptions, the potential impacts of a single proposed lease sale would be **minor** because the affected resource could be avoided with proper mitigation. The modeling results show that ozone exceeds the NAAQS in Galveston, Texas, and 24-hour $PM_{2.5}$ exceeds the Class I PSD increment at the Breton Wilderness Area. The impacts were sufficient to increase the future year design value from just below the NAAQS for ozone and over the Class I PSD increment, respectively.

In the air quality modeling study, Source Group B represents new platforms and emissions and their support vessels and aircraft. According to the modeling results, the impacts of criteria pollutants from Source Group B to air quality are below the NAAQS for all pollutants, except for ozone. At the Galveston, Texas, monitor, the contribution of Source Group A (new platforms) alone was sufficient to bump the future year design value from just below the NAAQS to just above the NAAQS.

The impacts to Class I areas from contributions of new platforms and their associated support vessels and aircraft show that proposed activities exceed the 24-hour $PM_{2.5}$ Class I PSD increments by 10 percent at the Breton Wilderness Area, which are a result of support vessels and helicopter traffic associated with the activities.

The impacts to sensitive Class II areas from contributions of all activities as a result of a single proposed lease sale are **minor** because, while maximum increases occur at the Gulf Islands National Seashore for all PSD pollutants and averaging times and increases occur for annual NO_2 at the Breton Wilderness Area, there are no exceedance of the PSD Class II increment.

4.1.2.4 Incomplete or Unavailable Information

This chapter discusses the incomplete or unavailable information needed to assess the impacts from OCS oil- and gas-related activities. Relevant final air modeling study results are unavailable at this time. However, BOEM has used preliminary results, which are provided in **Appendices F-H** in its place. These preliminary results were incorporated into the analysis and is the best science available. Furthermore, BOEM relied on data gathered from recent Gulf of Mexico OCS emission inventories, along with scenarios or estimates of future production. The scenarios provide (1) the assumptions for and estimates of future activities, (2) the rationale for the scenario assumptions and estimates, and (3) the type, frequency, and quantity of emissions from offshore sources associated with a proposed lease sale. Finally, emissions as a result of a proposed lease sale would be regulated at the postlease stage under air quality plan reviews. Additional monitoring measures and air quality dispersion modeling can be requested of the operator if a further analysis is needed and mitigation would be required as necessary.

BOEM determined the projected total emissions that would result from the activities on a lease based on estimated emissions from various OCS non-platform and OCS platform equipment types, such as diesel engines and generators, and the level of offshore activity projected in **Chapter 3.1**. These same emissions estimates were used as inputs for modeling scenarios to predict future impacts. The final study results are not available in time for this Multisale EIS, but BOEM expects that they would be included in future EIS documents. To address data gaps and current impacts, BOEM used the preliminary results, emissions inventory data, available studies, postlease plan information, and current proposed lease sale scenario data, as well as previous proposed action scenario data, to reach the impact conclusions.

The air quality in the GOM can be affected by the pollution emitted from OCS oil- and gas-related sources as well as non-OCS oil- and gas-related sources. These pollution sources can also emit a wide variety of pollutants. To improve air quality and reduce air pollution, the Clean Air

Act Amendments set regulatory limits on pollutants that help to ensure basic health and environmental protection from air pollution. To assess the amount of pollution being emitted, pollutants have to be measured. To determine impacts from these pollutants, emission-related conditions (e.g., rate of emission, height, and distance of sources from coastline) and environmental conditions (e.g., wind speed and direction, humidity, temperature, and height of the atmospheric surface layer where pollutants are transported) are calculated.

Emissions from activities related to prior lease sales are represented by the 2011 GWEI database. Emissions from BOEM's proposed lease sales are estimated from the exploration and development scenario and have been included in the emission inventory that will be used in the model to determine routine impacts. The "Air Quality Modeling in the Gulf of Mexico Region" study includes development of meteorological datasets appropriate for air quality modeling of the study area (which includes a proposed lease sale), comprehensive emissions inventory of all sources in the GOM region, and air quality modeling for the cumulative impacts and visibility assessment. Given that BOEM does not have the final results from the ongoing air quality modeling study yet, for this Multisale EIS, BOEM relied on emissions inventory data, available studies on OCS oil- and gas-related activities, postlease exploration and development plan information, and the preliminary modeling results to fill data gaps. This approach was adequate because it assessed a combination of pollutants from OCS oil- and gas-related activities, non-OCS oil- and gas-related activities, and non-oil and gas activities.

4.1.2.5 Alternative A—Regionwide OCS Lease Sale (The Preferred Alternative)

As mentioned in **Chapter 3**, for a proposed lease sale under **Alternative A**, BOEM projects that no more activity would occur than has resulted in the past from the highest CPA lease sale combined with the highest WPA lease sale. The contribution of routine and accidental events of a proposed lease sale to air quality would result in **minor** impacts because most impacts on the affected resource could be avoided with proper mitigation. The emission sources would not produce emissions sufficient to overwhelm the effects of wind and transport in a single area, causing deterioration of air quality over the regionwide OCS. The incremental contribution of a single regionwide proposed lease sale would likely have a **minor** impact on coastal areas because most impacts on the affected resource could be avoided with proper mitigation. The support vessels and aircraft associated with new platforms is a lead contributor to the increased impacts in the area.

4.1.2.6 Alternative B—Regionwide OCS Proposed Lease Sale Excluding Available Unleased Blocks in the WPA Portion of the Proposed Lease Sale Area

Since this Alternative excludes the available unleased blocks in the WPA, it would result in activity concentrated in the CPA/EPA. As mentioned in **Chapter 3**, for a proposed lease sale under **Alternative A**, BOEM projects that no more activity would occur than has resulted in the past from the highest CPA lease sale combined with the highest WPA lease sale. Therefore, the impacts to Alternative B would be very similar to Alternative A. The incremental contribution of a single CPA/EPA proposed lease sale would likely have a **minor** impact on coastal nonattainment areas because most impacts on the affected resource could be avoided with proper mitigation.

4.1.2.7 Alternative C—Regionwide OCS Proposed Lease Sale Excluding Available Unleased Blocks in the CPA/EPA Portions of the Proposed Lease Sale Area

Since this Alternative excludes the available unleased blocks in the CPA/EPA, it would result in activity concentrated in the WPA. As mentioned in **Chapter 3**, a maximum of 13 percent of the oil production and associated activity and 19 percent of the gas production and associated activity would occur in the WPA. While the WPA is a smaller area with less projected activity than is proposed for the CPA/EPA under Alterative B, the smaller area could decrease impacts to communities from production platforms and also increase total emissions due to travel distances for marine vessels; the potential impacts would remain **minor**. The incremental contribution of a single WPA proposed lease sale would likely have a **minor** impact on coastal areas because most impacts on the affected resource could be avoided with proper mitigation.

4.1.2.8 Alternative D—Alternative A, B, or C, with the Option to Exclude Available Unleased Blocks Subject to the Topographic Features, Live Bottom (Pinnacle Trend), and/or Blocks South of Baldwin County, Alabama, Stipulations

Alternative D would have the same analysis and potential impacts as Alternative A, B, or C because there are so few unleased blocks subject to the Topographic Features, Live Bottom (Pinnacle Trend), and Blocks South of Baldwin County, Alabama, Stipulations. The difference between Alternatives A, B, and C with and without any combination of these stipulations is **minor** for air quality. The impacts under Alternative D would not be much different and likely not even measurable when compared with the other alternatives.

4.1.2.9 Alternative E—No Action

BOEM has concluded in **Chapter 2.3** that the selection of Alternative E would result in no additional discernible impacts to the resources analyzed. Cumulative impacts of current and past activities, however, would continue to occur under this alternative.

4.2 WATER QUALITY

Water quality is a term used to describe the condition or environmental health of a waterbody or resource, reflecting its particular biological, chemical, and physical characteristics and the ability of the waterbody to maintain the ecosystems it supports and influences. It is an important measure for both ecological and human health.

For the purposes of this analysis, the GOM is divided into coastal and offshore waters. Coastal waters are defined to include all bays and estuaries from the Rio Grande River to Florida Bay. Offshore waters are defined to include those waters extending from outside the barrier islands to the Exclusive Economic Zone, located within State waters and the Federal OCS. The inland extent is defined by the CZMA. For the purposes of this chapter, offshore waters are 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 ft; 305 m).

Coastal water impacts associated with routine activities include increases in turbidity resulting from pipeline installation and navigational canal maintenance, discharges of bilge and ballast water from support vessels, and runoff from shore-based facilities. Offshore water impacts associated with routine activities result from discharge of drilling muds and cuttings, produced water, and residual chemicals used during workovers. The discharge of drilling muds and cuttings causes temporary increased turbidity and changes in sediment composition. The discharge of produced water results in increased concentrations of some metals, hydrocarbons, and dissolved solids. Structure installation and removal and pipeline placement disturb the sediments and cause increased turbidity. In addition, offshore water impacts result from supply and service-vessel bilge and ballast water discharges.

The activity associated with a proposed lease sale could contribute a small percentage of activity in addition to existing and future OCS oil- and gas-related activities. The specific discharges, drill muds, cuttings and produced water, and accidents resulting in spills would occur in proportion to production and, therefore, would add a small increase to the currently anticipated impacts. Furthermore, the vessel traffic and related discharges associated with a proposed lease sale are a fraction of the current ongoing commercial shipping and military activity in the Gulf of Mexico. The impact of discharges, sediment disturbances, and accidental releases are a small percentage of the current overall activity and the overall impacts to coastal and offshore waters. These OCS oil- and gas-related sources are related to the activities listed in **Table 4-8** below. This table also illustrates the impact-level conclusions for each impact-producing factor reached in this chapter's impact analysis.

Table 4-8. Water Quality Impact-Producing Factors That Are Reasonably Foreseeable.

Water Quality	Magnitude of Potential Impact[1]				
Impact-Producing Factors	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
Routine Impacts					
Geological Sampling	Negligible	Negligible	Negligible	Negligible	None
Bottom Area Disturbance	Negligible	Negligible	Negligible	Negligible	None
Operational Discharges and Wastes	Negligible to Moderate	Negligible to Moderate	Negligible to Moderate	Negligible to Moderate	None
Pipeline Installation	Negligible	Negligible	Negligible	Negligible	None
Decommissioning and Removal Operations	Negligible	Negligible	Negligible	Negligible	None
Accidental Impacts					
Drilling Fluid Spills	Minor	Minor	Minor	Minor	None
Chemical and Waste Spills	Minor	Minor	Minor	Minor	None

Water Quality	Magnitude of Potential Impact[1]				
Impact-Producing Factors	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
Oil Spills					
Without Mitigation	Moderate	Moderate	Moderate	Moderate	None
With Mitigation	Moderate	Moderate	Moderate	Moderate	None
Cumulative Impacts					
Incremental Contribution[2]	Negligible	Negligible	Negligible	Negligible	None
OCS Oil and Gas[3]	Negligible				
Non-OCS Oil and Gas[4]	Negligible				

[1] The analysis supporting these conclusions is discussed in detail in the "Environmental Consequences" chapter below.

[2] This impact level is the incremental contribution of a single proposed lease sale to all cumulative impacts in the GOM.

[3] This impact level is the cumulative impacts of all past, present, and reasonably foreseeable OCS oil- and gas-related activities in the GOM.

[4] This impact level is the cumulative impacts of all past, present, and reasonably foreseeable activities in the GOM.

Impact-Level Definitions

For the purpose of the following discussion, the significance of impact-producing factors on water quality is discussed below. The criteria for significance reflect consideration of the context and intensity of impact (40 CFR § 1508.27), based on four parameters: detectability (i.e., measurable or detectable impact); duration (i.e., short term, long term); spatial extent (i.e., localized, extensive); and severity (i.e., severe, less than severe). For water quality, the significance criteria have been broadly defined as follows:

- **Negligible** – Impacts are defined as short-term (less than 1 year), localized contaminants and turbidity that present little to no detectable impact.
- **Minor** – Impacts are defined as detectable, short-term, localized, or extensive but less than severe; however, detectable contaminant concentrations may exceed regulatory levels. Minor impacts may have little to no effect on marine life.
- **Moderate** – Impacts are defined as detectable, short term, extensive, and severe; or impacts are detectable, short term or long term, localized and severe; or impacts are detectable, long term, extensive, or localized but less than severe. Moderate impacts may result in acute or chronic effects to marine life.
- **Major** – Impacts are defined as detectable, short term or long term, extensive, and severe; however, major impacts may result in acute or chronic effects to marine life and may potentially cause human health effects.

4.2.1 Description of the Affected Environment

The U.S. portion of the GOM follows the coastline of five states, from the southern tip of Texas moving eastward through Louisiana, Mississippi, Alabama, and ending in the Florida Keys. Including the shorelines of all barrier islands, wetlands, inland bays, and inland bodies of water, the combined coastlines of these states total over 75,639 km (47,000 mi) (USDOC, NOAA, 2008a). The GOM coastal areas comprise over 750 bays, estuaries, and sub-estuary systems that are associated with larger estuaries (USEPA, 2012b). More than 60 percent of U.S. drainage, including outlets from 33 major river systems and 207 estuaries, flows into the GOM (USEPA, 2014c) and has a large influence on water quality. The largest contributing inputs from the U.S coast are from the Mississippi and Atchafalaya Rivers in Louisiana. Additional freshwater inputs into the GOM originate in Mexico, the Yucatán Peninsula, and Cuba.

The physical oceanography of the deep GOM (>1,000 m; 3,281 ft) can be approximated as a two-layer system with an upper layer about 800- to 1,000-m (2,625- to 3,281-ft) deep that is dominated by the Loop Current and associated clockwise (anticyclonic) eddies (Welsh et al., 2009; Inoue et al., 2008); and the lower layer below ~1,000 m (3,281 ft) that has near uniform currents (Welsh et al., 2009; Inoue et al., 2008). Deep waters east of the Mississippi River are affected by the Loop Current and associated warm-core anticyclonic eddies, which consist of clear, low-nutrient water (Muller-Karger et al., 2001). Cold-core cyclonic eddies also form at the edge of the Loop Current and are associated with upwelling and nutrient-rich, high-productivity waters. More details on the physical oceanography of the Gulf of Mexico are available in **Chapter 3.3.2.9.1**.

The primary factors influencing coastal and offshore environments are temperature, salinity, dissolved oxygen, chlorophyll content, nutrients, potential of hydrogen (pH), oxidation reduction potential (Eh), pathogens, transparency (i.e., water clarity, turbidity, or suspended matter), and contaminant concentrations (e.g., heavy metals, hydrocarbons, and other organic compounds).

Surface water temperatures in the Gulf of Mexico vary seasonally from about 29 ºC (84 ºF) in the summer to about 19 ºC (65 ºF) in the winter (Gore, 1992). In the summer, warm water may be found from the surface down to a thermocline at depths to about 160 ft (50 m). Minimum water temperatures below the 5,000-ft (1,524-m) water depth approach 4º C (39 ºF) (Forrest et al., 2007).

The salinity at the sea surface in the offshore Gulf of Mexico is generally 36 parts per thousand (ppt) (Gore, 1992). Lower salinities are characteristic nearshore where fresh water from the rivers mixes with shallow Gulf waters. For example, salinity in open water near the coast may vary between 29 and 32 ppt during fall and winter, but it may decline to 20 ppt during spring and summer due to increased runoff (USDOI, MMS, 2000b).

There is a surface turbidity layer associated with the freshwater plumes from the Mississippi and Atchafalaya Rivers due to suspended sediment in river discharge, especially during seasonal periods of heavy precipitation. High turbidity may extend up to 50 mi (80 km) offshore the

Mississippi River and lesser distances to the east and west along the coast. Outside of these areas, water clarity in the Gulf of Mexico improves, with low levels of suspended sediment.

During summer months, shelf stratification results in a large hypoxic zone on the Louisiana-Texas shelf in bottom waters (Turner et al., 2012; Obenour et. al., 2013). Hypoxia, the condition of having low dissolved oxygen concentration in the water (below 2 mg/L), is caused by excessive nutrients and other oxygen-demanding contaminants (refer to **Chapter 3.3.2.12**). Hypoxia often forms when the water column becomes vertically stratified and mixing between oxygenated surface waters and bottom waters cannot occur. Hypoxia is a widespread phenomenon on the continental shelf of the northern GOM and is the largest hypoxic zone in the western Atlantic Ocean (Rabalais and Turner, 2001). The hypoxic zone in the GOM occurs seasonally and is influenced by the timing of the Mississippi and Atchafalaya River discharge. Formation of the zone is attributed to nutrient influxes and shelf stratification, and the zone persists until wind-driven circulation mixes the water column. Recent estimates of the area of low oxygen by NOAA (USDOC, NOAA, 2015h) as of August 3, 2015, measured 6,474 mi^2 (16,760 km^2) (**Figure 3-20**), an increase from the size measured in 2014 (5,052 mi^2; 13,085 km^2) and larger than the estimated size (5,838 mi^2; 15,120 km^2) forecast by LUMCON (2015) in June 2015. These are the most recent data available, as a planned cruise to collect data in Summer 2016 was cancelled due to ship mechanical issues (USDOC, NOAA, 2016a). The size of the hypoxic zone has been shown to be directly correlated with the flux of nitrogen from the Mississippi River (Turner et al., 2012).

Anthropogenic factors that affect coastal water quality include urban runoff and eroded soil carrying oil and trace metals, agricultural runoff carrying fertilizer (e.g., nutrients including nitrogen and phosphorus), pesticides, fungicides, and herbicides; upstream withdrawals of water for agricultural, industrial, and domestic purposes; contamination by industrial and sewage discharges, dumping, atmospheric fallout, and spills of oil, chemicals, and hazardous materials (refer to **Chapter 3.3.2.3**). Mixing or circulation of coastal water can either improve water quality through flushing or be the source of factors contributing to its decline.

Oil and grease and other contaminants associated with the suspended load from rivers may ultimately reside in the sediments rather than in the water column. For example, a contaminant may react with the mineral particles in the sediment and be removed from the water column (e.g., sorption). Thus, under appropriate conditions, sediments can serve as sinks for contaminants such as metals, nutrients, or organic compounds. However, if sediments are (re)suspended (e.g., due to dredging, a storm event, or in conjunction with seasonal mixing and circulation patterns), the resuspension can lead to a temporary redox flux, including a localized and temporal release of any formerly sorbed metals or nutrients (Caetano et al., 2003; Fanning et al., 1982).

Offshore waters, especially deeper waters, are more directly affected by natural seeps (refer to **Chapter 3.3.2.9.2**). Hydrocarbons enter the Gulf of Mexico through natural seeps at a rate of approximately 980,392 bbl per year (a range of approximately 560,224-1,400,560 bbl per year) (NRC, 2003). Pelagic tar is a common form of hydrocarbon contamination present in the offshore environment of the GOM (USDHS, CG, 2015). Higher tar concentrations were closely correlated with proximity to the Loop Current. Van Vleet et al. (1983) estimated that approximately 7,000 tons (7,112,323 kg, or about 60,000 bbl) of pelagic tar are discharged annually from the GOM into the North Atlantic Ocean and that roughly half of the oil may be brought into the GOM from the Caribbean Sea via the Loop Current, while the remainder appears to originate in the GOM.

The USEPA's *National Coastal Condition Report IV* categorizes coastal waters of the United States based on an evaluation of five indices including water and sediment quality. The water quality index for the GOM's coastal waters was rated fair, and the sediment quality index was rated poor (USEPA, 2012b). Sediment quality poses an impact risk to coastal water quality as contaminants in sediments may be resuspended into the water by anthropogenic activities, storms, or other natural events. Sediments in the GOM coastal region have been found to contain pesticides, metals, polychlorinated biphenyls (PCBs), and occasionally polycyclic aromatic hydrocarbons (PAHs) (USEPA, 2012b).

4.2.2 Environmental Consequences

4.2.2.1 Routine Activities

Impact-producing factors from routine activities that could affect water quality are identified in **Chapter 3.1** and include

- geological sampling and bottom area disturbance including pipeline installation;
- operational discharges and wastes; and
- decommissioning and removal operations.

Geological Sampling and Bottom Area Disturbance Including Pipeline Installation

Geological sampling is performed for geological and geotechnical evaluation, using grab samples, box cores, and gravity, rotary, and piston core methods. Each of these sample techniques disturbs a small area of the seafloor (typically less than 1 ac [0.4 ha]), creating turbidity. Because these areas of disturbance are localized and short term, impacts from turbidity due to bottom-disturbing activities are considered **negligible**.

Bottom area disturbances create turbidity and occur during geological sampling, emplacement and removal of jack-up drill rigs, anchored semisubmersible drill rigs and drillships, platforms, pipelines, and subsea production systems. The emplacement or removal of these structures disturbs areas of the seafloor beneath or adjacent to the structure. Anchored catenary systems may disturb an area of seafloor up to about 5-7 ac (2-3 ha). Trenching for emplacement of pipelines disturbs an area of seafloor up to 2.5 ac (1.0 ha) per kilometer of pipeline (Cranswick, 2001). These bottom-disturbing activities impact water quality when sediments are resuspended, creating turbidity and resulting in a temporary redox flux, including a localized and temporal release of components such as metals or nutrients that were associated with the sediment, as described in

Chapter 4.2.1. Because these areas of disturbance are localized and short term, impacts from turbidity due to bottom-disturbing activities, including pipeline installation, are considered **negligible**.

Operational Discharges and Wastes

Operational wastes and discharges are discussed in detail in **Chapter 3.1.5.1**. These wastes include drilling fluids (also known as muds) and cuttings, which are discussed in detail in **Chapter 3.1.5.1.1**. Water-based muds and cuttings are discharged at the seafloor during drilling of the shallow portion of the well, prior to installation of a surface riser. The resulting splay (pattern of mud distribution) on the seafloor may be up to 2,000 ft (610 m) in radius (British Petroleum, 2015), indicating that turbidity resulting from riserless drilling settles out relatively quickly. After the riser is installed, drilling muds and cuttings are generally discharged from the drilling unit at or near the water surface. The heavier mud and cuttings fall close to the drilling unit; however, the resulting turbidity plume may extend more than a mile from the drilling unit, depending on currents. Similar to bottom-disturbing activities, turbidity generated from drilling muds and cuttings is temporary and would settle out quickly. Unlike bottom-disturbing activities, turbidity from drilling muds and cuttings is less likely to result in a redox flux.

The USEPA (Regions 4 and 6) regulates the discharge of routine operational waste streams generated from offshore oil- and gas-related activities. Section 403 of the Clean Water Act requires that NPDES permits be issued for discharges to State territorial waters, the contiguous zone, and the ocean in compliance with USEPA's regulations for preventing unreasonable degradation of the receiving waters. The authority for the NPDES program is Section 402 of the Clean Water Act, as codified in 40 CFR parts 121-125. The purpose of the NPDES program is to prevent the unreasonable degradation of the marine environment as described in 40 CFR § 125.122. In accordance with definitions stated at 40 CFR § 125.121, "unreasonable degradation of the marine environment" means (1) significant adverse changes in ecosystem diversity, productivity, and stability of the biological community within the area of discharge and surrounding biological communities; (2) threat to human health through direct exposure to pollutants or through consumption of exposed aquatic organisms; or (3) loss of aesthetic, recreational, scientific, or economic values, which is unreasonable in relation to the benefit derived from the discharge. Regulated wastes include drilling fluids, drill cuttings, deck drainage, produced water, produced sand, well treatment fluids, well completion fluids, well workover fluids, sanitary wastes, domestic wastes, and miscellaneous wastes. The bulk of waste materials produced by offshore oil- and gas-related activities are produced water (formation water) and drilling muds and cuttings (USEPA, 2009b). There are two general NPDES permits that cover the Gulf of Mexico. Permit GMG290000, issued by USEPA Region 6, covers the WPA and CPA; and Permit GEG460000, issued by USEPA Region 4, covers the EPA and a small part of the CPA. Updates to this permit are discussed in **Chapter 3.1.5.1**. The USEPA Regions' jurisdictional areas are shown in **Figure 3-10** (USEPA, 2009b).

To meet the goal of preventing unreasonable degradation of the marine environment, Section B of the NPDES permits specifies effluent limitations and monitoring requirements for offshore oil and gas facilities. Discharged regulated wastes may not contain free oil or cause an oil sheen on the water surface, and the oil/grease concentration may not exceed 42 milligrams per liter (mg/L) daily maximum or 29 mg/L monthly average. The discharge of drilling fluids containing oil additive or formation oil is prohibited, except that which adheres to cuttings and certain small volume discharges. Barite, used in drilling fluids, may not contain mercury or cadmium at levels exceeding certain concentrations (1.0 mg/kg mercury and 3.0 mg/kg cadmium). Wastes produced must also be characterized using a whole effluent toxicity test, where a population of mysid shrimp or inland silverside minnows are exposed to the waste stream, and mortality of the population must not exceed 50 percent. The NPDES permits allow a mixing zone as defined at 40 CFR § 125.121 to meet compliance using an approved plume model. The NPDES permits require no discharge within 1,000 m (3,281 ft) of an area of biological concern. Region 4 also requires no discharge within 1,000 m (3,281 ft) of any federally designated dredged material ocean disposal site.

The background (baseline) water quality conditions upstream (upcurrent) from discharging facilities under a proposed action are assumed to be free of "unreasonable degradation of the marine environment," as defined at 40 CFR § 125.121 and summarized in **Chapter 4.2** above. As discussed below, impacts on bottom sediments from the discharge of produced water have been observed at a distance of 1,000 m (3,281 ft).

Impacts on water quality from operational discharges related to a proposed lease sale are expected to be minimal because of the following: (1) USEPA regulations to prevent unreasonable degradation of the marine environment; (2) prohibitions on discharge of some waste types; (3) prohibitions on discharge near sensitive biological communities; (4) monitoring requirements and toxicity testing; (5) mixing zone and dilution factors; (6) operational discharges are temporary in nature; and (7) any effects from elevated turbidity would be short term, localized, and reversible. As such, assuming compliance with applicable regulations, the impacts from the discharge of regulated wastes from routine operations would require no additional mitigation.

The potential toxic effects of water-based and synthetic-based fluid (SBF) drilling muds are discussed in **Chapter 3.1.5.1.1**. The SBF is nonpetroleum manufactured hydrocarbons incorporated into the barite mud matrix. The SBF is well-characterized, has low toxicity and bioaccumulation potentials, and is biodegradable. Also, SBF is not soluble in water and is therefore not expected to adversely affect water quality. A previous study of an SBF spill (USDOI, MMS, 2004a) concluded that the released SBF dispersed into the water, settled to the seafloor, and biodegraded. The SBF would cause a temporary decrease in dissolved oxygen at the sediment/water interface. The discharge of SBF-wetted cuttings is allowed under the USEPA Region 4 and Region 6 NPDES general permits. Discharge of muds containing SBF is prohibited. However, SBF-wetted cuttings may be discharged after free SBF has been removed (up to 9.4% of SBM may be retained on cuttings for ocean discharge). Under the guidance of the NPDES permit, drilling muds can be discharged into the ocean (except in biologically sensitive areas) only if they meet USEPA requirements, which include testing for toxicity prior to discharge. If they fail the toxicity test, the materials cannot be discharged into the ocean. The discharge of drilling muds that meet the required regulatory criteria but include very low quantities of SBFs appear to have minimal and brief impacts to the ocean environment. As such, the impact from discharging drill cuttings is considered **negligible**.

Produced water is discussed in **Chapter 3.1.5.1.2**. Produced water can degrade water and sediment quality in the immediate vicinity of the discharge as it can contain well treatment chemicals, dissolved solids from the geological formation, inorganic and organic chemicals, and radionuclides, some of which are toxic and persist in the marine environment.

The discharge of produced water is allowed under the USEPA Region 4 and Region 6 NPDES general permits. The USEPA requires testing of produced water under the NPDES program. Analyses currently required by the NPDES permit include oil and grease (once per month, by gravimetric Method 10056) and chronic Whole Effluent Toxicity (once per 6 months after 3 consecutive bimonthly tests for USEPA Region 4; once annually after 4 consecutive calendar quarters [if less than 4,599 bbl/day] for USEPA Region 6).

Both Regions 4 and 6 require that well treatment fluids, completion fluids, and workover (WTCW) fluids must not contain priority pollutants, except in trace amounts. This requirement does not currently apply to produced water. Fluids injected into boreholes during hydraulic fracturing are considered well treatment (acidizing) and workover (proppant injection) fluids, as discussed in **Chapter 3.1.5.1.3**. Flowback fluids from hydraulic fracturing are managed as WTCW fluids under the NPDES permit.

When WTCW fluids are intermingled with produced water, the discharges are considered produced water, and the operator may report “no discharge” of WTCW fluids for monitoring and reporting purposes (refer to USEPA Region 4 and Region 6 NPDES permits). The regulated industry self-reports the results of NPDES testing to USEPA for entry into the Integrated Compliance Information System (ICIS) database.

Studies in coastal waters have shown contaminated sediments exist in areas up to 1,000 m (3,280 ft) from a produced-water discharge point, indicating that water quality in that zone has been affected by produced-water discharges (Rabalais et al., 1991). In shallow shelf waters, hydrocarbons from produced water have been shown to accumulate in bottom sediments up to 300 m (984 ft) from an outfall (Rabalais et al., 1991). In offshore waters, contaminated sediments are localized around offshore platforms (NRC, 2003). Therefore, the potential impact from the discharge of produced water is considered **negligible** (beyond 1,000 m; 3,281 ft) to **moderate** (within 1,000 m; 3,281 ft).

Furthermore, the loading of nitrogen and phosphorus in produced water discharged within the entire hypoxic zone are several orders of magnitude smaller than those entering the Gulf of Mexico from rivers. The total nitrogen loading from produced waters is about 0.16 percent and the total phosphorus loading is about 0.013 percent of the nutrient loading coming from the Mississippi and Atchafalaya Rivers (Argonne National Laboratory et al., 2005). As such, the incremental effect of produced water contributing to the effects of the hypoxic zone is considered **negligible**.

Other operational waste streams identified in **Chapter 3.1.5** include bilge, ballast, and fire water; cooling water; deck drainage; and treated domestic and sanitary wastes. These waste streams are also discharged in accordance with the USEPA Region 4 and Region 6 NPDES general permits with requirements for the treatment method and prior analytical testing. Wastes that do not meet regulatory requirements for offshore discharge into the ocean must be properly disposed of or recycled onshore according to State and Federal regulations. Assuming compliance with these requirements under the general NPDES permit, the impact of the discharge on water quality is considered **negligible**.

Discharges from supply/service vessels that support oil and gas operations are discussed in **Chapter 3.1.5.2**. These discharges typically include ballast water, trash and debris, and sanitary and domestic wastes. They are regulated under the NPDES Vessel General Permit (VGP), Small Vessel General Permit (sVGP), and the International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978 (MARPOL 73/78). All discharges of ballast water must comply with applicable U.S. Coast Guard regulations (33 CFR part 151). The NPDES permit defines mandatory ballast water practices required of all vessels. All discharges of oil, including oily mixtures, must not contain oil in quantities that may violate applicable water quality standards pursuant to 40 CFR part 110. Assuming compliance with these regulations, the impact of these discharges is considered **negligible**.

Discharges related to the onshore disposal of OCS oil- and gas-related wastes (**Chapter 3.1.5.3**) are limited to potential point-source runoff from the disposal facilities, which is regulated by the facility NPDES permit. Facility NPDES permits set discharge limits for each characterized waste stream to protect water quality standards of the receiving waters and require routine discharge monitoring to ensure compliance. As such, the impact of regulated point-source runoff on water quality is considered **negligible**.

Decommissioning and Removal Operations

Potential impacts to water quality related to decommissioning and removal operations are discussed in **Chapter 3.1.6**. Requirements for decommissioning are stated at 30 CFR § 250.1703. These activities include permanently plugging all wells, removal of platforms and other facilities, decommissioning of pipelines, and clearing the seafloor of all obstructions. The regulation at 30 CFR § 250.1750 allows pipelines (which may be interpreted to include umbilicals and jumpers that service a subsea completion) to be decommissioned in place if the pipeline does not constitute a hazard (obstruction) to navigation and commercial fishing operations, does not interfere with other OCS uses, and does not have adverse environmental effects. Pipelines decommissioned in place are required to be pigged, flushed, filled with seawater, and cut and plugged with the ends buried unless BSEE's Regional Supervisor of Field Operations waives these requirements. In some cases, umbilicals containing fluids (methanol and hydraulic fluid) may be abandoned in place with BSEE's Regional Supervisor of Field Operations' approval if operational difficulties (such as clogged tubing or a lack of infrastructure) prevent flushing. Water quality impacts may occur from this practice; however, any future release from these umbilicals is expected to be slow and to disperse quickly.

Decommissioning activities may use both explosive and nonexplosive technologies to remove structures to a depth of at least 15 ft (5 m) below the mudline. Prior to decommissioning, all tanks formerly containing oil or hazardous materials are removed, such that the decommissioning may only result in turbidity from the associated bottom-disturbing activity and temporary redox flux that could cause a release of formerly-sorbed components. As stated in **Chapter 3.1.6**, it is anticipated that the majority of decommissioning activities would take place landward of the 800-m (2,625-ft) isobath, where naturally occurring turbidity and impacted sediments are more likely to exist. Because these areas of decommissioning are localized and short term, impacts from turbidity due to the associated bottom-disturbing activities are considered **negligible**.

In summary, as OCS oil- and gas-related routine events are highly regulated, such that effects on water quality are short term, localized, and reversible, and therefore, they would be expected to have a **negligible** impact beyond 1,000 m (3,281 ft) from discharge outfalls.

4.2.2.2 Accidental Events

Impact-producing factors related to OCS oil- and gas-related accidental events are discussed in **Chapter 3.2**. These events primarily involve drilling fluid spills, chemical and waste spills, and oil spills.

Drilling Fluid Spills

Water-based fluid (WBF) and SBF spills may result in elevated turbidity, which would be short term, localized, and reversible. The WBF is normally discharged to the seafloor during riserless drilling, which is allowable due to its low toxicity. For the same reasons, a spill of WBF would have **negligible** impacts. As discussed in **Chapter 3.1.5.1.1**, the SBF has low toxicity, and the discharge of SBF is allowed to the extent that it adheres onto drill cuttings. Both USEPA Regions 4 and 6 permit the discharge of cuttings wetted with SBF as long as the retained SBF amount is below a prescribed percent, meets biodegradation and toxicity requirements, and is not contaminated with the formation oil or PAH. A spill of SBF may cause a temporary increase in biological oxygen demand and locally result in lowered dissolved oxygen in the water column. Also, a spill of SBF may release an oil sheen if formation oil is present in the fluid. Therefore, impacts from a release of SBF are considered to be **minor**. Spills of SBF typically do not require mitigation because SBF sinks in water and naturally biodegrades, seafloor cleanup is technically difficult, and SBF has low toxicity.

Chemical and Waste Spills

Accidental chemical spills could result in temporary localized impacts on water quality,, primarily due to changing pH. Chemicals spills are generally small volume compared with spills of oil and drilling fluids. As stated in **Chapter 3.2.6**, during the period of 2007 to 2014, small chemical spills occurred at an average annual volume of 28 bbl, while large chemical spills occurred at an average annual volume of 758 bbl. These chemical spills normally dissolve in water and dissipate quickly through dilution with no observable effects. Also, many of these chemicals are approved to be commingled in produced water for discharge to the ocean, which is a permitted activity. Therefore, impacts from chemical spills are considered to be **minor** and do not typically require mitigation because of technical feasibility and low toxicity after dilution.

Oil Spills

Oil spills have the greatest potential of all OCS oil- and gas-related activities to affect water quality. Small spills (<1,000 bbl) are not expected to substantially impact water quality in coastal or offshore waters because the oil dissipates quickly through dispersion and weathering while still at sea. Reasonably foreseeable larger spills (≥1,000 bbl), however, could impact water quality in coastal and offshore waters. Scenarios and impacts from very large oil spills are discussed in the *Catastrophic Spill Event Analysis* white paper (USDOI, BOEM, 2017). Oil spills, regardless of size, may allow hydrocarbons to partition into the water column in a dissolved, emulsion, and/or particulate phase. Therefore, impacts from reasonably foreseeable oil spills are considered **moderate**. Mitigation efforts for oil spills may include booming, burning, and the use of dispersants (**Chapter 3.2.8.2**). These methods may cause short-term secondary impacts to water quality, such as the introduction of additional hydrocarbon into the dissolved phase through the use of dispersants and the sinking of hydrocarbon residuals from burning. Since burning and the use of dispersants put additional hydrocarbons into the dissolved phase, impacts to water quality after mitigation efforts are still considered to be **moderate**, because dissolved hydrocarbons extend down into the water column resulting in additional exposure pathways via ingestion and gill respiration, and may result in acute or chronic effects to marine life.

4.2.2.3 Cumulative Impacts

Since routine and operational discharges from OCS oil- and gas-related activities are considered to dilute rapidly in the marine environment, particularly in deep water, this impact analysis considers the potential effects within 1,000 m (3,281 ft) from each OCS oil- and gas-related waste discharge point, since this is the maximum distance of known produced water impacts. As such, impacts on water quality from other discharging facilities, whether pre-existing or as part of a proposed action, are not expected to be additive because the areas of impact generally do not overlap (except where multiple outfalls may exist at a facility). For the same reason, impacts on water quality from discharging facilities are not expected to be additive with the other non-OCS impact-producing factors identified in **Chapter 3.3.2.3**.

The background (baseline) water quality conditions upstream (upcurrent) from discharging facilities under a proposed action are assumed to be free of “unreasonable degradation of the marine environment,” as defined at 40 CFR § 125.121 and summarized in **Chapter 4.2** above.

OCS Oil- and Gas-Related Impacts

As noted in **Chapter 4.2.2.1**, routine OCS oil- and gas-related impacts are considered to be a small contribution to cumulative impacts because they are considered to be **negligible** to **moderate** (refer to **Chapter 3.3.1**). Accidental OCS Program spills of drilling fluids, chemicals, and oil are considered to have **moderate** impacts. However, other contaminant sources unrelated to the OCS Oil and Gas Program contribute significant impacts to water quality in the GOM, as discussed below.

Non-OCS Oil- and Gas-Related Impacts

Impact-producing factors related to non-OCS oil- and gas-related anthropogenic events and natural processes discussed below are described in **Chapter 3.3.2**. These cumulative effects are important for comparison with OCS oil- and gas-related effects relative to their potential impacts on water quality.

Non-OCS oil-and gas-related anthropogenic impacts that are regulated include non-OCS oil-and gas-related activities in State waters, marine vessel activity, LNG ports and terminals, land-based point-source discharges, aquaculture, OCS sand borrowing, maintenance dredging, and dredged material disposal. Discharges as a result of these activities require NDPES permits. Discharges in compliance with regulations, including the NPDES permit and other provisions of the Clean Water Act, are considered negligible because the regulations are risk-based to assure little to no effect on marine life, and monitoring is required to demonstrate compliance. Therefore, the impacts on water quality from these activities are considered **negligible**.

Unregulated anthropogenic activities often have associated impacts on water quality of greater magnitude than regulated activities. Non-OCS oil- and gas-related oil spills present the same impacts as described above for OCS oil- and gas-related spills. Land-based nonpoint-source discharges from uncontained runoff and groundwater discharge are a source of suspended solids, organic matter, nutrients, and other pollutants in river outflow. Nutrients in river outflow cause eutrophication and hypoxia, which can cause unreasonable degradation of the marine environment. Therefore, impacts to water quality from hypoxia are considered **major**. The trend in the hypoxic zone area shows a relatively constant long-term average value of 14,000 km^2 (8,700 mi^2). Pollutants in nonpoint-source discharges are incorporated into bottom sediments within the coastal zone and have the potential to cause impacts to water quality. Therefore, impacts to sediments from nonpoint-source discharges are considered **moderate**.

Discharges associated with military activities (**Chapter 3.3.2.3.2**) were evaluated for their potential impacts to water quality. Debris released to into the GOM as a result of military activities may contain jettisoned fuel, propellants, aluminum, copper, lead, flares, smokes, and obscurants, which can impact water quality. These impacts are short term; therefore, the associated impacts to water quality are considered **minor**.

Potentially polluting shipwrecks (e.g., bulk cargo and fuel leakage from the wreck) and chemical weapon disposal areas, which may cause potential impacts to water quality, are discussed in **Chapters 3.3.2.3.1 and 3.3.2.3.3**. The potential impacts to water quality from shipwrecks are dependent on the type of fuel and cargo present on the wreck and the flow rate of contaminants into the water column. Light oils released from wrecks are localized and generally degrade in the short term, and may present only minor impacts to water quality. Chemical weapons were known to contain extremely toxic substances that, if leaked into the water column, could impact water quality over the long term. Some of the known disposal areas are in shallow waters, and there have been occurrences where trawlers have inadvertently raised 55-gallon drums suspected of containing chemical weapons. Since potential exposures to marine organisms and potentially the food chain from these substances may occur via the water column, the impacts to water quality are considered **moderate**.

Natural events also contribute to cumulative impacts on water quality resulting from oil seeps and turbidity caused by suspended sediment load from rivers and erosion from currents, storms, and downslope sediment transport. Hurricanes, human error, and acts of terrorism may increase the potential for spills. Chapter 3.4 of the Five-Year Program EIS discusses the risk of these low-probability catastrophic discharge events. Oil seeps (**Chapter 3.3.2.9.2**) present the same potential impacts as a small-scale accidental oil spill, except that the seeps may persist over the long term and are not subject to mitigation. Much of the oil from seeps may biodegrade before it reaches the surface. As such, the impacts to water quality are considered minor. Natural turbidity persists in coastal waters due to river outflow and may be intermittent in response to currents, storms, and downslope sediment transport. The effects from the elevated turbidity on water quality would be short term, localized, and reversible, and are considered **minor**.

Impacts from climate change are also considered potential cumulative impacts to water quality. These impacts include decreased oxygen (Long et al., 2016), changing nutrient loads, and altered ocean circulation (Brierley and Kingsford, 2009). Ocean acidification results from the increased concentration of carbon dioxide in the atmosphere (Feely et al., 2009; Doney et al., 2009). Excess atmospheric carbon dioxide partitions into the water column, forming carbonic acid and lowering the seawater pH. This chemical alteration leads to a decrease in carbonate ions, which are used in the formation of calcium carbonate. The natural ocean system buffers the lowered pH by liberating more calcium carbonate ions from seafloor sediments, which raises seawater pH to achieve equilibrium (Broeker and Takahashi, 1977). These ionic concentrations are critical to marine organisms that utilize calcium carbonate in their skeleton and shell formation. This complex process occurs on a global scale, resulting from a multitude of past and present atmospheric carbon dioxide sources, both naturally occurring and of anthropogenic origin, and affecting calcium carbonate deposits in shallow and deep water. Due to the complexity of the ocean acidification process, estimation of the incremental change in seawater pH as a result of a proposed action is beyond the scope of this Multisale EIS.

Incremental Cumulative Impacts

The impacts of routine operational discharges from the OCS oil and gas program on water quality are short term and localized, and are considered negligible to moderate. The potential impacts from reasonably foreseeable oil spills as a result of the proposed action on water quality after mitigation are also short term and are considered minor. The impacts from a proposed lease are a small addition to the cumulative impacts on water quality when compared with inputs from hypoxia, potentially leaking shipwrecks, chemical weapon dumpsites, natural oil seeps, and natural turbidity. The incremental contribution of the routine activities and accidental discharges associated with a proposed lease sale to the cumulative impacts on water quality would be **negligible**.

4.2.2.4 Incomplete or Unavailable Information

In preparation for this Multisale EIS, BOEM has reviewed the latest information available relative to the potential impact-producing factors on water quality, which is presented in **Chapter 3.1**. Much of the information pertaining to water quality impacts from the *Deepwater Horizon* oil spill and response has been discussed in previous NEPA documents, and water quality has recovered from this oil spill and response. BOEM has identified incomplete or unavailable information that may be relevant to reasonably foreseeable impacts on water quality. Much of this information relates to non-OCS oil- and gas- related impacts. Specifically, potentially polluting shipwrecks and chemical weapon disposal areas may cause potential impacts to water quality and the marine environment. There are no publicly available data regarding these potential impacts because no agency has been tasked with this responsibility. It is not foreseen that this information would be publicly available to include in this NEPA analysis regardless of the costs or resources needed. BOEM has used the best available scientific information to date and believes that any additional information would not likely change the ranking of impacts and is not essential to a reasoned choice among alternatives.

4.2.2.5 Alternative A—Regionwide OCS Lease Sale (The Preferred Alternative)

This chapter summarizes the potential impacts of routine activities, accidental events, and cumulative impacts associated with Alternative A on water quality. Under Alternative A, BOEM would hold a regionwide lease sale comprised of the WPA, CPA, and a portion of the EPA. BOEM estimates that a total of 53-984 exploration and delineation wells and 61-767 development and production wells would be drilled and that 221-1,332 mi (355-2,144 km) of pipeline would be installed over a 50-year period. The projected number of drilled wells and miles of pipeline are used as an indicator of total activity, which correlates to the volume of routine operational waste discharged. **Figures 3-5 and 3-6** show the expected duration of exploration/delineation and production well drilling over the 50-year period. As stated in **Chapter 3.1.2**, exploratory drilling activity would likely occur over the course of each lease, but it could begin within 1 year. As discussed in **Chapter 3.1.3**, the majority of development well drilling would likely occur in the first 25 years of each lease, and production of oil and gas could begin by the 3^{rd} year after the lease sale and would generally conclude by the 50^{th} year. Therefore, the discharge of drilling-related operational wastes (drill cuttings and mud, turbidity) and the potential for accidental drilling fluid and chemical/oil spills could be expected to occur from 1 to 25 years after a lease sale. The discharge of produced water, which primarily occurs in shallow water, could be expected from 3 to 50 years after a lease sale.

Routine operational discharges may result in localized negligible impacts from the discharge of SBF-wetted drill cuttings and long-term moderate impacts from the discharge of produced water and WTCW fluids within 1,000 m (3,281 ft) from outfalls. These impacts are unavoidable, and no mitigation exists for these discharges. Based on the previously discussed impact-producing factors for routine activites and accidental events and their estimated level of activity and occurrence across the entire proposed lease sale area, cumulative impacts to water quality under Alternative A is expected to be **minor** to **moderate**. The incremental contribution of the routine activities and accidental events associated with a single proposed lease sale to the overall cumulative impacts to water quality under Alternative A would be **negligible**.

4.2.2.6 Alternative B—Regionwide OCS Proposed Lease Sale Excluding Available Unleased Blocks in the WPA Portion of the Proposed Lease Sale Area

Under Alternative B, BOEM estimates that a total of 33-893 exploration and delineation wells and 46-671 development and production wells would be drilled and that 158-1,020 mi (254-1,641 km) of pipeline would be installed over a 50-year period. The projected number of wells and miles of pipeline are used as an indicator of total activity, which correlates to the volume of routine operational waste discharged, amount of bottom disturbance and drill cuttings causing turbidity, and the potential for drilling fluid and chemical and oil spills. Based on the previously discussed impact-producing factors for routine activities and accidental events, their estimated level of activity, commonly applied mitigating measures,and occurring mostly in the CPA/ and EPA portion of the proposed lease sale area, Alternative B is expected to result in **minor** to **moderate** impacts to water quality. The incremental contribution of the routine activities and accidental events associated with a single proposed lease sale to the overall cumulative impacts to water quality under Alternative B would be **negligible**. As under Alternative A, some localized and short-term negligible impacts as a result of drilling and long-term moderate impacts could occur; moderate impacts may occur from the discharge of produced water within 1,000 m (3,281 ft) of an outfall for site-specific actions. The environmental consequences of a proposed lease sale under Alternative B and the inherent resulting activities to water quality would be slightly smaller than proposed in Alternative A and would be more restricted to the CPA/EPA portion of the proposed lease sale area.

4.2.2.7 Alternative C—Regionwide OCS Proposed Lease Sale Excluding Available Unleased Blocks in the CPA/EPA Portions of the Proposed Lease Sale Area

Under Alternative C, BOEM estimates that a total of 17-91 exploration and delineation wells and 22-96 development and production wells would be drilled and that 65-314 mi (105-505 km) of pipeline would be installed over a 50-year period. While all of the leases issued under this alternative would occur in the WPA portion of the proposed lease sale area, activities such as vessel support and pipeline or coastal infrastructure construction could occur in the CPA portion of the proposed lease sale area. Based on the estimated level of activity and much smaller geographic area, Alternative C is expected to result in **minor** to **moderate** impacts, though fewer impacts than Alternative A or B. The incremental contribution of the routine activities and accidental events associated with a single proposed lease sale to the overall cumulative impacts to water quality under Alternative C would be **negligible**.

4.2.2.8 Alternative D—Alternative A, B, or C, with the Option to Exclude Available Unleased Blocks Subject to the Topographic Features, Live Bottom (Pinnacle Trend), and/or Blocks South of Baldwin County, Alabama, Stipulations

The number of available unleased blocks subject to the Topographic Features, Live Bottom (Pinnacle Trend), and Blocks South of Baldwin County, Alabama, Stipulations is small compared with the number of unleased blocks being offered under Alternatives A, B, or C. Therefore, the activity level (and water quality impacts) that can be expected for Alternative D is similar to Alternative A, B, or C, as applicable, which would be **minor** to **moderate** under all action alternatives. The incremental contribution of the routine activities and accidental events associated with a single proposed lease sale to the overall cumulative impacts to water quality under Alternative D would be **negligible**.

4.2.2.9 Alternative E—No Action

Under Alternative E, there would be no new activities related to the proposed action (no wells drilled and no pipelines installed). The resulting development of oil and gas would most likely be postponed to a future lease sale; therefore, the overall level of OCS oil- and gas-related activity would only be reduced by a small percentage, if any. The environmental impacts expected to result from a proposed action, which is described above, would not occur in the short term, but they would likely be postponed to any future lease sale and likely would not require oil and gas substites from other sources. The cancellation of a proposed lease sale would not significantly change the environmental impacts of overall OCS oil- and gas-related activity in the long term. Therefore, there would be no associated impacts to water quality resulting from a proposed lease sale, and additional impacts would be **none**.

4.3 COASTAL HABITATS

4.3.1 Estuarine Systems (Wetlands and Seagrass/Submerged Vegetation)

The estuarine system is the transition zone between freshwater and marine environments. It can consist of many habitats, including wetlands and submerged vegetation. While some seagrass species can be found farther offshore, the majority is within the coastal area of the GOM and will be covered in this chapter. The approach of the analysis is to focus on the potential impact-producing factors from routine OCS oil- and gas-related activities (i.e., exploration, development, and production), as well as accidental events and cumulative impacts. The potential magnitude for each of these impact-produring factors is provided in **Table 4-9** to help the reader quickly identify the level of potential impacts for each impact-producing factor. The impact-level definitions and the analyses supporting these conclusions are then discussed in detail in this chapter.

Table 4-9. Estuarine Systems Impact-Producing Factors That Are Reasonably Foreseeable.

Estuarine Systems	Magnitude of Potential Impact[1]				
Impact-Producing Factors	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
Routine Impacts					
Pipeline Construction and Maintenance	Negligible	Negligible	Negligible	Negligible	None
Navigation Channel Maintenance Dredging	Negligible to Minor	Negligible to Minor	Negligible to Minor	Negligible to Minor	None
Vessel Operation (support use of navigation channels)	Moderate	Moderate	Minor	Moderate	None
Disposal of OCS Oil- and Gas-Related Wastes	Negligible	Negligible	Negligible	Negligible	None
Construction and Use of Coastal Support Infrastructure	Negligible	Negligible	Negligible	Negligible	None
Accidental Impacts					
Oil Spills	Minor	Minor	Minor	Minor	None
Cumulative Impacts					
Incremental Contribution[2]	Moderate	Moderate	Minor	Moderate	None
OCS Oil and Gas[3]	Major				
Non-OCS Oil and Gas[4]	Major				

[1] The analysis supporting these conclusions is discussed in detail in the "Environmental Consequences" chapter below.
[2] This includes all activities (i.e., routine activities projected to occur and accidental events that could occur) as a result of a single proposed lease sale in the 2017-2022 Five-Year Program.
[3] This includes all activities (i.e., routine activities projected to occur and accidental events that could occur) from past, proposed, and future lease sales.
[4] This includes other past, present, and reasonably foreseeable future activities occurring within the same geographic range and within the same timeframes as a proposed action, but they are not related to the OCS Oil and Gas Program.

In this chapter, BOEM reviewed and analyzed routine OCS oil- and gas-related activities and reasonably foreseeable accidental events. Routine activities associated with a proposed lease sale that take place on the OCS, where wells are drilled and platforms and pipelines are installed, would not impact the wetlands or submerged vegetation that is located miles away. Other routine activities that support offshore oil and gas exploration, such as increased vessel traffic (**Chapter 3.1.4.3**), maintenance dredging of navigation canals (**Chapter 3.1.3.3.4**), pipeline installation (**Chapter 3.1.3.3.1**), disposal of OCS oil- and gas-related wastes (**Chapter 3.1.5**), and construction and maintenance of support infrastructure in the coastal areas (**Chapter 3.1.7**), could potentially impact wetlands. Of these impact-producing factors, vessel traffic was not analyzed with respect to seagrass and submerged vegetation because OCS vessels (due to their size and use of commercial ports) are generally not in areas shallow enough to have large submerged vegetation beds. An analysis of the potential impacts from accidental events, primarily oil spills, associated with a proposed lease sale is presented in this chapter, as is the incremental contribution of a proposed action to the cumulative impacts to wetlands and submerged vegetation. Cumulative impacts were analyzed for OCS oil- and gas-related activities and for other sources that could affect wetlands and submerged vegetation communities (i.e., human impacts, storms, and vessel traffic). Additional factors that could affect estuarine systems include subsidence and sea-level rise.

Impact-Level Definitions

For this analysis, the following definitions were used to categorize impacts to wetlands and submerged vegetation:

- **Negligible** – Little to no measurable impacts in the surrounding habitat (i.e., wetland segment and seagrass bed).
- **Minor** – Noticeable but short-term and localized impacts.
- **Moderate** – Damage to coastal habitats that is noticeable, spatially extensive, and long term or permanent.
- **Major** – Widespread, permanent loss of habitat; changes in species composition and abundance and/or altered ecological function well beyond that of normal variability. Changes would likely be both long lasting and spatially extensive for such an effect.

4.3.1.1 Description of the Affected Environment

The Mississippi Delta sits atop a pile of Mesozoic and Tertiary-aged sediments up to 7.5 mi (12.2 km) thick at the coast and it may be as much as 60,000 ft (18,288 m) or 11.4 mi (18.3 km) thick offshore (Gagliano, 1999). Five major lobes are generally recognized within about the uppermost 50 m (164 ft) of sediments (Britsch and Dunbar, 1993; Frazier, 1967, Figure 1). The oldest lobe contains peat deposits dated as 7,240 years old (Frazier, 1967). The youngest delta lobe of the Mississippi Delta is the Plaquemines-Balize lobe that has been active since the St. Bernard lobe was abandoned about 1,000 years ago. The lower Mississippi River has shifted its course to the Gulf of Mexico every thousand years or so, seeking the most direct path to the sea while building a new deltaic lobe. Older lobes were abandoned to erosion and subsidence as the sediment supply was shut off. Because of the dynamics of delta building and abandonment, the Louisiana coastal area (U.S. Dept. of the Army, COE, 2004) experiences relatively high rates of subsidence relative to more stable coastal areas eastward and westward.

4.3.1.1.1 Wetlands

A recent evaluation of wetland trends in the U.S. covering the period from 2004 to 2009 indicated that in 2009 there were 15.4 million ac (6.2 million ha) of coastal wetlands (including saltwater and freshwater wetlands) in the GOM region, a downward trend of 257,150 ac

(104,065 ha) (Dahl and Stedman, 2013) (**Figure 4-8**). In 2009, there were approximately 3.35 million ac (1.35 million ha) of intertidal wetlands in the GOM coastal region, which was a decline of approximately 2.8 percent since 2004 and represents 99 percent of all intertidal wetland losses across the three coastal regions of the conterminous U.S. These losses have been attributed to the effects of severe coastal storms, land subsidence, sea-level rise, and the construction of levees along the Mississippi River. In coastal Louisiana and Texas, oil, gas, and groundwater extractions have contributed to subsidence and relative sea-level rise (Dahl, 2011). A small percentage is attributed to discrete anthropogenic actions (Dahl and Stedman, 2013).

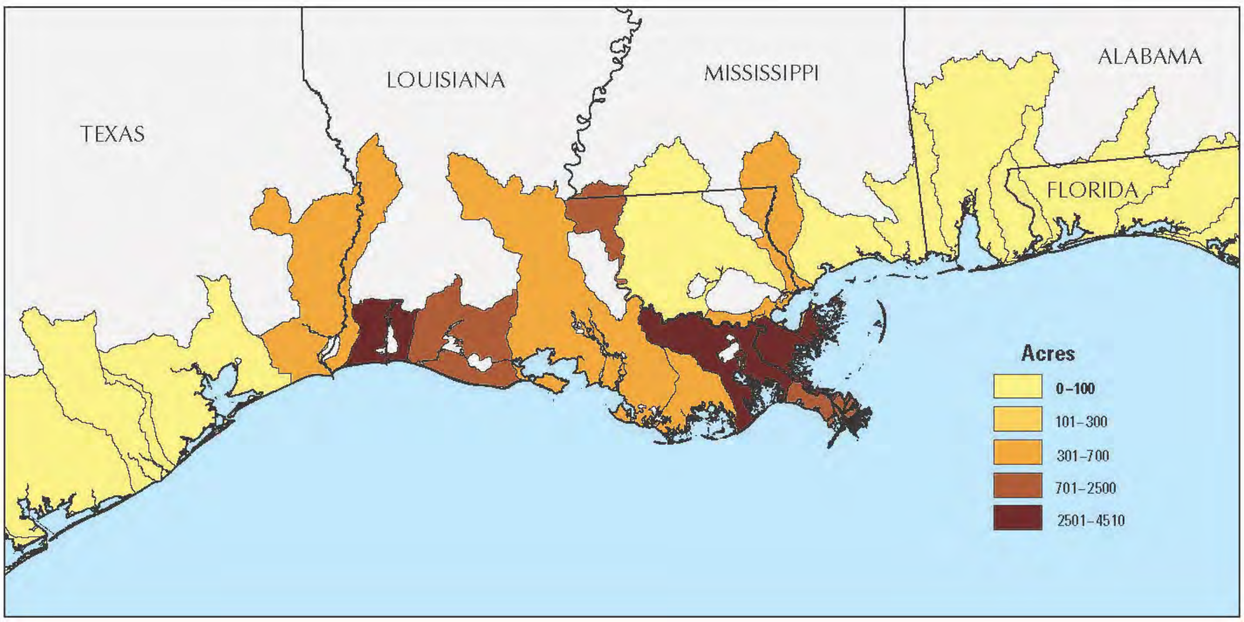

Figure 4-8. Coastal Watersheds of the Upper Gulf of Mexico Showing the Magnitude of Saltwater (intertidal) Wetland Loss to Open Water, 2004 to 2009 (from Dahl and Stedman, 2013).

An estimated 3.9 million ac (1.6 ha) of wetlands existed on the Texas coast in 1992. Approximately 210,600 ac (85,227 ha) had been lost since 1955. Approximately 1.7 million ac (687,966 ha) or 52 percent of the freshwater wetlands were classified as farmed wetlands. The greatest losses were of freshwater emergent and forested wetlands (Moulton et al., 1997). The major cause was faulting and land subsidence due to the withdrawal of underground water and oil and gas (onshore), which has resulted in the submergence of marshes (Moulton et al., 1997).

Coastal Louisiana, which contains about 37 percent of the estuarine herbaceous marshes in the conterminous U.S. and which supports the largest commercial fishery in the lower 48 States (**Chapter 4.10**), currently accounts for about 90 percent of the total coastal wetland loss in the continental U.S. (Couvillion et al., 2011). Coastal Louisiana has undergone a net change in land area of about -1,883 mi^2 (-4,877 km^2) from 1932 to 2010. Ninety-five percent of this loss is due to continual loss of land through subsidence, saltwater intrusion, and other factors. The wetland loss rate for Louisiana has slowed from 42 mi^2/yr (27,000 ac/yr) during the late 1960's to a rate of 16.57 mi^2 (43 km^2) per year from 1985 to 2010 (Couvillion et al., 2011). Separating the causes of such land loss is difficult, but one study estimated that the total of direct and indirect impacts from

OCS oil- and gas-related activities from 1955 to 1978 accounted for 21,863-49,884 ha (54,024-123,266 ac) or 8-17 percent of Louisiana's total wetland loss (Turner and Cahoon, 1987).

In 1999, Mississippi had approximately 64,000 ac (25,900 ha) of vegetated coastal wetlands (State of Mississippi, Department of Marine Resources, 1999). Estuarine wetlands are common in Mississippi and include marshes, mud flats, and forested wetlands. The estuarine marshes around Mississippi Sound and associated bays occur in discontinuous bands. The most extensive coastal wetland areas in Mississippi occur in the eastern Pearl River delta near the Louisiana/Mississippi border and in the Pascagoula River delta area near the Mississippi/Alabama border. Mississippi's wetlands seem to be more stable than those in Louisiana and Alabama (State of Mississippi, Department of Marine Resources, 1999; Wallace, 1996; Couvillion et al., 2011). Urban and suburban growth are suggested as the greatest contributors to direct coastal wetland loss in Mississippi and Alabama.

Alabama has approximately 118,000 ac (47,753 ha) of coastal wetlands. Between 1955 and 1979, 69 percent of the freshwater marsh and 29 percent of the estuarine marsh were lost (Wallace, 1996). Most coastal wetlands in Alabama occur on the Mobile River Delta or along the northern Mississippi Sound. Both Mississippi and Alabama have estuarine intertidal emergent habitats that include salt marsh, as well as intertidal forested/shrub that can include mangroves and other salt-tolerant shrubs. Urban and suburban growths are suggested as the greatest contributors to direct coastal wetland loss in Mississippi and Alabama.

Florida wetlands, at one time estimated to encompass over 20 million ac (8.1 million ha), have been converted through draining, dredging, filling, and flooding, until by 1996, approximately 11.4 million ac (4.6 million ha) remained (Dahl, 2005). Wetland loss rates in Florida, as high as 72,000 ac (29,137 ha) per year from the mid-1950's to the mid-1970's, declined by nearly 80 percent to 5,000 ac (2,023 ha) per year between 1985 and 1996. This decline was due largely to increased regulation and elimination of incentives for wetland drainage. Public education, protection programs, and policies that promoted wetland restoration and creation also contributed (Dahl, 2005).

Florida's salt marshes are most abundant on its central and northern coastlines (Mitsch and Gosselink, 2000). They are dominant along the Big Bend area of the Gulf Coast in low-energy shorelines, sands, lagoons, and bays. Florida's coastal zone contained approximately 21 percent of the estuarine and marine wetlands of the conterminous U.S. and 92 percent of estuarine shrub wetlands in 1996.

Coastal wetlands and barrier islands are complex systems that provide many important functions. One of these functions is as a front line of defense against storm surge. High organic productivity and efficient nutrient recycling are characteristic of coastal wetlands. These wetland corridors provide habitat for a great number and wide diversity of resident plants, invertebrates, fishes, reptiles, birds, and mammals. Marsh environments are particularly important nursery grounds for many economically important fish and shellfish juveniles. The marsh edge, where marsh and open water come together, is particularly important for its higher productivity and greater concentrations of organisms. Emergent plants produce the bulk of the energy that supports salt-marsh dependent animals.

The intensity and frequency of hurricanes in the GOM in recent years has greatly impacted the system of protective barrier islands, beaches, and dunes and associated wetlands along the Gulf Coast. Gulf shorelines have lost existing beach dunes and have experienced a decrease in beach ridge elevations, and barrier islands and wetlands have lost acreage to wave erosion due to hurricanes. As a result of decreased dune and barrier island elevations, as well as associated marshes and backshore and foreshore wetlands, the inland coasts and wetlands are more vulnerable to future hurricanes and wind-driven tidal or storm events.

The *Deepwater Horizon* oil spill was the largest spill ever recorded in the GOM and resulted in the oiling of an extensive portion of the northern Gulf Coast shoreline from Texas to northwest Florida (Florida Panhandle) (OSAT-2, 2011). Oil from the *Deepwater Horizon* explosion and oil spill was documented to have stranded on approximately 687 mi (1,105 km) of marsh shoreline (Nixon et al., 2016). In most areas, the oil stranded along the marsh edge, usually spreading into the marsh no more than about 33-49 ft (10-15 m) perpendicular to the shoreline. In the areas of heaviest oiling, the width of the impacted area was 56.4 ft (17.1 m). Cleanup activities were conducted on 8.9 percent of the affected marsh (Michel et al., 2013a; Deepwater Horizon Natural Resource Damage Assessment Trustees, 2016). Various cleanup techniques were employed, but as of 2012, recovery was not complete and negative effects were ongoing (Zengel et al., 2015).

4.3.1.1.2 Submerged Aquatic Vegetation

Submerged aquatic vegetation can be defined as the collection of benthic plants that settle and grow in the marine and estuarine waters but that do not emerge from it. Distribution and composition of the species present depend on an interrelationship among a number of environmental factors, including water temperature, depth, turbidity, salinity, turbulence, and substrate suitability (Kemp, 1989; Onuf, 1996; Short et al., 2001). In high salinity waters, submerged aquatic vegetation are marine seagrasses that generally occur in relatively shallow and clear protected waters with substrates firm enough to enable colonization (Short et al., 2001). For estuarine waters with low salinity, submerged aquatic vegetation may include several species of vegetation typically considered to be freshwater species but are tolerant of low levels of salinity (Castellanos and Rozas, 2001). In the higher salinity waters of the GOM, there are five true seagrass species and one similar species, although not technically a true seagrass (Zieman, 1982; Short et al., 2001; Berns, 2003; Handley et al., 2007; Cho and May, 2008). Where salinity is lower, there are four genera that routinely comprise the community (Castellanos and Rozas, 2001; Cho and May, 2008). Submerged vegetative habitats are important in carbon sequestration, nutrient cycling, and sediment stabilization (Heck et al., 2003; Duarte et al., 2005; Orth et al., 2006; Frankovich et al., 2011). Submerged vegetation functions as an important habitat for many species by providing protection from predation. It also provides food resources for associated infaunal species, nekton, and other megaherbivores and over wintering waterfowl (Rozas and Odum, 1988; Rooker et al., 1998; Castellanos and Rozas, 2001; Heck et al., 2003; Orth et al., 2006; Maiaro, 2007). One of the more important functions of submerged aquatic vegetation systems is the transfer of primary production from epiphytic algae into the ecosystem via grazing of those epiphytes by secondary consumers; however, without grazers, excessive epiphyte growth can become a hindrance to growth (Howard and Short, 1986; Bologna and Heck, 1999; Heck et al., 2006).

According to the most recent and comprehensive data available, approximately 1.25 million ac (500,000 ha) of seagrass beds are estimated to exist in exposed, shallow coastal/nearshore waters and embayments of the GOM; over 80 percent of these beds are in Florida Bay and Florida coastal waters (calculated from Handley et al., 2007). In the northern GOM from south Texas to Mobile Bay, seagrasses occur in relatively small beds behind barrier islands in bays, lagoons, and coastal waters (**Figure 4-9**), while freshwater submerged aquatic vegetation occurs in the upper regions of estuaries and rivers (Onuf, 1996; Castellanos and Rozas, 2001; Handley et al., 2007). Increased nutrients and sediments from natural (e.g., tropical cyclones) or anthropogenic events (e.g., nutrient loading, sedimentation, and declining water quality) are common and are a significant cause of seagrass declines worldwide (Orth et al., 2006; Carlson and Madley, 2007; Waycott et al., 2009). The USGS's *Seagrass Status and Trends in the Northern Gulf of Mexico: 1940-2002* demonstrated a decrease of seagrass coverage across the northern Gulf of Mexico from the bays of Texas to the Gulf shores of Florida; this loss was from approximately 1.02 million ha (2.52 million ac) estimated in 1992 to approximately 500,000 ha (1.25 million ac) calculated in the 2002 report (Handley et al., 2007). While declines have been documented for different species in different areas, it is difficult to estimate rates of decrease because of the fluctuation of biomass among the different species seasonally and yearly.

Figure 4-9. Seagrass Locations of the Northern Gulf of Mexico.

These coastal habitats also play an important role to ESA-listed species; BOEM consults on these species with FWS and NMFS. These species include nearshore fishes, sea turtles, beach mice, and birds; to read about the protected species that use these habitats, refer to **Chapters 4.7**

(Fish and Invertebrate Resources), **4.9.2** (Sea Turtles), **4.9.3** (Beach Mice), and **4.9.4** (Protected Birds).

4.3.1.2 Environmental Consequences

4.3.1.2.1 Routine Activities

Impact-producing factors and scenarios for routine operations can be found in **Chapter 3.1**. In this chapter, consideration is given to impacts to coastal wetlands, marshes, and submerged aquatic vegetation from routine activities associated with a proposed lease sale. The primary impact-producing factors associated with a proposed lease sale that could affect wetlands and marshes include pipeline emplacement, construction, and maintenance; navigation channel use (vessel traffic) and maintenance dredging; disposal of OCS oil- and gas-related wastes; and use and construction of support infrastructure in these coastal areas.

Pipeline Emplacement

Many existing OCS pipelines make landfall on barrier island and wetland shorelines (**Chapter 3.1.3.3.1**). Approximately 4,971 mi (8,000 km) of OCS oil- and gas-related pipelines cross marsh and upland habitat in Louisiana (USDOI, MMS, 2007c). Wetlands protect pipelines from waves and help to keep the lines buried and in place. At least two studies have shown a connection between land loss and existing pipelines. One study indicated that existing pipelines have caused direct land loss averaging 6 ac (2.43 ha) per linear km of pipeline for the 1955-1978 time period (Bauman and Turner, 1990). Bauman and Turner (1990) also indicated that the widening of OCS pipeline canals does not appear to be an important factor for total net wetland loss in the coastal zone because few pipeline canals are open to navigation. In contrast, Johnston et al. (2009) found that land loss was consistently higher in the vicinity of pipelines compared with more general, regional trends of land loss, suggesting that they contributed to the loss.

Modern pipeline construction typically employs horizontal, directional (trenchless) drilling techniques and open-water routes to the extent possible to avoid damages to estuarine systems (i.e., emergent wetlands and submerged vegetation beds) and beaches. Similar features are now commonly required to minimize any impacts from pipeline landfalls. Currently, no new construction of flotation canals (the most harmful construction technique) is being allowed in vegetated areas (Johnston et al., 2009). There is only 0-1 pipeline landfalls projected to result from a proposed action. About 12-20 ac (5-8 ha) of land loss for the projected 1.2 mi (2 km) of pipeline (based on historic loss rates) are expected from a proposed action. This represents approximately 0.19 percent of the total land loss estimated to occur along the Louisiana coast in 1 year (Couvillion et al., 2011). This estimate does not take into account mitigating measures from the present regulatory programs of Federal or State agencies, modern installation techniques, and the Federal “no net loss” policy. These programs and techniques include compensatory mitigations and less destructive construction methods among others. Because of the regulations and new construction methods, and the limited projection for, at most, one new pipeline landfall, pipeline emplacement would be expected to result in zero to negligible impacts to estuarine habitats.

Five pipeline installation techniques are used throughout the coastal zone of the Gulf of Mexico: upland trenching; jetting; building flotation canals; push-pull ditching; and directional drilling. Of these, flotation canals have the most harmful effects. Push-pull ditching can also be used to effectively minimize wetland impacts when postconstruction mitigation methods such as backfilling are used (Johnston et al., 2009). Trenchless, or directional drilling, is the newest and favored technique in sensitive habitats. This technique is considered to be extremely protective of sensitive habitats. At present, directional drilling is required almost without exception for crossing barrier island and shore faces. Impacts are limited to the access and staging sites for the equipment. By using directional drilling, pipeline installation can occur without having to cut through shore facings, minimizing any erosion and surface habitat disturbance.

Because of the modern installation techniques and mitigations, the small number of projected pipeline landfalls, and the present regulatory programs of the COE and the Gulf Coast States, impacts to wetlands and other estuarine areas from pipeline emplacement associated with a proposed lease sale are expected to be **negligible**.

Dredging

Maintenance dredging of navigation channels and canals is expected to occur with minimal impacts to wetlands. It is assumed that the need for maintenance dredging is proportional to the percentage of the vessel traffic; therefore, a proposed lease sale is expected to only contribute minimally to the need for this dredging, accounting for less than 2 percent, of all traffic using navigation channels in the GOM (**Chapter 3.1.3.3.4**; **Tables 3-2 and 3-7**). Thus, vessel traffic related to a proposed action is only a small portion of the traffic that would require maintenance dredging of channels. However, occasionally a channel would be dredged ahead of its normal maintenance schedule in order to accommodate the transport of large OCS platforms.

Beneficial use of dredged material can be used to enhance and create coastal wetlands after material has been tested for the presence of contaminants. The COE's New Orleans District annually removes approximately 46-53 million m^3 (60-70 million yd^3) of dredged material from 10 Federal navigation channels throughout coastal Louisiana, and approximately 26 percent of this material is used for coastal wetland restoration projects (Creef, official communication, 2011). As a result of the tremendous wetlands land loss in the Louisiana coastal region, the beneficial use of dredged material is expected to increase. Executive Order 11990 (1977) requires that, where appropriate, material from maintenance dredging be considered for use as a sediment supplement in deteriorating wetland areas to enhance and increase wetland acreage. Given the COE's policy of beneficial use of dredged material, increased emphasis has been placed on the use of dredged material for marsh creation.

Despite the beneficial uses described above, dredging and dredged-material disposal can also be detrimental to coastal environments and associated fish and wildlife that use the affected areas for nursery grounds and protection. These impacts may include increased erosion rates, removal of sediments, increased turbidity, and changes in salinity (Onuf, 1996; Kenworthy and

Fonseca, 1996; Erftemeijer and Lewis, 2006). Many of these impacts are reduced through the use of modern disposal practices.

Because of the mitigations and regulations connected with coastal dredging operations, the impacts outlined above are expected to only occur in localized areas over a short amount of time; therefore, the overall level of impact to coastal communities is minor. Due to the small contribution of a proposed action to the need for dredging, impacts to coastal habitats from a proposed action are expected to be **negligible** to **minor**.

Navigation Channels and Vessel Traffic

Most navigation channels projected to be used to support a proposed action are currently used by vessels that support the OCS Program (**Chapter 3.1.3.3.4**; **Table 3-7**). BOEM conservatively estimates that there are approximately 3,013 mi (4,850 km) of Federal navigation channels, bayous, and rivers potentially exposed to OCS oil- and gas-related traffic (**Table 3-7**) in the GOM. Of that total, approximately 1,988 mi (3,200 km) of existing OCS oil- and gas-related navigation canals, bayous, and rivers pass through wetlands, as opposed to passing through large bays, sounds, and lagoons. No new navigation channels are expected as a result of a proposed action, although channels within ports may be created or enlarged. Ports that have navigation channels deep enough to accommodate deeper-draft vessels may expand their infrastructure for better accommodation. An example of a significant expansion of a service base is Port Fourchon in coastal Louisiana. Port Fourchon has deepened the existing channel and has dredged additional new channels to facilitate the expansion. Port Fourchon currently services approximately 90 percent of all deepwater rigs and platforms in the GOM (Loren C. Scott and Associates, 2008), and approximately half of all offshore service vessel trips from 2012 through 2017 are expected to emanate from there (Kaiser, 2015b).

Vessel traffic that may support a proposed action is discussed in **Chapter 3.1.4.3**. Waves generated by boats, ships, barges, and other vessels erode unprotected shorelines and accelerate erosion in areas already affected by natural erosion processes. Much of the service-vessel traffic that is a necessary component of OCS oil- and gas-related activities uses the channels and canals along the Louisiana coast. The most heavily used OCS navigation channel is the channel from Port Fourchon to the GOM, which is heavily armored and is less erodible. However, some of this traffic may also use Bayou Lafourche from Leeville to Port Fourchon, which is not armored. Recent studies have found that armored canals have reduced loss rates compared with unarmored canals (Johnston et al., 2009; Thatcher et al., 2011) and that widening rates have slowed based on maintenance techniques. A recent BOEM and USGS-funded study (Thatcher et al., 2011) examined the susceptibility to erosion of navigation channels based on cover and substrate. They found that canal erosion rates have slowed in recent years. Indirect impacts from wake erosion and saltwater intrusion are expected to result in minor impacts, which are indistinguishable from direct impacts from inshore activities.

A proposed action is estimated to contribute <2 percent of the total traffic from 2017 through 2066. Further details concerning vessel traffic can be found in **Chapter 3.1.4.3**. Navigation channels projected to be used in support of a proposed action are discussed in **Chapter 3.1.3.3.4**. According to BOEM's calculations, all estimated navigational use (both OCS and other) is expected to contribute approximately 336 ha/yr (831 ac/yr) of land loss per year. A proposed action accounts for a relatively small percentage of vessel traffic, and ongoing armoring and regular maintenance along the waterways tends to reduce erosion. However, BOEM's estimates of land loss due to a proposed action range from 28 to 350 ha (~70 to 860 ac) over 70 years. Therefore, **minor** to **moderate** impacts related to the vessel traffic would result from a proposed action.

Disposal of OCS-Related Wastes

Produced sands, oil-based or synthetic-based drilling muds and cuttings, along with fluids from well treatment, workover, and completion activities, would be transported to shore for disposal (**Chapter 3.1.5**). Sufficient disposal capacity is expected to be available in support of a proposed action (**Chapter 3.1.7.2.6**). Produced-water discharges from OCS wells would be too distant from coastal habitats to have anything more than negligible impacts. Because of wetland-protection regulations, no new waste disposal sites are expected to be developed in wetlands. Some seepage or discharges from existing waste sites into adjacent wetland areas may occur and toxic wastes could kill wetland plants, but such seepage resulting from a proposed action is expected to be **negligible**.

Onshore Facilities

Various kinds of onshore facilities service OCS development. All projected new facilities that are attributed to the OCS Program and a proposed action are described in **Chapter 3.1.7**. State and Federal permitting agencies discourage the placement of new facilities and the expansion of existing facilities in wetlands. However, any large construction project in the coastal zone is likely to impact some wetland acreage. Any impacts upon wetlands are mitigated in accordance with the Clean Water Act requirements and the COE's 404 permit and State permitting programs. The high cost of wetland mitigation discourages industry from causing damage to wetlands when building onshore facilities. Since no new facilities are estimated with a proposed action and any possible impacts would be mitigated, the impact level from the associated factors discussed above would be **negligible**.

4.3.1.2.2 Accidental Events

A detailed description of the impact-producing factors and scenario for accidental events from a proposed action are given in **Chapter 3.2**. There is also a risk analysis of oil spills in **Chapter 3.2.1**. The main impact-producing factors that would affect wetlands are oil spills. Chemical spills could also potentially affect wetlands, but they are rare (**Table 3-21**).

Both coastal and offshore oil spills can be caused by large tropical storm events, faulty equipment, or human error. The degree of coastal impact is a function of many factors, including the source oil type, volume, and condition of the oil as it reaches shore, along with the season of the spill and the composition of the wetland plant community affected. Barrier island loss due to hurricanes and anthropogenic factors has reduced protection of wetlands from offshore oil spills, and thus, there is a greater potential for the oiling of coastal wetlands during an accidental event. Refer to the *Catastrophic Spill Event Analysis* white paper for an analysis of impacts from a low-probability catastrophic spill event (USDOI, BOEM, 2017).

Primary Impacts of Oil Spills

The geoprahic distribution of OCS oil- and gas-related activity reduces the probability of unweathered oil reaching coastal wetlands. The OCS production facilities are located at least 3 nmi (3.5 mi; 5.6 km) from coastal wetlands, and much of the OCS oil- and gas-related activity is much farther. Recent trends towards drilling in deeper water have increased the proportion of OCS oil- and gas-related activity in distant locations, many of which are well over 100 nmi (115 mi; 185 km) offshore. This allows for the toxicity of spilled oil from offshore to be greatly reduced or eliminated by weathering and biodegradation (OSAT-2, 2011).

Coastal Spills

The greatest threat to estuarine habitat with regards to an oil spill is from a coastal spill resulting from a vessel accident or pipeline rupture. These spills are a concern since they would be much closer to the estuarine resources. Resulting contact would likely be greater, and toxicity would tend to be greater due to reduced weathering of the oil. While a resulting slick may cause impacts to estuarine habitat, the cleanup effort (i.e., equipment, chemicals, and personnel) can generate additional impacts to the area. Associated foot and vehicular traffic may work oil farther into the sediment than would otherwise occur. Further, physical prevention methods such as booms, barrier berms, and diversions can alter hydrology, specifically changing salinity and water clarity. These changes could cause mortality or reduced productivity in certain species of submerged vegetation because they are only tolerant to certain salinities and light levels (Zieman et al., 1984; Kenworthy and Fonesca, 1996; Frazer et al., 2006). Close monitoring and restrictions on the use of bottom-disturbing equipment would be needed to avoid or minimize those impacts.

Numerous investigators have studied the immediate impacts of oil spills on GOM coastal habitats and elsewhere. Often, seemingly contradictory conclusions are generated from these impact assessments. These contradictions can be explained by differences in parameters, including oil concentrations and chemical composition, season or weather, vegetation type and density, whether the area is in a low- or high-energy environment, preexisting stress level on the vegetation, soil types, anoxic condition of the soil, and water levels. Data indicate that vegetation that is lightly oiled would experience plant die-back, followed by recovery without replanting; therefore, most impacts from light oiling to vegetation are considered to be short term and reversible (Lytle, 1975; DeLaune et al., 1979; Webb et al., 1985). However, Alexander and Webb (1987) noted erosion of the shoreline in areas affected with high oil content and Fischel et al. (1989) found that, while some oiled marsh areas showed recovery of vegetation a year after a spill, other areas had converted to mud flats or open water.

Oil has been found or estimated to persist for at least 17-20 years in low-energy environments like salt marshes (Teal et al., 1992; Baker et al., 1993; Burns et al., 1993; Irvine, 2000). If thick oil is deposited on marsh in low-energy environments, effects on marsh vegetation can be severe and recovery can take decades (Baca et al., 1987; Baker et al., 1993). The sediment type, the anoxic condition of the soils, and whether the area is in a low- or high-energy environment all play a part in the persistence of oil in marsh sediment (Teal and Howarth, 1984), so different shorelines exhibit varying levels of oil persistence (Hayes et al., 1980; Irvine, 2000). Oil is more persistent in anoxic sediments and, as a result of this longer residence time, has the potential to do damage to both marsh vegetation and associated benthic species. Batubara et al. (2014) found that PAH degradation is higher in intertidal than in subtidal wetland soils. For submerged vegetation the same is true, and oil can cause decreased water clarity from coating, and shading could cause reduced chlorophyll production and could lead to a decrease in vegetation (Erftemeijer and Lewis, 2006).

Cleanup activities in marshes that can last years to decades following a spill may accelerate erosion rates and retard recovery rates. While oil can completely foul wetland plants, it is the amount and type of oil, as well as the particular plant that determines recovery. Pezeshki et al. (2000) found that Louisiana crude oil was less damaging and fatal to *Spartina alterniflora* marsh grass than the heavier crudes. Heavy oiling can stop photosynthetic activity, but the *S. alterniflora* produced additional leaves and was able to recover without shoreline cleanup. Except in areas of heavy oiling, it is better to let wetland areas recover naturally (Zengel et al., 2014).

Numerous studies have demonstrated that different species of plants respond differently to oiling. Lin and Mendelssohn (1996) found that Louisiana crude oil applied to three species of marsh plants resulted in no regrowth after 1 year in applications for *Spartina alterniflora* and *S. patens*, but resulted in increased regrowth with increased oil application for *Sagittaria lancifolia*. Kokaly et al. (2011) found that, where the predominant marsh grass is tall (*Phragmites australis)* and less susceptible to being completely oiled, damage is minimized. Judy et al. (2014) also found high tolerance of *P. australis* to weathered and emulsified oil. Coastal marshes impacted by crude oil were observed to show evidence of recovery within 1 year after oil was stranded and covered vegetation, with shoot production observed in heavily oiled areas, although depending on vegetation type, the amount of recovery varied (Delaune and Wright, 2011). When a spill contacts wetlands, one impact from the resulting depletion of marsh vegetation is increased and accelerated erosion, and resulting land loss (Alexander and Webb, 1987). Other studies documented increased erosion at highly oiled sites 26 months after a spill (McClenachan et al., 2013), and oiled islands were found to have greatly increased the rates of erosion, which were 200 percent of the rates of unoiled islands for the first 2.5 years after the oiling (Turner et al., 2016).

Some OCS oil- and gas-related pipelines traverse wetland areas, and pipeline accidents could result in high concentrations of oil directly contacting localized areas of wetland habitats (Fischel et al., 1989). In a study of a coastal pipeline break by Mendelssohn et al. (1993), a 300-bbl spill of Louisiana crude oil impacted 49 ac (20 ha) of wetlands, resulting in considerable short-term effects on the brackish marsh community. While considerable die out of the marsh was noted, recovery of the marsh was complete within 5 years despite the residual hydrocarbons that were found in the marsh sediment. The study also noted that the health of the recolonizing vegetation was not significantly different from the health of vegetation found in the areas that were not oiled. Patterns of land loss were spatially variable, but the rate of loss in the oiled areas was similar to that of the unaffected areas (Mendelssohn et al., 1993).

BOEM's analysis shows that 96 percent of reasonably foreseeable spills from OCS oil-and gas-related activity are <1 bbl, with an average size of <0.05 bbl (Anderson et al., 2012). Because of the small contribution to all such spills from a proposed action, the small size of most spills, and with current safety measures and cleanup guidance in place, the impacts from the impact-producing factors of a coastal spill are expected to be **minor** for estuarine communities.

Offshore Spills

The probabilities of an offshore spill ≥1,000 bbl occurring and contacting environmental features are described in **Chapter 3.2.1.4.8**. In addition, the results of a risk analysis estimating the likelihood of a spill <1,000 bbl occurring and contacting environmental resources (including wetlands) can be found in **Chapter 3.2.1.6.2**. Most spills from the OCS are likely to be distant enough that, should a slick from such a spill make landfall, the volume of oil remaining in the slick is expected to be small. This is because the distance of the spill to the coast allows oil to evaporate, break down, and disperse. Also, due to the tidal flushing on the coast, a slick would be broken down further. However, should spills from the OCS occur proximate to State waters, they could reach shore before much weathering, evaporation, or dispersal had occurred. The probabilities of oil spills ≥1,000 bbl occurring and contacting coastal shorelines varies by location, with the highest probability as a result of a proposed action estimated at 8 percent for one location; for most locations, it was <0.5-1 percent (**Figure E-20**).

Because of the small contribution to all such spills from a proposed action, the distance from coastal communities, improved technologies, and the dynamic nature of the coastal environment, offshore spills are expected to have a **minor** impact on the estuarine community.

Spills that occur in or near Chandeleur Sound or Mississippi Sound could affect estuarine habitat in the Gulf Islands National Seashore (135,458 ac; 545,818 ha), including its Wilderness Area (4,080 ac; 1,651 ha), and the Breton National Wildlife Refuge (18,273 ac; 7,395 ha) with its Wilderness Area (5,000 ac; 2,023 ha). Although the wetland acreage on these islands is small, the wetlands and associated communities make up an important element in the habitat of the islands. The inlets that connect Mississippi Sound with the marsh-fringed estuaries and lagoons within the islands are narrow; therefore, a small percentage of the oil that contacts the Sound side of the islands would be carried by the tides into interior lagoons.

Secondary Impacts of Oil Spills

The short-term effects of oil on wetland plants range from reduction in transpiration and carbon fixation to plant mortality. Depending on the type and quantity of oil in the sediment, mineralization of nutrients can be blocked so that there is less nutrient uptake from the soils. The potential impact of the oiling on the wetland habitats is dependent on several factors, including season. In general, most wetland plants are more susceptible to impacts from oiling during the growing season. Heavy oil causes mortality by coating gas exchange surfaces on the plants and by sealing sediment, which limits nutrient exchange to below-ground tissue. Light weight oils have been found to be more toxic to various marsh plants and associated organisms because the oil alters membrane permeability and disrupts metabolism (Pezeshki et al., 2000). Due to the difference in oil tolerances of various wetland plants, changes in species composition may be evident as a secondary impact of the spill (Pezeshki et al., 2000). Studies indicated that some dominant freshwater marsh species (*Sagittaria lancifolia*) are tolerant to oil fouling and may recover without being cleaned (Lin and Mendelssohn, 1996). Secondary impacts can also include impacts caused by cleanup activities, as discussed below. Because these secondary impacts would not noticeably affect GOM coastal plant communities as a whole, impacts are expected to be **minor**.

Cleanup Activities

Current methods to clean up oil spills include mechanical removal, *in-situ* burning, and bioremediation (refer to **Chapter 3.2.8** for more information). Generally speaking, unless the oiling is extremely heavy, the best approach has been to avoid measures that would further drive oil into the sediment (e.g., vessel and foot traffic) or damage vegetation. Often that means it is best to do nothing and let nature take its course. Oil spill cleanup in coastal marshes remains a problematic issue because wetlands and submerged vegetation can be extremely sensitive to the disturbances associated with cleanup activities. Once a marsh is impacted by an oil spill, a decision must be made concerning the best method of clean up and restoration. Often the best course of action is to let the impacted area(s) recover naturally in order to avoid secondary impacts associated with the cleanup process, such as trampling vegetation, accelerating erosion, and burying oil (Zengel and Michel, 2013; Long and Vandermeulen, 1983: Getter et al., 1984; Mendelssohn et al., 1993). In areas of thick oil deposits, however, a cleanup effort would result in greater recovery (Baker et al., 1993). Because oil spills that require cleanup can have noticeable but localized impacts, cleanup activities are expected to have a **minor** effect on the estuarine community.

Trash and Debris

Trash and debris can be an issue for estuarine communities in that the fauna in these areas could ingest or become entangled in the trash and debris. BOEM and BSEE have addressed the marine debris issue by imposing marine debris awareness and prevention measures on the oil and gas industry through NTL 2015-BSEE-G03, which provides guidance to the industry operators regarding dumping trash and debris into the marine environment and informs operators of regulations set by other regulatory agencies (i.e., USEPA and USCG). Because of the mitigations and awareness, OCS oil- and gas-related trash and debris from a proposed action would result in **negligible** impacts to estuarine habitat.

4.3.1.2.3 Cumulative Impacts

Estuarine habitats are vulnerable to many impact-producing factors from OCS oil- and gas-related and non-OCS oil- and gas-related impacts. Specific OCS oil- and gas-related, impact-producing factors considered in this cumulative analysis include the following: (1) oil spills; (2) OCS oil- and gas-related vessel traffic and navigation canals; (3) construction of OCS oil- and gas-related infrastructure and support structure (including pipelines); and (4) waste disposal. Non-OCS oil and gas-related, impact-producing factors would potentially impact wetland resources, including the following: (1) State oil and gas activities; (2) non-OCS oil- and gas-related vessel traffic and navigation canals; (3) coastal infrastructure and development; (4) natural processes (including hurricanes and subsidence); and (5) sea-level rise (natural causes of subsidence are combined with subsidence caused by extraction and other man made alterations). While each of these factors can cause negative impacts to wetlands, a proposed action would not greatly increase the overall impacts.

OCS Oil- and Gas-Related Impacts

Oil Spills

The potential for coastal oil spills poses a threat for coastal habitats due to the proximity of the spills to these vegetated areas. Aging infrastructure including refineries, onshore production facilities, platforms, and pipelines would continue to be an increasing source of potential spills, but future spills from these types of facilities would be less likely because these older facilities are gradually either structurally updated or replaced by the owner/operator. The number and most likely spill sizes to occur in coastal waters in the future are expected to resemble the patterns that have occurred in the past (not including catastrophic spills), as long as the level of energy-related commercial and recreational activities remains the same.

The *Deepwater Horizon* oil spill was the largest spill ever recorded in the GOM and resulted in the oiling of an extensive portion of the northern Gulf Coast shoreline from Texas to northwest Florida (Florida Panhandle) (OSAT-2, 2011). This event must be considered in the cumulative baseline due to the volume of oil released and the geographic area affected. Oil from the *Deepwater Horizon* explosion and oil spill was documented to have stranded on approximately 687 mi (1,105 km) of marsh shoreline (Nixon et al., 2016). In most areas, the oil stranded along the marsh edge, usually spreading into the marsh no more than about 33-49 ft (10-15 m) perpendicular to the shoreline. In the areas of heaviest oiling, the width of the impacted area was 56.4 ft (17.1 m) (Michel et al., 2013a; Deepwater Horizon Natural Resource Damage Assessment Trustees, 2016).

The Trustees, in their recent PDARP/PEIS (Deepwater Horizon Natural Resource Damage Assessment Trustees, 2016), documented reduced vegetative cover and vegetated (aboveground) biomass, and an increase in marsh edge erosion as a result of the *Deepwater Horizon* oil spill. The *Deepwater Horizon* oil spill resulted in increased rates of coastal erosion, and erosion rates approximately doubled along at least 108 mi (174 km) of shoreline over at least 3 years. These results are similar to the findings from the previous *Deepwater Horizon* studies summarized above.

The Trustees' PDARP/PEIS also documented injury to wetlands caused by spill response, including the following:

- more than 497 mi (800 km) of boom was stranded in marshes, injuring vegetation and birds;
- the removal of stranded boom also affected the wetlands, i.e., vegetation was crushed by airboats, walking boards, foot traffic, and the dragging of the boom across the wetland surface;
- the footprint of stranded boom totaled approximately 52 ac (21 ha; 0.08 mi^2 or 0.21 km^2), which does not include the greater area of wetland swept by the boom when it was moved by storm waves. (Deepwater Horizon Natural Resource Damage Assessment Trustees, 2016); and
- submerged aquatic vegetation habitats were lost from oiling and from physical disturbance as part of response actions. Chandeleur Islands' submerged aquatic vegetation, which is uniquely valuable in the region, was particularly affected, with more than 270 ac (109 ha) of seagrass destroyed. Injuries to submerged aquatic vegetation habitats were also documented within the boundaries of the Gulf Islands National Seashore and in Jean Lafitte National Historical Park and Preserve (Deepwater Horizon Natural Resource Damage Assessment Trustees, 2016).

Cleanup activities were conducted on 8.9 percent of the affected marsh. The most heavily oiled marshes in Barataria Bay, Louisiana, were cleaned using intensive manual and mechanical raking and cutting methods (Michel et al., 2013a). This oil and the associated cleanup activities have impacted wetlands in Louisiana, Mississippi, Alabama, and the panhandle of Florida. While there were localized severe impacts to wetlands, many of the areas affected have recovered or show a moderate level of impact. The oil was released and treated in deep water nearly 48 mi (77 km) from shore. This contributed to the weathering and detoxification of the oil that reached the shoreline. It is too early to determine the cumulative long-term effect of this spill and its contribution to the ongoing marsh loss or the acceleration of that loss. New regulations focusing on improved safety, more regulatory checks, and inspections should decrease the already small likelihood of the occurrence of such spills, which are not part of a proposed action and not reasonably expected to occur. Potential impacts as a result of a low-probability catastrophic event are discussed in the *Catastrophic Spill Event Analysis* white paper (USDOI, BOEM, 2017).

Oil from offshore spills is less likely to reach the estuarine habitat in the same condition it was released due to weathering, potential dispersant treatment, and blockage by barrier islands and shorelines. However, erosion of these barriers by hurricanes and tropical storms has decreased the level of protection afforded the mainland, so flood tides could bring oil through tidal inlets (USDOC, NMFS, 2007a). For many spills, light oiling of vegetated wetlands may occur. Adverse impacts from light oiling that may occur to wetland plants are expected to be short lived, with possible plant die-back, followed by recovery without replanting (Lytle, 1975; DeLaune et al., 1979; Webb et al., 1985). However, spill data from the OCS show that, over decades of activity, tens of thousands of barrels of oil have been spilled (**Chapter 3.2.1.1.3**), not including oil from the *Deepwater Horizon* oil spill. Cumulative OCS oil- and-gas-related spills resulting from all past and present leasing activities are estimated to have a **major** impact on the estuarine community. The incremental contribution of a proposed action, however, to the impacts of cumulative OCS oil- and gas-related spills are expected to be **minor** due to the small contribution to all such spills from a proposed action, the small size of most spills, the distance from estuarine communities, improved technologies, and the dynamic nature of the coastal environment.

Vessel Traffic

Navigation channels in the coastal areas of the GOM support both OCS oil- and gas-related and non-OCS oil- and gas-related vessel traffic. Waves generated by boats, ships, barges, and other vessels erode unprotected shorelines and accelerate erosion in areas already affected by the natural erosion process. BOEM conservatively estimates that there are approximately 3,013 mi (4,850 km) of Federal navigation channels, bayous, and rivers potentially exposed to OCS oil- and gas-related traffic (**Table 3-7**) in the GOM. Conservative estimates show that land loss in Federal navigation channels over the next 70 years from various activities (non-OCS oil- and gas-related and OCS oil- and gas-related) could total approximately 58,000 ac (24,000 ha), while land loss from cumulative OCS oil- and gas-related activities could total approximately 4,500-14,000 ac (1,800-5,500 ha). Adjusted for the approximately 30 percent of channel length that is armored, which greatly reduces erosion, this land loss could total approximately 3,100-9,500 ac (1,300-3,900 ha). This number is considered conservative because open waterways were included in the total length of Federal navigation channels, vessel size was not taken into consideration, and there are sources of erosion to navigation canals other than vessel traffic alone. In addition, approximately half of all offshore service vessel trips from 2017 through 2022 are expected to originate from Port Fourchon, Louisiana (Kaiser, 2015b), and the channel from the Gulf to Port Fourchon is mostly armored, reducing channel widening. If this reliance on Port Fourchon continues, the land loss related to OCS channel use would be less than that estimated above. However, as noted above, some of this traffic may also use Bayou Lafourche from Leeville to Port Fourchon, which is not armored.

Coastal wetland loss is greatest in Louisiana. In the Louisiana Coastal Master Plan (State of Louisiana, Coastal Protection and Restoration Authority, 2012), it is estimated that up to 1,750 mi^2 (4,500 km^2) of land would be lost in the next 50 years. Using BOEM's conservative estimates of waterways exposed to OCS traffic in the Louisiana Coastal Area (LCA) and the average canal widening rate, and comparing those data to estimated land loss in Louisiana over the next 50 years, BOEM estimates that approximately 3.7 percent of the total land loss in Louisiana would occur due to saltwater intrusion, hurricanes, and vessel traffic (OCS oil- and gas-related and non-OCS oil- and gas-related) in navigation canals. Because OCS oil- and gas-related vessel traffic constitutes only 9-27 percent of the total vessel traffic in the GOM, BOEM conservatively estimates that OCS oil- and gas-related vessel traffic could contribute approximately 1 percent or less of the land loss in coastal Louisiana in the next 70 years.

The OCS oil- and gas-related vessel traffic associated with the increased number of offshore platforms is expected to contribute minimally to the need for maintenance dredging activity of navigation canals. The primary support, transfer, and production facilities used for OCS oil- and gas-related activities are located along armored canals and waterways, thus minimizing marsh loss. If new onshore transfer or production facilities would be constructed, access channels may have to be dredged. In the foreseeable future, there would be a continuing need for dredged material for coastal restoration, wetland creation, and to some extent, offshore sediments (e.g., sand, etc.) needed for beach restoration and hurricane protection. Alternative dredged-material disposal methods can be beneficially used for wetland creation or restoration as required by the COE's permitting program.

A proposed action would result in a small incremental increase in cumulative impacts to coastal wetlands associated with OCS oil- and gas-related vessel traffic, and these impacts are offset by the benefits of wetland creation using dredged material from navigation channels. However, due to the permanent loss of hundreds of acres of wetlands, impacts of a proposed action are expected to be **moderate**.

Coastal Infrastructure and Pipelines

Projected new facilities that are attributed to the OCS Program and a proposed lease sale would not be primarily in wetland areas, and no additional service bases, heliports, platform fabrication yards, shipyards, pipe-coating facilities, or refineries are expected (**Chapter 3.3.1.10**). State and Federal permitting agencies discourage the placement of new facilities or expansion of existing facilities in wetlands. However, any sizable coastal facility may have construction impacts in wetlands. Any localized impacts upon wetlands from existing facilities are expected to be mitigated because of the Clean Water Act permitting requirements.

BOEM projects 0-1 new gas processing facilities and 0-1 new pipeline landfalls for a proposed action. A more detailed description of coastal infrastructure is provided in **Chapter 4.14.1**. If a new facility is constructed and a pipeline makes landfall, any impacts upon wetlands would be mitigated in accordance with the Clean Water Act requirements and the COE's 404 permit and State permitting programs. These mitigations and regulatory requirements, such as avoidance and compensatory wetland mitigation, would result in **negligible** impacts to coastal habitats.

Several methods exist to further reduce the number of new pipeline landfalls and their cumulative impact, e.g., the addition of corrosion preventatives to the pipeline itself (reducing the probability of accidental leakage from aging pipelines), in combination with "tie ins" to existing Federal or State pipelines with shore connections. While impacts are greatly reduced by mitigation techniques, existing pipelines were placed using older techniques and have caused, and would continue to cause, impacts to adjacent wetlands. Remaining impacts may include expansion of tidal influence, saltwater intrusion, hydrodynamic alterations, erosion, sediment transport, and habitat conversion (Cox et al., 1997; Morton, 2003; Ko and Day, 2004b). Pipeline maintenance activities that disturb wetlands are very infrequent and are mitigated through regulatory programs, including review by the State of Louisiana through its coastal use permit requirements and through the Clean Water Act Section 404 and Rivers and Harbors Act Section 10 permits.

The continued widening of OCS pipeline canals from erosion does not appear to be an important factor contributing to OCS oil- and gas-related direct land loss. This is because few pipelines are open to navigation and the impact width of these pipelines does not appear to be significantly different from that for pipelines closed to navigation. Based on the projected coastal Louisiana wetlands over 50 years (Couvillion et al., 2013), land loss resulting from new OCS pipeline construction represents <1 percent of the total expected loss. This estimate does not take into account the present regulatory programs and modern installation techniques that would be expected to further mitigate this potential impact. Throughout the 50-year life of a proposed lease sale, a majority of the already old pipeline distribution and production systems would continue to age. This could result in an increasingly large inventory of pipelines and support structures that would need to be replaced or repaired. The replacement and repair of the pipeline system may temporarily impact wetlands in the pipeline corridors, as crews could trample wetland plants or access would have to be dredged; however, if proper mitigation is implemented and maintained, impacts should be minimal and temporary. In the absence of the replacement of these aging pipelines, the potential risk for spills and leaks would increase in coastal and offshore waters. Because of the mitigations and regulations connected with coastal operations, the impacts outlined above are expected to only occur in localized areas over a short amount of time and, therefore, the overall level of impact to estuarine communities is **minor**.

Waste Disposal

Discharge of OCS oil- and gas-related produced water is generally into offshore Gulf waters in accordance with NPDES permits or injected back down into wells; therefore, produced waters from the OCS are not expected to affect coastal wetlands (**Chapter 3.3.1.8**). Produced sands, oil-based or synthetic-based drilling muds and cuttings, along with fluids from well treatment, workover, and completion activities from OCS wells, would be transported to shore for disposal in existing disposal facilities approved by the USEPA for handling these materials. Because of wetland-protection regulations, no new waste disposal site would be developed in wetlands. Some seepage from waste sites into adjacent wetland areas may occur and result in damage to wetland vegetation ranging from sublethal effects to mortality, depending on the toxicity of the waste.

Trash and debris can potentially impact coastal estuarine communities in that the fauna in these areas could ingest or become entangled in the trash and debris. BOEM and BSEE have addressed the marine debris issue by imposing marine debris awareness and prevention measures on the oil and gas industry through NTL 2015-BSEE-G03, as noted above. Past and present OCS oil- and gas-related activity has been the source of trash and debris that finds its way into coastal areas, resulting in **minor** to **moderate** impacts to estuarine habitat. However, due to the small contribution of a proposed action to OCS oil- and gas-related activity, trash and debris from a proposed action would result in **negligible** to **minor** impacts to estuarine habitat.

Non-OCS Oil- and Gas-Related Impacts

State Oil and Gas

Impacts are expected to occur as a result of oil spills, dredging for new pipeline canals, maintenance, and usage of existing rig access canals and drill slips, and for the preparation of new well sites related to State oil and gas activities (**Chapter 3.3.2.1**). Such activity has taken a tremendous toll on coastal wetlands, particularly in Louisiana (Turner et al., 1994). Many pipelines carry product from both OCS oil- and gas-related and non-OCS oil- and gas-related sources. The impacts from these activities are generally the same as those described in the "Routine Activities," "Accidental Events," and "OCS Oil- and Gas-Related Impacts" sections above, although these impacts may be more pronounced due to the proximity of oil and gas activities on State lands to wetlands. Another impact from State oil and gas activity is local subsidence. This subsidence may be due to the extraction of large volumes of oil and gas, sulfur, and salt from subsurface reservoirs (Morton, 2003; Morton et al., 2002 and 2005), but subsidence associated with this factor seems to have slowed greatly over the last three decades as the reservoirs are depleted. Subsidence leads to the drowning of marsh plants and conversion to open water. Because of the continued effects of the extensive dredging of canals through coastal wetlands, impacts from State oil and gas activities are expected to be **major**.

Vessel Traffic and Navigation Canals

Non-OCS oil- and gas-related vessel traffic in the GOM includes commercial shipping, support for State oil and gas activities, commercial and recreational fishing vessels, pleasure boating, and other types of traffic (**Chapter 3.3.2.2**). Waves generated by boats, ships, barges, and other vessels erode unprotected shorelines and accelerate erosion in areas already affected by the natural erosion process. In many cases, this erosion results in wetland loss. Submerged vegetation communities can be damaged by boat anchors, keels, and propellers, and by activities such as trampling, trawling, and State oil- and gas-related or scientific seismic surveys (Sargent et al., 1995; Dunton et al., 1998). Navigation channels require routine maintenance dredging. Minor adverse impacts on wetlands from maintenance dredging are expected because the large majority of the material would be either used to enhance or create marsh, or disposed upon existing disposal areas.

Net land loss due to navigation canals alone can be calculated by comparing erosion rates with beneficial activities such as land gained through the use of dredged sands; refer to the estimates in "OCS Oil- and Gas-Related Impacts" section above.

Wetland losses may be generated by the secondary impacts of saltwater intrusion, flank subsidence, freshwater-reservoir reduction, and deeper tidal penetration. Navigation channels contribute to the negative impacts from saltwater intrusion (Gosselink et al., 1979; Wang, 1987). Wang (1987) developed a model demonstrating that, under certain environmental conditions, saltwater penetrates farther inland in deep navigation channels than in shallower channels, suggesting that navigation channels act as “salt pumps.” This change in salinity results in a substantial habitat transition from freshwater to brackish water, then to saltwater, and ultimately to open-water systems. An example is the construction of the Mississippi River Gulf Outlet, which transformed many of the cypress swamps east of the Mississippi River below New Orleans into open water or areas largely composed of marsh vegetation (*Spartina* spp.) among dead cypress tree trunks. This channel was closed in 2009, and further saltwater intrusion through it has been curtailed.

Onshore activity that would contribute to wetland loss includes additional construction of access channels (for instance at fabrication yards) and onshore construction of new well sites and the expansion or construction of onshore production facilities or receiving and transferring facilities. Most of these facilities would be located in Louisiana. Management activities, including erosion protection and restoration along the edges of these canals, can significantly reduce canal-widening impacts on wetland loss (Johnston et al., 2009; Thatcher et al., 2011). Because of the large contribution to total vessel traffic from non-OCS oil- and gas-related sources, the secondary impacts of navigation canals, such as saltwater intrusion, and the continuing impacts of existing access channels, the impacts from non-OCS oil- and gas-related vessel traffic and related activities are expected to be **major**.

Coastal Infrastructure and Development

The development of estuarine habitat for agricultural, residential, industrial, commercial, and silvicultural (forest expansion) uses (**Chapter 4.14.1**) would continue but with more regulatory and planning constraints required under the Clean Water Act and other regulations. Impacts from these developments, such as alteration to habitat or hydrology, are expected to continue as development in coastal regions around the GOM continues.

Urban and rural development was an important factor in wetland loss in coastal watersheds from 1998 through 2004 (Stedman and Dahl, 2008; Dahl and Stedman, 2013). Agricultural, residential, industrial, and commercial developments, including recreational and tourist developments, have been particularly destructive to coastal wetlands in the GOM by altering habitat and hydrology, which can contribute to the loss of wetland ecosystems through mechanisms such as the addition of pollutants, creating or widening channels, or physical removal of habitat. Indirect effects of such development can include expansion of supporting infrastructure, including roads, bridges, and utilities, with related impacts similar to those mentioned above.

Infrastructure that serves the transportation of foreign oil, such as oil ports, can have wetland impacts to the extent that it is constructed on or adjacent to wetlands. The current regulatory programs, modern construction techniques, and mitigations have reduced recent impacts to wetlands from pipeline installation. The continued presence of existing pipelines can contribute to wetland loss (Johnston et al., 2009). Oil spills caused by leaking or broken pipelines can also impact wetlands.

Existing regulations and development permitting procedures indicate that development-related wetland loss may be slowed. Between 2004 and 2009, there were very few (<1%) estuarine emergent losses attributed to discrete anthropogenic actions that fill or otherwise convert salt marsh areas to uplands. This suggests that marine and estuarine vegetated wetlands (tidal salt marsh and shrubs) have been afforded protection by various State and Federal coastal regulatory measures (Dahl, 2011). Impacts are to some extent offset by coastal restoration programs. Examples of these programs are the Coastal Impact Assistance Program (CIAP), the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA), and the Resources and Ecosystems Sustainability, Tourist Opportunities and Revived Economies of the Gulf Coast States Act (RESTORE Act) (refer to **Chapter 3.3.2.8.3**). Although development-related wetland loss may be slowed, cumulative impacts of past development and related infrastructure are expected to be **moderate**.

Sea-Level Rise

There is increasing new evidence of the importance of the effect of sea-level rise (and marsh subsidence) as it relates to the loss of marsh or changes in marshes, marsh types, and plant diversity (**Chapter 3.3.2.8.1**; Spalding and Hester, 2007). Spalding and Hester (2007) show that the very structure of coastal vegetative communities would likely be altered by sea-level rise because community shifts would be governed by the responses of individual species to new environmental conditions. This could change the vegetative make up of different estuarine habitats and, in turn, could change faunal species presence.

Gulf Coast wetlands tend to occur at low elevations, often between 1 and 2 ft (0.3 and 0.6 m) above sea level. For example, if current projections are realized and sea level increases by 3.5 ft (1.1 m) in Galveston, Texas, by the year 2100 (USEPA, 2013a), most of Texas' coastal wetlands would be under water well before 2100. A more conservative estimate of sea-level rise, known as the AR4 scenario, calls for an increase (globally) of 16 in (41 cm) by 2100 (NRC, 2010). Even this rate of increase would be likely to drown large areas of Gulf Coast wetlands, especially when local, relative sea-level rise is considered. Since 1870, global sea level has risen by about 8 in (20 cm) (USEPA, 2013a). Even at current measured rates of relative sea-level rise, vast areas of Gulf coastal wetlands can be expected to convert to open water as low-lying coastal marshes are inundated (refer to **Chapter 3.3.2.8.1**). Impacts to coastal habitats are expected to be **major** due to the large scale of wetland loss from sea-level rise.

Natural Processes

Along with increased human activities, hurricanes and tropical storms in the GOM have greatly impacted coastal habitats (**Chapter 3.3.2.9**). Intense storms can erode all of the vegetation and soil from some areas of marsh, leaving behind a body of water. An extreme example occurred when hurricanes in 2005 resulted in land loss in Louisiana equivalent to approximately 42 percent of the projected total land loss over the next 50 years (Barras et al., 2003; Barras, 2006). These storms can also remove or bury submerged beds and the barriers that protect these beds from storm surges. This could weaken the existing populations of local submerged vegetation. Seagrass beds have been repeatedly damaged from hurricane overwash of barrier islands onto the beds. The presence of strong tropical storms is a routine background condition in the GOM that contributes to cumulative impacts to wetlands. Natural subsidence has caused wetland loss through compaction of Holocene strata (the rocks and deposits from 10,000 years ago to present). Stephens (2010) has identified faulting mechanisms in coastal Louisiana that actually may be causing what appears as subsidence. Refer to **Chapter 3.3.2.8** for more information.

Whether it is from anthropogenic activities or a natural cycle, increased surface water temperature, sea levels, and storm events have impacts on seagrass beds by adding stress (e.g., burial, salinity changes, turbidity changes etc.) to this sensitive and already stressed ecosystem (Orth et al., 2006). Impacts to estuarine habitats are expected to be **major** because of the large scale of wetland loss from hurricanes and subsidence added to the ongoing stress these communities endure.

Mississippi River Hydromodification

With the construction of levees, dams, and other flood control structures along the Mississippi River, some of the natural processes that built the coastal Louisiana delta have been prevented, which has had serious impacts (**Chapter 3.3.2.10**). Beneficially, the hydromodification has allowed human settlement and development in coastal areas of Louisiana while also providing a stable navigation channel. However, by channelizing the river, it is prevented from flooding and distributing sediments that can build wetlands and counteract the effects of sea-level rise (Yuill et al., 2009). When the Mississippi River floods, it brings nutrient-rich water and alluvial sediments to the wetlands. The water would provide nutrients for wetland vegetation, thereby encouraging plant growth. This growth can stabilize wetland sediments, which makes them less susceptible to erosion. The water also prevents the sediments from drying out and compacting due to loss of pore water and oxidation of organic material (Yuill et al., 2009). Sediment deposition in wetlands is vital for the area to stave off sea-level rise. Without new sediments coming into the marsh, a major contributor to vertical building processes is removed, and the wetlands become more at risk to being inundated by rising sea levels (Yuill et al., 2009). The hydromodification of the Mississippi River has exacerbated these issues by preventing the flooding of coastal wetlands in Louisiana, and as a result, those areas are experiencing some of the highest land-loss rates in the world; therefore, the impact has been **major**. While the cumulative impacts to coastal habitats from the factors described above range from negligible to major, the incremental impact to those habitats from a proposed lease sale would be **moderate**. The relatively small contribution of a proposed lease sale to OCS oil- and gas-related activity would have impacts that are much less than those attributed to several sources, as noted above.

Coastal Restoration Programs

There are numerous coastal restoration programs that have been initiated since 1990 to address the long-term impacts to the Gulf of Mexico coastal ecosystem. These programs include State, Federal, and private funding and have resulted in substantial beneficial impacts to coastal habitats. The Coastal Wetlands Planning, Protection and Restoration Act, the Energy Policy Act of 2005, the Oil Pollution Act of 1990, and the Resources and Ecosystems Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States Act are among the Federal laws providing billions of dollars in funding for coastal restoration in the Gulf Coast States. Louisiana's Coastal Protection and Restoration Authority has produced a Coastal Master Plan for implementing related restoration projects. The various programs involved are discussed in detail in **Chapter 3.3.2.8.3**.

4.3.1.2.4 Incomplete or Unavailable Information

BOEM has identified incomplete or unavailable information regarding estuarine habitat. There is incomplete information about routine impacts, as the scenario forecast is only an estimate, and many global factors can affect OCS oil- and gas-related activity. There also remains unavailable information about the future rates of oil spills, as well as spill locations and volumes of oil.

There are unknowns regarding the future restoration efforts that are being planned, such as what projects would ultimately be constructed and how successful they may be. In addition, the future rates of relative sea-level rise are not known with certainty, and thus, resulting impacts to wetlands are unknown. Future rates of coastal development are unknown, as is the extent of impacts to estuarine systems thereof.

BOEM acknowledges that there remains incomplete or unavailable information that may be relevant to reasonably foreseeable significant impacts on estuarine systems. This incomplete or unavailable information includes potential data on the *Deepwater Horizon*, explosion, oil spill, and response that may be forthcoming. As there is substantial information available since the *Deepwater Horizon* explosion, oil spill, and response, which is included in this Multisale EIS, BOEM believes that the incomplete or unavailable information regarding the effects of the *Deepwater Horizon* explosion, oil spill, and response on estuarine systems would likely not be essential to a reasoned choice among alternatives. Regardless of the costs involved, it is not within BOEM's ability to obtain this information from the NRDA process within the timeline contemplated in the NEPA analysis for this Multisale EIS. BOEM's subject-matter experts have used what scientifically credible information is available in their analyses, and applied it using accepted scientific methodology. BOEM has determined that the information is not essential to a reasoned choice among alternatives. Many studies have been produced that demonstrate the effects of exposure of wetland plants to crude oil, covering a wide range of exposure intensity, longevity, and oil characteristics. Much has been learned about the different survival and recovery rates of various plant species. In addition, studies have been produced regarding the long-term impacts of canal dredging and pipeline installation on wetlands. A proposed lease sale would result in a relatively minor addition to existing routine activities and accidental events, and therefore, the incremental contribution to wetland impacts from a proposed lease sale would be **minor** to **moderate** depending on the alternative and given what is currently known.

The potential for impacts from changes to the affected environment (post-*Deepwater Horizon*) and cumulative impacts remains whether or not the No Action or an action alternative is chosen, and therefore, the incremental contribution from a proposed action would be **minor** relative to cumulative impacts. BOEM used reasonably accepted scientific methodologies to extrapolate from existing information in completing this analysis and formulating the conclusions presented here.

4.3.1.2.5 Alternative A—Regionwide OCS Lease Sale (The Preferred Alternative)

BOEM reviewed and analyzed the impacts to coastal habitats from routine OCS oil- and gas-related activities, reasonably foreseeable accidental events, and the incremental contribution of a proposed action to the cumulative impacts to wetlands. It is expected that impacts from pipeline emplacement would be negligible with only 0-1 pipeline landfalls projected, and any impacts would be reduced or eliminated through mitigation (e.g., avoidance of impacts by use of modern techniques such as directional drilling). Although maintenance dredging of navigation channels and canals is expected to occur, a proposed action is expected to contribute only minimally to the need for this dredging. Secondary impacts to estuarine systems from a proposed action would result from OCS oil- and gas-related vessel traffic contributing to the erosion and widening of navigation channels and canals. Overall, the impacts to these habitats from routine activities associated with a proposed action are expected to be moderate due to the small length of projected onshore pipelines, the minimal contribution to the need for maintenance dredging, the mitigating measures that would be used to further reduce these impacts, and taking into account the estimated hundreds of acres of land loss attributed to vessel traffic related to a proposed action over 70 years.

The greater threat from an oil spill to coastal habitat is from a coastal spill as a result of a nearshore vessel accident or pipeline rupture. While a resulting slick may cause impacts to wetland habitat and surrounding seagrass communities, the equipment, vessel traffic, and personnel used to clean it up can also generate impacts to the area. Close monitoring and restrictions on the use of bottom-disturbing equipment would be needed to avoid or minimize those impacts. In addition, an assessment of the area covered, oil type, and plant composition of the wetland oiled should be made prior to choosing remediation treatment. Offshore oil spills resulting from a proposed action would have a low probability of contacting and damaging large areas of the coast, except in the case of a catastrophic event, which is not reasonably foreseeable and not expected to occur as a result of a proposed lease sale (*Catastrophic Spill Event Analysis* white paper, USDOI, BOEM, 2017). This is because of the distance of the projected OCS oil- and gas-related activity to the coast, the likely weathered and therefore less toxic condition of oil (through evaporation, dilution, and biodegradation) should it reach the coast, and because wetlands are somewhat protected by barrier islands, peninsulas, sand spits, and currents. Overall, impacts to estuarine habitats from oil spills associated with activities related to a proposed action would be expected to be minor because of the distance of most of the resulting activities from the coast, expected weathering of spilled oil, projected low probability of large spills near the coast, resiliency of wetland vegetation, and available cleanup techniques.

Cumulative impacts to wetlands are caused by a variety of factors, including the OCS oil- and gas-related and non-OCS oil- and gas-related activities discussed above. Development pressures in the coastal regions of the GOM have been largely the result of tourism and residential beach side development, and this trend is expected to continue. The cumulative effects of human and natural activities in the coastal area have severely degraded the deltaic processes and have shifted the coastal area from a condition of net land building to one of net land loss. Deltaic Louisiana is expected to continue to experience the greatest loss of wetland habitat in the GOM. Wetland loss is also expected to continue in coastal Texas, Mississippi, Alabama, and Florida, but at slower rates. As a result, numerous coastal restoration programs have been initiated since 1990 to address the long-term impacts to the Gulf of Mexico coastal ecosystem. These programs include State, Federal, and private funding and have resulted in substantial beneficial impacts to coastal habitats. A proposed action represents a small (>4.5%) portion of the cumulative OCS Program that would occur over the 50-year analysis period. Impacts associated with a proposed action are a minimal part of the overall OCS oil- and gas-related impacts. The incremental contribution of a proposed action to the cumulative impacts on coastal wetlands is expected to be **moderate**.

4.3.1.2.6 Alternative B—Regionwide OCS Proposed Lease Sale Excluding Available Unleased Blocks in the WPA Portion of the Proposed Lease Sale Area

The impacts of this alternative would be similar to those of Alternative A, except that there would be **negligible** impacts to coastal wetlands and submerged vegetation in Texas because no new OCS oil- and gas-related activity is forecasted in the WPA along the Texas coast with this alternative. Under Alternative B, the resulting OCS oil- and gas-related activity would be located off the coasts of Louisiana, Mississippi, and western Florida. The greater distance between these activities and the coastal habitats of Texas would reduce the impacts along the Texas coast, whether from routine activities or accidental events. Less use of service bases in Texas is likely, and the distance between oil spills associated with this alternative and the Texas coast is expected to be greater. The incremental contribution of Alternative B to the cumulative impacts on coastal wetlands is expected to be **moderate**.

4.3.1.2.7 Alternative C—Regionwide OCS Proposed Lease Sale Excluding Available Unleased Blocks in the CPA/EPA Portions of the Proposed Lease Sale Area

The impacts of this alternative would be less than those of Alternative A, as only a fraction of the resulting activity forecast for Alternative A is projected under Alternative C. For this alternative, there would be **negligible** impacts to coastal wetlands and submerged vegetation in Louisiana; **negligible** impacts to Mississippi, Alabama, and the panhandle of western Florida; and incrementally more impacts to the wetlands and submerged vegetation of Texas, compared with Alternative A. However, Alternative C would have less potential for impact than Alternative A or B as the level of projected OCS oil- and gas-related activities and impact-producing factors are much less in the WPA. For example, a range of 22-96 production wells are projected to be drilled and developed under Alternative C, whereas 46-671 production wells are projected to occur under Alternative B. The significance of impact-producing factors on estuarine habitats would be less for Alternative C than for Alternative A, as discussed in **Chapter 2.2.2**. Therefore, the incremental contribution of Alternative C to the cumulative impacts on coastal wetlands is expected to be **minor**.

4.3.1.2.8 Alternative D—Alternative D—Alternative A, B, or C, with the Option to Exclude Available Unleased Blocks Subject to the Topographic Features, Live Bottom (Pinnacle Trend), and/or Blocks South of Baldwin County, Alabama, Stipulations

The impacts of this alternative would be nearly identical to those of Alternative A because the available unleased blocks with topographic features do not contain wetlands or submerged vegetation and are too distant (over 25 km; 16 mi) from the coast to have indirect impacts either. In addition, there are only 367 blocks subject to the Topographic Features Stipulation, 74 blocks subject to the Live Bottom (Pinnacle Trend) Stipulation, and 32 blocks subject to the Blocks South of Baldwin County, Alabama, Stipulation. This relatively small percentage of the total number of unleased blocks would not be expected to generate a great contribution to OCS oil- and gas-related activity if leased.

4.3.1.2.9 Alternative E—No Action

If a proposed action does not occur, there would be no additional impacts to estuarine habitats; however, cumulative impacts from all sources, including OCS and non-OCS sources, would be the same as Alternative A. There could be some incremental increase in impacts caused by a compensatory increase in imported oil and gas to offset reduced OCS production, but it would likely be **negligible**.

4.3.2 Coastal Barrier Beaches and Associated Dunes

> *The coastal barrier beaches and associated dunes are those beaches and dunes that line the coast of the northern Gulf of Mexico, including both barrier islands and beaches on the mainland.*

In this chapter, BOEM reviewed and analyzed OCS oil- and gas-related routine activities and reasonably foreseeable accidental events. The approach of the analysis is to focus on the potential impact-producing factors from OCS oil- and gas-related routine activities (i.e., exploration, development, and production), as well as accidental events and cumulative impacts (**Table 4-10**). Routine activities associated with a proposed action that takes place on the OCS, where wells are drilled and platforms and pipelines are installed, would not impact the coastal barrier beaches, which are located from 3 to greater than 200 nmi (3.5 to 230.2 mi; 5.6 to 370.4 km) away. Other routine activities that support offshore oil and gas exploration, such as increased vessel traffic, maintenance dredging of navigation canals, pipeline installation, trash and debris, and construction of support infrastructure in the coastal areas, could potentially impact beaches and dunes. An analysis of the potential impacts from accidental events, primarily oil spills, associated with a proposed action is presented in this chapter, as is the incremental contribution of a proposed action to the cumulative impacts to beaches and dunes. Cumulative Impacts were analyzed for OCS oil- and gas-related activities and for other sources that could affect coastal barrier beaches and dunes (i.e., human impacts, storms, vessel traffic, subsidence, and sea-level rise).

Table 4-10. Coastal Barrier Beaches and Associated Dunes Impact-Producing Factors That Are Reasonably Foreseeable.

Coastal Barrier Beaches and Associated Dunes	Magnitude of Potential Impact[1]				
Impact-Producing Factors	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
Routine Impacts					
Pipeline Construction and Maintenance	Negligible	Negligible	Negligible	Negligible	None
Navigation Channel Maintenance Dredging	Minor	Minor	Minor	Minor	None
Vessel Operation (Support Use of Navigation Channels)	Negligible	Negligible	Negligible	Negligible	None
Disposal of OCS-Related Wastes	Negligible	Negligible	Negligible	Negligible	None
Construction and Use of Coastal Support Infrastructure	Negligible	Negligible	Negligible	Negligible	None
Accidental Impacts					
Oil Spills	Minor	Minor	Minor	Minor	None
Cumulative Impacts					
Incremental Contribution[2]	Minor	Minor	Minor	Minor	None
OCS Oil and Gas[3]	Major				
Non-OCS Oil and Gas[4]	Major				

[1] The analysis supporting these conclusions is discussed in detail in the "Environmental Consequences" chapter below.
[2] This includes all activities (i.e., routine activities projected to occur and accidental events that could occur) as a result of a single proposed lease sale in the 2017-2022 Five-Year Program.
[3] This includes all activities (i.e., routine activities projected to occur and accidental events that could occur) from past, proposed, and future lease sales.
[4] This includes other past, present, and reasonably foreseeable future activities occurring within the same geographic range and within the same timeframes as a proposed action, but they are not related to the OCS Oil and Gas Program.

Impact-Level Definitions

For this analysis, the following definitions were used to categorize impacts to coastal beaches and dunes:

- **Negligible** – Little to no measurable impacts in species composition and abundance and/or altering of beach profile or ecological function.
- **Minor** – Measureable but short-term and localized impacts to species composition and abundance and/or altering of beach profile or ecological function.
- **Moderate** – Damage to coastal habitats (impacts to species composition and abundance and/or altering of beach profile or ecological function) that is detectable, spatially extensive, but temporary and not severe. Can also be used to describe localized land loss.
- **Major** – Severe, bringing about detectable changes in species composition and abundance and/or altering of beach profile or ecological function well beyond that of normal variability. Changes would likely need to be both long-lasting and spatially extensive to have such an effect.

4.3.2.1 Description of the Affected Environment

Barrier beaches and associated dune habitats from Texas to the Florida panhandle may be impacted by activities resulting from a proposed action. These areas are comprised of the following geologic subareas:

- the barrier island complex of southern Texas;
- the Chenier Plain of eastern Texas and western Louisiana;
- the Mississippi River Delta complex of southeastern Louisiana;
- the barrier-island and Pleistocene Plain complex of Mississippi and Alabama; and
- the Florida panhandle.

Barrier islands make up more than two-thirds of the northern GOM shore (Morton et al., 2004). These shorelines are usually sandy beaches that can be divided into several interrelated environments. Generally, beaches consist of a shoreface, foreshore, and backshore. The shoreface slopes downward and seaward from the low-tidal water line, under the water. The nonvegetated foreshore slopes up from the water to the beach berm-crest. The backshore is found between the beach berm-crest and the dunes, and may be sparsely vegetated. 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.

Tropical storms and hurricanes are normal occurrences in the GOM and along the coast. The GOM has been hit extremely hard by very powerful hurricanes. These storms caused damage to barrier islands and beaches in all five of the Gulf Coast States. Beaches can recover naturally from the damage done by storms, but it may take many years (Houser et al., 2015). During storms, large waves can overwash lower coastal barriers, creating overwash fans or terraces behind and between the dunes. With time, opportunistic plants would 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 consists of scrubby woody vegetation, marshes, and forested wetlands. Saline and freshwater ponds may be found among the dunes and on the landward flats. 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.

Once formed, barrier islands are not static landforms; they are dynamic, with winds and waves constantly reworking and moving the barrier island sand, wherefore barrier landform configurations continually change, accreting and eroding, in response to these environmental conditions. Landform changes can be seasonal and cyclical, such as seen with the onshore movement of sand during the summer and offshore movement during the winter. Noncyclical changes in landforms can be progressive, causing barrier island movement. Barrier islands are also periodically reworked due to hurricanes and tropical storms.

Transgressive and regressive landforms are common across the GOM. A transgressive sequence moves the shore landward. Transgressive coastal landforms around the GOM have low profiles and are characterized by narrow widths; low, sparsely vegetated, and discontinuous dunes; and numerous, closely spaced, active washover channels. A regressive sequence moves the shore seaward. Regressive barriers have high and broad dune profiles. These thick accumulations of sand may form parallel ridges.

Barrier islands, particularly vegetated ones with freshwater and or saltwater pools, may serve as habitat for a wide variety of animal life, especially birds (**Chapter 4.8**), including threatened and endangered species. The islands and spits protect the bays, lagoons, estuaries, salt marshes, seagrass beds, and other wetland environments, some of which may contain threatened or endangered species (**Chapter 4.9**). Barrier islands in the northern GOM extending from Atchafalaya Bay, Louisiana, to Mobile Bay, Alabama, are disintegrating rapidly as a result of combined physical processes involving sediment availability, sediment transport, and sea-level rise.

Oil from the *Deepwater Horizon* explosion and oil spill was documented by shoreline assessment teams to have stranded on approximately 600 mi (965 km) of beach shoreline (Deepwater Horizon Natural Resource Damage Assessment Trustees, 2016). Cleanup activities were conducted on 410 mi (660 km) of the affected beach. Two years after the spill, some oil remained on 427 mi (687 km) but at much lesser amounts (Michel et al., 2013a; OSAT-2, 2011). Beach shorelines were affected by oiling and response actions, with the most severe cleanup actions killing all creatures that burrow in beach sand (Deepwater Horizon Natural Resource Damage Assessment Trustees, 2016). As beaches experienced erosion and deposition, oil would become buried, exposed, and remobilized multiple times, resulting in chronic re-oiling. Tropical

Storm Lee (2011) and Hurricane Isaac (2012) caused extensive beach erosion and remobilization of oil residues. Oil residue mats were observed between the toe of the beach and the first offshore sand bar, providing another source of chronic sources of surface residue balls and surface residue patties (Michel et al., 2013a). Over time, more of the remaining oil has continued to be removed, while toxicity has decreased as the oil is further weathered. The buried supratidal samples underwent less biodegradation due to lack of oxygen, but they were estimated in 2011 to decrease to 20 percent of current levels within the next 5 years (OSAT-2, 2011).

As a result of the *Deepwater Horizon* explosion and oil spill, protective berms were constructed in Louisiana seaward of barrier islands to protect the inland marshes, wetlands, and seagrasses from incoming oil associated with this large spill. The berms were ineffective in stopping the oil, and none of the estimates of how much oil was collected on the berms was much more than 1,000 bbl (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2011). It took approximately 5 months to build roughly 12.5 mi (20.1 km) of berms at a cost of approximately $220 million. Long-term effects can include changes in hydrology and sediment transport along the coastal barrier islands, the loss of sand resources, and adverse impacts to benthic and pelagic organisms (Martinez et al., 2012). As a result, such berms are not likely to be approved as a response measure in the future.

Texas Barrier Island Complex

The barrier islands in Texas extend from the Mexican border to Galveston Bay. The GOM coastline of Texas is about 367 mi (590 km) long. The average rate of erosion of the Texas shoreline, from 1950 through 2012, was 2.3 ft (0.7 m) per year. While some of the coast has been gaining land, rates vary by location, with numerous locations experiencing rates of more than 11.5 ft (3.5 m) per year (State of Texas, General Land Office, 2015).

The barrier islands are mostly accreted sediments that were reworked from river deposits, previously accreted Gulf shores, bay and lagoon sediments, and exposed seafloors (White et al., 1986). The Texas coast has both low- and high-profile barriers. South Padre Island is an example of a low-profile barrier, with its narrow shape and discontinuous frontal dunes that are inundated by storm surges. Matagorda Island is an example of a high-profile barrier, which is typically wide with continuous, well-vegetated dune ridges (Morton et al., 2004).

Padre Island National Seashore encompasses 70 mi (112 km) of coastline, making it the longest stretch of undeveloped barrier island in the world. It borders the Laguna Madre, a hypersaline lagoon, and it provides habitat for numerous plants and animals. It also serves as an important nesting ground for the endangered Kemp's ridley sea turtles.

Chenier Plain

The Chenier Plain of eastern Texas and western Louisiana began developing about 2,800 years ago. During that period, Mississippi River Delta sediments were intermittently eroded, reworked, and carried into the Chenier Plain area by storms and coastal currents. This deposition gathered huge volumes of mud and sand, forming a shoreface that slopes very gently, almost imperceptibly, downward for a very long distance offshore. This shallow mud bottom is viscous and elastic, which generates hydrodynamic friction (Bea et al., 1983). Hence, wave energies along the barrier shorelines of the Chenier Plain are greatly reduced, causing minimal longshore sediment transport along the Chenier Plain (USDOI, GS, 1988). More recently, this shoreline has been eroding as sea level rises, converting most of this coast to transgressive shorelines.

The barrier beaches of the Chenier Plain are generally narrow, low, and sediment starved due to the nature of coastal currents and the shoreface. In some places, beach erosion has exposed relic marsh platforms that were buried by past overwash events, resulting in beaches composed of shelly sand, or discontinuous mud deposits among muddy sands.

Mississippi River Delta Complex

The Mississippi River Delta region comprises much of coastal Louisiana and adjacent Mississippi. It stretches from the Atchafalaya Bay to the Chandeleur Islands of Louisiana. Most barrier shorelines of the Mississippi River Delta are transgressive and trace the seaward remains of a series of five abandoned deltas. As a lobe of the Delta is abandoned by a shift in drainage, that portion begins to subside slowly into the sea and is further reduced by erosion. Some of the sediment may be reworked by wind and waves into barrier islands. The Chandeleur Islands and Grand Isle are examples of this. Gradually, woodland vegetation became established on the dune sands (e.g., oaks and oleander). Salty meadows, marshes, and lagoons occupy the lower terrain. The shorefaces of the Mississippi River Delta complex slope gently seaward, which reduces wave energies at the shorelines. Mud flats are exposed during very low tidal events. This slope is not as shallow as that found off the Chenier Plain.

The barrier islands associated with the Mississippi River Delta are at the greatest risk for degradation from hurricanes and sand budget deficits; these include the Chandeleur-Breton Island, Timbalier Island, and Isle Dernieres chains in Louisiana. These chains of individual transgressive barrier island segments have progressively diminished in size while migrating landward (McBride et al., 1992). Most of southeastern Louisiana's barrier beaches are composed of medium to coarse sand. Most dune zones of the Mississippi River Delta contain low, single-line dune ridges that may be sparsely to heavily vegetated.

Mississippi and Alabama Coasts

The Dog Keys define the Mississippi Sound of Mississippi and Alabama. The Mississippi-Alabama barrier islands have experienced increased rates of land loss since the mid-1800's because of storms and sand budget deficits. The centers of most of the islands are migrating westward (Richmond, 1962; Otvos, 1979). These islands generally have high beach ridges and prominent sand dunes. They are well vegetated among and behind the dunes and around ponds.

Mississippi has about 33.9 mi (54.6 km) of barrier beaches (USDOI, FWS, 1999). The western district of the Gulf Islands National Seashore is located in Mississippi. Some of the habitats representative of coastal barrier and seagrass ecosystems are found on or behind Horn and Petit Bois Islands, which were designated as Wilderness Areas by Congress in 1978 through the establishment of the Gulf Islands Wilderness Area.

Dauphin Island, Alabama, represents about another 7 mi (11 km) of barrier beaches. The beaches are separated by wide passes with deep channels. Shoals (a place where a sea, river, or other body of water is shallow) are typically adjacent to these barriers. Unlike the other barrier islands, Dauphin Island is essentially a low-profile, transgressive barrier island, except for its eastern end. The western end is characterized by small dunes and many washover fans, exposed marsh deposits, and tree stumps exposed in the surf zone. The Gulf Shores region of Alabama extends from Mobile Point eastward to the Florida boundary, a distance of about 31 mi (50 km) (Smith, 1984).

Florida Panhandle

The Florida panhandle has extensive beaches with multiple habitats, including sandy mainland beaches, broad peninsulas, and narrow barrier islands. Two long, narrow barrier islands (Santa Rosa Island and Perdido Key) form the Gulf shore west of Destin and are part of the Gulf Islands National Seashore (**Figure 4-26** in **Chapter 4.12.1**). Both can be reached by road and experience tourism in the form of camping, picnicking, swimming, bird watching, and fishing.

Coastal land loss from shoreline change in the Florida panhandle is associated with erosion of sandy beaches and barrier islands, especially around inlets, while bays and lagoons tend to experience lower loss rates because the waterbodies are generally small or protected by erosion control structures (Morton et al., 2004). The average long-term erosion rate, from the 1800's through 2001, was estimated as -2.6 ft/yr (-0.8 m/yr), which is lower than the other Gulf Coast States. This can be attributed to relatively low wave energy and frequent beach nourishment (Morton et al., 2004).

These barrier beaches and dune habitats also play an important role to ESA-listed species; BOEM consults on these species with FWS. These species include sea turtles, beach mice, and birds; to read about the protected species that use these habitats, refer to **Chapters 4.9.2, 4.9.3, and 4.9.4**, respectively.

4.3.2.2 Environmental Consequences

4.3.2.2.1 Routine Activities

This chapter considers impacts from routine activities associated with a proposed action to the physical shape and structure of barrier beaches and associated dunes. The primary impact-producing factors from routine activities associated with a proposed action that could affect these environments include pipeline emplacements, vessel traffic (navigation channel use) and dredging, trash and debris, and infrastructure construction.

Pipeline Emplacements

Many existing OCS Program-related pipelines made landfall on barrier islands and shorelines (**Chapter 3.1.3.3.1**). Pipeline landfall sites on barrier islands could potentially cause accelerated beach erosion and island breaching. This occurs when pipeline canals are dug through beaches, and then widen over time. A proposed action is not expected to include new pipelines that make landfall on barrier islands or mainland beaches (0-1 new pipeline landfalls are projected). Modern pipeline construction typically employs horizontal, directional (trenchless) drilling techniques and open-water routes to the extent possible to avoid damages to estuarine systems and beaches. Similar features are now commonly required to minimize any impacts from pipeline landfalls. Studies have shown that little to no impact to barrier beaches results from techniques like directional pipeline emplacement (LeBlanc, 1985; Wicker et al., 1989). Federal and State regulatory programs and permitting processes encourage the use of directional boring technology to reduce and perhaps eliminate impacts to barrier beaches or dunes. Because of the regulations and new construction methods, and the limited projection for, at most, one new pipeline landfall, the effects on barrier beaches and dunes from pipeline laying activities associated with a proposed lease sale are expected to be **negligible.**

Vessel Traffic and Dredging

Vessel traffic that may support a proposed action and navigation channels projected to be used in support of a proposed action are discussed in **Chapters 3.1.3.3.4 and 3.1.4.3** and are shown in **Table 3-7**. As a result of a proposed action, it is not expected that the number of OCS oil- and gas-related navigation channels would change. Waves generated by boats, ships, barges, and other vessels erode unprotected shorelines and accelerate erosion in coastal barrier beaches already affected by natural erosion processes. Only a limited reach of the navigation channels cross the shoreline adjacent to beaches or dunes, and these reaches are generally armored with rock. The existing armored navigation channels minimize or eliminate the potential for shoreline erosion from vessel traffic.

A proposed action is estimated to account for <2 percent of the service-vessel traffic in navigation canals associated with the OCS Program from 2017 through 2066 (**Chapters 3.1.3.3.4 and 3.1.4.3**; **Tables 3-2 and 3-7**). Erosion of coastal barrier beaches and associated dunes from vessel traffic resulting from a proposed action are expected to be **negligible** because of the small percentage of total vessel traffic related to the OCS Program and the armoring of the channels most highly used for OCS oil- and gas-related activities.

Periodic maintenance dredging is expected in existing navigation channels through barrier passes and associated bar channels. Maintenance dredging of barrier inlets and bar channels removes sediment from the system, contributing to beach erosion. Materials from maintenance dredging of bar and pass channels are typically discharged to nearby ocean dumping sites in the GOM (**Chapter 3.3.2.8.5**) or they are used for marsh creation or beach nourishment projects as part of mitigation (Morton, 2008). Jetties or bar channels serve as sediment sinks by intercepting sediment in longshore littoral drift (the movement of sediment along the shoreline by currents).

Negative effects of sediment sinks created by jetties can be mitigated by filling the downdrift side of the jetty with appropriate sediment. These dredging activities are permitted, regulated, and coordinated by the COE with the appropriate State and Federal resource agencies. Effects from maintenance dredging related to a proposed action on coastal barrier beaches and associated dunes are expected to be **minor** due to the small contribution from a proposed action to total channel use and the offsetting effects of beach nourishment.

Coastal Infrastructure Construction

Projected new facilities that are attributed to the OCS Program and a proposed action would rarely, if ever, be located on coastal barrier beaches (**Chapter 3.1.7**). There are 0-1 gas processing plants projected to be constructed as a result of a proposed action. Existing inland facilities may, through natural erosion and shoreline recession, be located in the barrier beach and dune zone and contribute to erosion there. A proposed action may extend the life and presence of facilities in eroding areas, which could accelerate localized erosion; however, the impacts on coastal barrier beaches and associated dunes in the vicinity of the construction of a gas processing plant from a proposed action are expected to be **negligible** or **none**, as the location of such a facility is not likely to be adjacent to beaches.

4.3.2.2.2 Accidental Events

The types and sources of spills that may be reasonably foreseeable from a proposed lease sale and their characteristics are described in **Chapter 3.2**. There is also a risk analysis of oil spills in **Chapter 3.2.1**. A low-probability catastrophic spill is discussed in the *Catastrophic Spill Event Analysis* white paper (USDOI, BOEM, 2017).

The only accidental event associated with a proposed action likely to impact beaches would be a spill and the associated cleanup activities. Impacts to biological, recreational, and archaeological resources associated with beach and dune environments are described in the impact analysis chapters for those specific resources (**Chapters 4.9**, Protected Species; **4.12**, Recreational Resources; and **4.13**, Archaeological Resources).

Effects of Oil on Beaches

The effects from coastal oil spills depend on the geographic location, volume, and rate of the spill, type of oil, oil-slick characteristics, oceanic conditions, season at the time of the spill, and response and cleanup efforts (**Chapter 3.2.8**). The resiliency of coastal beaches and the impact of oil on these beaches are, in part, based on the toxicity of the oil's components once it reaches the beaches. Microbial biodegradation can reduce the toxicity of crude oil by decreasing PAH concentrations. However, submerged oil mats found in GOM waters adjacent to beaches can resist weathering and may serve as long-term sources of remnant oil and PAHs to beach ecosystems (Hayworth et al., 2011; Elango et al., 2014). In addition, buried supratidal samples undergo less biodegradation due to a lack of oxygen (OSAT-2, 2011).

If unweathered oil reached the beaches, the associated interstitial microfauna would be affected in several ways, including community shifts, toxic effects, and the physical disturbance of response efforts. A shift in the microbial community would tend to increase dominance by hydrocarbon degraders (Kostka et al., 2011). This shift can occur within days of contamination with crude oil, stimulating the breakdown of the contaminants present in the oil (Horel et al., 2012). Toxic constituents of the oil can have both lethal and sublethal impacts to resident plants and fauna. Equipment and personnel used in cleanup efforts can generate the greatest direct impacts to an area, such as the removal of sand from the beaches, disturbance of beach and foredune sands through foot traffic, mechanized cleanup equipment (e.g., sifters), dispersal of oil deeper into sands and sediments, and foot traffic in marshes impacting the distribution of oils and marsh vegetation.

Coastal Spills

Coastal spills from damage to pipelines, vessel collisions, and malfunctions of onshore production or storage facilities have the greatest potential for affecting the coastal barrier beaches due to their proximity to the resources. Because very little OCS oil- and gas-related activity takes place on beaches, inland spills that occur in the vicinity of GOM tidal inlets present a greater potential risk to barrier beaches and dunes because the inlets can provide a path for oil to reach the beaches.

The number and most likely spill sizes to occur in coastal waters in the future are expected to resemble the patterns that have occurred in the past as long as the level of energy-related, other commercial, and recreational activities remains the same. BOEM's analysis shows that 96 percent of spills from OCS oil-and gas-related activity are <1 bbl, with an average size of <0.05 bbl (Anderson et al., 2012). **Table 3-13** shows that there was only one spill ≥1,000 bbl in the coastal waters from Texas through Alabama during the period 2002-2015. Because of the small contribution to all such spills from a proposed action, the small size of most spills, the percentage of spilled oil volume that would likely reach coastal barrier beaches, and the breakdown of contaminants by microbial communities, impacts of coastal spills to barrier beaches and dunes are expected to be **minor**.

Offshore Spills

There are various factors and conditions that affect the toxicity and severity of the impacts of oil spills on the barrier island systems, dunes, and the associated vegetation. For an offshore spill <1,000 bbl to make landfall, the spill would have to occur proximate to State waters (defined as 3-12 mi [5 19 km] from shore). If a spill were to occur proximate to State waters, only a spill >50 bbl would be expected to have a chance of persisting long enough to reach land. Spills ≥50 and <1,000 bbl are infrequent (**Chapter 3.2.1.5.4**). If an oil spill contacted the shoreline, the intertidal area and the beach face would likely be contacted. For the oil to contact the dunes, extreme high tides would be needed to carry oil from a spill across and onto the dunes.

Two important variables during an oil spill for impacts on beaches and dunes involve location (distance of spill from landfall) and weather. For example, if there is sufficient distance and favorable weather conditions between the spill and landfall, the oil can be dispersed, thinned, and emulsified. This would allow for conditions supportive of biodegradation, volatilization, and photooxidation to break down the oil. Most spills from the OCS are likely to be distant enough that, should a slick from such a spill make landfall, the volume of oil remaining in the slick is expected to be small. Due to the distance of the spill from shore, the weather, the time oil remains offshore, and dispersant use (**Chapter 3.2.8.2.2**), OCS crude oil would be less toxic when it reaches the coastal environments. For example, after the *Deepwater Horizon* explosion and oil spill, the majority of oil deposits on GOM beaches were highly weathered and samples showed 86-98 percent depletion of total polycyclic aromatic hydrocarbons (PAHs) (OSAT-2, 2011). However, should spills from the OCS occur proximate to State waters, they could reach shore before much weathering, evaporation, or dispersal had occurred.

The probabilities of an offshore spill ≥1,000 bbl occurring and contacting environmental features are described in **Chapter 3.2.1.4.8**. The probabilities of oil spills ≥1,000 bbl occurring and contacting State waters can be found in **Figure E-20**. The highest probability as a result of a proposed action is estimated at 26 percent for the State waters of both Texas and West Louisiana. Should spills from the OCS occur proximate to State waters, they could reach shore before much weathering, evaporation, or dispersal had occurred. However, because the majority of spills estimated to occur are relatively small (>99% estimated to be <50 bbl), the distance from coastal communities, improved technologies, and the dynamic nature of the coastal environment, offshore spills are expected to have a **minor** impact on the estuarine community.

Trash and Debris

Trash and debris (**Chapter 3.2.7**) can be an issue for coastal habitats, including beaches and dunes and the fauna that reside in these habitats. Fauna that utilize barrier beaches and dunes could ingest or become entangled in trash and debris. This can have lethal impacts like suffocation or sublethal impacts like loss of a limb. The BSEE provides information on marine debris and awareness and requires training of all OCS personnel through NTL 2015-BSEE-G03, which also informs operators of regulations set forth by other regulatory agencies (i.e., the USEPA, USCG, and others). Due to the annual awareness training required by marine debris mitigations, the handling of waste and trash by industry has improved greatly and the effects on coastal habitats are minimized. Because lease stipulations and regulations, as clarified by NTLs, are in place to reduce impacts from marine trash and debris, impacts related to marine trash and debris would result in **negligible** impacts to coastal barrier beaches and associated dunes.

4.3.2.2.3 Cumulative Impacts

This cumulative analysis considers the effects of impact-producing factors related to a proposed action, prior and future OCS lease sales in the Gulf of Mexico, State oil and gas activities, other governmental and private projects and activities, and pertinent natural processes that may affect barrier beaches and dunes.

OCS Oil- and Gas-Related Impacts

Pipeline Emplacements, Vessel Traffic (Navigation Channel Use), Dredging, Trash and Debris, and Infrastructure Construction

Continued navigation channel use and dredging support of a proposed action could impact coastal habitats. Maintenance dredging of barrier inlets and bar channels is expected to continue, which removes sediment from the system, contributing to beach erosion. Mitigation of impacts involves strategically placing dredged sediment where adjacent barrier-island shores would receive it for island nourishment and rebuilding (Morton, 2008). Beneficial uses of dredged material include beach nourishment for the more sandy materials, and much of the impacts from dredging are expected to be mitigated through the beneficial use program implemented by the COE. Further discussion of the beneficial use of dredged material can be found in **Chapter 3.3.2.3.5**. Impacts to beaches from maintenance dredging would occur regardless if a proposed action is implemented or not. Between 6 and 19 percent of traffic using navigation channels in the GOM is expected to be related to the cumulative OCS Program (**Tables 3-23 and 3-7**). A proposed action is estimated to account for less than 2 percent of the service-vessel traffic in the OCS. Impacts to beaches from maintenance dredging related to a proposed action are expected to be **minor**. Impacts to beaches from OCS oil- and gas-related marine debris would be **negligible**.

The effects to coastal barrier beaches and associated dunes from pipeline emplacements and the construction or continued use of infrastructure in support of a proposed action are expected to be restricted to temporary and localized disturbances. Existing pipelines were placed using older techniques and have caused and would continue to cause barrier beaches to narrow and breach. Pipeline landfalls projected in support of the cumulative OCS scenario are expected to cause **negligible** impacts to barrier beaches because of the use of modern, nonintrusive installation methods.

Oil Spills

Due to the proximity of coastal spills to barrier islands and beaches, such spills pose a threat to coastal barrier beaches and dunes. As noted in **Table 3-13**, a few coastal spills ≥1,000 bbl have been recorded in the coastal waters from Texas through Alabama during the period 2002-2015. Spills that occur in or near the Chandeleur or Mississippi Sounds could affect the coastal barrier beaches and dunes in the Gulf Islands National Seashore and the Breton National Wildlife Refuge.

Oil from most offshore spills, except perhaps from OCS oil- and gas-related activities close to the boundary with State waters, is expected to be weathered and normally treated offshore. Therefore, most of the toxic components would have dissipated by the time it contacts coastal beaches. The cleanup impacts of these spills could result in a short-term (up to 2 years) adjustment in beach profiles and configurations as a result of sand removal and disturbance during the cleanup operations. Cleanup efforts would be monitored in an effort to ensure the least amount of disturbance to the areas. Oil from the Deepwater Horizon explosion and oil spill was documented by shoreline assessment teams to have stranded on approximately 600 mi (965 km) of beach shoreline

(Deepwater Horizon Natural Resource Damage Assessment Trustees, 2016). Cleanup activities were conducted on 410 mi (660 km) of the affected beach. Two years after the spill, some oil remained on 427 mi (687 km) but at much lesser amounts (Michel et al., 2013a; OSAT-2, 2011). Beach shorelines were affected by oiling and response actions, with the most severe cleanup actions killing all creatures that burrow in beach sand (Deepwater Horizon Natural Resource Damage Assessment Trustees, 2016). As beaches experience erosion and deposition, oil would become buried, exposed, and remobilized multiple times, resulting in chronic re-oiling. Tropical Storm Lee (2011) and Hurricane Isaac (2012) caused extensive beach erosion and remobilization of oil residues. Oil residue mats were observed between the toe of the beach and the first offshore sand bar, providing another source of chronic sources of surface residue balls and surface residue patties (Michel et al., 2013a). Over time, more of the remaining oil has continued to be removed, while toxicity has decreased as the oil is further weathered. The buried supratidal samples underwent less biodegradation due to lack of oxygen, but they were estimated to decrease to 20 percent of current levels within 5 years (OSAT-2, 2011). Accidental spills as a result of a low-probability catastrophic event are discussed in the *Catastrophic Spill Event Analysis* white paper (USDOI, BOEM, 2017).

Spill data from the OCS shows that, over decades of activity, tens of thousands of barrels of oil have been spilled (**Chapter 3.2.1.1.3**), not including oil from the *Deepwater Horizon* oil spill. Cumulative OCS oil- and-gas-related spills resulting from all past and present leasing activities, including the millions of barrels that entered the Gulf of Mexico from the *Deepwater Horizon* oil spill, are estimated to have had a **major** impact on coastal barrier beaches and dunes. However, the incremental increase in impacts from reasonably foreseeable oil spills related to a proposed action is expected to be **minor**.

Non-OCS Oil- and Gas-Related Impacts

Vessel Traffic (Navigation Channel Use)

Construction of the existing navigation channels has replaced beaches with the waterways in some cases, while other channels were constructed using existing passes (**Chapter 3.3.2.8.5**). Construction of the channels involves removal of sand that is no longer available for longshore drift to adjacent beaches. Maintenance dredging of barrier inlets and bar channels would continue to remove sediment from the system, contributing to beach erosion. Sand is removed during dredging, and only a fraction of this sand is used for beach nourishment. Disposal of dredged material outside of the littoral zone represents a net loss of sand to the system, and thus, maintenance dredging has contributed to net deficits (Byrnes et al., 2012). These impacts would occur from necessary channel maintenance to accommodate all vessel traffic, resulting in **moderate** impacts to beaches.

Oil Spills

Non-OCS oil- and gas-related oil spills can occur as a result of import tankers, barge, or shuttle tanker accidents during transit or offloading, State-related oil production activities, and various kinds of petroleum product transfer accidents. State-related oil production activities are concentrated in coastal areas, where spills could potentially cause greater impacts to beaches. The impacts of non-OCS oil- and gas-related spills are expected to be **minor** to **moderate**.

The GOM has more natural oil seeps (providing ~980,000 bbl/year; refer to **Chapter 3.3.2.9.2**) than any other marine environment in North America; therefore, it has a resident population of microbiota, including oil-biodegrading bacteria, that degrades additional oil that enters the environment (Atlas and Hazen, 2011). This resident microbial population increases the resiliency of beaches to oil spill impacts.

River Hydromodification and Beach Protection

Over the course of geological history, the barrier islands have migrated toward the present coast. The Gulf-facing coasts of the barrier islands have been eroded by the steady relative rise in sea level. Human disturbance has hastened the erosion of barrier beaches and dunes. Channel deepening and widening along the Mississippi River and other major coastal rivers, in combination with channel training and bank stabilization work, has resulted in the reduced delivery of sediment to the eroding deltas along the mouths of the rivers and to the offshore barrier islands. This, coupled with beach building and stabilization projects utilizing mined sands, jetties, groins, and other means of sediment capture, is depriving natural restoration of the barrier beaches through sediment nourishment and sediment transport.

Subsidence, erosion, and dredging of inland coastal areas with the concurrent expansion of tidal influences continually increase tidal prisms around the GOM. These changes may result in the opening and deepening of many new tidal channels that connect to the GOM and inland waterbodies. Due to the increased flow, these incremental changes would cause adverse impacts to barrier beaches and dunes. Efforts to stabilize the GOM shoreline have adversely impacted barrier landscapes. Large numbers and varieties of stabilization techniques for navigation channels have been applied along the Gulf Coast. These efforts have contributed to coastal erosion by depriving downdrift beaches of sediments, which accelerates erosion there, and by increasing or redirecting the erosional energy of waves (Morton, 1982). Over the last 20 years, dune and beach stabilization have been better accomplished by using more natural applications such as sand dunes, beach nourishment, and vegetative plantings. Impacts of river channelization and beach protection are expected to be **moderate** because of the disruption of sediment nourishment and sediment transport.

Other Anthropogenic and Natural Processes

Barrier beaches along the Gulf Coastal have experienced erosion and landward retreat (marine transgression) because of natural processes enhanced by human activities (**Chapters 3.3.2.8 and 3.3.2.9**). Adverse effects on barrier beaches and dunes have resulted from changes to the natural dynamics of water and sediment flow along the coast. This can happen in an attempt to control catastrophic floods and change the natural environment to better accommodate navigation on waterways used to support OCS oil- and gas-related and non-OCS oil- and gas-related vessel traffic. Rising sea levels are expected to continue to inundate or fragment low-lying coastal areas, including sandy beaches and barrier islands (Dahl, 2011). Sea-level rise and coastal subsidence and tropical storms exacerbate and accelerate the erosion of coastal barrier beaches along the Gulf Coast. The Gulf Coast and the associated barrier islands and dunes have been impacted by high-intensity hurricanes and tropical storms over the past millenia, resulting in natural changes in barrier island topography and decreases in beach elevation (USDOI, GS, 2008; Barras, 2007). Due to the more gentle slopes, removal of beach ridges, and cuts into the mainland barrier beaches, the remnant transition zone between the water and the current beach ridge may be more vulnerable to spills. Historically, recovery of beaches to their pre-storm state ranges from years to decades (Houser et al., 2015).

If the topography is modified, it may result in hydrological changes that enable further sediment transport from the islands. This provides pathways for further erosion and saltwater intrusion into the less salt-tolerant interior vegetated habitats of the islands. The loss of elevation, combined with the shoreline retreat and removal of vegetation further aggravated by the hurricanes, allows for the expansion of the overwash zone. This lessens the pre-storm protection of the coast provided by these barrier islands. The reduction in island elevation results in less frontline protection to valuable marshes and puts urban and industrial areas protected by these marshes at a higher risk (USDOC, NMFS, 2007b).

Hurricanes and tropical storms would remain a part of the Gulf Coast weather pattern and would continue to affect the elevations of barrier islands, mainland beaches, and dunes. Depending on storm frequency and intensity, it may be possible for coastal restoration and protection projects to mitigate some of the physical damage to these areas.

Gulf Coast barrier beaches tend to occur at low elevations, between sea level and several feet above sea level. Beach erosion due to sea-level rise has increased along certain shorelines (Dahl, 2011). If current projections are realized and the sea level increases by 3.5 ft (1.1 m) in Galveston, Texas, by 2100 (USEPA, 2013a), much of Texas' coastal beaches would be under water well before 2100. A more conservative estimate of sea-level rise, known as the AR4 scenario, calls for an increase (globally) of 16 in (41 cm) by 2100 (NRC, 2010). Even this rate of increase would be likely to impact Gulf Coast beaches, especially when local, relative sea-level rise is considered. Since 1870, global sea level has risen by about 8 in (20 cm) (USEPA, 2013a). Even at current measured rates of relative sea-level rise, large areas of GOM coastal beaches can be expected to be inundated (refer to **Chapter 3.3.2.8.1**). Impacts to coastal habitats are expected to be **major** due to the large scale of inundation from sea-level rise and the erosion due to hurricanes and human activities.

Recreational Use, Tourism, and Development

Recreational use of beaches is discussed in **Chapter 4.12** (Recreational Resources). Recreational use of barrier beaches and dunes can have impacts on the stability of the landform. Vehicle and pedestrian traffic on sand dunes can stress and reduce the density of vegetation that binds the sediment and stabilizes the dune. Destabilized dunes are more easily eroded by winds, waves, and traffic. Recreational vehicles and even hikers have caused impacts where road access is available and the beach is wide enough to support vehicle use. Most barrier beaches in Texas are accessible to people for encouraged recreational use because of public road access. It also provides for public acquisition of private beachfront property. Most barrier beaches in Louisiana are relatively inaccessible for regular recreational use because they are in coastal areas with limited road access. Mississippi has coastal beaches behind the barrier islands that are accessible for recreational use, and the barrier islands experience extensive recreational use by boaters. Most barrier beaches in Alabama and the panhandle of Florida are accessible to foot traffic through road access, and their use is encouraged. There would continue to be seaside real-estate development where road access is available. The protection of dunes, beaches, and coastal environments are regulated through the Coastal Management Programs of the states, as well as the COE's permitting program. This helps to assure that projects are constructed consistent with the Federal CZMA guidelines in order to preserve the integrity of the coastal ecosystem. In the years 2004 through 2009, there were modest gains in marine and estuarine nonvegetated wetlands, a category that includes beaches (Dahl, 2011; Dahl and Stedman, 2013). A proposed action would not provide any additional access that would result in increased negative cumulative impact to the barrier beaches and dunes.

Development along the Gulf Coast has impacted coastal barrier beaches. Census data show that coastal areas are experiencing much higher growth than noncoastal areas. However, census data may underestimate this trend due to undercounting of seasonal residents. Infrastructure needed to support seasonal influxes of people can impact coastal barrier beaches (Dahl and Stedman, 2013). Hotels, restaurants, stores, and bars have been built on or adjacent to many coastal beaches, resulting in loss of habitat as well as the introduction of wastewater into coastal waters. High-use "amenity" beaches can benefit from frequent beach nourishment projects that supply large quantities of sand. Impacts are to some extent offset by coastal restoration programs. Examples of these programs are the Coastal Impact Assistance Program (CIAP), the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA), and the RESTORE Act (refer to **Chapter 3.3.2.8.3**). Due to the protection from development of beaches included in the Gulf Islands National Seashore, restrictions on development by the various regulatory programs and continuing cumulative impacts of past development on coastal barrier beaches, impacts are expected to be **moderate**.

Coastal barrier beaches have experienced severe adverse cumulative impacts from human activities and natural processes. Human activities that have caused the greatest adverse impacts are navigation channel stabilization and maintenance, beach stabilization structures, oil spills, recreation and development, river channelization and damming, and pipeline canals. Most barrier beaches in Texas, Alabama, and Florida are accessible to people for recreational use, and their use is encouraged and intense. Excessive recreational use can result in damage to dunes, resulting from the loss of dune stabilizing plants. Existing pipelines were placed using older techniques and have caused and may continue to cause barrier beaches to narrow and breach. Natural and anthropogenic events have combined to cause erosion of barrier and shoreline landforms along the

Gulf Coast. Cumulative impacts to barrier beaches and dunes from these sources are considered to be **major**.

While the cumulative impacts to coastal barrier beaches from the factors described above range from **negligible** to **major**, the incremental impact to beaches from a proposed lease sale would be **minor**. The relatively small contribution of a proposed lease sale to OCS oil- and gas-related activity would have impacts that are much less than those attributed to several sources, as noted above.

4.3.2.2.4 Incomplete or Unavailable Information

BOEM acknowledges that there remains incomplete or unavailable information regarding coastal barrier beaches and associated dunes in the GOM. There is incomplete information about routine impacts, as the scenario forecast is only an estimate, and many global factors can affect OCS oil- and gas-related activity. There also remains unavailable information about future rates of oil spills, as well as the locations and volumes of oil. Future rates of coastal development are unknown, as is the extent of such impacts to coastal barrier beaches. There are also unknowns regarding the future restoration efforts being planned, such as what specific projects would ultimately be constructed and how successful they may be. In addition, the future rates of relative sea-level rise are not known with certainty (Hausfather, 2013), and thus, the resulting impacts to coastal barrier beaches and associated dunes are unknown.

A large body of information regarding impacts of the *Deepwater Horizon* explosion, oil spill, and response upon coastal barrier beaches and associated dunes has been developed and continues to be developed through the NRDA process, but information remains incomplete. As there is substantial information available since the *Deepwater Horizon* explosion, oil spill, and response, which has been analyzed for this Multisale EIS, BOEM believes that the incomplete or unavailable information regarding the effects of the *Deepwater Horizon* explosion, oil spill, and response on coastal barrier beaches and dunes would likely not be essential to a reasoned choice among alternatives. The incomplete information would not be available within the timeframe contemplated by the NEPA analysis of this Multisale EIS. However, much is known about the extent of the oiling of beaches and the continuing degradation of the remaining oil.

BOEM has determined that the information is not essential to a reasoned choice among alternatives. BOEM's subject-matter experts have used what scientifically credible information is available in their analyses, applied using accepted scientific methodology. Many studies have been produced that demonstrate the effects of exposure of beaches to crude oil, covering a wide range of exposure intensity, longevity, and oil characteristics. Much has been learned about the effect of oil-spill cleanup on beaches and the degradation rates of oil over time. In addition, studies have been produced regarding the long-term impacts of navigation canal dredging on beaches and barrier islands. A proposed lease sale would result in a relatively minor addition to existing routine activities and accidental events, and therefore, the incremental increase in impacts to coastal barrier beaches and dunes from a proposed lease sale would be minor given what is currently known. The potential for impacts from changes to the affected environment (post-*Deepwater Horizon*) and cumulative impacts remains whether or not the No Action or an action alternative is chosen.

4.3.2.2.5 Alternative A—Regionwide OCS Lease Sale (The Preferred Alternative)

Impacts from most routine activities related to a proposed action would be expected to be **minor** since most routine activities are located far from coastal beaches. Impacts to coastal barrier beaches and associated dunes from pipeline emplacements, and construction or continued use of infrastructure in support of a proposed action are expected to be restricted to temporary and localized disturbances and to cause **negligible** impacts to barrier beaches because of the small number of expected pipeline landfalls and the fact that any new OCS oil- and gas-related infrastructure would not be expected to be constructed on barrier beaches. The contribution from a proposed action to channel use and maintenance is expected to result in **minor** impacts. Indirect impacts from routine activities, such as disruption of sediment transport by maintenance dredging of channels or erosion resulting from pipeline emplacements, are **minor**.

Minor and localized impacts to the physical shape and structure of barrier beaches and associated dunes may be expected to occur as a result of accidental events, such as oil spills, associated with a proposed action. Such impacts could be a result of cleanup efforts in addition to the spill itself. Should a spill contact a barrier beach, sand removal during cleanup activities would likely be minimized because current spill-response activities discourage physical cleanup methods that impact beach profiles. The Net Environmental Benefits Analysis done as part of the OSAT-2 report (2011) noted that the environmental impacts of residual oil remaining after cleanup are relatively small when compared with the impacts of continued cleanup efforts on both beach habitats and associated resources.

The impacts of oil spills and related cleanup efforts from both OCS oil- and gas-related and non-OCS oil- and gas-related sources to the Gulf Coast depend on the size, frequency, distribution, locations, and collective spatial and temporal features of the spills. Impacts would include stranding of surface residue balls and patties, and submerged tar mats may persist in adjacent waters, representing a chronic source of contamination, observed particularly after storms. Changes to beach topography could result from cleanup efforts. Overall impacts from oil spills are expected to be **minor**, with the exception of a catastrophic event, which is not considered reasonably foreseeable and is not part of a proposed action or likely expected to occur. Impacts as a result of a low-probability catastrophic event are discussed in the *Catastrophic Spill Event Analysis* white paper (USDOI, BOEM, 2017).

Compared with other impact-producing factors on coastal barrier beaches and dunes, the incremental contribution of Atlernative A to the cumulative impacts to these resources is expected to be **minor**.

4.3.2.2.6 Alternative B—Regionwide OCS Proposed Lease Sale Excluding Available Unleased Blocks in the WPA Portion of the Proposed Lease Sale Area

The impacts of this alternative would be similar to those of Alternative A, except that there would be **negligible** impacts to coastal barrier beaches and dunes in Texas because no OCS oil- and gas-related activity is forecast in the WPA along the Texas coast with this alternative. Under Alternative B, the resulting OCS oil- and gas-related activity would be located off the coasts of Louisiana, Mississippi, and western Florida. The greater distance between these activities and the coastal habitats of Texas would reduce impacts along the Texas coast whether from routine activities or accidental events. Less use of service bases in Texas is likely, and the distance between oil spills associated with this alternative and the Texas coast is expected to be greater. Compared with other impact-producing factors on coastal barrier beaches and dunes, the incremental contribution of Atlernative B to the cumulative impacts to these resources is expected to be **minor**.

4.3.2.2.7 Alternative C—Regionwide OCS Proposed Lease Sale Excluding Available Unleased Blocks in the CPA/EPA Portions of the Proposed Lease Sale Area

The impacts of this alternative would be less than those under Alternative A, as only a fraction of the resulting activity forecasted for Alternative A is projected for Alternative C. For this alternative, there would be **negligible** incremental impacts to coastal barrier beaches and dunes in Louisiana; and zero to **negligible** impacts to Mississippi, Alabama, and the panhandle of western Florida; and incrementally more impacts to the beaches and dunes of Texas. However, Alternative C would have less potential for impact than Alternative A or B as the level of projected OCS oil- and gas-related activities and impact-producing factors are much less in the WPA. For example, a range of 11-67 production wells are projected to be drilled and developed under Alternative C, whereas 58-464 production wells are projected to occur under Alternative B. The significance of impact-producing factors on coastal barrier beaches and dunes would be somewhat less for Alternative C than for Alternative A, as discussed in **Chapter 2.2.2**. Compared with other impact-producing factors on coastal barrier beaches and dunes, the incremental contribution of Atlernative C to the cumulative impacts to these resources is expected to be **negligible** to **minor**.

4.3.2.2.8 Alternative D—Alternative D—Alternative A, B, or C, with the Option to Exclude Available Unleased Blocks Subject to the Topographic Features, Live Bottom (Pinnacle Trend), and/or Blocks South of Baldwin County, Alabama, Stipulations

The impacts of this alternative would be nearly identical to those of the alternative it is combined with because the available unleased blocks with topographic features do not contain coastal barrier beaches and dunes and are too distant (over 25 km; 16 mi) from the coast to have indirect impacts. In addition, there are only 367 blocks subject to the Topographic Features Stipulation, 74 blocks subject to the Live Bottom (Pinnacle Trend) Stipulation, and 32 blocks subject to the Blocks South of Baldwin County, Alabama, Stipulation. This relatively small percentage of the total number of available unleased blocks would not be expected to generate a great contribution to OCS oil- and gas-related activity, if leased.

4.3.2.2.9 Alternative E—No Action

If a proposed lease sale does not occur, there would be no additional impacts to barrier beaches and associated dunes; however, cumulative impacts would be the same as for Alternative A. There could be some incremental increase in impacts caused by a compensatory increase in imported oil and gas to offset reduced OCS production, but it would likely be **negligible**.

4.4 DEEPWATER BENTHIC COMMUNITIES

This chapter presents an analysis of the potential impacts on deepwater benthic communities as a result of routine activities and accidental events associated with a GOM proposed action and a proposed action's incremental contribution to cumulative impacts. The analysis is not exhaustive of all possible impacts of routine activities and accidental events; rather, it focuses on those most relevant for decisionmakers. Potential impacts from a catastrophic oil spill, including long-term impacts and recovery, are detailed in the *Catastrophic Spill Event Analysis* white paper (USDOI, BOEM, 2017). "Deep water" is a term of convenience used in this analysis to refer to water depths >300 m (984 ft). BOEM defines "deepwater benthic communities" as including both chemosynthetic communities (chemosynthetic organisms plus seep-associated fauna) and deepwater coral communities (deepwater coral plus coral-associated fauna).

Chemosynthetic communities are based on the presence of various organisms that do not depend on photosynthetic processes for metabolism. In the GOM, they are formed around natural hydrocarbon seepages where chemosynthetic bacteria consume methanes and sulfides and chemosynthetically derive amino acids and sugars for respiration, and then excrete carbon dioxide that may result in calcium carbonate precipitation. Eventually, sufficient precipitates can form hard carbonate substrates on which higher order megafauna such as structure-forming deepwater sponges and corals can settle. Relatively large numbers of invertebrate and fish species (refer also to **Chapter 4.7**) may be attracted to structurally complex microhabitats, which can provide shelter, feeding areas, and nursery grounds (Fraser and Sedberry, 2008). Over 330 chemosynthetic communities have been confirmed in the GOM to date (for spatial distribution, refer to **Figure 4-11** in **Chapter 4.4.1.1** below). More communities likely exist, but much of the seafloor has not yet been visually surveyed to allow direct observation. Much is still unknown about chemosynthetic communities, despite increasing research in recent decades.

Deepwater coral communities are known to occur throughout the GOM (**Figure 4-10**) and new communities are routinely discovered with almost every new deepwater research cruise (USDOC, NOAA, 2014a). As with shallow-water live bottom communities (**Chapter 4.6**), most GOM deepwater corals require exposed hard substrate for attachment and growth. They often co-occur on authigenic substrates (substrates that have been generated where they are found) created by chemosynthetic processes; however, they also routinely colonize other natural or artificial hard substrates not associated with hydrocarbon seepage. In addition to hard and soft deepwater corals, these communities include other associated sessile and motile benthic megafauna such as sponges, anemones, echinoderms, crustaceans, and fishes.

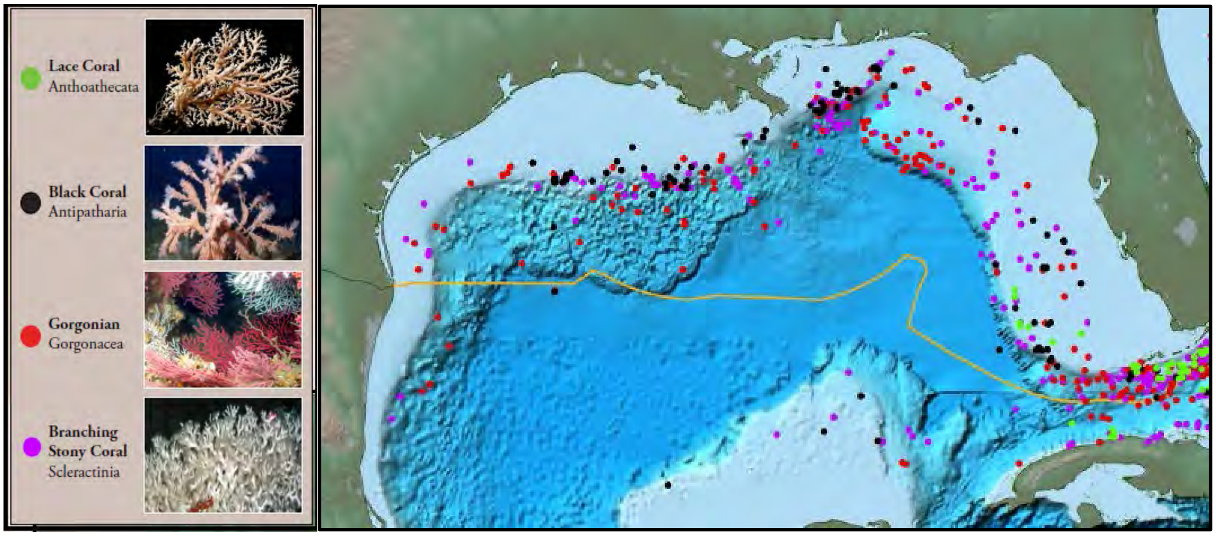

Figure 4-10. Deepwater Coral Records from NOAA's National Deep-Sea Coral and Sponge Database (USDOC, NOAA, 2014a).

Impact Analysis Process and Scope

The impact significance criteria and resulting conclusions presented in **Table 4-11** focus on the overall functioning, resilience, and ecosystem level importance of deepwater benthic communities throughout U.S. waters of the GOM. The potential magnitude of impact for each of these impact-producing factors that are reasonably foreseeable is provided in **Table 4-11** to help the reader quickly identify the level of potential impacts for each impact-producing factor, shown in the table both with and without the anticipated BOEM mitigations to make clear the considerable difference that results from these mitigations. The impact-level definitions and the analyses supporting these conclusions are then discussed in detail in this chapter. Postlease, site-specific analyses would focus more on potential localized impacts of individual development activities (e.g., proposed drilling of a well) to individuals, discrete communities, and small patches of benthic habitat. Those analyses would also detail site-specific protective mitigations required prior to approval of such activities.

Table 4-11. Deepwater Benthic Communities Impact-Producing Factors That are Reasonably Foreseeable.

Deepwater Benthic Communities	Magnitude of Potential Impact[1]				
Impact-Producing Factors	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
Routine Impacts					
Bottom-Disturbing Activities and Drilling-related Sediment and Waste Discharges					
With Mitigation	Negligible	Negligible	Negligible	Negligible	None
Without Mitigation	Minor to Major	Minor to Moderate	Minor to Moderate	Minor to Major	None

Accidental Impacts					
Bottom-Disturbing Activities and Drilling-Related Sediment and Operational Waste Discharges					
With Mitigation	Negligible to Minor	Negligible to Minor	Negligible to Minor	Negligible to Minor	None
Without Mitigation	Minor to Major	Minor to Moderate	Minor to Moderate	Minor to Major	None
Oil Spills					
With Mitigation	Negligible to Minor	Negligible to Minor	Negligible to Minor	Negligible to Minor	None
Without Mitigation	Minor to Major	Minor to Moderate	Minor to Moderate	Minor to Major	None
Cumulative Impacts					
Incremental Contribution[2]	Negligible	Negligible	Negligible	Negligible	None
OCS Oil and Gas[3]	Negligible to Minor				
Non-OCS Oil and Gas[4]	Negligible to Major				

[1] The analysis supporting these conclusions is discussed in detail in the "Environmental Consequences" chapter below.

[2] This includes all activities (i.e., routine activities projected to occur and accidental events that could occur) as a result of a single proposed lease sale in the 2017-2022 Five-Year Program.

[3] This includes all activities (i.e., routine activities projected to occur and accidental events that could occur) from past, proposed, and future lease sales.

[4] This includes other past, present, and reasonably foreseeable future activities occurring within the same geographic range and within the same timeframes as a proposed action, but they are not related to the OCS Oil and Gas Program.

Impact-Level Definitions

For this analysis, the following definitions were used to categorize impacts to deepwater benthic communities:

- **Negligible** – Impacts to deepwater benthic communities are largely undetectable. There is some potential for even undetectable impacts to cause slight changes to a local community's species abundance and composition, community structure, and/or ecological functioning, but any such changes would be spatially localized, short term in duration, and would not alter the overall status of GOM deepwater benthic communities.
- **Minor** – Impacts to deepwater benthic communities are detectable but cannot be clearly distinguished from natural variation. Such impacts could result in changes to a local community's species abundance and composition, community structure, and/or ecological functioning, but would be spatially localized, short

term in duration, and would not alter the overall status of GOM deepwater benthic communities.

- **Moderate** – Impacts to deepwater benthic communities detectably cause substantial, population-level changes in species composition, community structure, and/or ecological functioning. These impacts would be expected to be spatially extensive but are expected to only temporarily alter the overall status of GOM deepwater benthic communities; long-term recovery to pre-impact levels is likely.
- **Major** – Impacts to deepwater benthic communities detectably cause substantial, population-level changes in species composition, community structure, and/or ecological functioning. These impacts would be expected to be spatially extensive and noticeably alter the overall status of GOM deepwater benthic communities such that long-term recovery to pre-impact levels is unlikely.

Because of the similarity and overlap of the effects of many activities that occur in the OCS, the primary, reasonably foreseeable routine and accidental impact-producing factors for deepwater benthic habitats can be grouped into three main categories:

(1) bottom-disturbing activities (**Chapter 3.1.3.3.2**; routine and accidental);

(2) drilling-related sediment and waste discharges (**Chapter 3.1.5.1**; routine and accidental); and

(3) oil spills (**Chapter 3.2.1**; accidental).

Cumulative Impacts were also considered, in two steps: impacts resulting from OCS oil- and gas-related activities (same as routine activities and accidental events); and impacts resulting from non-OCS oil- and gas-related sources, namely fishing and climate change.

Some impact-producing factors relevant to deepwater benthic communities are already analyzed in greater detail in other sections and need only be briefly summarized here. **Chapter 4.7** (Fishes and Invertebrate Resources) details the potential impacts to marine invertebrates from anthropogenic sound and concludes the impact would be **negligible**. Note that despite the growing body of information available for fishes, there is comparatively little information available on sound detection and sound-mediated behaviors for marine invertebrates. **Chapter 4.7** (Fish and Invertebrate Resources) also details the impacts of routine activities and the cumulative impacts from the presence and subsequent removal of OCS oil- and gas-related infrastructure. These impacts include the post-installation physical presence of OCS oil- and gas-related infrastructure, effects of decommissioning activities such as explosive and nonexplosive removals, and conversion of platforms to artificial reefs. While the total contribution of OCS infrastructure is still only a small percentage of natural hard bottoms (Gallaway et al., 2009), and is projected to further decrease throughout the period covered by this analysis (**Chapter 3.3.1.5**), the presence, removal, and/or conversion of artificial hard substrates colonized by sessile invertebrates are likely to result in localized community changes, such as changes in species diversity in the area (Schroeder and Love, 2004). While individual presence, removal, or conversion actions at specific locations do not cause more than **negligible** impacts when considered against the broader scope of this analysis, when the sum of such actions are considered cumulatively for all planning areas and over 50 years, such impacts could be greater for individual species . This is because select sessile benthic species commonly associated with OCS oil and gas structures could be noticeably influenced over time by the overall presence (or removal) of OCS oil- and gas-related infrastructure. For example, a particular deepwater coral species' Gulfwide spatial distribution may shift over time because of the presence or removal of structures in otherwise soft bottom-dominated areas. Such a change (were it to occur) could be considered a moderate level impact for that species If it represented a detectable change in the species' spatial distribution, such a range shift might have potential long-term effects related to dispersal and genetic connectivity to other populations of that species. Such potential impacts are not necessarily either positive or negative; that would be dependent on the species and a number of complex ecological factors. Some evidence of these types of changes (in particular, range expansion) has been documented for some shallow-water hermatypic species (Sammarco et al., 2012), but similar research specific to deepwater coral is lacking, as noted in the "Incomplete or Unavailable Information" section below. More peer-reviewed literature about this topic is available for fish resources, as detailed in **Chapter 4.7**.

Several additional impact-producing factors described in **Chapter 3.1** were evaluated for potential impacts on deepwater benthic communities. These impact-producing factors were not carried forward for full analysis because any potential effects were judged to be either not reasonably foreseeable or having such a miniscule impact that they would not rise to the level of negligible impact. These impact-producing factors include surface oil-spill response efforts (refer to **Chapter 4.6.1**, Topographic Features), impacts from geological and geophysical activities other than bottom disturbance (bottom disturbance is covered below), and potential impacts from a sinking vessel. A sinking vessel settling on a deepwater benthic community is not a reasonably foreseeable impact-producing factor. Even if such an incident did occur, it would not have a population-level impact despite likely crushing or smothering deepwater benthic organisms in the local area of direct contact.

Some potential impact-producing factors are already regulated by other Federal agencies and/or international treaties. For example, the discharge of marine debris is subject to a number of laws and treaties (refer to **Chapter 3.2.7**). These include the Marine Debris Research, Prevention, and Reduction Act; the Marine Plastic Pollution Research and Control Act; and the MARPOL-Annex V Treaty. Regulation and enforcement of these laws is conducted by a number of agencies such as the U.S. Environmental Protection Agency, NOAA, and the U.S. Coast Guard. To further reduce potential impacts, the BSEE provides information on marine debris and requires training of all OCS personnel through the "Marine Trash and Debris Awareness and Elimination" NTL (NTL 2015-BSEE-G03). This NTL instructs OCS operators to post informational placards that outline the legal consequences and potential ecological harm of discharging marine debris. This NTL also states that OCS workers should complete annual marine debris prevention training; operators are also instructed to develop a certification process for the completion of this training by their workers.

Historically, compliance with this NTL has been mandatory as a result of the Protected Species Stipulation that has been applied at the lease sale stage. These various laws, regulations, and NTL would likely minimize any potential damage to live bottom resources from the discharge of marine debris related to OCS oil- and gas-related operations. Nonetheless, some accidental release of marine debris is still likely to occur as a result of OCS oil- and gas-related operations and could theoretically have limited effects on deepwater benthic organisms (e.g., physical damage caused by strong currents pushing debris into fragile organisms or ingestion of plastics by invertebrates). However, the amount of debris in question would not suffice to cause even negligible impacts when considered at the scale of the overall population of deepwater benthic communities in the GOM. One possible exception would be frequent accidental losses of very large items such as pipeline segments with the potential to crush or smother organisms. That impact-producing factor is briefly discussed under "Accidental Events: Bottom-Disturbing Activities" below, even though any such losses are expected to be very rare. In all cases, the likelihood of spatial overlap with debris from OCS oil- and gas-related vessels or infrastructure is inherently small due to the relatively rare and patchy distribution of live bottom communities in the GOM, particularly in areas of the western and northern GOM, which have the greatest amount of OCS oil- and gas-related operations.

Another potential impact-producing factor that is largely governed by (and potential impacts reduced by) external regulations is the potential presence of toxins in drilling muds and cuttings and/or produced waters (**Chapter 3.2.6**). Because of the regulations issued by the USEPA and/or international treaties designed to keep toxins below harmful levels, hazardous levels of toxins are generally not expected to reach deepwater benthic communities. Nonetheless, potential impacts from toxins are briefly discussed under "Routine Activities" below.

Historical Protections of Deepwater Benthic Communities

Protective measures have been developed over time based on the nature and sensitivity of various benthic habitats and their associated communities, as understood from decades of BOEM-funded and other environmental studies. NTL 2009-G40, "Deepwater Benthic Communities," provides operators with relevant information and consolidates guidance for the avoidance and protection of the various types of potentially suitable habitat for chemosynthetic organisms and deepwater coral. As detailed in NTL 2009-G40, all plans submitted for permitted deepwater (300 m [984 ft] or greater) activities are reviewed for the presence of deepwater benthic communities that may be impacted by the proposed activity. Lessees must provide site-specific survey and narrative information regarding sensitive benthic features with each exploration plan (EP), development operations coordination document (DOCD), and development and production plan. These plans are reviewed by subject-matter experts on a case-by-case basis to determine whether a proposed operation could impact a benthic community. If an impact from drilling or other seafloor disturbance (e.g., anchors, anchor chains, rig emplacement, pipeline emplacement) is judged likely based on site-specific information derived from the geohazard survey data, BOEM's databases and studies, other published research, or another creditable source, the operator would be required to relocate the proposed operation (i.e., distancing) or undertake other appropriate mitigations to prevent such an impact. As detailed above, BOEM's subject-matter experts make use of the best available datasets to identify probable habitat that could support deepwater chemosynthetic and coral communities, including BOEM's publicly available database of water-bottom anomalies (USDOI, BOEM, 2015b). This analysis assumes continuation of the protective measures outlined in NTL 2009-G40.

4.4.1 Description of the Affected Environment

Gulf of Mexico Continental Slope and Deepwater Biological Resources

The northern GOM's continental slope region has been described as the most complex in the world (Carney, 1997 and 1999; Rowe and Kennicutt, 2009). It is a transitional environment influenced by processes of both the shelf (<650 ft; 200 m) and the abyssal GOM (>3,199 ft; 975 m). This transitional character applies to both the pelagic and the benthic realms. Regional topography of the slope consists of basins, knolls, ridges, and mounds derived from the dynamic adjustments of salt to the introduction of large volumes of sediment over long time scales.

Deepwater environments of the GOM have only been well studied in recent decades. Historically, there have been relatively few studies due to the logistical difficulties involved in deepwater research. The first substantial collections of deep GOM benthos were made during the cruises of the USCG and Geodetic Steamer, *Blake*, between 1877 and 1880. Rowe and Menzel (1971) reported the first quantitative data published about GOM infauna for this region. Texas A&M University researchers performed the first major study of the deep northern GOM between 1964 and 1973 (Pequegnat, 1983). A more recent study was completed by LGL Ecological Research Associates and Texas A&M University in 1988 (Gallaway et al., 1988). The major *Northern Gulf of Mexico Continental Slope Habitats and Benthic Ecology Study* (Rowe and Kennicutt, 2009) lasted 6 years. The recent studies provide extensive background information on deepwater GOM habitats and biological communities relevant to this analysis and can be referenced for more detail.

The proposed lease sale area encompasses a vast range of habitats and water depths. The shallowest portions start nearshore at the boundary of State waters, and the deepest portions extend to approximately 11,483 ft (3,500 m) south of the Sigsbee Escarpment (which is centrally located in the Gulf of Mexico), nearly into the deepest part of the GOM (14,383 ft; 4,384 m). De Soto and Mississippi Canyons are perhaps the two most notable geologic seafloor features in the northern GOM, exerting control over water currents, upwelling features, and biological productivity. The sediment-laden freshwater plume from the Mississippi River and the Gulf Loop Current are the major controlling oceanographic factors in the GOM.

As noted in the introduction, "deep water" is a term of convenience used in this analysis to refer to water depths >300 m (984 ft). The majority of deepwater seafloor in the GOM is typically covered by clay and silt (Jenkins, 2011). In, on, and directly above these sediments live a wide variety of "benthos," or benthic organisms, from microbiota up through megafauna. Their ecological adaptations are extremely varied and can include absorption of dissolved organic material, symbiosis, collection of food through filtering, mucous webs, seizing, or other mechanisms, including chemosynthesis.

Deepwater fauna can be grouped into major assemblages defined by depth: (1) upper slope; (2) mid-slope; (3) lower slope; and (4) abyssal plain (Rowe and Kennicutt, 2009). The 450-m (1,476-ft) depth contour delimits the approximate beginning of the aphotic zone where visible light no longer penetrates and where photosynthesis cannot occur, with resultant changes to processes of food consumption, biological decomposition, and nutrient regeneration. The continental shelf-slope transition zone begins at approximately 150 m (492 ft) and the abyssal zone begins at approximately ≥1,000 m (3,281 ft). The different zones can be subdivided into the following divisions and characteristic faunal assemblages:

- Shelf-Slope Transition Zone (150-450 m; 492-1,476 ft)—A very productive part of the benthic environment. Demersal fish are dominant, many reaching their maximum populations in this zone. Asteroids, gastropods, and polychaetes are common.
- Archibenthal Zone – Horizon A (475-740 m; 1,558-2,428 ft)—Although less abundant, demersal fish are a major constituent of the fauna, as are gastropods and polychaetes. Sea cucumbers are more numerous.
- Archibenthal Zone – Horizon B (775-950 m; 2,543-3,117 ft)—This zone represents a major change in the number of species of demersal fish, asteroids, and echinoids, which reach maximum populations here. Gastropods and polychaetes are still numerous.
- Upper Abyssal Zone (1,000-2,000 m; 3,281-6,562 ft)—Number of fish species decline while the number of certain invertebrate species appear to increase. Sea cucumbers and galatheid crabs are common
- Mesoabyssal Zone (2,300-3,000 m; 7,546-9,843 ft)—Fish species are few, and echinoderms continue to dominate the megafauna.
- Lower Abyssal Zone (3,200-3,800 m; 10,499 to 12,468 ft)—A large asteroid is the most common megafaunal species.
- The lowermost layer is the benthic zone, defined as the seafloor itself and the waters immediately above it. This zone is a repository of sediments where nutrient storage and regeneration take place in association with the solid and semisolid substrate (Pequegnat, 1983). Characteristic fauna may be different depending on the actual depth of the seafloor.

The vast majority of the GOM seabed is comprised of soft sediments (Rezak et al., 1983; Jenkins, 2011). Sediments in the EPA consist primarily of sand, while a more heterogeneous mix of sand, silt and clay sediments are found in the CPA and WPA (Brooks and Darnell, 1991). Grain size is the most important substrate characteristic affecting the distribution of benthic fauna (Vittor, 2000). Major groups of animals that live in sediments include (1) megafauna (visible to the naked eye), (2) macrofauna (>0.01 in; 0.3 mm), (3) meiofauna (0.002-0.01 in; 0.063-0.3 mm), and (4) bacteria and other microbiota. All of these groups are represented throughout the entire GOM − from the continental shelf to the deepest abyssal depths. This analysis focuses on the better known megafauna and their habitats.

4.4.1.1 Chemosynthetic Communities

Chemosynthetic communities begin with chemosynthetic bacterial mats that consume methane and sulfides; their respiration results in the precipitation of calcium carbonate, forming a new, hard substrate. Certain deepwater coral and sponge species can then attach to exposed hard substrates, thereby adding to the structural complexity of the microhabitat. The new benthic habitats provided by chemosynthetic fauna themselves (i.e., tubeworm bushes), the precipitated hard substrates, and the framework-forming corals can all be used by a variety of benthic invertebrates, including echinoderms (e.g., brittle stars and basket stars), sea anemones, crustaceans, and other benthic megafauna such as fishes, forming a broader chemosynthetic community.

The GOM has some of the most active natural oil and gas seeps in the world (refer to **Chapter 3.3.2.9.2**; NRC, 2003), and these seeps can support development of complex deepwater faunal communities (MacDonald et al., 1993; Cordes et al., 2010). The food chain for this ecosystem relies on bacterial primary producers that consume methanes and sulfides rather than performing photosynthesis. Chemosynthetic bacteria, which live on mats, in sediment, and in symbiosis with chemosynthetic invertebrates, use a carbon source independent of photosynthesis to make sugars and amino acids. Chemosynthetic invertebrates including tube worms and bivalves occur at or near hydrocarbon seeps and are dependent upon these symbiotic chemosynthetic bacteria as their primary food source (MacDonald, 1992). The bacteria live within specialized cells in the invertebrate organisms and are supplied with oxygen and chemosynthetic compounds by the host via specialized blood chemistry (Fisher, 1990). The host, in turn, lives off the organic products subsequently released by the chemosynthetic bacteria and may even feed on the bacteria themselves.

Distribution and Detection

Chemosynthetic communities typically occur in the GOM at water depths greater than 300 m (984 ft). Temperatures at these depths range from about 55°F to 39°F (13°C to 4°C). Water currents at the seafloor are typically about 2-4 inches/second (5-10 centimeters/second). The chemosynthetic communities occur as widely scattered, patchy habitat, developing where hydrocarbons seep up with a moderate flow.

Seeps occur where hydrocarbons vertically migrate up through faults, fractures along the flanks of salt, or other conduits to the seafloor. The exact number of natural oil prone seeps in the GOM is not known, although volume estimates have been made using surface oil slicks and the numbers are considerable (MacDonald et al., 1993; NRC, 2003). Even less is known about the number and flux of gas prone seeps in the GOM since no observable sea-surface slicks are present. What is known is that the overwhelming majority of seeps are gas prone, not oil prone. Hydrocarbon source rocks occur over broad areas several kilometers beneath the seafloor of the GOM, but chemosynthetic communities occur in isolated areas at the seafloor. Seepage from deep hydrocarbon sources through subsurface conduits tends to be focused through the sediments, carbonate outcrops, and hydrate deposits at the seafloor. Therefore, GOM 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).

As of 2015, at least 330 chemosynthetic communities have been confirmed (by government, academia, and industry) to exist in the Gulf of Mexico (**Figure 4-11**). Chemosynthetic communities dependent on hydrocarbon seepage have been documented in water depths as shallow as 951 ft (290 m) (Roberts et al., 1990) and at least as deep as 9,000 ft (2,743 m) (Roberts et al., 2010). But these known depth limits may only be reflective of the current limits of exploration due to the logistic difficulties of deepwater research; relatively few available submersibles are capable of exploring deeper than 3,281 ft (1,000 m). Given the rapid rate of discovery and improved understanding in recent years, the evidence suggests chemosynthetic communities could be more prevalent than once thought.

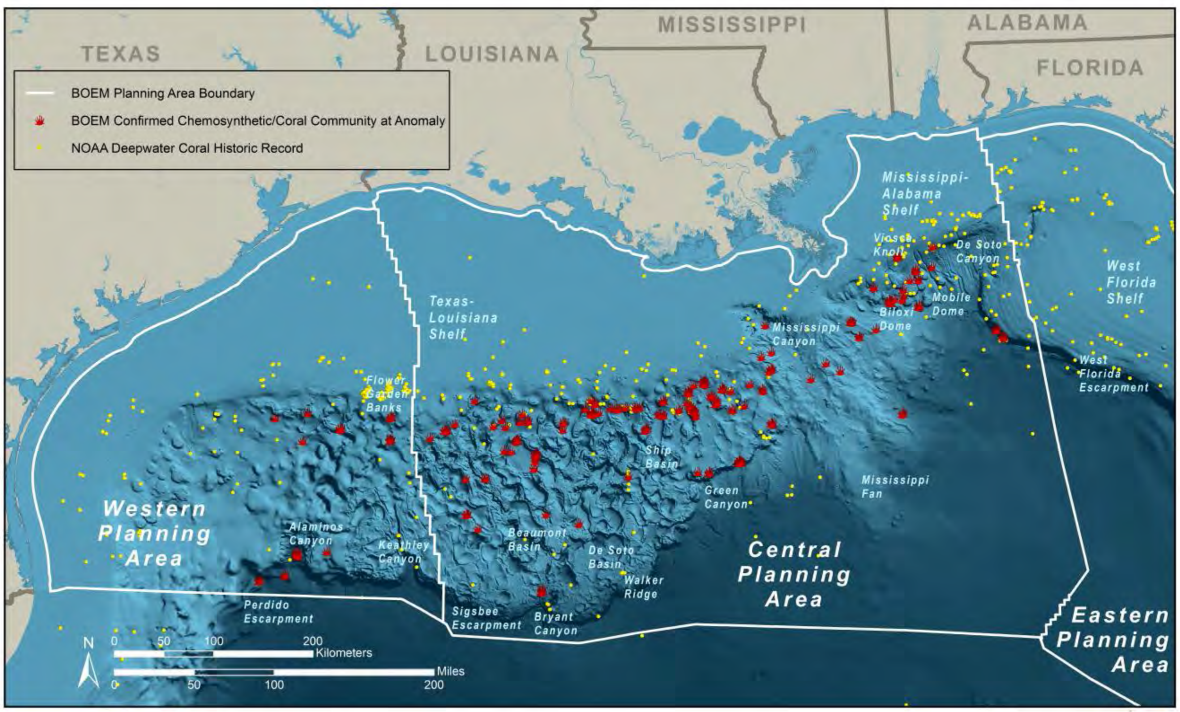

Figure 4-11. Estimated Distribution of Known Deepwater Benthic Communities in the Gulf of Mexico as of 2015.

Hydrocarbon seeps and chemosynthetic communities living on them modify the near-surface geological characteristics in ways that can be remotely detected, such as through 2D and 3D seismic anomaly detection (USDOI, BOEM, 2015b). These known sediment modifications include the following: (1) precipitation of authigenic carbonate in the form of interstitial cements, micronodules, nodules, or rock masses; (2) formation of gas hydrates; (3) modification of sediment composition through concentration of hard chemosynthetic organism remains (such as shell fragments and layers); (4) formation of interstitial gas bubbles or hydrocarbons; and (5) formation of depressions or pockmarks by gas expulsion. These features give rise to various detectable acoustic effects (details in Behrens, 1988; Roberts and Neurauter, 1990). Potential locations for most types of communities can be estimated by careful interpretation of these various geophysical modifications (Sager, 1997) and can help direct and focus follow-up visual surveys needed to definitively confirm the presence or absence of chemosynthetic communities.

BOEM's subject-matter experts make use of the best available datasets to identify probable habitat that could support deepwater benthic communities. A primary such dataset is BOEM's publicly available database of water-bottom anomalies (USDOI, BOEM, 2015b). Using decades of 3D seismic amplitude data, BOEM geoscientists have identified and mapped over 31,000 water-bottom (seafloor) acoustic amplitude anomalies covering a majority of the deep waters in the northern Gulf of Mexico (**Figure 4-12**). One of the purposes of this effort is to better understand the distribution of natural hydrocarbon seeps and related chemosynthetic communities and deepwater coral communities. The areas of anomalously high or low seafloor reflectivity have been classified into general categories of seafloor features, including those that are thought to support chemosynthetic and deepwater coral communities (USDOI, BOEM, 2015b). As of 2015, BOEM was aware of a total of 332 seep anomalies that have been visually confirmed through photography, video, and manned submersible dives to contain associated chemosynthetic and/or coral communities (**Figure 4-12**, shown in orange); however, that relatively low number is largely due to a lack of visual survey effort required for definitive visual confirmation. Several of the other anomaly categories may also contain potential habitat capable of supporting deepwater chemosynthetic and coral communities. Additional information is being collected and analyzed by BOEM's geoscientists and provided to BOEM's subject-matter experts on an ongoing basis.

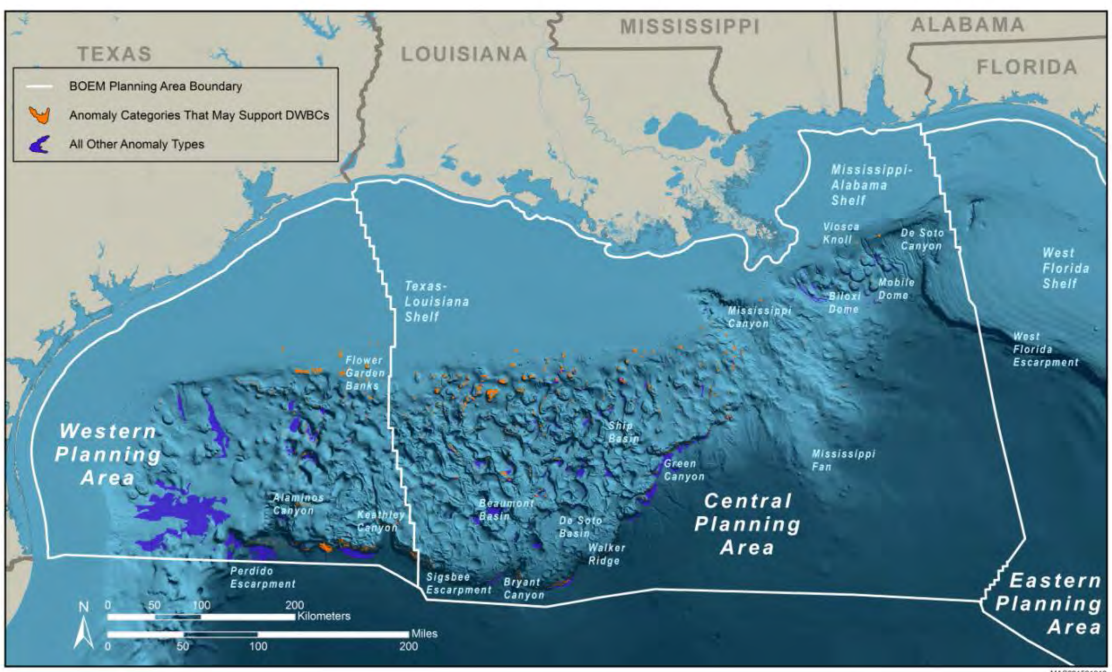

Figure 4-12. BOEM's Water Bottom Seismic Anomaly Database Showing Grouped Anomaly Categories Thought Likely to Support Deepwater Benthic Communities (shown in orange) and Those That Generally Do Not (shown in purple)

Biology

MacDonald et al. (1990) described four general community types: (1) tube worms; (2) mussels; (3) clams at the seafloor surface; and (4) burrowing clams. 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 associated with them. Individual tube worms can reach lengths of over 10 ft (3 m) and live hundreds of years (Fisher et al., 1997). Average growth rates determined from marked tube worms have been variable, but they average approximately 7.1 millimeters/year (0.28 inches/year) for some species. Tube worm spawning and recruitment is episodic. Mytilid mussels have been found to reach reproductive age relatively quickly, with growth rates slowing in adulthood (Fisher, 1995). These factors lead to long-lived individuals and communities. Powell (1995) estimated that some clam and mussel communities at chemosynthetic sites have been present in the same location for between 500 and 4,000 years, with most communities showing no evidence of changes in the dominant faunal organisms over time. Local extinctions and recolonizations are likely gradual and rare.

Other common heterotrophic organisms often found at chemosynthetic community sites include a variety of mollusks, crustaceans, and echinoderms (Carney, 1993). 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 energy sources and may also contribute substantially to overall production (MacDonald, 1998). Some of the species found at GOM seep communities are new to science and remain undescribed.

Persistence

According to Sassen (1998), the role of naturally occurring methane hydrates to influence the morphology and characteristics of chemosynthetic communities has been greatly underestimated. Gas hydrates are a unique and poorly understood class of chemical substances. The dynamics of hydrate alteration could play a major role in the release of hydrocarbon gases to fuel biogeochemical processes and could influence community stability (MacDonald, 1998). Changes in bottom-water temperature of several degrees (39-41 °F [4-5 °C] at 1,640-ft [500-m] depth) may result in dissociation of hydrates and an accompanying increase in gas fluxes (MacDonald et al., 1994). Although not as destructive as the volcanism at vent sites o° the mid-ocean ridges, the dynamics of shallow hydrate formation and movement could clearly affect sessile animals around the seepage barrier because of the potential for an entire layer of shallow hydrate to break free of the bottom, which would result in considerable impacts to local communities of chemosynthetic fauna. At deeper depths (>3,281 ft; >1,000 m), the bottom-water temperature is colder and undergoes less fluctuation.

Precipitation of authigenic carbonates and other geologic events would alter surface seepage patterns and available substrates over periods of only a few years. However, through taphonomic (death assemblages of shells) studies and interpretation of seep assemblage composition from cores, Powell (1995) reported that, overall, seep communities were persistent over periods of 500-4,000 years. Powell found few cases in which the community type changed (from mussel to clam communities, for example) over time. When recovery occurred after a past destructive event, the same chemosynthetic species reoccupied a site. MacDonald et al. (1995) observed no changes in chemosynthetic fauna distribution or composition at seven separate study sites. In the case of one well-known chemosynthetic community (Bush Hill), no mass die-offs or large-scale shifts in faunal composition were observed over 12 years of research.

4.4.1.2 Deepwater Coral Communities

Deepwater corals are sessile invertebrates in the phylum Cnidaria. They live at great depths (as deep as 10,000 ft [3,048 m] in some cases) where there is little to no light. As with the better known shallow-water corals, deepwater corals are colonial animals. Individual polyps extend tentacles into passing currents to feed on nutrients, which can be relatively scarce at depth. Energy supply is further limited by the lack of light-dependent mutualistic zooxanthellae algae that benefit many shallow-water coral species. As a result, deepwater coral colonies grow very slowly; colonies may live to be hundreds or even thousands of years old (USDOC, NOAA, 2014a).

Deepwater corals are found in all the world's oceans and actually have a higher overall diversity of species than shallow-water coral (Cairns, 2007). Yet it is only in recent decades that they have become a focus of scientific research (Freiwald et al., 2004) and management concern (USDOC, NOAA, 2014a; CSA, 2002), as anthropogenic threats such as bottom disturbance (e.g., from fishing gear) have become more clear. Their very slow growth rates and fragile skeletal structures make them especially vulnerable to physical disturbance. Once damaged, deepwater corals and the associated communities they support may take centuries to fully recover (USDOC, NOAA, 2014a), which is why mitigation efforts aim to prevent any direct physical contact.

In the GOM, almost all deepwater corals are found attached to exposed surfaces of hard substrates. These substrates include chemosynthetically produced carbonate substrates (**Chapter 4.4.1.1**), but they can also include exposed sedimentary bedrock and even artificial structures such as shipwrecks and oil platforms.

Some species of deepwater corals and sponges are known to create large, three-dimensional structures, which are sometimes referred to as deepwater reefs. Some of these have grown many feet tall over time. Structure-forming corals include branching scleractinian species, Antipatharians (black corals) and gorgonians (sea whips/sea fans). *Lophelia pertusa*, the most well-known scleractinian deepwater coral, can form vast reef-like thickets that can stretch to over 3,280 ft (1,000 m) in surface extent. In a historic 1955 trawl collection from a depth of 1,381-1,680 ft (421-512 m), Moore and Bullis (1960) retrieved more than 300 pounds (136 kilograms) of *Lophelia pertusa* from the Viosca Knoll area in the CPA.

Similar to shallow-water live bottom microhabitats (**Chapter 4.6**), deepwater coral microhabitats enhance the structural complexity of the local environment, providing shelter, feeding sites, and nursery grounds that are attractive to a large variety of other invertebrates and fishes, including a few commercially harvested species (Schroeder et al., 2005; Fisher et al., 2007; Fraser and Sedberry, 2008; Sulak et al., 2008; Cordes et al., 2008; USDOC, NOAA, 2014a; Hourigan, 2014). Common crustaceans include golden crab *(Chaceon fenneri*) and squat lobster (*Eumunida picta*). Common echinoderms include brittle stars (order Ophiurida) and baskets stars (order Euryalida). Deepwater reef-associated fish are known to include barrelfish (*Hyperoglyphe perciformis*), wreckfish (*Polyprion americanus*), and snowy grouper (*Epinephelus niveatus*) at shallower locations and blackbelly rosefish (*Helicolenus dactylopterus*), roughys (*Hoplotsethus* spp.), and thornyheads (*Sebastolobus* spp.) at deeper sites (Hourigan, 2014; refer to **Chapter 4.7**).

Distribution

Distribution of individual deepwater coral and associated species assemblages is influenced by depth, available substrate, and other environmental conditions such as bottom currents. At least six different types of octocoral assemblages occur in the deep northwestern Gulf and the West Florida Slope at depths of 820-8,200 ft (250-2,500 m). The black coral, *Leiopathes* spp., appears broadly distributed across both regions. Although *Lophelia pertusa* is best represented in water depths of the upper slope, it has occasionally been reported as deep as 9,842 ft (3,000 m) in some parts of the world.

The NOAA's Deep Sea Coral Research and Technology Program and NOAA's National Centers for Coastal Ocean Science have been continuously compiling a detailed national database of known observations of deepwater corals and sponges (USDOC, NOAA, 2014a and 2015j) (**Figures 4-10 and 4-11**), but these confirmed visual observations likely represent only a fraction of the populations. Deepwater research cruises, for example those undertaken by NOAA's deep-sea research vessel *Okeanos Explorer*, routinely discover additional deepwater coral locations. However, even with ongoing additions of observation records, the majority of deepwater coral communities would not be directly observed and documented in the near future due to the inherent logistical difficulties of deepwater research and data collection.

Therefore, extrapolative analyses such as one undertaken by NOAA (**Figure 4-13**) have also included efforts to predictively model suitable habitat for deepwater coral and sponges, based on existing observation records combined with the best available physical datasets. These models can serve as an important tool to help identify where deepwater coral communities are likely to be found and to help focus future data collection and research efforts. For example, based in part on previous databases and models, the Gulf of Mexico Fishery Management Council (GMFMC) is currently evaluating advisory panel recommendations to designate up to 47 new, small areas as deepwater coral Habitat Areas of Particular Concern (CSA, 2002). Future research, including a planned BOEM-funded study (Interagency Agreement #M15PG00020), may improve on previous deepwater coral modeling and expand to include chemosynthetic communities.

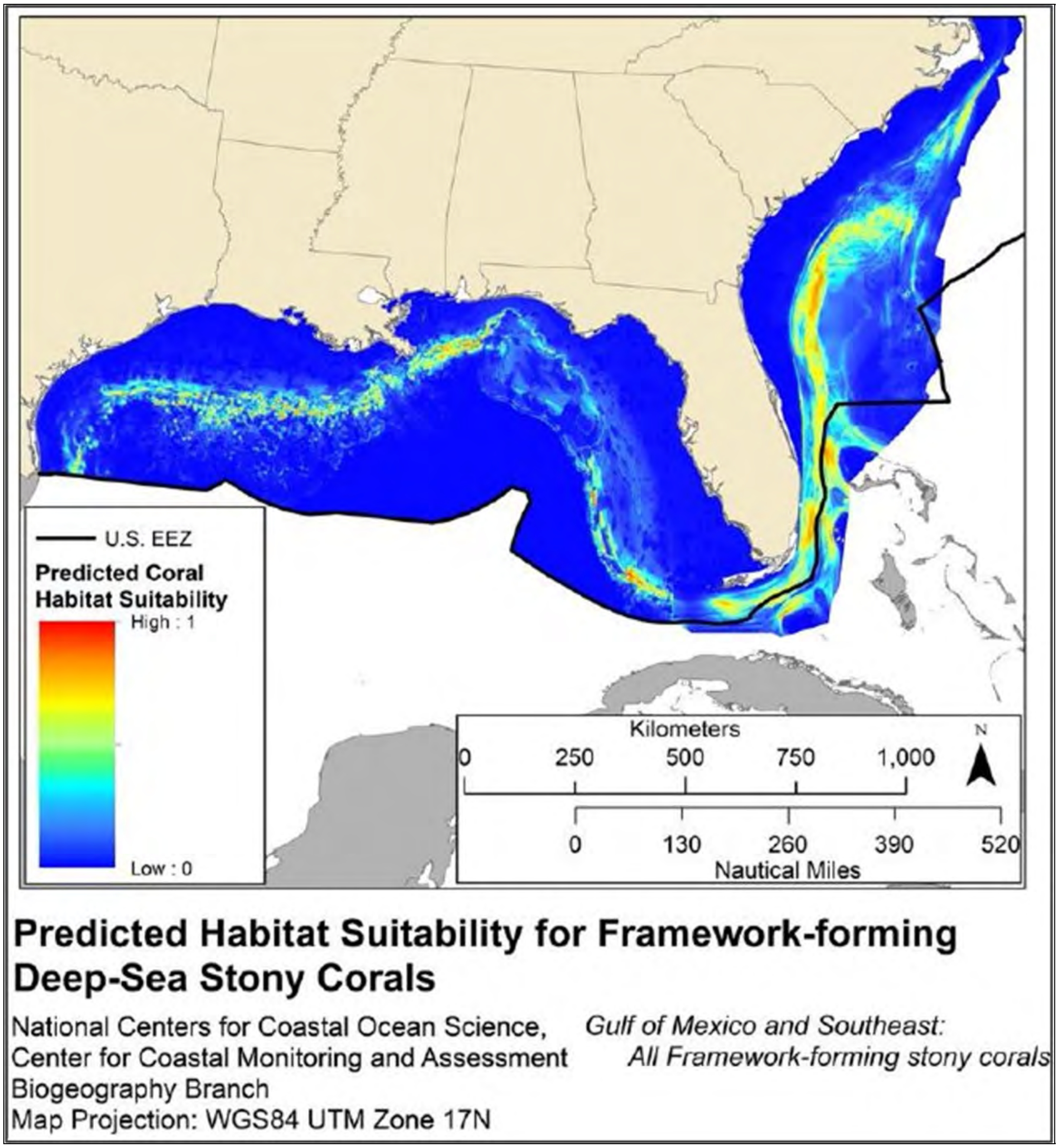

Figure 4-13. Example of a Predictive Habitat Suitability Model for Selected Deepwater, Framework-Forming Scleractinian Corals (excerpted with permission from USDOC, NOAA, 2014a).

4.4.2 Environmental Consequences

4.4.2.1 Routine Activities

A number of routine OCS oil- and gas-related impact-producing factors may cause adverse impacts to deepwater benthic communities. As noted above, some factors with only minimal impacts are presented in greater detail in other chapters, and full analyses are not repeated here. The potential routine impact-producing factors on deepwater benthic habitats analyzed here are grouped into two main categories having similar impacts: (1) bottom-disturbing activities; and (2) drilling-related sediment and waste discharges. These impact-producing factors have the potential to damage deepwater benthic habitats and disrupt associated communities if not sufficiently distanced via mitigations.

Bottom-Disturbing Activities

Bottom-disturbing activities can be described as any activities that result in the physical disturbance of the seafloor during the exploration, production, or decommissioning phase of OCS operations (refer to **Chapters 3.1.2, 3.1.3.3, and 3.1.6**). Anchoring, drilling, trenching, pipe-laying, and structure emplacement and removal are examples of OCS oil- and gas-related activities that disturb the seafloor (refer to **Chapters 3.1.3.3 and 3.1.6**). The spatial extent of the seafloor disturbance and the magnitude of the effect on deepwater benthic organisms would depend on the specific activity, local environmental conditions (e.g., currents, water depth, etc.), and species-specific behaviors and habitat preferences.

Turbidity from suspended sediments, along with sediment displacement resulting from routine, bottom-disturbing oil- and gas-related activities, generally has localized effects. Impacts to deepwater benthic communities could include any or all of the following: reduced settlement and growth opportunities due to loss of available hard substrate; inhibited feeding leading to reduced reproductive fitness; and mortality of individuals (e.g., coral polyps and 1 or 2 tubeworms) and groups (e.g., entire coral colonies and tubeworm “bushes”). Reductions in overall biological cover could have secondary ecological effects on organisms that were using the complex structural microhabitats, for example the loss of a shark spawning ground (some sharks deposit eggs in deepwater coral [Etnoyer and Warrenchuk, 2007]) that reduces future shark populations. Some mobile invertebrates (e.g., brittle stars) are expected to be able to move to avoid the heaviest sediment displacement and highest suspended sediment loads within 33 ft (10 m) of a disturbance, while sessile invertebrates (e.g., corals) cannot. Sessile and mobile invertebrate species adapted to living in turbid environments, such as many gorgonians, may be less affected by increased turbidity. Such organisms may also be adapted to remove some covering sediment via tentacle motion and mucus secretion (Shinn et al., 1980; Hudson and Robbin, 1980). Other species that typically inhabit less turbid waters would suffer relatively greater impacts (Rogers, 1990; Gittings et al., 1992a). Solitary octocorals and gorgonians may be tolerant of a certain amount of sedimentation, partly because they grow tall and are flexible, reducing sediment accumulation and allowing for easier removal (Marszalek, 1981; Torres et al., 2001; Gittings et al., 1992a), but are not completely resilient to impacts (Doughty et al., 2014).

The OCS oil- and gas-related infrastructure/equipment also has the potential to damage or kill deepwater benthic organisms should the equipment itself make direct contact. Any object placed on or through (e.g., a piston-driven core sampler) a deepwater benthic organism or supporting substrate can cause partial or complete breakage, crushing, or smothering. In addition to mortality, there could be any or all of the potential sublethal impacts already described above in relation to turbidity and sediment displacement. The severity of community impacts from direct physical contact would vary in direct proportion to the surface area and mass of the specific equipment. For example, the placement of a large bottom-founded platform on a deepwater benthic community would have a much greater impact than placement of a small umbilical cable.

Similarly, anchor damage is one of the greatest threats to benthic biota in the GOM if it is not prevented (Rezak and Bright, 1979; Rezak et al., 1985; Gittings et al., 1992a; Hudson et al., 1982). Anchors may break, fragment, or overturn tubeworms, bivalves, corals, sponges, or any other sessile benthic organisms, and the anchor chain or cable may drag across and shear organisms off the substrate (Dinsdale and Harriott, 2004). This would result in consequences ranging from increased stress to mortality (Dinsdale and Harriott, 2004). The impact of dragging an anchor across a deepwater benthic community would depend on the distance and duration of bottom contact, but it could be considerable due to the forces involved; dragged anchors often leave seafloor scars noticeable on sidescan sonar imagery years later. Damage to a coral community may take decades to recover (Fucik et al., 1984; Rogers and Garrison, 2001).

Drilling-Related Sediment and Waste Discharges

Drilling of new wells is one of the activities with the greatest impact potential due to the associated sedimentation/turbidity caused by the drilling process and from the release of drilling cuttings and discharges (**Chapter 3.1.5.1**). Drilling an exploratory well produces approximately 2,000 metric tons of combined drilling fluid and cuttings, though the total mass may vary widely for different wells (Neff, 2005). Cuttings discharged at the surface tend to disperse in the water column and be distributed at low concentrations (CSA, 2004a). In deep water, the majority of cuttings discharged at the sea surface are likely to be deposited within 820 ft (250 m) of the well (CSA, 2006). Cuttings shunted to the seafloor form piles concentrated within a smaller area than do sediments discharged at the sea surface (Neff, 2005).

Apart from the direct impacts of turbidity and sedimentation, the chemical content of drilling muds and cuttings (and, to a lesser extent, produced waters) are another potential impact-producing factor since these may contain hydrocarbons, trace metals including heavy metals, elemental sulfur, and radionuclides (Kendall and Rainey, 1991; Trefry et al., 1995). Substances containing heavy metals and other potentially toxic compounds would have the potential to be moderately toxic to deepwater benthic organisms, but only if they were to come into contact in undiluted strengths (CSA, 2004b). Although the literature has not reported impacts to chemosynthetic organisms, gorgonians, or soft corals as a result of exposure to contaminants in cuttings, infauna have shown effects at distances <330 ft (<100 m) from the discharge. These include reduced reproductive fitness, altered populations, and acute toxicity (Montagna and Harper, 1996; Carr et al., 1996; Kennicutt et al., 1996; Hart et al., 1989; Chapman et al., 1991; CSA, 2004b). Because of BOEM's distancing requirements for new wells, contact with concentrated (and potentially harmful) levels of any such toxins is not expected. As they travel from a source, produced waters (refer to **Chapter 3.1.5.1.2** for more detail) are rapidly diluted with distance, and impacts are generally only observed within very close proximity of the discharge point (Gittings et al., 1992a; Neff, 2005). In addition to the protection offered by BOEM's distancing requirements, releases of toxic discharges are regulated by the USEPA through the issuance of NPDES permits. Adherence to these regulations would help ensure that water quality is maintained at nontoxic levels.

In addition to drilling activities, the process of installing and removing OCS oil- and gas-related infrastructure (i.e., pipelines, platforms, and subsea systems including cables) also has the potential to displace large volumes of sediment (**Chapters 3.1.3.3 and 3.1.6**). The resulting localized increases in turbidity and sedimentation would have the same indirect impacts as those caused by drilling-related sediment movement.

As further detailed in other chapters, explosive severance methods used during decommissioning activities could result in damage or mortality to any organisms within the vicinity of the blast or associated sediment plume, although long-term turbidity is not expected from platform removal operations. The shockwave from a nearby blast could also damage or destroy the underlying hard substrates required to support some deepwater benthic communities. The BSEE Interim Policy Document 2013-07, "Rigs-to-Reefs Policy," specifies that the use of explosive severance methods would not be approved if site-specific analysis determines they would cause harm to natural deepwater benthic communities.

Compared with shallow-water live bottom communities, some deepwater benthic organisms may be slower to recover from any of the impacts described above due to the generally much slower growth and recruitment rates that are typical of these longer-lived species and communities (Powell, 1995). For example, Doughty et al. (2014) demonstrated that *Paramuricea* spp., some of the most common deepwater corals in the GOM, may have very low recruitment rates and therefore slow recovery.

Potential impacts resulting from all of the above routine activities (both bottom-disturbing activities and drilling-related sediment and waste discharges) are mitigated through the protective measures (primarily distancing) described above and in NTL 2009-G40. The postlease, site-specific survey information and mitigation options described in NTL 2009-G40 would allow BOEM to identify and sufficiently distance deepwater benthic features from any proposed OCS oil- and gas-related routine activity during postlease reviews. If all of these requirements are applied as expected, at the scope of this analysis, the impacts of routine activities would be expected to be **negligible**.

Without adherence to those requirements or absent expected USEPA restrictions on discharges, impacts to deepwater benthic communities from the above routine activities could rise to minor, moderate, or even major, depending on the number and locations of specific activities. The highest impact levels are possible in the improbable (but theoretically possible) case that a large number of routine activity disturbances were to physically impact a large number of deepwater benthic communities. Even without mitigations, the likelihood is very low that a large number of OCS oil- and gas-related activities would occur in close proximity because the hard substrate habitats supporting deepwater benthic communities are patchily distributed throughout the GOM and are relatively rare compared with soft bottom substrates. But this possibility cannot be definitively ruled out without knowing both the precise spatial distribution of both future OCS oil- and gas-related activities and deepwater benthic communities.

4.4.2.2 Accidental Events

The primary accidental impact-producing factors affecting deepwater benthic communities analyzed here are grouped into two categories: (1) bottom-disturbing activities; and (2) oil spills and associated cleanup responses. These factors have the potential to damage deepwater benthic habitats and disrupt associated benthic communities if not sufficiently distanced or otherwise mitigated.

Bottom-Disturbing Activities

Impacts resulting from bottom-disturbing activities were already detailed in “Routine Activities” section above and are largely the same for accidental events. There are only slight differences that need to be considered here and are related to mechanisms and potential severity. The primary, accidental bottom-disturbing activity is the inadvertent deposition or placement of equipment on deepwater habitats. Accidental loss of equipment could occur during transfer operations between vessels and platforms, during vessel transit, during an “on deck” accident, as a consequence of a severe storm, or if a structure, drill, or anchor is unintentionally placed in the wrong location during operations. During routine operations, the distancing mitigations offer some protections against these types of impact, but those protections may not apply to all accidents, other than to reduce the likelihood of routine activities occurring in those areas in the first place. Any object placed on or through a deepwater benthic habitat could cause partial or complete breakage, crushing, or smothering of both substrate and organisms, and/or increased sedimentation as equipment disturbs the seafloor. In addition to mortality, deepwater benthic communities could experience any or all of the potential sublethal impacts already described in the “Routine Activities” section above. The severity of impacts from direct physical contact would vary in direct proportion to the surface area and mass of the specific equipment. Given the relative rarity of deepwater benthic habitats and communities in the GOM, accidental impacts from bottom-disturbing equipment are expected to be infrequent and highly localized, with the likelihood of accidental contact further reduced by the expected distancing mitigations. However, because of the unplanned and potentially uncontrolled nature of accidental bottom-disturbing events, there exists greater uncertainty about their potential impact severity than exists for planned routine activities. Therefore, at the scale of this analysis, impacts to deepwater benthic communities from accidental, bottom-disturbing activities could range from **negligible** to **minor**, depending on their overall frequency and severity and whether or not community-level accidental impacts can be clearly distinguished from natural variation.

Without the protective mitigations provided by postlease reviews and distancing, the potential impacts of accidental bottom disturbances could rise to moderate or even major levels, in the improbable (but theoretically possible) case that a large number of accidental disturbances were to physically impact a large number of deepwater benthic communities. Even without mitigations, the likelihood is very low that a large number of OCS oil- and gas-related activities would occur in close proximity to the relatively rare hard substrate habitats supporting deepwater benthic communities. However, this possibility cannot be definitively ruled out without knowing both the precise spatial distribution of both future OCS oil- and gas-related activities and deepwater benthic communities.

Oil Spills and Associated Cleanup Responses

Oil spills, historic trends, the characteristics of oil, and factors affecting the fate of oil released into the marine environment are discussed in detail in **Chapter 3.2.1** (Oil Spills), and the potential impacts to water quality are analyzed in **Chapter 4.2** (Water Quality). For additional information on impacts resulting specifically from a catastrophic spill, refer to the *Catastrophic Spill Event Analysis* white paper (USDOI, BOEM, 2017).

Impacts related to an accidental release of oil or other contaminants could adversely affect deepwater benthic communities. Potential impacts related to an accidental spill would depend on the combination of these various components: surface oil; subsurface oil; chemical dispersants and dispersed oil; sedimented oil (oil adsorbed to sediment particles); sedimentation caused by a loss of well control; and certain spill-response activities. Adherence to well-distancing requirements should serve to reduce such impacts.

Biological impacts resulting from exposure to accidentally released oil droplets and/or chemical dispersants are anticipated to be mostly sublethal and recoverable. Sublethal impacts that may occur to exposed deepwater benthic organisms may include reduced feeding, reduced reproduction and growth, physical tissue damage, and altered behavior. For example, short-term, sublethal responses of a shallow-water coral species included mesenterial filament extrusion, extreme tissue contraction, tentacle retraction, and localized tissue rupture reported after 24 hours of exposure to dispersed oil at a concentration of 20 ppm (Knap et al., 1983; Wyers et al., 1986). Laboratory tests by DeLeo et al. (2015) on the relative effects of oil, chemical dispersants, and chemically dispersed oil mixtures on three species of northern GOM deepwater corals found much greater health declines in response to chemical dispersants and to oil-dispersant mixtures than to oil-only treatments, which did not result in mortality. It is important to note that, generally, laboratory experimental concentrations are designed to discover toxicity thresholds (as in DeLeo et al., 2015) that exceed probable exposure concentrations in the field.

Chemosynthetic organisms are naturally adapted to handle the limited amounts of hydrocarbons that are typical at slow-flowing seeps. While they have not been as well studied as deepwater corals, there have not been documented impacts from the *Deepwater Horizon* oil spill to chemosynthetic communities (USDOI, BOEM, 2012b; Shedd, official communication, 2015). It is possible that some deepwater coral species also have limited capabilities to endure oil exposure. Results from DeLeo et al. (2015) suggested that *Callogorgia delta*, a soft coral often associated with natural hydrocarbon seeps, may have some natural adaptation to short-term oil exposure. Al-Dahash and Mahmoud (2013) suggest that a possible mechanism for this is coral harboring of symbiotic oil-degrading bacteria. Oil spills originating at the surface have fairly limited potential to directly impact deepwater benthic communities. Oil becomes diluted as it physically mixes with the surrounding water and moves into the water column, and the physical mixing zone of surface oil is generally limited to approximately 33 ft (20 m) (Lange, 1985; McAuliffe et al., 1975 and 1981a; Tkalich and Chan, 2002; Thompson et al., 1999; Schroeder, 2000). In one extraordinary circumstance with an unusual combination of conditions, a tropical storm forced a large volume of *Deepwater Horizon* oil spill-linked dispersant/oil mixture as deep as 246 ft (75 m), causing temporary exposure to mesophotic corals in the Pinnacle Trend area (Silva et al., 2015), but that depth is still far shallower than that of the deepwater benthic communities considered here.

The USCG may allow the application of chemical dispersants in certain spill situations. Chemical dispersion of oil can help to break up concentrations of oil, accelerate natural weathering processes, and promote bacterial biodegradation (**Chapter 3.2.8**). Use of dispersants may, however, have unintended effects. For example, it may allow surface oil to penetrate to greater depths than expected from normal physical mixing, and dispersed oil more often remains below the water's surface (McAuliffe et al., 1981b; Lewis and Aurand, 1997), possibly leading to negative impacts such as those observed by Silva et al. (2015). DeLeo et al. (2015) demonstrated that concentrated amounts of dispersant and oil/dispersant mixtures caused more severe health declines to deepwater coral than oil-only mixtures.

In a subsurface spill or loss of well control situation, it is expected that the majority of released oil would rise quickly to the surface due to the characteristics of northern GOM oil reserves. However, if an oil spill occurs at great depths and is subjected to higher water pressures, some oil droplets may emulsify and become entrained deep in the water column (Boehm and Fiest, 1982), creating a subsurface plume (Adcroft et al., 2010). During the *Deepwater Horizon* oil spill, dispersants were applied subsea at the source of the blowout. Stratified density layers of water allowed the oil/dispersant plume to remain at depth instead of dispersing up into the water column (Joint Analysis Group, 2010), and these concentrated plumes likely contributed to the serious (but localized) damage to deepwater coral communities. If a concentrated plume comes into continuous contact with a deepwater benthic community, the general impacts could include mortality, tissue loss, opportunistic hydroid overgrowth, failed reproductive success, reduced biodiversity, reduced coverage of fauna and flora on hard substrates, and changes in community structure (White et al., 2012; Hsing et al., 2013; Fisher et al., 2014a; Silva et al., 2015). Exact impacts would depend on the location, age of the spill, and the hydrographic characteristics of the area. Adherence to the distancing requirements described above and in NTL 2009-G40 should reduce such impacts.

For any accidental spill, it is expected that a certain quantity of oil may eventually settle on the seafloor through a binding process with suspended sediment particles (adsorption) or after being consumed and excreted by phytoplankton (Passow et al., 2012, Valentine et al., 2014) (refer to the *Catastrophic Spill Events Analysis* white paper for larger events that are not considered reasonably foreseeable [USDOI, BOEM, 2017]). The product of these processes is sometimes referred to as "marine snow." It is expected that the greatest amount of adsorbed oil particles would occur close to the spill, with the concentrations reducing over distance. Adherence to the original well distancing requirements should therefore reduce such impacts.

If a spill does occur close to a deepwater benthic habitat, some of the organisms may become smothered by marine snow particles and/or other sediments, and experience long-term exposure to hydrocarbons and/or oil-dispersant mixtures that could persist within the sediments (Hsing et al., 2013; Fisher et al., 2014a; Valentine et al., 2014). White et al. (2014) found the anionic surfactant DOSS (dioctyl sodium sulfosuccinate) persisting for at least 6 months within a deepwater coral community, although that study did not measure toxicity. Krasnec et al. (2015) did measure toxicity of sediments collected within 2 km (1.2 mi) of the *Macond*o wellhead, but they did not measure the effects on deepwater megafauna. The study found varying levels of mortality and growth inhibition for a small shrimp-like crustacean species, with the relative degree of toxicity decreasing over time (lower toxicity found in 2014 samples than in 2011 samples). Beyond the localized area of impact in such cases, particles would become increasingly biodegraded and dispersed. Localized impacts to deepwater benthic organisms from marine snow would be expected to be mostly sublethal and could include reduced recruitment success, reduced growth, and reduced biological cover as a result of impaired recruitment (Rogers, 1990; Kushmaro et al., 1997).

Sediments suspended or displaced as a result of a loss of well control could also impact deepwater benthic organisms. These impacts would be largely identical to those caused by sedimentation stirred up by bottom-disturbing equipment, with the possible addition of toxic hydrocarbons or drilling muds in the sediments (refer to "Routine Activities" above). Because OCS-permitted wells would have been distanced from deepwater benthic habitats before installation, it is expected that the heaviest sediment concentrations would fall out of suspension and disperse before reaching sensitive benthic communities, preventing most impacts. Some live bottom organisms, such as flexible sea fans, are naturally adapted to turbid conditions and may not be as negatively affected. Outside of a catastrophic blowout situation, a very substantial amount of sediment burial of organisms during an accidental spill event is not considered reasonably foreseeable (refer to the *Catastrophic Spill Events Analysis* white paper, USDOI, BOEM, 2017).

Finally, spill cleanup/response activities could themselves have negative impacts (**Chapter 3.2.8**). During a response operation, the risk of accidental impacts of bottom-disturbing equipment is increased. There could be unplanned emergency anchoring or accidental losses of equipment from responding vessels. Response-related equipment such as seafloor-anchored booms may be used and could inadvertently contact deepwater habitats and organisms. In addition, drilling muds may be pumped into a well to stop a loss of well control. It is possible that during this process some of this mud may be forced out of the well and deposited on the seafloor near the well site. If this occurs, the impacts would be severe for any organisms buried; however, the impact beyond the immediate area would be limited and adherence to the original distancing requirements should prevent or reduce most impacts.

Accidental spills have historically been small and relatively rare events (**Chapters 3.2.1.4, 3.2.1.5, and 3.2.1.6**; **Table 3-12**). The total number of deepwater benthic communities is relatively small and they are widely distributed throughout the AOI, so a localized impact from one noncatastrophic accidental event would only impact a small portion of the overall resource.

All of these oil spill and associated cleanup response activities could lead to lethal or sublethal impacts on individual deepwater benthic communities, with the range of impacts dependent on the quantity of spilled oil and proximity to habitats. While a spill resulting from a catastrophic-level blowout in deep water (such as the *Deepwater Horizon* oil spill) has the potential to seriously impact individual deepwater benthic communities over a long time period, such a spill is not considered reasonably foreseeable as a result of a proposed lease sale. Impacts from individual routine activities and reasonably foreseeable accidental events are usually temporary, highly localized, and expected to impact only small numbers of organisms and substrates at a time. Natural adaptations to small quantities of oil (Al-Dahash and Mahmoud, 2013; DeLeo et al., 2015) and/or recovery over time (Hsing et al., 2013) is possible for certain deepwater benthic species. Moreover, use of the expected site-specific plan reviews/mitigations would distance activities from deepwater benthic communities, greatly diminishing the likelihood and severity of potential effects. Therefore, at the scale of this analysis and with application of the expected mitigation practices, impacts on deepwater benthic communities from accidental spills are expected to range from **negligible** to **minor**. This range of potential impact levels reflects the relative uncertainty associated with unplanned and potentially uncontrolled accidental events and the uncertainty about the precise distribution of deepwater benthic communities. The exact impact would depend on overall frequency, extent, and severity of accidental spills and whether or not community-level accidental impacts can be clearly distinguished from natural variation.

Without the protective mitigations provided by postlease reviews and distancing, the potential impacts of accidental spills could rise to moderate or even major levels, in the improbable (but theoretically possible) case that a large number of accidental spills were to occur at wells in close proximity to a large number of deepwater benthic communities. Even without mitigations, the likelihood is very low that a large number of accidental spills would occur in close proximity to the relatively rare hard substrate habitats supporting deepwater benthic communities, but this possibility cannot be definitively ruled out without knowing both the precise distribution of such spills and of deepwater benthic communities.

4.4.2.3 Cumulative Impacts

Cumulative impacts on deepwater benthic communities are of concern in part because of their very slow growth rates, which may increase their vulnerability to disturbance over time (Prouty et al., 2014). This analysis considers the cumulative impacts on deepwater benthic communities resulting from (1) the incremental impacts from future routine and accidental oil- and gas-related operations from a proposed lease sale, as well as those resulting from past and future OCS leasing; and (2) potential impacts stemming from other non-OCS oil- and gas-related factors.

OCS Oil- and Gas-Related Impacts

The Cumulative OCS Oil and Gas Program (**Chapter 3.3.1**) impacts to deepwater benthic communities include the incremental contribution of the routine and accidental bottom-disturbing activities outlined above: (1) bottom-disturbance; (2) sediment and waste discharges; and (3) accidental oil spills. As already detailed, these impact-producing factors have the potential to damage individual deepwater habitats and disrupt associated benthic communities if insufficiently distanced or otherwise mitigated.

Bottom-disturbing activities could result in the physical destruction of benthic habitat and organisms or the disturbance of sediments within the environment, resulting in partial or complete burial and/or increased turbidity (**Chapter 3.3.1.5**). Routine and accidental waste discharges could be toxic if contacted in undiluted form near the source, but that is generally unlikely.

Oil spills and chemical dispersants are known to have negative, acute effects on deepwater benthic organisms such as corals (e.g., DeLeo et al., 2015). The cumulative, long-term effects of persistent, low-level exposure to oil are not yet fully understood, although such research is ongoing following the *Deepwater Horizon* oil spill (e.g., White et al., 2014; Baguley et al., 2015). All of these activities could lead to lethal or sublethal impacts on individual deepwater benthic communities. Although a spill resulting from a catastrophic-level blowout in deep water, such as *Deepwater Horizon* blowout (refer to the *Catastrophic Spill Events Analysis* white paper, USDOI, BOEM, 2017), has the potential to seriously impact individual deepwater benthic communities over a long time period (Hsing et al., 2013), the spatial extent of impacts from even such a large spill remains relatively limited (Montagna et al., 2013; Fisher et al., 2014b) and the probability of additional catastrophic-level spills of that size is low.

Impacts from these individual routine activities and accidental events are usually temporary, highly localized, and expected to impact only small numbers of organisms and substrates at a time. Recovery over time from such impacts is possible for certain species (e.g., Hsing et al., 2013). Moreover, use of the expected site-specific plan reviews/mitigations would distance activities from deepwater benthic communities, greatly diminishing potential effects. Therefore, the cumulative contribution of all OCS oil- and gas-related activities is expected to have only **negligible** to **minor** impacts while the much smaller incremental cumulative impact of a single proposed lease sale is expected to contribute only a **negligible** amount to the total level of cumulative impacts.

Non-OCS Oil- and Gas-Related Impacts

The cumulative, long-term impacts on deepwater benthic communities of reasonably foreseeable, non-OCS anthropogenic activities and shifting baseline environmental conditions could be substantial, although they are difficult to quantify, particularly when projecting future conditions out over the next 50 years. A brief summary analysis is provided here. It should be noted that BOEM's site-specific mitigations are not designed to mitigate against the potential impacts posed by these non-OCS anthropogenic activities and environmental factors; they are designed to protect deepwater benthic resources from OCS oil- and gas-related activities within BOEM's jurisdiction and to mitigate against any proposed action's incremental contribution to the overall OCS and non-OCS cumulative impacts.

The primary anthropogenic activities are related to commercial fishing (**Chapter 4.10**). Bottom-tending fishing gear of any type (e.g., trawls, traps, bottom-set longlines, and gillnets) can affect deepwater benthic communities by dislodging or crushing organisms attached to the bottom, with trawls representing the most serious threat (Hourigan, 2014). Currently, the overall amount of fishing effort in very deep waters of the GOM is spatially and temporally limited and primarily consists of a relatively small royal red shrimp fishery and only sporadic reports of golden crab traps (CSA, 2002). Therefore, at the present time, commercial fishing impacts on GOM deepwater benthic communities are **negligible**. Should the overall amount of effort or types of gear used change dramatically over time, fishing impacts could become considerably greater, perhaps as great as major, although that theoretical impact level is highly speculative and dependent on unknown and perhaps improbable future changes in fishery practices.

Climate change-related effects have the potential to alter baseline environmental conditions in the GOM, including in deep waters. A review of climate change is presented in Chapter 4.2.1 of the Five-Year Program EIS (USDOI, BOEM, 2016b), and there is extensive scientific literature available about climate change in general. However, there is currently relatively little literature dedicated to the potential impacts on deepwater benthic communities. Of primary concern for deepwater benthic communities is a projected decline of ocean pH of 0.3-0.5 units over the next century, a shift which would significantly alter calcium carbonate saturation states in the ocean (Doney et al., 2009), reducing the bioavailability of calcium carbonate. Decreased calcification rates have been observed in numerous shallow-water zooxanthellate corals (refer to Hofmann et al., 2010). Similar effects could be expected for deepwater corals such as *Lophelia pertusa* (Lunden et al., 2013; Lunden et al., 2014, Hennige et al., 2015) and for various other calcifying organisms in deep water (Thresher et al., 2015), and such effects could make it more difficult for deepwater calcifying organisms to form or maintain calcium carbonate-based skeletons or shells, possibly inhibiting growth. At the depths of these communities, little to no effect is expected from potential increases in storm frequency and intensity that could possibly be attributed to climate change. The cumulative impact level of future climate change-related factors is difficult to accurately estimate with the current level of scientific understanding. Important baseline data, such as basic measurements of aragonite saturation horizons, are still in the early years of collection and analysis, and the many unknown factors involved make it difficult to accurately assign an authoritative impact level for this impact-producing factor at the long-term scope of this analysis. At present, the overall impact of climate change-related effects on deepwater benthic communities is likely **negligible**. However, over the next 50 years, this impact level could rise to higher levels, even as great as major**,** should the most extreme impacts possible as a result of projected climate change-associated factors come to pass.

Incremental Contribution of a Single Proposed Lease Sale to Overall Cumulative Impacts

Weighed against these potential non-OCS oil- and gas-related impacts from anthropogenic activities and influential baseline environmental conditions, the much smaller incremental cumulative impact of a proposed lease sale is expected to contribute only a **negligible** amount to the total potential level of impacts. Based on current conditions, the overall cumulative impact of everything (OCS and non-OCS) is **negligible** to **minor**. This total impact level has the potential to rise over the next 50 years to higher levels, even possibly major, should projected trends of non-OCS oil- and gas-related activities (particularly climate change) continue or worsen.

4.4.2.4 Incomplete or Unavailable Information

For decades, BOEM has funded research related to deepwater benthic environments in order to further the scientific understanding necessary for informed decisionmaking. However, due in part to the inherent difficulty of data collection in deepwater environments, there is (and likely always would be) incomplete or unavailable information about deepwater benthic communities. BOEM has specifically identified incomplete information for OCS oil- and gas-related impacts related to the following: locations of deepwater benthic communities in the GOM; toxicity of oil and dispersants to deepwater benthic organisms; long-term effects of the totality of the presence of OCS oil- and gas-related infrastructure; long-term effects associated with various climate change-related factors; cascading ecological effects and interactions between deepwater benthic communities and deepwater fish communities; and long-term impacts from the *Deepwater Horizon* explosion, oil spill, and response (refer to the *Catastrophic Spill Events Analysis* white paper, USDOI, BOEM, 2017).

As described above, BOEM's databases of confirmed deepwater benthic communities and 3D seismic water-bottom anomalies are used when reviewing deepwater exploration and development plans. As part of postlease, site-specific development plans, operators must provide a variety of high-resolution survey data, including assessments of potential habitat for sensitive benthic communities. If data are sparse or additional detail is needed, site-specific video or photographic surveys can be requested and used to develop appropriate mitigations. While extremely helpful, BOEM's databases and survey data are not comprehensive of all deepwater benthic communities. For example, available information may not always be of sufficient resolution to identify small areas of scattered hard substrate, such as dead clam shells, that may support small patches of deepwater benthic habitat, as discussed by Quattrini et al. (2013).

To help fill data gaps about locations of deepwater benthic communities, BOEM may also be able to make use of additional datasets created by other Federal agencies. For example, NOAA's Deep Sea Coral Research and Technology Program and NOAA's National Centers for Coastal Ocean Science have been compiling a database of known observations of deepwater corals and sponges (USDOC, NOAA, 2015i). This database of confirmed deepwater coral observations could be used as an ancillary information source during site-specific plan reviews. However, even with the continued additions of observation records over time, it is unlikely that the majority of deepwater coral communities would be directly observed and documented because of the inherent logistical difficulties involved in deepwater research and data collection. Past research by NOAA (Kinlan et al., 2013) has also included efforts to predictively model suitable habitat for deepwater coral and sponges, based on the best available physical/environmental datasets. Future research may improve on these efforts and expand to include chemosynthetic communities. New datasets and models such as these, once they are complete, scientifically vetted, and publicly available, could provide helpful ancillary information to further assist BOEM's site-specific evaluations.

BOEM will continue to analyze and support the continued collection of the best available scientific information related to deepwater benthic communities. However, the best available information does not provide all of the data necessary for a complete understanding of these communities. For example, there is incomplete information with respect to potential long-term effects resulting from exposure to spilled oil, including potential impacts of a catastrophic spill such as the *Deepwater Horizon* oil spill. Known information about the potential impacts of a theoretical catastrophic spill is detailed in the *Catastrophic Spill Events Analysis* white paper (USDOI, BOEM, 2017), and further information was made available with the publication of NOAA's *Deepwater Horizon Oil Spill: Final Programmatic Damage Assessment and Restoration Plan and Final Programmatic Environmental Impact Statement* in 2016 (Deepwater Horizon Natural Resource Damage Assessment Trustees, 2016). The content of that report was reviewed as part of this analysis. Some information related to impacts specific to the *Deepwater Horizon* explosion, oil, spill, and response, such as long-term monitoring results, is still incomplete or unavailable. Impending reports are not expected to reveal additional significant effects that would alter the overall conclusions about reasonably foreseeable impact-producing factors associated with a proposed lease sale. However, in completing this analysis and in making conclusions, BOEM used the best available science to determine the range of reasonably foreseeable impacts, applying accepted scientific methodologies to both integrate existing information and extrapolate potential outcomes. Therefore, BOEM has determined that the incomplete information is not essential to a reasoned choice among alternatives.

4.4.2.5 Alternative A—Regionwide OCS Lease Sale (The Preferred Alternative)

The activities proposed under Alternative A could directly impact deepwater benthic communities within the GOM. The primary, reasonably foreseeable impact-producing factors for deepwater benthic habitats can be grouped into three main categories: (1) bottom-disturbing activities; (2) sediment and waste discharges; and (3) oil spills.

BOEM's site-specific reviews of permit applications would, through distancing and other appropriate mitigations, greatly reduce potential impacts to deepwater benthic communities as a result of routine activities and accidental events. At the broad scope of this analysis, and assuming adherence to all expected postlease, protective restrictions and mitigations, the routine activities are expected to have largely short-term, localized and temporary effects on deepwater benthic communities that may not be easily detectable or clearly distinguishable from natural variation. Therefore, the impacts of routine activities would be expected to be **negligible**. Accidental events (below the threshold of a catastrophic spill, detailed in the *Catastrophic Spill Event Analysis* white paper [USDOI, BOEM, 2017]) do have the potential to cause detectable, severe damage to individual deepwater benthic communities. However, the number of such events is expected to be very small and is not expected to have population-level localized impacts and, therefore, might not be clearly distinguishable from natural variation. Therefore, the impacts of accidental events would be expected to be **negligible** to **minor**. Absent the expected information requirements and mitigation practices, the impacts resulting from the routine activities and accidental events of a proposed lease sale could be greater; the overall population-level impact level could range from

minor to **major** (in a theoretical, if improbable, worst-case scenario). However, those information requirements and mitigation practices are expected to continue.

Proposed OCS oil- and gas-related activities would also contribute incrementally, but only a **negligible** amount, to the overall OCS oil- and gas-related and non-OCS cumulative effects experienced by deepwater benthic communities. The previous and continuing OCS oil- and gas-related cumulative impacts beyond the incremental contribution of a proposed action (a specific lease sale) are estimated to have **negligible** to **minor** impacts. Non-OCS oil- and gas-related activities such as commercial fishing (currently negligible) and shifting baseline environmental conditions related to climate change (currently negligible but likely to increase to major over time should current trends continue or worsen) could cause more noticeable impacts on deepwater benthic communities over the next 50 years.

4.4.2.6 Alternative B—Regionwide OCS Proposed Lease Sale Excluding Available Unleased Blocks in the WPA Portion of the Proposed Lease Sale Area

Under Alternative B, BOEM would hold a lease sale excluding the available unleased blocks in the WPA and would offer all available unleased blocks in the CPA and a portion of the EPA. Alternative B would not fundamentally alter the conclusions reached for Alternative A, but it would reduce the potential impacts of a proposed lease sale to deepwater benthic communities in the WPA. The impacts from proposed activities to deepwater benthic communities would remain the same in leased portions of the CPA/EPA. Impacts resulting from accidental events should remain relatively localized, with the number of features affected being directly proportional to the size of the accident. An accident along the CPA/WPA border has the possibility to impact features in either planning area. Although the area proposed for leasing in the WPA is relatively smaller than the proposed area of the CPA/EPA and would experience less projected OCS oil- and gas-related activity (refer to **Chapter 3**), deepwater benthic communities are found throughout all deep waters of the GOM (refer to **Figure 4-10 through Figure** 4-13 above) and, therefore, the impacts associated with Alternative B could still potentially cause some population-level effects.

At the regional, population-level scope of this analysis, the overall impact to deepwater benthic communities as a result of the activities proposed in Alternative B are expected to be the same as Alternative A, i.e., **negligible**, assuming the continuation of expected mitigation practices. Absent these mitigations, the impacts resulting from the routine activities and accidental events of a proposed lease sale could be greater; the overall population-level impact could range from **minor** to **moderate** (in a theoretical, if improbable, worst-case scenario). This upper impact level is less than the potential major level impact that would be possible (absent mitigations) under Alternatives A and D. This difference is due to the greatly reduced area available for new leasing under Alternatives B and C, which would somewhat limit the number of potentially affected deepwater benthic communities and increase the likelihood of long-term recovery to pre-impact levels. However, it is believed that existing mitigation practices would continue to be applied to the proposed activities under Alternatives A-D, reducing the expected level of impacts from a proposed lease sale.

Proposed OCS oil- and gas-related activities would also contribute incrementally, but only a **negligible** amount, to the overall OCS oil- and gas-related and non-OCS cumulative effects experienced by deepwater benthic communities. The previous and continuing OCS oil- and gas-related cumulative impacts beyond the incremental contribution of a proposed action (a specific lease sale) are estimated to have **negligible** to **minor** impacts. Non-OCS oil- and gas-related activities such as commercial fishing (currently negligible) and shifting baseline environmental conditions related to climate change (currently negligible but likely to increase to major over time should current trends continue or worsen) could cause more noticeable impacts on deepwater benthic communities over the next 50 years.

4.4.2.7 Alternative C—Regionwide OCS Proposed Lease Sale Excluding Available Unleased Blocks in the CPA/EPA Portions of the Proposed Lease Sale Area

Under Alternative C, BOEM would hold a lease sale excluding the available unleased blocks in the CPA/EPA and would offer all available unleased blocks in the WPA. Alternative C would not fundamentally alter the conclusions reached for Alternative A, but it would reduce the potential impacts of a proposed lease sale in the available unleased block in the CPA/EPA. The impacts from the proposed activities to deepwater benthic communities would remain the same in leased portions of the WPA. Impacts resulting from accidental events should remain relatively localized, with the number of features affected being directly proportional to the size of the accident. An accident along the WPA/CPA border has the possibility to impact features in either planning area. Although the area proposed for leasing in the WPA is relatively smaller than the proposed area of the CPA/EPA and would experience less projected OCS oil- and gas-related activity (refer to **Chapter 3**), deepwater benthic communities are found throughout all deep waters of the GOM (refer to **Figure 4-10 through Figure** 4-13 above) and, therefore, the impacts associated with Alternative C could still potentially cause some population-level effects.

At the regional, population-level scope of this analysis, the overall impact to deepwater benthic communities as a result of the activities proposed under Alternative C are expected to be the same as Alternative A, i.e., **negligible**, assuming the continuation of expected mitigation practices. Absent these mitigations, the impacts as a result of the routine activities and accidental events of a proposed lease sale could be greater; the overall population level impact could range from **minor** to **moderate** (in a theoretical, if improbable, worst-case scenario). This upper impact level is less than the potential major level impact that would be possible (absent mitigations) under Alternatives A and D. This difference is due to the greatly reduced area available for new leasing under Alternatives B and C, which would somewhat limit the number of potentially affected deepwater benthic communities and increase the likelihood of long-term recovery to pre-impact levels. However, it is believed that existing mitigation practices would continue to be applied to the proposed activities under Alternatives A-D, reducing the expected level of impacts from a proposed lease sale.

Proposed OCS oil- and gas-related activities would also contribute incrementally, but only a **negligible** amount, to the overall OCS oil- and gas-related and non-OCS cumulative effects experienced by deepwater benthic communities. The previous and continuing OCS oil- and gas-related cumulative impacts beyond the incremental contribution of a proposed action (a specific lease sale) are estimated to have **negligible** to **minor** impacts. Non-OCS oil- and gas-related activities such as commercial fishing (currently negligible) and shifting baseline environmental conditions related to climate change (currently negligible but likely to increase to major over time should current trends continue or worsen) could cause more noticeable impacts on deepwater benthic communities over the next 50 years.

4.4.2.8 Alternative D—Alternative A, B, or C, with the Option to Exclude Available Unleased Blocks Subject to the Topographic Features, Live Bottom (Pinnacle Trend), and/or Blocks South of Baldwin County, Alabama, Stipulations

The exclusion of any or all of the available unleased blocks subject to the either the Topographic Features, Live Bottom (Pinnacle Trend), and/or Blocks South of Baldwin County, Alabama, Stipulations (Alternative D) would not alter the above conclusions reached for Alternative A, B, or C. Under Alternative D, BOEM could hold a lease sale excluding the leasing of all blocks subject to the Topographic Features, Live Bottom (Pinnacle Trend), and/or Blocks South of Baldwin County, Alabama, Stipulations. This area exclusion would do relatively little to reduce the impacts as a result of the routine activities, accidental events, or cumulative impacts to deepwater benthic communities. Deepwater benthic communities are generally found in depths >300 m (984 ft), and the vast majority of lease blocks covered by these three stipulations are in shallower waters. Non-OCS oil- and gas-related activities are also not expected to decrease under this alternative. At the regional, population-level scope of this analysis and assuming continuation of expected mitigation practices, the overall impact to deepwater benthic communities as a result of the activities proposed under Alternative D are expected to be the same as Alternatives A-C, i.e., **negligible**. Absent the expected information requirements and mitigation practices, the impacts resulting from the routine activities and accidental events of a proposed lease sale could be greater; the overall population-level impacts could range from **minor** to **major** (in a theoretical, if improbable, worst-case scenario). However, those information requirements and mitigation practices are expected to continue.

Proposed OCS oil- and gas-related activities would also contribute incrementally, but only a **negligible** amount, to the overall OCS oil- and gas-related and non-OCS cumulative effects experienced by deepwater benthic communities. The previous and continuing OCS oil- and gas-related cumulative impacts beyond the incremental contribution of a proposed action (a specific lease sale) are estimated to have **negligible** to **minor** impacts. Non-OCS oil- and gas-related activities such as commercial fishing (currently negligible) and shifting baseline environmental conditions related to climate change (currently negligible but likely to increase to major over time should current trends continue or worsen) could cause more noticeable impacts on deepwater benthic communities over the next 50 years.

4.4.2.9 Alternative E—No Action

Under Alternative E, a proposed lease sale would be cancelled. The potential for impacts would be **none** because new impacts to deepwater benthic communities related to a cancelled lease sale would be avoided entirely.

Continuing impacts to the communities would be limited to existing routine activities, accidental events, and cumulative impacts associated with previous OCS lease sales. BOEM's current mitigation practices already regulate these activities and should continue to limit associated impacts to the **negligible** to **minor** range for OCS oil- and gas-related cumulative impacts. Ongoing non-OCS oil- and gas-related activities are **negligible** at present time, but they could potentially become greater, even rising to major, should there be future changes in fishing practices or worst-case changes in climate change-related environmental conditions.

4.5 *SARGASSUM* AND ASSOCIATED COMMUNITIES

The Sargassum *cycle is expansive, encompassing most of the western Atlantic Ocean and the Gulf of Mexico.*

Sargassum is a genus of large brown seaweed (a type of algae) that floats in island-like masses (USDOC, NOAA, Office of Ocean Exploration and Research, 2014). In the Gulf of Mexico, *Sargassum* and the organisms that reside within or around the matrix of plants are some of the most widely distributed and easily recognizable species in the GOM. *Sargassum*, as pelagic algae, is a widely distributed resource that is ubiquitous throughout the northern GOM and northwest Atlantic, and it is part of a cycle that spans most of the Northern Hemisphere of the Atlantic Ocean including the Caribbean Sea. As such, *Sargassum* might be potentially vulnerable to OCS oil- and gas-related activities. The analysis is focused on the potential impact-producing factors from OCS oil- and gas-related routine activities (i.e., exploration, development, and production), accidental events, and cumulative impacts. The potential magnitude of impact for each of these impact-producing factors is provided in **Table 4-12** to help the reader quickly identify the level of potential impacts for *Sargassum* and its associated communities. The impact level definitions and the analyses supporting these conclusions are then discussed in detail in this section. The description of the affected environment provides a baseline that encompasses all previous and ongoing OCS oil- and gas-related and non-OCS oil- and gas-related activities.

Table 4-12. *Sargassum* and Associated Communities Impact-Producing Factors That Are Reasonably Foreseeable.

Sargassum and Associated Communities	Magnitude of Potential Impact[1]				
Impact-Producing Factors	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
Routine Impacts					
Vessel Operations	Negligible	Negligible	Negligible	Negligible	None
Drilling Operations	Negligible	Negligible	Negligible	Negligible	None
Accidental Impacts					
Drilling Operations	Negligible	Negligible	Negligible	Negligible	None
Vessel Operations	Negligible	Negligible	Negligible	Negligible	None
Oil Spill and Cleanup	Negligible	Negligible	Negligible	Negligible	None

Cumulative Impacts					
Incremental Contribution[2]	Negligible	Negligible	Negligible	Negligible	None
OCS Oil and Gas[3]	Minor to Moderate				
Non-OCS Oil and Gas[4]	Negligible				

[1] The analysis supporting these conclusions is discussed in detail in the "Environmental Consequences" chapter below.
[2] This includes all activities (i.e., routine activities projected to occur and accidental events that could occur) as a result of a single proposed lease sale in the 2017-2022 Five-Year Program.
[3] This includes all activities (i.e., routine activities projected to occur and accidental events that could occur) from past, proposed, and future lease sales.
[4] This includes other past, present, and reasonably foreseeable future activities occurring within the same geographic range and within the same timeframes as a proposed action, but they are not related to the OCS Oil and Gas Program.

Within this chapter, characteristics unique to *Sargassum* are discussed along with life history. In addition, the roles of *Sargassum* functioning as a habitat, the species that depend on *Sargassum,* and factors that influence *Sargassum* are also discussed. During this analysis, the following potential impact-producing factors were screened for their potential to impact *Sargassum*:

- vessel operations (**Chapter 3.1.4.3**);
- presence of toxins in water column (**Chapters 3.1.5.1 and 3.1.5.2**);
- sediment deposition on seafloor (**Chapters 3.1.3.3.2 and 3.1.3.3.3**);
- sediment deposition into water column (**Chapter 3.1.3.3.3**);
- alteration of water-flow patterns;
- impingement (**Chapter 3.1.5.1.6**);
- vessels sinking (**Chapter 3.2.5**);
- marine debris (**Chapter 3.2.7**);
- oil spills (**Chapter 3.2.1**);
- oil-spill cleanup (**Chapter 3.2.8**); and
- chemical and drilling-fluid spills (**Chapter 3.2.6**).

An in-depth analysis of these potential factors determined that, although many may occur within the GOM, few occur at an extent that could cause impacts to the population of *Sargassum* as a whole. This includes sediment deposition on the seafloor or in the water column, vessels sinking, impingement, marine debris, and alteration of water flow patterns. Additionally, impacts associated with the presence of toxins and sediments in the water column from discharges during routine operations are managed through the NPDES permitting process or by the MARPOL Annex V Treaty. Regulation and enforcement of these laws is conducted by a number of agencies, such as the U.S.

Environmental Protection Agency, NOAA, and the U.S. Coast Guard. These regulations were put in place to protect water quality so that it is maintained at a level that is nontoxic to the organisms in the water where it is being discharged and are not addressed in this chapter for Sargassum, but rather are discussed in **Chapter 4.2** (Water Quality). Additionally, cooling water discharges from vessels are also not addressed because, compared with the surface area of the environment, the area that could be impacted by vessel discharges is miniscule. Finally, the spatial extent and the transient nature of the *Sargassum* cycle is such that it would take a low-probability catastrophic event to affect enough *Sargassum* to result in population-level impacts across the GOM for more than a season, which is not reasonably foreseeable as a result of a proposed lease sale. Other factors like deposition of sediments onto the seafloor do not occur within the same section of the water column where *Sargassum* occurs. As such, only the following impact-producing factors were identified as having the potential to impact *Sargassum* and were carried forward to a full analysis:

- vessel operations (**Chapter 3.1.4.3**; routine and accidental, including discharges);
- chemical and drilling-fluid spills (**Chapter 3.2.6**; accidental only);
- oil spills (**Chapter 3.2.1**; accidental only); and
- oil-spill cleanup (**Chapter 3.2.8**; accidental only).

To facilitate a discussion on the spatial extent of the *Sargassum* cycle and to put the impact-producing factors in context, **Figure 4-14** depicts how these plants move around the Northern Hemisphere. The *Sargassum* loop system initiates in the Sargasso Sea. Atmospheric conditions create wind patterns that push *Sargassum* south, into the Caribbean Sea where it is pushed west by the oceanic and atmospheric currents carrying it into the Gulf of Mexico. There it washes ashore on the Gulf Coast or gets swept out the Florida Strait via the Gulf Stream (Gower et al., 2013; Frazier et al., 2015). **Figure 4-14** represents the spatial extent of *Sargassum*, demonstrating that there is a high degree of connection among the Gulf of Mexico OCS planning areas and other oceanic basins and large-scale oceanic features (e.g., Gulf Stream).

Figure 4-14. Sargassum *Loop System (adapted from Gower et al., 2013, and Frazier et al., 2015).*

Impact-Level Definitions

For this analysis, the following criteria were used to categorize the effects of impact-producing factors to *Sargassum* and associated communities:

- **Negligible** – Impacts are undetectable or limited in scale to the immediate area of the impact-producing factor. This may include mortality of the plants or animals associated with *Sargassum*. Such impacts may result in changes to a local community's species abundance and composition, community structure, and/or ecological functioning, but any such changes would be spatially localized, short term in duration, and would not alter the overall status of *Sargassum* or associated communities in the GOM.
- **Minor** – Impacts are detectable and result in changes beyond the immediate area of the impact-producing factor. Such impacts could result in noticeable changes to a local community's species abundance and composition, community structure, and/or ecological functioning, but would be spatially localized, short

term in duration, and would not alter the overall status of *Sargassum* or associated communities in the GOM.

- **Moderate** – Impacts cause substantial, population-level changes in species composition, community structure, and/or ecological functioning beyond the immediate area of the impact-producing factor. These impacts would be expected to be spatially extensive and may impact communities that rely on *Sargassum* for transportation of larvae, settlement, or food beyond the area of the impact-producing factor. However, impacts to *Sargassum* and associated communities are expected to be temporary, and there would be no disruption of the global *Sargassum* cycle.

- **Major** – Impacts result in the loss of *Sargassum* over large sections of the GOM. This would result in substantial, population-level changes in species composition, community structure, and/or ecological functioning for *Sargassum* and communities that rely on *Sargassum* for transportation of larvae, settlement, or food beyond the area of the impact-producing factor. These impacts would be expected to be spatially extensive and possibly disrupt the global *Sargassum* cycle.

4.5.1 Description of the Affected Environment

Plant Characteristics

The pelagic complex in the GOM is comprised of *Sargassum natans* and *Sargassum fluitans* (Lee and Moser, 1998; Stoner, 1983; Littler and Littler, 2000). Both species of macrophytes live immediately below the water surface and are fully adapted to a pelagic existence (Lee and Moser, 1998). As can be seen in **Figure 4-15**, *Sargassum* is characterized by a brushy, highly branched thallus with numerous leaf-like blades and berrylike pneumatocysts (Coston-Clements et al., 1991; Lee and Moser, 1998; Littler and Littler, 2000). These air bladders contain mostly oxygen and can facilitate buoyancy (Hurka, 1971). Net production in *Sargassum* also exceeds respiration by 1.3 times (Blake and Johnson, 1976), and the population can double in size every 3 months (Lapointe, 1986), suggesting that *Sargassum* may be important in the global carbon cycle. *Sargassum* plants may be up to a few meters in length and may be found floating alone or in larger rafts or mats depending on the environmental and physiochemical factors. Reproduction

Figure 4-15. Pelagic Brown Algae in the Genus Sargassum (image courtesy of H. Scott Meister, South Carolina Department of Natural Resources) (USDOC, NOAA, 2014b).

typically occurs through fragmentation, and the size, shape, and distribution of *Sargassum* mats can change rapidly depending on currents, wind, and other factors.

Life History

The life history of *Sargassum* in the GOM is part of a larger cycle that includes the mid-Atlantic Ocean and the Caribbean Sea (Frazier et al., 2015). This cycle begins in the Sargasso Sea where *Sargassum* remains year round. However, winds and currents move some of this *Sargassum* south into the Caribbean Sea and eventually into the GOM via the Yucatan Channel. Once in the GOM, it moves into the western area where it uses nutrient inputs from coastal rivers, including the Mississippi River, for growth. As *Sargassum* abundance increases, plants would continue to travel east during the summer months; however, a large quantity of plants would travel in to the nearshore where they would be deposited on coastal beaches. *Sargassum* deposition on Gulf Coast beaches is important because *Sargassum* facilitates dune stabilization and provides a pathway for nutrient and energy transfer from the marine environment to the terrestrial environment (Webster and Linton, 2013). Eventually the plants moving east would be incorporated into the Gulf Stream where they return to the Sargasso Sea (**Figure 4-14**). Throughout this cycle, plants would continue to grow, reproduce, and die. When a plant dies, it can sink to the seafloor, transporting nutrients and resources to the seafloor (Coston-Clements et al., 1991; Parr, 1939; Wei et al., 2012). Although the cycle continues year round, the rapid growth of *Sargassum* populations in the western GOM typically occurs during spring/summer (Gower et al., 2006; Gower and King, 2008; Gower and King, 2011). Estimates suggest that between 0.6 and 6 million metric tons of *Sargassum* are present annually in the GOM, with an additional 100 million metric tons exported to the Atlantic basin (Gower and King, 2008; Gower and King, 2011, Gower et al., 2013). The spatial expanse of this life history facilitates the rapid recovery from episodic environmental perturbations because of the remote probability that any single event could impact the entire spatial distribution.

Habitat Function

While in the oligotrophic waters of the GOM, *Sargassum* provides islands of high energy and carbon content in an otherwise nutrient and carbon poor environment (Stoner, 1983). As can be seen in **Figure 4-16**, *Sargassum* mats, comprised of a single or multiple plants in a matrix, support a diverse assemblage of marine organisms, including micro- and macro-epiphytes (Carpenter and Cox, 1974; Coston-Clements et al., 1991), fungi (Winge, 1923), more than 100 species of invertebrates (Coston-Clements et al., 1991; Huffard et al., 2014), over 100 species of fish (Dooley, 1972; Stoner, 1983; Huffard et al., 2014), four species of sea turtles (Carr, 1987a; Manzella et al., 2001), and various marine birds

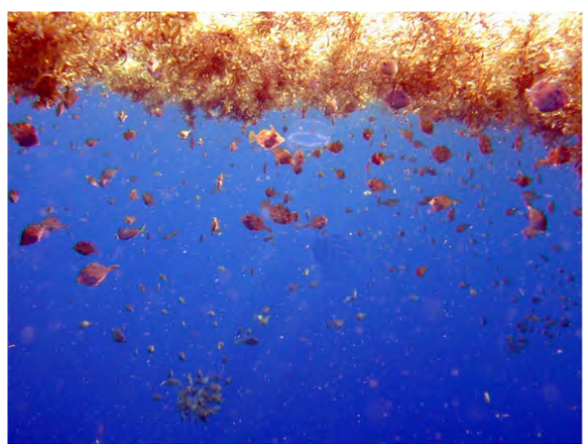

Figure 4-16. Small Fishes in Sargassum (USDOC, NOAA, Office of Ocean Exploration and Research, 2010).

(Lee and Moser, 1998). *Sargassum* serves as nurseries, sanctuaries, and forage grounds for both commercially and recreationally exploited species (Adams, 1960; Bortone et al., 1977; Dooley, 1972; Wells and Rooker, 2004). *Sargassum* has also been identified as a critical habitat for the loggerhead sea turtle (*Caretta caretta*) (*Federal Register*, 2014a). Community composition of *Sargassum* mats vary spatiotemporally depending on the environmental and physiochemical factors of the waters where the *Sargassum* mats reside, resulting in a high degree of biologic diversity in species abundance, composition, and life history (Wells and Rooker, 2004).

Sargassum-Dependent Communities

Invertebrates

Epiphytic cyanobacteria contribute to overall production and nutrient recycling within the *Sargassum* complex (Wells and Rooker, 2004). *Sargassum* is colonized by bacteria, hydroids, and bryozoans, providing the base of a food web (Dooley, 1972). Both sessile and motile invertebrates are found within the *Sargassum* community. Epifaunal organisms include colonial hydroids, encrusting bryozoans, the polychaete Spirorbis, barnacles, sea spiders, and the tunicate Diplosoma (Dooley, 1972; Coston-Clements et al., 1991; Huffard et al., 2014). Older plants can become heavily encrusted with these organisms, causing them to sink to the seafloor. Some of the motile fauna found within the *Sargassum* matrix include polychaetes, flatworms, nudibranchs, decapod crustaceans, and various molluscs (Parr, 1939; Coston-Clements et al., 1991). *Sargassum* matrices provide a habitat that affords a degree of protection, entrains food, and is an effective method for traversing long distances for *Sargassum*-dependent and *Sargassum* and associated organisms.

Sea Turtles

Four of the five species of sea turtles found in the GOM (all are listed under the ESA) are associated with floating *Sargassum* (Carr and Meylan, 1980; Carr, 1987a; Coston-Clements et al., 1991; Schwartz, 1988; Witherington et al., 2012). The hatchlings of loggerhead, green (*Chelonia mydas*), Kemp's ridley (*Lepidochelys kempii*), and hawksbill (*Eretmochelys imbricata*) sea turtles are thought to find the *Sargassum* rafts when actively seeking frontal zones, then utilizing the habitat as foraging grounds and protection during their pelagic "lost years" (juvenile years in which turtle sightings are scarce) (Carr, 1987a; Coston-Clements et al., 1991; Witherington et al., 2012; Putman and Mansfield, 2015). In 2014, NOAA designated critical habitat for the Northwest Atlantic Ocean Distinct Population Segment for loggerhead sea turtles in waters including associated *Sargassum* habitat and beach habitat of the GOM and along the U.S. Atlantic Coast (*Federal Register*, 2014a). For additional information on sea turtles, refer to **Chapter 4.9.2** (Protected Species).

Birds

The presence of *Sargassum* can also influence local abundance and occurrence of certain species of marine birds by concentrating food, as many birds actively feed on or around the mats (Lee and Moser, 1998; Moser and Lee, 2012). Birds with over 25 percent of their prey living in *Sargassum* are classified as *Sargassum* specialists. Specialist species included several species of shearwaters, terns, phalaropes, petrels, and gulls (Moser and Lee, 2012). For the birds that rely on

Sargassum for food or rest, the importance of the *Sargassum* and associated communities to seabird abundance and seasonal distribution is expected to be high (Moser and Lee, 2012). For additional information on birds, refer to **Chapter 4.8**.

Fish

The assemblages of fishes using *Sargassum* as a habitat are highly variable in time and space (Huffard et al., 2014). Jacks, pompanos, mackerels, scads, triggerfishes, filefishes, seahorses, pipefishes, and frogfishes represent up to 97 percent of the fishes in *Sargassum* mats (Dooley, 1972; Bortone et al., 1977). Some species that are endemic to *Sargassum* utilize the habitat for early life stages as well as adult stages, while other species may rely on the habitat only as a source of food, protection, and a method of passive transportation during early life stages (Bortone et al., 1977; Wells and Rooker, 2004). The abundance of juvenile fish associated with these mats suggests that they serve as an important nursery habitat for numerous species (Dooley, 1972). By serving as a nursery habitat for pelagic, benthic, and even estuarine species, *Sargassum* may have influence on the recruitment success of the fishes using it as habitat. For additional information on fish, refer to **Chapter 4.7**.

4.5.2 Environmental Consequences

Because of the spatial extent of the *Sargassum* cycle, the community dynamics of *Sargassum* and *Sargassum*-dependent species are influenced by a myriad of complicated factors. Many of these factors are poorly understood due to the size and scope of the *Sargassum* cycle. For example, without any substantial changes in environmental conditions, the biomass of *Sargassum* was 200-fold greater in 2011 than the previous 8-year average (Gower and King, 2011). The event had its origin north of the mouth of the Amazon (Gower et al., 2013). The resulting large quantities of *Sargassum* washing up on beaches became a nuisance for recreation. Additionally, comparisons across a 40-year period documented that there was a change in community composition for the *Sargassum*-dependent species found in the Atlantic Ocean (and presumably a pre-cursor to GOM populations). However, no specific anthropogenic or environmental factor could be identified as the source of change (Huffard et al., 2014). Conversely, one factor that may negatively influence *Sargassum* communities is that the oceanographic processes that concentrate *Sargassum* into mats and rafts may also concentrate surface pollutants and marine debris (Burns and Teal, 1973; Laffoley et al., 2011; Powers et al., 2013). This was evident during the *Deepwater Horizon* explosion, oil spill, and response as many *Sargassum* mats were found immersed in oil with little or no visible living associated organisms (Powers et al., 2013). Additionally, S*argassum* may be influenced by many nonpoint sources of pollution as pollutants are concentrated, possibly magnifying the environmental impacts of those substances (Laffoley et al., 2011).

Of major importance is that these communities play an important role to ESA-listed species by providing food, habitat, and a method of transportation. BOEM consults on these species with the FWS and NMFS. These species include sea turtles and birds; to read about the protected species that use these habitats, refer to **Chapters 4.9.2 and 4.9.4**, respectively.

4.5.2.1 Routine Activities

Impact-producing factors associated with routine activities for a proposed action that could affect *Sargassum* are limited to impacts from vessel operations and impingement on oil and gas structures. However, the impediment of the movement of *Sargassum* mats is expected to affect such a small quantity of algae that impacts would be **negligible** with no consequences to the overall *Sargassum* community.

Vessel Operations

It is expected that a fleet of vessels would be used to support oil and gas exploration, production, and possibly other OCS oil- and gas-related operations across the GOM (**Chapter 3.1.4.3**). Because of the pelagic life history of *Sargassum,* vessels supporting oil and gas operations would routinely come in contact with *Sargassum* and associated communities. When impacts occur, it would be the result of oil or fuel spills (discussed in the "Accidental Events" chapter below) or *Sargassum* coming in contact with the vessel hull or in contact with the propulsion system. The consequence could be the break-up of *Sargassum* plants into smaller pieces, death of *Sargassum* plants, or dislodging and/or death of epiphytic organisms or organisms living in close proximity to *Sargassum.* However, impacts to *Sargassum* would only occur if the vessel is traveling at a high rate of speed and comes in contact with the plants. If individual plants are broken into moderately sized pieces during low-speed travel, it is expected that the plants would continue to grow as multiple separate entities through vegetative propagation. For *Sargassum*-dependent organisms that are physically attached to the plant matrix (e.g., epiphytes), dislodgement would result in death as they sink to the seafloor or are preyed upon. For animals that live in close proximity to *Sargassum*, it is expected that dislodgement would be temporary as they would find their way back to the plant, or other plants, after the vessel had passed. Again, this would only occur if contact occurs with the vessel traveling at a rate of speed great enough to actually dislodge organisms. This critical speed would be dependent on sea-state, types of organisms present, vessel size, and depth of *Sargassum* in the water column.

Regardless of the possibility of impacts to individual *Sargassum* plants and associated communities, vessel operations are expected to have **negligible** impacts on the population of *Sargassum* or to the animals that colonize the plants. The primary reason is that the *Sargassum* cycle rapidly replaces (in days to weeks) any plants that are damaged or destroyed by OCS oil- and gas-related vessels in a given area. Vessels and *Sargassum* each move haphazardly, minimizing the possibility of contact to any particular piece of *Sargassum*. If contact does occur, there are few locations on the vessel (e.g., rudders, intakes) where *Sargassum* could actually become impinged. Additionally, the oceanographic processes that cause *Sargassum* to form large rafts would also cause large pieces of marine debris (e.g., trees, lumber, and trash) to collect with the *Sargassum*. As such, many vessels would avoid large rafts or slow down as they pass through, minimizing potential impacts to *Sargassum*. Finally, many of the vessels working in the OCS oil- and gas-related fields rely on displacement hulls rather than planing hulls. Because of this, most vessels would push plants away from the vessel rather than colliding with the plants. Damage would be limited to those that pass through the propulsion system of the vessel. Even on the largest vessels, the diameter of the propellers is relatively small, resulting in short-term, localized damage that should have **negligible** impacts to the population of *Sargassum* or the organisms that coexist within the plant matrix.

4.5.2.2 Accidental Events

Impact-producing factors associated with accidental events for a proposed action include (1) impacts associated with drilling operations, (2) impacts due to vessel operations, and (3) impacts resulting from an oil spill and associated cleanup operations. These impact-producing factors would have varied effects depending on the intensity of the spill, the presence of *Sargassum*, and the abundance of *Sargassum* in the vicinity of the spill.

Drilling Operations

Accidental events associated with drilling operations are limited to the accidental discharge of oil (discussed separately below), drilling muds, and chemicals into the water column (**Chapter 3.2.6**). This type of event may occur if the equipment separating SBFs from the cuttings malfunctions. Although the toxicity of SBFs is regulated by the USEPA and are not typically toxic (USEPA, 2004, 2007, and 2009b), an unexpected release into a *Sargassum* raft could potentially result in damage to the plants or the organisms that inhabit *Sargassum*. Because of the high cost of SBFs, the systems responsible for separating SBFs from the drill cuttings for reuse are monitored closely; as such, accidental discharges of SBFs would tend to be limited in size and scope. Once in the water column, SBFs would clump and sink quickly and impact only the plants and animals that come in contact with the SBFs. Because *Sargassum* is constantly moving horizontally within the environment, the abundance of plants that could be impacted by any given accident would be minimal. Due to the cyclical life history of *Sargassum*, dead plants would sink to the seafloor and would rapidly be replaced by new plants moving into the area. Although impacts could occur at isolated locations and at a small scale, they would be limited in size, scope, and duration, with **negligible** population-level impacts expected.

Vessel Operations

Although regulated by MARPOL and other regulations, one type of accidental event associated with vessel operations that may impact *Sargassum* is the release of floating debris into the surface waters of the GOM (**Chapters 3.1.5.2 and 3.2.7**). Another is spills caused by vessel collisions. The accidental release of marine debris could occur when cargo is not properly restrained on deck while underway or during transfer operations between vessels and platforms. Losses of large quantities of debris are rare; however, losses of smaller pieces of debris might happen (e.g., trash, safety vests, hardhats, etc.). Floating debris is subject to the same oceanographic process that influences and moves *Sargassum*, resulting in marine debris and *Sargassum* rafting together. Marine debris may have little impact on the plants, but the organisms living in close proximity might be impacted. This includes the ingestion of plastics by sea turtles, ingestion of microplastics by fishes and invertebrates, or the release of toxins from within an object (e.g., a bucket of paint) or as an object undergoes degradation (Engler, 2012; Schuyler et al., 2012; Wright et al., 2013). Given the lack of stationary gyres in the GOM, OCS oil- and gas-related floating debris would not be expected to remain long enough to undergo substantial degradation before washing ashore along a beach or sinking to the seafloor. There is a remote possibility that some debris might be advected within the Gulf Stream and carried to the gyre in the mid-Atlantic. This debris could remain long enough to undergo degradation or be ingested; however, this would be a small enough amount of debris from OCS oil- and gas- related activities to have a **negligible** impact. BOEM and BSEE have addressed the marine debris issue by historically imposing marine debris awareness and prevention on the oil and gas industry through NTL 2015-BSEE-G03 as a part of the Protected Species Stipulation. Overall, vessel operations are expected to have a **negligible** impact on *Sargassum* and their associated communities because of the minimal volume expected and short residency times.

Oil Spills and Associated Cleanup Operations

Oil spills are the major accidental events of concern to the *Sargassum* community (refer to **Chapter 3.2.1** for information on oil spills). The risk of various sizes of oil spills occurring as a result of a proposed lease sale is presented in **Table 3-17**.

All known reserves in the GOM have specific gravity characteristics that indicate the oil would float to the sea surface (**Chapter 3.2.1.2**). Oil on the sea surface has the potential to negatively impact *Sargassum* communities. Some components of oil on the sea surface would be removed through evaporation, dissipation, biodegradation, and oil-spill cleanup operations; however, depending on the size of the spill, some of them could persist, contacting *Sargassum* communities (**Chapters 3.2.1.3 and 3.2.8**). Oil at the sea surface can be mixed into the upper water column by wind and wave action to a depth of approximately 33 ft (10 m) (Lange, 1985; McAuliffe et al., 1975 and 1981b; Knap et al., 1985). With vigorous wave action, the oil can form an emulsion with water that is viscous and persistent. Oil treated with dispersant on the sea surface would mix with the water where its contact with *Sargassum* may be temporarily increased in the upper few meters of the water column (McAuliffe et al., 1981a). As time passes, the oil would begin to adhere to particles in the water column, form clumps, and sink toward the seafloor (International Tanker Owners Pollution Federation Limited, 2002; Kingston et al., 1995; Powers et al., 2013).

The impacts of oil contact with *Sargassum* communities would vary depending on the severity of exposure. *Sargassum* that contacts concentrated oil that coats the algae and attached organisms would likely die and sink to the seafloor (Powers et al., 2013). Motile organisms that are dependent on the algae for habitat (e.g., shrimp, crabs, nudibranchs, snails, *Sargassum* fish, etc.) may also be directly contacted by the oil, resulting in death, or may be displaced into open water. *Sargassum* exposed to oil in lower concentrations may suffer sublethal impacts and concentrate hydrocarbons, toxins, and chemicals (Burns and Teal, 1973). Exposure to these low-level toxins could result in the loss of associated organisms that use the algae as a substrate and other organisms that use the matrix as habitat due to the presence of bacterial-mediated hypoxic conditions in the immediate vicinity of the plant as the oil is consumed (Powers et al., 2013). However, hypoxia would be naturally mitigated due to wave action. Pelagic organisms feeding on or around the community may suffer sublethal effects that could reduce health and reproduction through reduced growth or fecundity. For information on fauna that can be part of the *Sargassum* community, refer to **Chapters 4.7** (Fish and Invertebrate Resources), **4.8** (Birds), **4.9.2** (Sea Turtles), **and 4.9.4** (Protected Birds).

Spill-response activities may contribute to negative impacts on *Sargassum* (refer to **Chapter 3.2.8** for information on oil-spill response activities). The number of vessels concentrated in a given area to clean up a spill can increase physical damage to the *Sargassum* community, especially in the immediate vicinity of the spill. Response activities, such as skimming oil from the sea surface or burning oil at the surface, can damage and remove *Sargassum* that may not have contacted oil. However, for oil-coated *Sargassum*, these impacts may be inconsequential, as a large part of the *Sargassum* affected would not be expected to survive (Powers et al., 2013). Another major response activity that may occur is the spraying of dispersant. Direct effects of dispersant on many of the more mobile constituents of the *Sargassum* community are limited, but dispersants are toxic to *Sargassum* plants and many invertebrates (Powers et al., 2013; Almeda et al., 2014). The use of dispersants is a trade-off to achieve the least overall environmental damage. For example, dispersants may increase short-term contact of oil with *Sargassum* and may have some inherent toxic properties, but their use can promote diffusion of oil, resulting in biodegradation, clumping, and sinking.

A spill may impact the survivability and productivity of *Sargassum* in an area (Powers et al., 2013). However, an accidental spill would only be expected to have an impact in the immediate area and would be short in duration. Given the life history of *Sargassum,* it is expected that, for an accidental spill, fresh plants would replace the old plant within days to weeks. The new plants would also provide habitat for any organisms with the desire to leave impacted plants, which could happen in the natural life cycle of *Sargassum*. The *Sargassum* community is widely distributed over a very large area, including two oceans, and appears to have an annual cycle of growth that lends itself to resilient recovery in a short time. Due to the spatial extent of the *Sargassum* cycle, impacts due to an accidental oil spill (large or small) are expected to be **negligible** to the *Sargassum* population; however, in the immediate area of a spill, the localized and short-term impacts could range from moderate to major depending directly on the size of the spill and amount of *Sargassum* in the area.

4.5.2.3 Cumulative Impacts

Several impact-producing factors can affect *Sargassum*, including vessel-related operations, oil and gas drilling discharges, operational discharges, accidental spills, non-OCS oil- and gas-related vessel activity, and coastal water quality.

Cumulative OCS Oil and Gas Program

Vessels transiting the GOM pass through *Sargassum* mats and may produce slight impacts to the *Sargassum* community, such as some propeller-related impacts, and possible impingement impacts (refer to **Chapter 3.3.1.7** for information on cumulative service-vessel numbers). None of these would have more than minor localized impacts to the mats, but they could lead to the loss of plants or stress for organisms, albeit haphazardly due to the variability in vessel traffic and

Sargassum movement patterns. The OCS oil- and gas-related structures can impede the movement of *Sargassum* mats and may entrap small quantities of the algae. Combined, these impacts are expected to remain **negligible** with no consequences to the overall *Sargassum* community either spatially or temporally.

The OCS oil- and gas-related drilling results in discharges of drill cuttings with small quantities of associated drilling muds and well treatment chemicals. Most cuttings from well drilling are discharged from the drill platform at the sea surface where they disperse (CSA, 2006; Kennicutt et al., 1996; NRC, 1983). Floating mats of *Sargassum* that pass by a drilling operation would experience short-term exposure to drill cuttings with associated muds and well treatment chemicals. Discharges are regulated by USEPA to require that discharges released into the environment are nontoxic or not concentrated enough to become toxic (USEPA, 2004, 2007, and 2009b). Drilling operations create an area of high turbidity in the vicinity of cuttings discharges. Impacts from sedimentation to the community organisms may include "changes in respiration rate, abrasion and puncturing of structures, reduced feeding, reduced water filtration rates, smothering, delayed or reduced hatching of eggs, reduced larval growth or development, abnormal larval development, or reduced response to physical stimulus" (Anchor Environmental CA, L.P., 2003). Combined with other impacts, the results would still remain **negligible** given the haphazard nature of *Sargassum* movements.

The OCS oil- and gas-related platforms and drill ships produce similar effects with operational discharges. Larger vessels and offshore platforms discharge effluents from sanitary facilities (gray water) and circulate seawater to cool ships' engines, electric generators, and other machines. The cooling water discharge may be up to 20 °F (11 °C) warmer than the surrounding seawater (USDHS, CG and USDOT, MARAD, 2003; Patrick et al., 1993). This temperature difference can accumulate in the vicinity of the discharge. For OCS oil- and gas-related stationary platforms and drill ships, localized warming of the water could occur (Emery et al., 1997; USDHS, CG, and USDOT, MARAD, 2003). However, the warm water is rapidly diluted, mixing to background temperature levels within 328 ft (100 m) of the source (USDHS, CG and USDOT, MARAD, 2003). Additionally, produced waters from stationary locations are rapidly diluted, and impacts are only observed within 328 ft (100 m) of the discharge point (Neff and Sauer, 1991; Trefry et al., 1995; Gittings et al., 1992b). Those effects are localized, with only brief contact to passing *Sargassum* before dilution to background levels; however, this could result in discomfort, displacement, or death to some of the more sensitive organisms. These effects would comprise a **negligible** portion of the overall cumulative impact to *Sargassum* communities.

Accidental spills of oil and other chemicals could affect *Sargassum* and its community wherever they contact the algae. Small spills would have a limited local effect on a small portion of the *Sargassum* community. Short-term exposure of *Sargassum* to high concentrations of oil and chemicals could result in death and sinking of the algae and organisms contacted. The size of the overall impact on *Sargassum* and associated communities would depend on the size of the spill and the success of spill-response efforts; substantial impacts could be expected to the organisms exposed. This includes death if oil concentrations in the water column are great enough to result in ingestion of oil or coating of the organisms residing in the vicinity of Sargassum mats (Fucik et al., 1995; Brewton et al., 2013).

Cumulative impacts of the OCS Oil and Gas Program include past actions such as the *Deepwater Horizon* oil spill. Studies of the impact of the spill on *Sargassum* have shown that the spilled oil affected 23 percent of the *Sargassum* in the northern Gulf of Mexico with heavy oil. In addition to the 873-1,749 km^2 (337-675 mi^2) of area in which *Sargassum* was contacted by oil, total loss to the population was estimated to include an additional 4,524-9,392 km^2 (1,747-3,626 mi^2) of foregone area from lost growth (Deepwater Horizon Natural Resource Damage Assessment Trustees, 2016). This represents a major impact to the *Sargassum* of the Gulf of Mexico. Due to the high growth rate, which is estimated to be approximately 4 percent per day, recovery would be swift. Powers et al. (2013), using aerial surveys in 2010, 2011, and 2012, documented a four-fold increase in *Sargassum* abundance above that observed in 2010 during and shortly after the spill. Therefore, due to the extensive nature of the impact and the resilient nature of the *Sargassum* population, the cumulative impacts to *Sargassum* are estimated to be **minor** to **moderate**.

Non-OCS Oil- and Gas-Related Impacts

Marine vessels of all types produce at least some minor effects to the environment (refer to **Chapter 3.3.2.2**). Increased abundance of non-OCS oil- and gas-related vessels operating in the same environment as *Sargassum* presents an increase in the expected vessel-related damage to *Sargassum* and associated communities. Given that most vessels are limited to the waters nearshore (e.g., recreational fishermen), the impacts on *Sargassum* are expected to be minor. *Sargassum* found in near-coastal waters is expected to eventually senesce (the process of aging in plants) and sink to the seafloor or be deposited on coastal beaches. As such, additional damage to any *Sargassum* that may occur would not impact the population. Offshore traffic would be limited and occur in a haphazard manner beyond shipping lanes. As such, the movement of *Sargassum*, combined with the movement of vessels, reduces the potential for impacts to any given *Sargassum*, resulting in **negligible** cumulative impacts by non-OCS oil- and gas-related vessel traffic.

Declining coastal water conditions in the Gulf of Mexico, due to eutrophication, are a non-OCS oil- and gas-related impact that could result in landscape level impacts to *Sargassum* (**Chapter 3.3.2.11**). Increased nutrient loading can lead to increased turbidity from plankton growth (e.g., in the summer; refer to **Chapter 3.3.2.12**). Turbidity could result in a decrease in *Sargassum* production and result in stress to the organisms utilizing these habitats, while increased nutrients could result in an increased growth of *Sargassum*. A reduction in production could result in a decrease in the ability of *Sargassum* to sequester nutrients and carbon dioxide and to produce oxygen, while an increase in production could provide more habitat. The exact impact of declining water quality is unknown because *Sargassum* can pass in and out of these waters depending on the prevailing conditions, and much of the more hypoxic and highly turbid waters occur nearshore where *Sargassum* would not normally survive because it would be deposited on a coastal beach or senesce (the process of aging in plants) and sink to the seafloor.

Impacts associated with possible climate change impacts remain unknown for a habitat with such a wide-ranging distribution. Increased temperatures could result in benefits to *Sargassum* by increasing the range where the plants could be found and by increasing growth rates. This could result in beneficial impacts like increased sequestration of nutrients and more potential habitat for colonization and increased larval survival. However, it is possible that growth rates could increase to a point where the fouling of beaches and shipping lanes in the GOM and the Atlantic Ocean could become problematic, resulting in moderate to major impacts to coastal communities. Additionally, stratification of the water column and changes in current patterns due to a changing climate could alter access to nutrients and move *Sargassum* into areas not previously observed. Finally, organisms that colonize *Sargassum* could be impacted as pH levels fluctuate, resulting in negative impacts. Combined, this would result in impacts ranging from **beneficial** to **major** and would be expected to vary by location, given the distribution of *Sargassum.* As such, impacts of climate change to *Sargassum* are not easily estimated.

Combined, the cumulative impacts of OCS oil- and gas-related operations would be **minor** to **moderate** to the population, as there have been extensive impacts to *Sargassum* and associated communities, but recovery has been rapid. Because the *Sargassum* cycle occurs across a large portion of the Western Hemisphere (Frazier et al., 2015), because OCS oil- and gas-related operations rarely occur in dense aggregations, especially with respect to drilling operations, and especially because of the high reproductive rates of *Sargassum,* the incremental impacts of a proposed action on the population of *Sargassum* would be **negligible**. Non-OCS oil- and gas-related vessel traffic is not expected to have a substantial impact on *Sargassum* and associated communities; however, declining coastal water quality as a result of eutrophication could, as described in **Chapter 4.2** (Water Quality). Regardless, the incremental impact of a proposed action on the population of *Sargassum* would be **negligible** when considered in the context of cumulative impacts to the population. Impacts from changing water quality and climate change would be much more influential on *Sargassum* than OCS development and would still occur without the presence of OCS oil- and gas-related operations.

4.5.2.4 Incomplete or Unavailable Information

Although much is known about *Sargassum* and its life history, incomplete or unavailable information still remains. This incomplete or unavailable information includes information on the effects of *in situ* oil exposure and the factors impacting the movement patterns of *Sargassum.* BOEM used existing information and reasonably accepted scientific methodologies to extrapolate in completing the analysis above. BOEM has determined that there are few foreseeable significant adverse impacts to the *Sargassum* population associated with a proposed action, using publications such as Frazier et al. (2015), Gower and King (2011), Gower et al. (2013), and Powers et al. (2013). Gower and King (2011) and Gower et al. (2013) suggest that *Sargassum* is continually present in the west-central GOM and that it moves in a general west-to-east pattern during the growing season; however, movements at a finer temporal or spatial scale are more difficult to predict. Frazier et al. (2015) built upon these studies and developed a more finite life cycle for *Sargassum* that links the Sargasso Sea *Sargassum* populations with the GOM populations. With respect to the effects of oiling from the *Deepwater Horizon* oil spill, Liu et al. (2014) noted that the toxicity or the presence of oil across the surface waters of the GOM was also variable at any given time, suggesting that it is difficult to predict the effects of *Sargassum* coming into contact with surface oil. Additionally, Lindo-Atichati et al. (2012) suggested that patterns of larval fish in the surface currents in the northern GOM were not consistent spatially or temporally and that they were highly dependent on mesoscale current structures like the Loop Current and associated eddies. Combined, these studies suggest that, as *Sargassum* is passively moved in the surface waters, its presence at any given location or at any given time is difficult to predict, especially as the population grows exponentially during the growing season. Ultimately, the ephemeral and wide-ranging nature across the northern GOM and the reproductive capabilities of *Sargassum* provide a life history that is resilient towards localized or short-term deleterious impacts, such as those expected to be associated with OCS oil- and gas-related routine activities and noncatastrophic oil or SBF spills. Therefore, BOEM has determined that the incomplete information on *Sargassum* is not essential to a reasoned choice among alternatives and that the information used in lieu of the unavailable information is acceptable for this analysis.

4.5.2.5 Alternative A—Regionwide OCS Lease Sale (The Preferred Alternative)

Sargassum has a yearly cycle that promotes quick recovery from impacts. Therefore, most routine and accidental impact-producing factors would be expected to result in **negligible** impacts because they only impact a small percentage of the population and impacts would be limited in size and scope as new plants rapidly replace the impacted plants. In addition, the cumulative impact on *Sargassum* and associated communities for Alternative A would be **minor** to **moderate** due to the large scale of the impacts from the *Deepwater Horizon* oil spill to the population, the extremely large-scale distribution, and the high reproductive rate of *Sargassum.* The incremental impacts of Alternative A to *Sargassum* and associated communities are expected to be **negligible**.

4.5.2.6 Alternative B—Regionwide OCS Proposed Lease Sale Excluding Available Unleased Blocks in the WPA Portion of the Proposed Lease Sale Area

Under this Alternative, impacts to *Sargassum* and associated communities would be mostly eliminated in the WPA area. Some remaining impacts would occur from vessels docking in the WPA and operating in the CPA or EPA, and from the cumulative impacts associated with previous OCS oil- and gas-related development and non-OCS oil- and gas-related activities. Any spill-related impacts would be limited to the areas along the WPA/CPA boundary and would not impact *Sargassum* communities beyond the area of the spill. While the CPA/EPA has the greatest potential for OCS oil and gas-related activity, *Sargassum* is common throughout the area and it routinely moves across the Gulf. As such, any localized impacts would be short-term as plants are replaced, resulting in no population-level impacts, and therefore, impact conclusions do not differ from Alternative A, which are **negligible**.

4.5.2.7 Alternative C—Regionwide OCS Proposed Lease Sale Excluding Available Unleased Blocks in the CPA/EPA Portions of the Proposed Lease Sale Area

Under this Alternative, impacts to *Sargassum* and associated communities would be mostly eliminated in the CPA/EPA area. Some remaining impacts would occur from vessels docking in the CPA and operating in the WPA, and from the cumulative impacts associated with previous OCS oil- and gas-related development and non-OCS oil- and gas-related activities. Any spill-related impacts would be limited to the areas along the WPA/CPA boundary and would not impact *Sargassum* communities beyond the area of the spill. While the WPA is a smaller area with less projected activity than is proposed for the CPA/EPA, *Sargassum* is common throughout the area and it routinely moves across the Gulf. As such, any localized impacts would be short-term as plants are replaced, resulting in no population-level impacts, and therefore, impact conclusions do not differ from Alternative A or B, which are **negligible**.

4.5.2.8 Alternative D—Alternative A, B, or C, with the Option to Exclude Available Unleased Blocks Subject to the Topographic Features, Live Bottom (Pinnacle Trend), and/or Blocks South of Baldwin County, Alabama, Stipulations

Under this Alternative, impacts to *Sargassum* would be similar to those described in Alternative A, which are **negligible**. *Sargassum* moves in the Gulf of Mexico over great spatial scales and it would be expected to move in and out of these currently available unleased blocks depending on prevailing meteorological processes. Additionally, the exclusion of any or all of the blocks subject to these stipulations would remove only a relatively small number of blocks (<4%) and would not be expected to reduce the potential for any of the impacts decribed in Alternatives A, B, and C.

4.5.2.9 Alternative E—No Action

Under Alternative E, a proposed lease sale would be cancelled and the potential for impacts from routine activities and accidental events would be **none**. Under this Alternative, impacts to *Sargassum* would be limited to cumulative impacts associated with past, present, and future OCS oil- and gas-related development and non-OCS oil- and gas-related activities. *Sargassum* moves in the Gulf of Mexico over great spatial scales and it would be expected to move in and out of the previously leased blocks depending on prevailing meteorological processes. In addition, many blocks already have OCS oil- and gas-related development, and *Sargassum* would continue to be impacted by routine activities and accidental events from pre-existing OCS oil- and gas-related development, although future impacts would likely be **negligible**.

4.6 LIVE BOTTOM HABITATS

This chapter describes shallow-water hard/live bottom habitats in Gulf of Mexico OCS planning areas. Hard bottoms are naturally occurring, rocky, consolidated substrates that are geological (e.g., exposed sedimentary bedrock) or biogenic (e.g., carbonate relic coral reef) in origin. These habitats occur throughout the GOM but are relatively rare compared with the soft bottoms that are ubiquitous. Hard bottoms, particularly those having measurable vertical relief, can serve as important habitat for a wide variety of marine organisms. Encrusting algae and sessile invertebrates such as corals, sponges, sea fans, sea whips, hydroids, anemones, ascidians, and bryozoans may attach to and cover hard substrates, thereby creating “live bottoms,” a term first coined by Cummins et al. (1962). The attached flora and fauna of live bottoms, such as large sponges and structure-forming corals, further enhance the structural complexity of the benthic environment. Complex structure offers shelter that can be attractive to smaller invertebrates and fishes (Fraser and Sedberry, 2008), which, in turn, can provide food for a variety of larger fishes, including some commercially important fisheries (Szedlmayer and Lee, 2004; Gallaway et al., 2009). Refer to **Chapter 4.7** (Fishes and Invertebrate Resources) and the *Essential Fish Habitat Assessment* white paper (USDOI, BOEM, 2016d) for more detail. Seagrasses can also be considered a type of live bottom, but they have very different physical characteristics and species assemblages than the above and are thus analyzed separately in **Chapter 4.3.1**.

Defined topographic features (**Chapter 4.6.1**) are a subset of GOM live bottom habitats that are large enough to have an especially important ecological role, with specific protections defined in the Topographic Features Stipulation. The Live Bottom (Pinnacle Trend) Stipulation (**Appendix D**) has historically been applied to specific lease blocks in the CPA and EPA (**Figure 4-17**, areas shown in red) with the highest known concentrations of other live bottom features. These features are much smaller in size than the topographic features. Live bottom habitats found outside these stipulation lease blocks are not specifically included in the stipulation but are still given site-specific protections by BOEM during site-specific plan reviews (**Appendix B**). In **Figure 4-17**, the smaller black polygons represent the 38 named topographic features; selected fishery management areas on the West Florida Shelf, known to have high concentrations of live bottoms, are shown in gray. The GOM live bottoms are not limited to the features/areas shown in **Figure 4-17**.

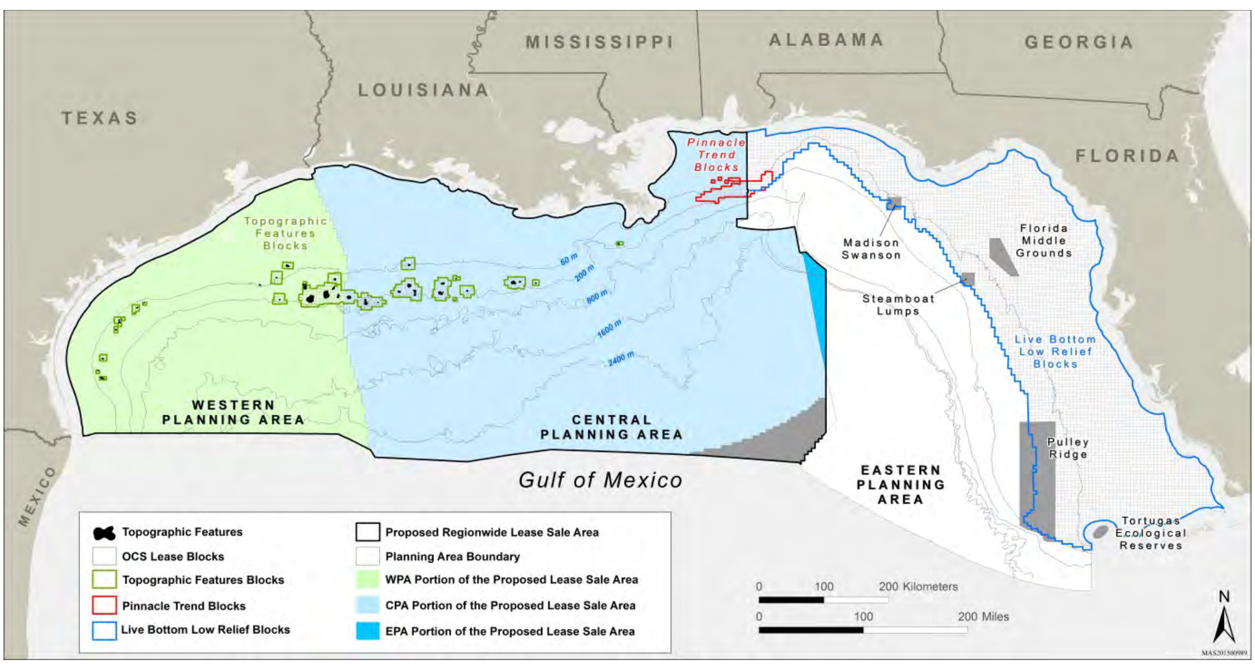

Figure 4-17. Lease Blocks Subject to the Topographic Features and Live Bottom (Pinnacle Trend) Stipulations.

4.6.1 Topographic Features and Associated Communities

This analysis considers the reasonably foreseeable impacts of a proposed action's routine activities, accidental events, and the incremental contribution to cumulative impacts on GOM topographic features and these physical features' associated benthic communities (hereafter referred to as "topographic features") over a 50-year period. Because a catastrophic oil spill is not considered reasonably foreseeable, those potential impacts (including long-term recovery) are addressed in the *Catastrophic Spill Event Analysis* white paper (USDOI, BOEM, 2017). The impact significance criteria and resulting conclusions presented here (**Table 4-13**) focus on the overall functioning, resilience, and ecosystem-level importance of topographic features throughout U.S. waters of the GOM.

Because of the similarity and overlap of the effects of many oil- and gas-related activities that occur in the OCS, the impact-producing factors considered for topographic features can be divided into three broad categories: drilling and exploration operations; vessel operations; and oil spill and associated cleanup activities. The impact-producing factors evaluated for this resource are listed below:

- Drilling, Exploration, and Decommissioning
  - Bottom-disturbing activities (**Chapter 3.1.3.3.2**)
  - Deposition of sediments onto the seafloor (**Chapter 3.1.3.3.3**)
- Vessel Operation
  - Bottom-disturbing activities (**Chapter 3.1.3.3.2**)
  - Loss of debris
- Accidental Spills and Associated Cleanup
  - Spills resulting from surface or subsea sources (**Chapter 3.2.1**)
  - Sediment burial
  - Chemical and drilling-fluid spills (**Chapter 3.2.6**)
  - Cleanup operations not related to vessel operation (**Chapter 3.2.8**)

An in-depth analysis of these potential impact-producing factors determined that, although many may occur within the GOM, few could occur at an extent sufficient to cause impacts to the topographic features as a whole (**Table 4-13**), partly because the topographic features are spread widely across the GOM. The potential magnitude of impact for each of the analyzed impact-producing factors is provided in **Table 4-13** to help the reader quickly identify the level of potential impacts for each impact-producing factor. The impact-level definitions and the analyses supporting these conclusions are then discussed in detail in this chapter.

Table 4-13. Topographic Features Impact-Producing Factors That Are Reasonably Foreseeable.

Topographic Features	Magnitude of Potential Impact[1]				
Impact-Producing Factors	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
Routine Impacts					
Bottom-Disturbing Activities Associated with Drilling, Exploration, and Decommissioning					
With Mitigation	Negligible	Negligible	Negligible	Negligible	None
Without Mitigation	Moderate	Moderate	Moderate	Negligible	None
Bottom-Disturbing Activities Associated with Vessel Operations					
With Mitigation	Negligible	Negligible	Negligible	Negligible	None
Without Mitigation	Moderate	Moderate	Moderate	Negligible	None
Accidental Impacts					
Bottom-Disturbing Activities Associated with Drilling, Exploration, and Decommissioning					
With Mitigation	Negligible	Negligible	Negligible	Negligible	None
Without Mitigation	Moderate	Moderate	Moderate	Negligible	None
Chemical and Drilling-Fluid Spills					
With Mitigation	Negligible	Negligible	Negligible	Negligible	None
Without Mitigation	Moderate	Moderate	Moderate	Negligible	None
Bottom-Disturbing Activities Associated with Vessel Operations					
With Mitigation	Negligible	Negligible	Negligible	Negligible	None
Without Mitigation	Moderate	Moderate	Moderate	Negligible	None
Oil Spills and Associated Cleanup Activities					
Large and Small Spills Resulting from Surface or Subsea Sources					
With Mitigation	Negligible	Negligible	Negligible	Negligible	None
Without Mitigation	Moderate	Moderate	Moderate	Negligible	None
Cleanup Operations Not Related to Vessel Operation					
With Mitigation	Negligible	Negligible	Negligible	Negligible	None
Without Mitigation	Moderate	Moderate	Moderate	Negligible	None
Cumulative Impacts					
Incremental Contribution[2]	Negligible	Negligible	Negligible	Negligible	None
OCS Oil and Gas[3]	Negligible				
Non-OCS Oil and Gas[4]	Negligible to Moderate				

[1] The analysis supporting these conclusions is discussed in detail in the "Environmental Consequences" chapter below.

[2] This includes all activities (i.e., routine activities projected to occur and accidental events that could occur) as a result of a single proposed lease sale in the 2017-2022 Five-Year Program.

[3] This includes all activities (i.e., routine activities projected to occur and accidental events that could occur) from past, proposed, and future lease sales.

[4] This includes other past, present, and reasonably foreseeable future activities occurring within the same geographic range and within the same timeframes as a proposed action, but they are not related to the OCS Oil and Gas Program.

Impact-Level Definitions

For this analysis, the following definitions were used to categorize impacts to topographic features:

- **Negligible** – Impacts to topographic feature communities are largely undetectable. There is some potential for even undetectable impacts to cause slight changes to a local community's species abundance and composition, community structure, and/or ecological functioning, but any such changes would be spatially localized, short term in duration, and would not impact other topographic features.
- **Minor** – Impacts to topographic feature communities are detectable but cannot be distinguished from natural variation. Such impacts could result in noticeable changes to a local community's species abundance and composition, community structure, and/or ecological functioning, but would be spatially localized, short term in duration, and recovery would be expected.
- **Moderate** – Impacts to topographic feature communities that result in substantial, population-level changes in species composition, community structure, and/or ecological functioning. These impacts would be expected to be spatially extensive, spanning across several topographic features, but impacts are expected to result in temporary changes and recovery would be likely.
- **Major** – Impacts to topographic feature communities that result in substantial, population-level changes in species composition, community structure, and/or ecological functioning. These impacts would be expected to be spatially extensive and noticeably alter the overall status of many topographic features communities in the GOM. Long-term recovery to pre-impact community structure, species abundance, or ecological function is unlikely.

The impact-producing factors related to the release of toxins and sediments were not carried forward for further analysis because these discharges are managed through the NPDES permitting process or MARPOL Annex V Treaty. Regulation and enforcement of these laws is conducted by a number of agencies, including USEPA, NOAA, BSEE, and USCG, and is intended to ensure that water quality is maintained at an acceptable level. Compliance is assumed; therefore, these factors are not further analyzed in this chapter. Similarly, the release of marine debris is also regulated by the USCG and MARPOL and is strictly prohibited; this is reinforced by NTL 2015-BSEE-G03, which imposes marine debris awareness and prevention measures on the oil and gas industry. Historically, NTL 2015-BSEE-G03 has been made a binding part of leases through the Protected Species Stipulation. As such, accumulation of debris at levels great enough to impact a topographic feature is unlikely. Another impact-producing factor not carried forward for further analysis is impacts resulting from a vessel sinking and coming to rest on a topographic feature. An OCS oil- and gas-related vessel sinking is a rare event and it is not reasonably expected that a vessel sinking in the OCS would come to rest on a topographic feature. Sediment burial and surface response operations that would occur during an oil spill were also not carried forward. Response operations may occur at the water surface above a topographic feature; however, none of the technologies employed to remove oil at the surface operate at a depth deep enough to impact a topographic feature. An accidental sediment burial of organisms during a spill was also not carried forward because it is not reasonably foreseeable that this type of event would occur outside of a catastrophic situation. A review of BSEE's records show that an accidental burial event has not occurred since at least 2006, which was when reporting requirements changed to require reporting of this type of event (USDOI, BSEE, 2015d). As such, only the following impact-producing factors were carried forward to a full analysis for routine activities and accidental events:

- Routine Activities
  - Drilling, exploration, and decommissioning (Bottom-disturbing activities)
  - Vessel operation (Bottom-disturbing activities)
- Accidental Events
  - Drilling, exploration, and decommissioning
    - Bottom-disturbing activities
    - Chemical and drilling-fluid spills
  - Vessel operation (bottom-disturbing activities)
  - Oil spill and associated cleanup
    - Large and small spills resulting from surface or subsea sources
    - Cleanup operations not related to vessel operations

Historical Protections of Topographic Features

In the Gulf of Mexico, topographic features are known to function as large-sized, hard substrate habitats that enable settlement of sensitive benthic organisms, concentrate fishes, and substantially contribute to the ecology of the GOM. Many of these features have been identified as locations of particular value that may require a greater degree of protection from OCS oil- and gas-related activities. As such, beginning in 1973, BOEM's predecessor agency established and implemented a Topographic Features Stipulation (also referred to here just as "stipulation") that applies conditions to OCS oil- and gas-related activities occurring in the vicinity of these features.

Adherence to the provisions of this stipulation helps protect the resources by distancing OCS oil- and gas-related activities away from the most sensitive areas of topographic features in order to minimize negative impacts of routine activities and accidental events. Historically, this stipulation has been applied consistently to all leases in OCS areas with defined topographic features. The stipulation establishes a No Activity Zone around the most ecologically sensitive core area of each identified topographic feature, within which no bottom-disturbing activities are allowed. Additionally, BOEM extends a 500-ft (152-m) buffer around each of these No Activity Zone boundaries, further restricting bottom-disturbing activity. The additional 500-ft (152-m) buffer policy was developed in consultation with NOAA to further protect areas of topographic features that were not originally included in the defined No Activity Zones. In addition, for most of the features, the stipulation also establishes variably sized concentric shunting zones surrounding the No Activity Zones, within which BOEM requires that drill cuttings and drilling fluids be shunted to near the seafloor to minimize the seafloor area affected by the cuttings and fluids.

Refer to **Appendix D** for further details of the Topographic Features Stipulation and NTL 2009-G39, "Biologically-Sensitive Underwater Features and Areas," which provides information and consolidates guidance to help operators understand BOEM's requirements related to sensitive shallow-water benthic habitats. These requirements are designed to prevent or limit any impacts to topographic features from routine activities and accidental events. This analysis assumes that these (or functionally equivalent) protections will continue to be a requirement for OCS oil- and gas-related activities resulting from a proposed action throughout the 50-year analysis period. Furthermore, the Secretary of the Interior has decided in the Record of Decision for the Five-Year Program to include the Protection of Biologically Sensitive Underwater Features as landscape mitigation for the 10 proposed lease sales in the GOM (USDOI, 2017).

4.6.1.1 Description of the Affected Environment

Topographic features (also called banks) are a subset of hard bottom habitats found in the GOM that are large enough in individual size to have a particularly important role in the GOM ecosystem. Although large in size, these features (and hard bottom habitats as a whole) are relatively rare compared with the expansive soft bottoms found throughout the central and western GOM (Parker et al., 1983). Topographic features can be created through the uplift of bedrock by underlying salt diapirs and the exposure of fossilized barrier islands, or they can be formed from relic carbonate reefs (Rezak and Bright, 1981a and 1981b; Berryhill et al., 1987). Regardless of origin, these subsea banks provide areas of hard substrate that support benthic and fish communities with relatively high biomass, diversity, and abundance. The structurally complex habitats of these features also provide shelter, food, and nursery grounds that support large numbers of commercially and recreationally important fishes (Johnston et al., 2015; Nash et al., 2013). Many of these habitats remain relatively pristine and have a high aesthetic and scientific value in part because they represent ecological and/or geographic extremes for many species (Rezak and Bright, 1981a; Nash et al., 2013; Johnston et al., 2015).

Within the GOM, BOEM has identified 38 topographic features with sufficiently unique geography and ecology (Rezak and Bright, 1981a; Rezak et al., 1983) to continue warranting some degree of protection from OCS oil- and gas-related activities. There are 22 topographic features in the WPA, 16 in the CPA, and 0 in the EPA (**Figure 4-17**). As detailed above, in previous lease sales, all of these banks were provided a designated No Activity Zone, in which all OCS oil- and gas-related bottom-disturbing activities were prohibited. The No Activity Zones were defined based on a specific depth contour for each feature. They are designed to protect the most sensitive area of the features. In addition, EFH programmatic consultation with NMFS specified that drilling should not occur within 152 m (500 ft) of a No Activity Zone of a topographic feature. Any bottom-disturbing activities within that buffer distance would first require project-specific EFH consultation with NMFS. Most of the topographic features have also been given additional restrictions beyond the No Activity Zone, specifically the drilling discharge shunting zones.

Figure 4-18 presents an illustrative example of the ecology of topographic features, showing the various types of habitats found at different depths. Each of the labels represents different ecological zones common to topographic features. Note that rarely do all of the possible zones occur on a single feature. For example, East Flower Garden Bank contains all but one of the ecotones, i.e., the Millepora-Sponge Zone. This zone occupies depths comparable to the *Diploria-Montastraea-Porites* Zone on the claystone-siltstone substrate of the Texas-Louisiana midshelf banks. Crusts of hydrozoan corals (*Millepora alcicornis*), sponges, and other epifauna typically occupy the tops of outcrops in this zone, but scleractinian corals and coralline algae are rare (Rezak et al., 1990).

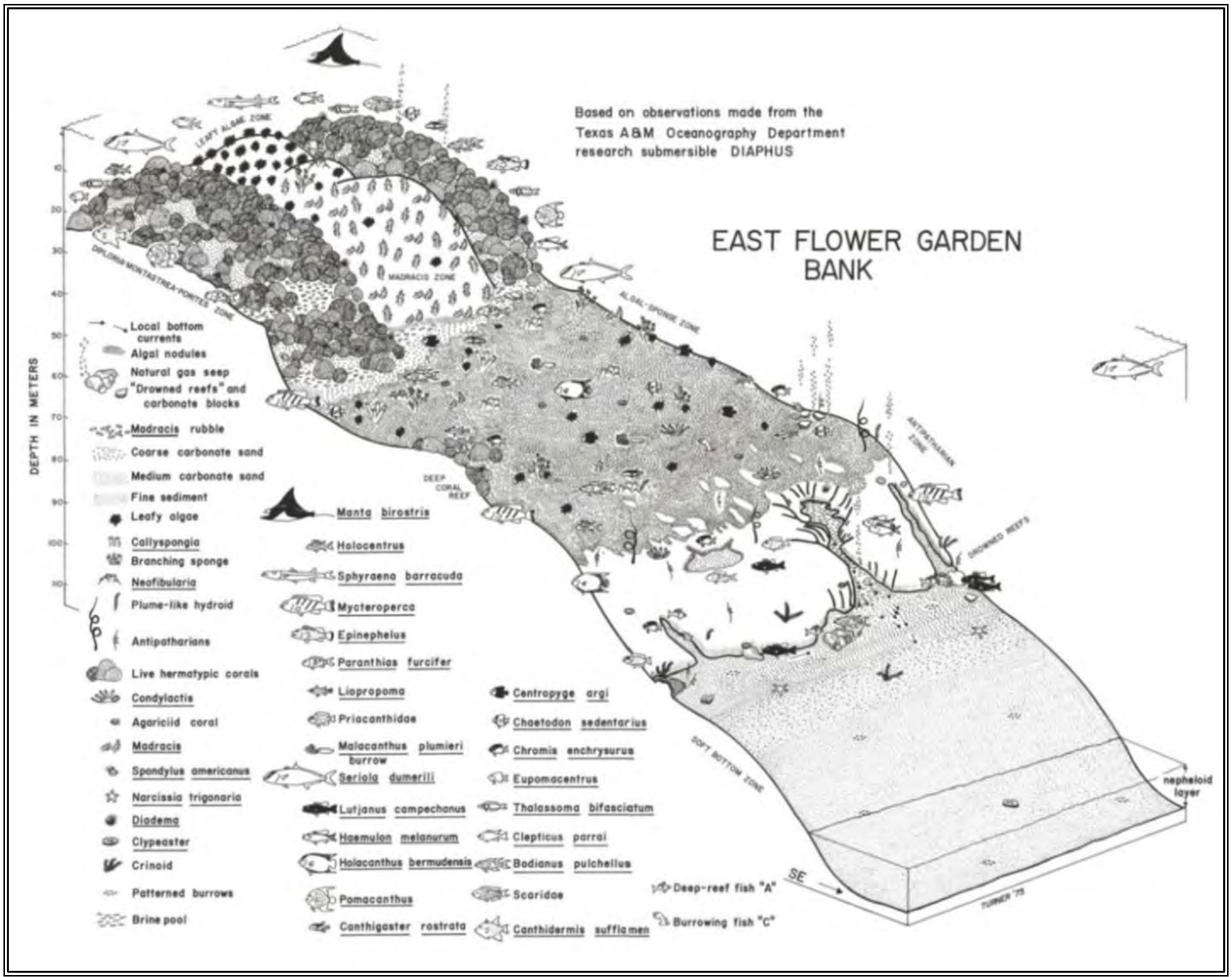

Figure 4-18. Ecological Representation of Common Features on Topographic Features in the Gulf of Mexico.

Topographic features in the GOM are subject to an array of environmental conditions, resulting in a large number of ecological community types. This includes a range from the highly productive hermatypic (i.e., reef building) corals found at the Flower Garden Banks to habitats such as Dunn Bar, which possess less productive and less diverse benthic habitats but are still known to concentrate fishes (Rezak and Bright, 1981b; Nash et al., 2013).

Bank Classification

Shelf-Edge Banks

The shelf-edge banks generally exhibit the greatest range of habitat types of all the topographic features because they have the greatest vertical relief (Rezak et al., 1983). In general, banks that have the greatest vertical relief also possess the greatest number of habitat categories. The habitats of topographic features can be classified into seven categories. All of these categories can be found on the various shelf-edge banks, although not all of them occur simultaneously at the same bank (Rezak et al., 1983). These habitats range from the reef-building, shallow-water corals, the most complex and diverse of the habitat types, to less diverse habitats found in the high-turbidity nepheloid layer. The nepheloid layer is a zone of suspended sediment-laden water of variable density and vertical size that persists above the seafloor. It can be a controlling factor for the many live bottom species that are sensitive to turbidity (Rezak et al., 1990), exerting a considerable influence on species' bathymetric and geographic distribution. Generally, high levels of suspended sediments can limit species diversity and abundance, at least for the sessile benthic live bottom species considered in this chapter. Light penetration, depth, and sediment loading are the most influential environmental controls on communities that colonize topographic features (Rezak et al., 1983). There is a direct relationship between light levels at depth and the biodiversity of these habitats.

Among the shelf-edge banks, the Flower Garden Banks and McGrail Bank have been identified as exceptionally important components of the GOM ecosystem. These banks represent the northernmost colonies of hermatypic corals and may provide larvae/recruits for other coral reefs far away (Goodbody-Gringley et al., 2012). Shelf-edge banks also serve as seasonal feeding, mating, and nursery grounds for many species, such as manta and devil rays, whale sharks, and hammerhead sharks (Burks et al., 2006; USDOC, NOAA, 2010c; Johnston et al., 2013; Johnston et al., 2015). Additionally, many of these banks are important for commercial or recreational fisheries because they provide structurally complex habitat for recruitment and concentrate harvestable quantities of fish (Rezak et al., 1983). There is also a diverse group of tropical reef fish species found on these banks. There are at least 175 tropical reef species that have been observed within the high-diversity zone at the Flower Garden Banks (Dennis and Bright, 1988; Pattengill, 1998).

Midshelf Banks

The midshelf banks typically have less vertical relief than the shelf-edge banks, and they also occur in waters with reduced light penetration (due to higher primary production and/or higher sediment loading). As such, hermatypic coral reefs are rare and thought to be limited to Stetson Bank (part of the Flower Garden Bank National Marine Sanctuary). Dominant benthic species on these banks are algaes, sponges, and ahermatypic (i.e., non-reef building) corals. The nepheloid layer often enfolds most portions of these banks because of their reduced vertical relief (at least compared with shelf edge banks). The presence of the nepheloid layer can influence light penetration and ultimately reduce biodiversity, with the turbid conditions favoring fewer but more robust and resilient species. Midshelf banks are known to concentrate many pelagic species of fishes and are visited regularly by commercial and recreational fishermen (Simmons et al., 2014).

South Texas Banks

The South Texas Banks are geographically and geologically distinct from the shelf-edge and midshelf banks (Rezak and Bright, 1981b; Berryhill et al., 1987). Several of the South Texas Banks are low-relief banks comprised of a series of patch-reef habitats. Some of these banks were created from the exposure of fossilized shorelines along the prehistoric coastline, or from drowned reefs created during a period when sea levels were considerably lower. These banks generally exhibit reduced biotic diversity. They have lower relief than the other bank types, fewer hard-substrate outcrops, and higher sediment loading due to the presence of a nepheloid layer at many of the banks (Rezak et al., 1983). The dominant benthic species on the South Texas Banks include sponges, hydroids, octocorals, and ahermatypic corals, although portions of these banks remain barren (Rezak and Bright, 1983; Dokken et al., 1993). Yet these banks are still known to provide habitat for many species of commercially and recreationally important fishes, which could be related to their relatively close proximity to the shoreline (Simmons et al., 2014).

Environmental Sensitivity of Banks

The importance of these topographic features has long been understood by BOEM and its predecessor agencies. It is also known that the same geologic processes that create some types of topographic features (i.e., salt domes) also create reservoirs where hydrocarbons can become trapped and subsequently harvested. As such, in the 1970's, BOEM's predecessor agency developed the Topographic Features Stipulation to ensure that the most sensitive sections of these features were not negatively impacted by OCS oil- and gas-related activities. The primary concern was sediment deposition and subsequent smothering of organisms during drilling operations. As such, BOEM (formerly MMS) funded a series of exploratory cruises to better understand the ecology of these banks. The result was the creation of an environmental priority index that rates the sensitivity of the various topographic features (Rezak and Bright, 1981a). In order of decreasing sensitivity, the following classification was used:

(1) Shelf-edge, carbonate banks possessing clear-water coral reefs and Algal-Sponge Zones, transitional assemblages approximating the Antipatharian Zone and Nepheloid Zone (surrounding depths of 276-656 ft [84-200 m], crests 49-246 ft [15-75 m]).

(2) Midshelf, Tertiary-outcrop banks bearing clear-water, Millepora-Sponge Zone and turbid-water-tolerant Nepheloid Zone (surrounding depths of 164-203 ft [50-62 m], crests 59-131 ft [18-40 m]).

(3) Midshelf and South Texas carbonate banks bearing poorly developed elements of the Algal-Sponge Zone, transitional Antipatharian Zone assemblages, and Nepheloid Zone (surrounding depths of 328-361 ft [100-110 m], crests 220-240 ft [67-73 m]).

(4) Midshelf and South Texas banks bearing turbidity-tolerant assemblages approximating the Antipatharian Zone and Nepheloid Zone (surrounding depths of 197-262 ft [60-80 m], crests 184-230 ft [56-70 m]).

From this index, MMS (BOEM's predecessor) developed the No Activity Zones and additional discharge restrictions. Features most sensitive to turbidity were given the greatest levels of protection. For example, the Flower Garden Banks were given the most generous No Activity Zone and a 4-mi (6-km) zone with discharge restrictions. Other sensitive banks, such as McGrail Bank, were given a No Activity Zone outlining the most sensitive habitats along with a 1-mi (1.6-km) zone and a 3-mi (4.8-km) zone with varying degrees of discharge regulations. Banks such as Sackett Bank have only a No Activity Zone and a 3,280-ft (1,000-m) discharge shunting zone. Finally, lower relief banks with a relatively high degree of turbidity tolerance, such as Big Adam Bank, only have a No Activity Zone.

There is evidence of a large-scale die-off of seaweeds and rhodoliths on several topographic features (Sackett and Ewing Banks) that occurred in 2010, possibly related to changes in environmental conditions and, as of 2013, there had been only limited recovery (Felder et al., 2014; Fredericq et al., 2014). The result was a reduction in diversity and abundance of benthic species at Ewing Bank, a reduction in abundance of benthic species at Sackett Bank, and an increase in injuries and population declines of decapods at both banks. Although there was little *in situ* recovery, it was found that the rhodoliths on these banks may be functioning as a "seed bank" for these habitats (Felder et al., 2014; Fredericq et al., 2014). This suggests that there is an unknown environmental variable in-place that may be preventing *in situ* conditions required for recovery. The ultimate cause of these changes remains unknown; however, this area was subjected to ecosystem-level insults from 2009 through 2012, in addition to the *Deepwater Horizon* explosion, oil spill, and response. With respect to oil exposure, the surface waters above Sackett and Ewing Banks had some degree of exposure, but there is no direct evidence that implicates oil-related impacts as the trigger for these changes (Felder et al., 2014; Fredericq et al., 2014). These banks are located in areas highly influenced by the outfall of the Mississippi River. Between 2009 and 2012, the Mississippi River outfall was highly irregular compared with normal outfall patterns (Pollak, 2013). From late 2009 to late 2010 and 2011, the Mississippi River maintained an exceptionally high flow rate with an abnormal seasonal pattern, and this was followed by record low outfall levels in 2012. These areas were also subjected to differing levels of hypoxia, with major hypoxic events occurring in the vicinity of Ewing Bank in the summers of 2009, 2010, and 2011 (USDOC, NOAA, 2010d and 2015j). Although there were also many hypoxic events prior to 2009, these occurred during periods of river outfall patterns exhibiting a more "normal" seasonal pattern, and these events may have contributed to the changes seen on these banks.

The banks of the northern GOM also experienced exponential population growth of the invasive lionfish (*Pterois volitans and Pterois miles*) during this same time period (USDOI, GS, 2015; Johnston et al., 2013). Lionfish are known to drive down diversity and abundance of benthic organisms, especially crabs, demersal fishes, and shrimps (Green et al., 2012). The lionfish expansion could result in a top-down control of grazers, ultimately preventing recolonization by seaweeds due to increased grazing on seaweed recruits by herbivores released from decapod predation due to lionfish pressure. It is a reasonable conclusion that the possible ecosystem-level changes on these two banks are the result of the cumulative impacts of many factors (e.g., Karnauskas et al., 2015) rather than a single cause-effect relationship (i.e., the *Deepwater Horizon* oil spill).

Habitat Areas of Particular Concern and Endangered Species Act Listings

The NMFS has designated habitat areas of particular concern (HAPCs) within identified EFH. The direct and/or indirect impacts from cumulative OCS oil- and gas-related and non-OCS oil- and gas-related activities on EFH are considered and summarized in the *Essential Fish Habitat Assessment* white paper (USDOI, BOEM, 2016d). The HAPC-designated areas are considered as providing particularly important habitat for federally managed fish species and are considered priority areas for research and conservation. Designation is based on ecological importance, sensitivity to potential stressors/impacts, and rarity (GMFMC, 2005 and 2010). The only bank designated as Coral HAPC is McGrail Bank (GMFMC, 2005 and 2010; Simmons et al., 2014). Hard-bottom HAPCs include Sonnier Bank, Geyer Bank, Bouma Bank, Rezak Bank, Sidner Bank, Alderice Bank, Jakkula Bank, and parts of McGrail Bank (GMFMC, 2005 and 2010; Simmons et al., 2014). The HAPC designation has no regulatory consequences for BOEM-permitted activities; however, BOEM does consult with NMFS on issues related to HAPCs when appropriate. In 2014, 20 additional coral species were listed as threatened under the ESA, and several of these species are found in the northern GOM (*Federal Register,* 2014b). For analysis and impact conclusions specific to these protected species, refer to **Chapter 4.9.5**.

4.6.1.2 Environmental Consequences

4.6.1.2.1 Routine Activities

The reasonably foreseeable potential routine impact-producing factors that could affect topographic features in the GOM are caused by bottom-disturbing activities that may occur during drilling, exploration, and decommissioning operations and vessel operations.

Drilling, Exploration, and Decommissioning Operations

The term bottom-disturbing activities includes any activity that results in the disturbance of the seafloor during the exploration, production, or decommissioning phase of OCS operations. This includes (but is not limited to) drilling activities (**Chapters 3.1.2 and 3.1.3.1**), structure installation and removal (**Chapters 3.1.3.3 and 3.1.6**), and pipelaying activities. Regardless of the activity, the severity of the impact to topographic features is the same, although the extent of the impact would vary in direct proportion to the material's size.

The bottom-disturbing activity with the largest areal impact would be the discharge of muds and cuttings into the water column. Drilling operations in close vicinity to topographic features could deposit large amounts of sediment onto the features (maximum amounts estimated to be approximately 2,000 metric tons) (Neff, 2005). This could have severe impacts, including increased stress as the organisms cope with the increased sediment load, a decline in production due to decreased light, or mortality caused by smothering (Wilber et al., 2005). Sedimentation of uncolonized substrates could also render these areas uninhabitable for future recruits settling on the topographic feature. However, because of the distancing and shunting requirements of the anticipated Topographic Features Stipulation, these potential impacts are reduced to a negligible level.

The placement of any structures or equipment on the seafloor could also result in substantial impacts to the benthic communities on the topographic features. Any object placed on the seafloor could result in the crushing deaths of any organisms contacted during emplacement activities. Mortality due to smothering could also occur if sediments are moved from the seafloor to a new location (e.g., trenching a pipeline or emplacement of initial casings). Sedimentation of uncolonized substrates could also render these areas uninhabitable for future recruits to settle on the topographic feature.

Explosive severance for the removal of structures is another bottom-disturbing activity associated with OCS oil- and gas-related operations that can impact communities associated with topographic features. This could result in damage or death to any organisms within the vicinity of the blast or associated sediment plume, although long-term turbidity is not expected from platform removal operations. The shockwave from the blast could also potentially damage the underlying hard substrates required by many benthic organisms.

Without adherence to the distancing and shunting requirements of the Topographic Features Stipulation, impacts to topographic features could be severe and long lasting. However, if the requirements of the Topographic Features Stipulation continue to be applied as expected, operations would remain a safe distance away from critical areas of topographic features. Additionally, restrictions on discharges would be in place and few organisms would experience substantial levels of sedimentation. It is expected that this stipulation would continue to be a requirement for OCS operators throughout the analysis period. Therefore, with adherence to the requirements of the Topographic Features Stipulation, impacts from drilling, exploration, and decommissiong operations would be **negligible**.

Vessel Operations

The only aspect of routine vessel operations that would result in bottom-disturbing activities that could impact portions of topographic features would be the use of anchors by vessels. Anchor damage is one of the greatest threats to the biota of the offshore banks in the GOM (Rezak and Bright, 1979; Rezak et al., 1985; Gittings et al., 1992a; Hudson et al., 1982). Anchors may break, fragment, or overturn corals, sponges, and other benthic organisms, and the anchor chain or cable may drag across and shear organisms off the substrate (Dinsdale and Harriott, 2004). This would result in consequences ranging from increased stress to mortality (Dinsdale and Harriott, 2004). Damage to a coral community may take 10 or more years to recover (Fucik et al., 1984; Rogers and Garrison, 2001).

The Topographic Features Stipulation and EFH programmatic consultation with NMFS prohibit bottom-disturbing activities, including anchoring, within the most sensitive areas of topographic features as defined by the individual bank's No Activity Zones. Anchoring in other less-sensitive portions of topographic features, such as the outer edges, could be permitted, but only after BOEM's subject-matter experts perform site-specific reviews of high-resolution survey information and apply any appropriate mitigating measures, as detailed in NTL 2009-G39, "Biologically-Sensitive Underwater Features and Areas" (**Appendix D**). Without adherence to the distancing requirements of the Topographic Features Stipulation, anchoring impacts to topographic features could be severe and long lasting. However, under the requirements of the Topographic Features Stipulation, which is a required mitigation as a result of the Five-Year Program's Record of Decision, anchor placement from OCS oil- and gas-related vessels would not be allowed on or near the most sensitive areas of the features and impacts would be **negligible**.

4.6.1.2.2 Accidental Events

The potential impact-producing factors resulting from accidental events on topographic features in the GOM include bottom-disturbing activities, releases of toxins and sediment into the water column, and oil spills and associated cleanup activities. Each of these impact-producing factors can occur during hydrocarbon extraction activities or during vessel operations.

Drilling, Exploration, and Decommissioning Operations

Bottom-Disturbing Activities

Reasonably foreseeable accidental bottom-disturbing activities include accidental overboard losses of equipment, either during vessel-platform transfer operations or during vessel transits; equipment loss overboard from platforms; severe weather, causing underwater equipment movement; or operator error during equipment placement (e.g., setting an anchor in the wrong location). Regardless of the cause, the consequence would be crushing and the likely mortality of contacted benthic organisms. The areal extent of impact would be directly related to the size of the equipment making contact. Larger pieces of equipment could also influence water-flow patterns on or around topographic features, potentially influencing the movement of larvae and food. However, any equipment that is deposited on the seafloor would also become a new hard substrate available for settlement by sessile benthic organisms, with potential subsequent ecological benefits. Any recovery operations would have to abide by the Topograhic Features Stipulation's requirements, including restrictions on bottom-disturbing activities.

Without adherence to the distancing requirements of the Topographic Features Stipulation, such impacts to topographic features could be severe and long lasting. However, if the distancing requirements of the stipulation are applied and adhered to, the probability of such events would be small. Because of the overall unlikelihood of such events and the inherently limited nature of any such impacts' size and scope, the overall impact of accidental bottom-disturbing activities is expected to be **negligible**.

Chemical and Drilling-Fluid Spills

Accidental spills, such as from a platform or vessel, could include releases of substances such as diesel fuel, marine paint, drilling fluids, and untreated sewage, or those that could occur through the incorrect separation of cuttings and drilling muds (**Chapter 3.2.6**). Most spills on the OCS would have little impact on the organisms of a topographic feature because spills of this type are expected to be relatively small, and it is expected that spilled substances would either remain in the surface waters or would be rapidly diluted and dispersed. For substances such as drilling muds, an accidental release could have substantial impacts to a topographic feature as those materials usually settle rapidly to the seafloor, smothering any contacted organisms, some of which cannot cope with large quantities of sediments. Exposures to concentrated drilling muds can result in a wide range of impacts to corals, ranging from mortality to multiple sublethal responses to no response at all (Thompson, 1979). Such impacts would likely be proportional to the size of the spill and the vicinity of the spill to topographic features. The composition of muds is strictly regulated, and discharges of cuttings/muds are tested to ensure that toxicity levels are below the limits allowed by NPDES permits (USEPA, 2004, 2007, and 2009b). It is expected that such an accidental spill would be stopped quickly or would be relatively small given the limited amounts that are typically transfered at one time.

Without adherence to the distancing requirements of the Topographic Features Stipulation, impacts to topographic features from chemical and drilling-fluid spills could be as great as **moderate**. However, if the distancing requirements of the Topographic Features Stipulation are applied, such impacts would be minimized. This would allow more time and distance for dilution and dispersion of substances. Given the inherently low likelihood of an accidental spill, and assuming adherence to the Topographic Features Stipulation and the low likelihood of this type of spill occurring near a topographic feature, the impact of accidental releases of toxins into the water column is expected to be **negligible**.

Vessel Operations

The only reasonably foreseeable aspect of vessel operations that could result in bottom disturbance of topographic features would be vessel anchoring. Anchor damage is one of the greatest threats to the biota of the offshore banks in the GOM (Rezak and Bright, 1979; Rezak et al., 1985; Gittings et al., 1992a; Hudson et al., 1982). Anchors may break, fragment, or overturn corals, sponges, and other sessile benthic organisms, and anchor chains or cables may drag across and shear organisms off the substrate (Dinsdale and Harriott, 2004). This could result in consequences ranging from increased stress to mortality (Dinsdale and Harriott, 2004). Such damage to a coral community may take 10 or more years to recover (Fucik et al., 1984; Rogers and Garrison, 2001).

Because of the Topographic Features Stipulation, such anchoring is not expected during routine activities. However, unplanned anchoring could occur as a result of an accident or during a life-threatening emergency situation on a vessel (e.g., loss of propulsion) to preserve the safety of the vessel and crew. In that case, impacts to benthic organisms on topographic features would be locally severe at the location where the anchor lands; however, impacts would be limited to that location and should not threaten communities across an entire topographic feature. In addition, an emergency requiring anchoring is expected to be a rare event. Without adherence to the distancing requirements of the Topographic Features Stipulation, such impacts to topographic features could be severe and long lasting at the specific location where accidental anchoring occurs. However, if the requirements of the Topographic Features Stipulation are applied, the chances of accidental anchor placement happening in the most sensitive areas of topographic features is low, and impacts of accidental anchoring events are expected to be **negligible**.

Oil Spill and Cleanup Activities

Impacts that may occur to topographic features' benthic communities as a result of an oil spill would depend on the type of oil spill, the features' distance from the spill, relief of the biological feature, and surrounding physical characteristics of the environment (e.g., turbidity). Oil transport and fate is discussed in **Chapter 3.2.1.3**, and oil spills <1,000 bbl and oil spills ≥1,000 bbl are discussed in **Chapters 3.2.1.4 and 3.2.1.5**, respectively. In large enough quantities, oil spills could result in lethal or sublethal impacts to organisms, including reduced fitness, growth, or reproduction. The depth of topographic features below the sea surface should minimize contact with surface oil where it is expected to be advected away or cleaned up by response crews.

If an oil spill occurs at depth in deep water and the oil is ejected under pressure, some oil would rise to the surface, but some oil droplets may become entrained deep in the water column (Boehm and Fiest, 1982), creating a subsurface plume (Adcroft et al., 2010). If this plume was to come in contact with the benthic organisms on a topographic feature, the impacts could be severe. Consequences could include mortality, loss of habitat, reduced biodiversity, reduced live bottom coverage, changes in community structure, and reduced reproductive success (Reimer, 1975; Guzmán and Holst, 1993; Negri and Heyward, 2000; Silva et al., 2015). The extent and severity of impacts would depend on the location and weathering of the oil and the hydrographic characteristics of the area (Bright and Rezak, 1978; Rezak et al., 1983; McGrail, 1982; Le Henáff et al., 2012). Because all of the topographic features are located on the continental shelf and because upwelling events are generally limited to hurricanes, eddy formations, or when certain meteorological conditions exist (Walker, 2001; Collard and Lugo-Fernandez, 1999; Zavala-Hidalgo et al., 2006), contact of a small subsurface plume with a topographic feature would only occur under the most ideal and unlikely conditions (such as in Silva et al., 2015). There is a possibility that, if a subsurface plume becomes entrained in the nepheloid layer, organisms in this layer could be greatly impacted. In shallow waters, this layer is typically restricted to the bottom 66 ft (20 m) of the water column (Bright et al., 1976; Bright and Rezak, 1978).

Use of chemical dispersants on a larger spill (refer to **Chapter 3.2.8.2.2**) would enable dispersed oil to mix into the water column and possibly impact benthic organisms on topographic features, similar to what was documented in Silva et al. (2015). For a surface spill, dispersed oil is not expected to reach the topographic feature (Guo et al., 2014; Lange, 1985; Tkalich and Chan, 2002); however, if dispersants are applied to a subsurface plume, any dispersed oil in the water column that comes in contact with corals may evoke short-term negative responses, including reduced feeding and photosynthesis or altered behavior (Wyers et al., 1986; Cook and Knap, 1983; Dodge et al., 1984; Ross and Hallock, 2014). For larvae, the response may be even more profound, with implications for dispersant use during coral spawning season (Negri and Heyward, 2000; Goodbody-Gringley et al., 2013). There is some evidence that dispersant-treated areas may recover more rapidly than areas where oil is allowed to decay naturally (Lessard and Demarco, 2000).

For any accidental spill, it is also expected that a certain quantity of spilled oil may eventually settle on the seafloor due to the formation and settlement of “marine snow,” which involves a binding process with suspended sediment particles and/or consumption and excretion by phytoplankton (International Tanker Owners Pollution Federation Limited, 2002; Passow et al., 2012). It is anticipated that the greatest amount of oil adsorbed to sediment particles would occur close to the spill, with concentrations reducing with distance from the source. If the spill occurs very close to a topographic feature, the underlying benthic communities may become smothered by the settling particles and thereby exposed to hydrocarbons. Beyond that immediate area, impacts would be more limited due to particles biodegrading and dispersing. Sublethal impacts to benthic organisms from any such exposure may include reduced recruitment success, reduced growth, and reduced coral cover as a result of impaired recruitment (Rogers, 1990; Kushmaro et al., 1997).

A different type of impact could occur during a response operation in which drilling muds are pumped into a well to regain well control. It is possible that, during this process, such muds may be forced out of the well and deposited on the seafloor near the well site. If this were to occur, the localized impacts would be severe for the organisms buried; however, any impact beyond the immediate area would be very limited.

In conclusion, without adherence to the distancing requirements of the Topographic Features Stipulation, oil-spill impacts to topographic features could be severe and long lasting due to the various mechanisms outlined above, including oiling, cleanup activities, toxins from dispersants, and/or bottom-disturbing activities. However, if the requirements of the Topographic Features Stipulation are applied as expected, these impacts should be **negligible**.

4.6.1.2.3 Cumulative Impacts

OCS Oil- and Gas-Related Impacts

The cumulative impact of OCS oil- and gas-related activities include routine bottom-disturbing activities (e.g., anchoring, structure emplacement and removal, and muds and cuttings discharges) and accidental events (e.g., bottom disturbance, the discharge of oil, and/or spill cleanup).

The OCS oil- and gas-related bottom-disturbing activities could result in the physical destruction of benthic habitat and organisms or the disturbance of local sediments leading to burial or increased stress. However, the proposed Topographic Features Stipulation has been in effect for decades, limiting historical OCS oil- and gas-related impacts, and it is expected to remain in effect. An example of this is the continued high degree of coral coverage and biodiversity documented by the long-term monitoring program at the Flower Garden Banks National Marine Sanctuary (Johnston et al., 2015). The area in the vicinity of the Sanctuary has seen a substantial amount of oil and gas production for decades, and overall coverage by benthic organisms has remained high and stable.

Impacts on topographic features could occur as a result of future OCS oil spills. To date, previous noncatastrophic spills have not had any identifiable impact (cumulative or otherwise) on any topographic features. Because of the physical properties of northern GOM oil, subsea oil spills generally rise quickly to surface waters before contacting benthic communities on topographic features, and the distancing requirements of the Topographic Features Stipulation further reduce the likelihood of contact. The depths of the crests of the topographic features are generally deep enough (>49 ft; >15 m) that surface oil should not reach benthic communities on topographic features in sufficient concentrations to cause impacts. As observed in Silva et al. (2015), the deep mixing of oil, particularly following use of chemical dispersants, is possible during unusually extreme weather events and could result in negative impacts if contact is made at sufficiently high concentrations. Excluding such an event, any dispersed surface oil reaching benthic communities of topographic features in the GOM should be at a low enough concentration to not cause discernible long-term impacts (Lewis, 1971; Elgershuizen and De Kruijf, 1976; Dodge et al., 1984; Wyers et al., 1986).

Continued adherence to the Topographic Features Stipulation's restrictions would prevent or minimize most adverse impacts on the benthic communities of topographic features (refer to **Chapter 2.2.4.1 and Appendix D**). Overall, it is expected that, given adherence to the proposed stipulation, the OCS oil- and gas-related cumulative impacts will continue to be **negligible**.

Non-OCS Oil- and Gas-Related Impacts

The potential cumulative impacts to topographic features from non-OCS oil- and gas-related sources include anchoring, fishing pressure, invasive lionfish, hurricanes, damage by recreational scuba diving, and environmental influences such as climate change and severe weather events.

Most of these features are deep enough that recreational scuba diving activities are fairly limited. In most areas where such diving does occur (particularly the Flower Garden Banks), that activity is managed by other Federal agencies (e.g., the Flower Garden Banks National Marine Sanctuary), with management practices that protect habitats from modification or destruction.

Because many of the topographic features are found near established shipping fairways and are well-known fishing areas, vessel anchoring at a topographic feature could and has damaged the biota (refer to **Chapter 3.3.2.2**) with the degree of damage dependent on the size of the anchor and chain (Lissner et al., 1991).. Anchor damages incurred by benthic organisms may take more than 10 years to recover (Fucik et al., 1984; Rogers and Garrison, 2001). Anchoring is currently prohibited within the boundaries of the Flower Garden Banks National Marine Sanctuary (which includes East and West Flower Garden Banks plus Stetson Bank) and for fishing vessels within the McGrail Bank Coral HAPC boundaries designated by NMFS and the Gulf of Mexico Fishery Management Council. The exact cumulative impact of non-OCS oil- and gas-related anchoring activities on topographic features is unknown.

Fishing pressure could alter fish community structure and potentially have a top-down trophic impact on fish populations, ultimately leading to ecosystem-driven impacts to the benthic community. This could occur through unsustainable harvest practices, although, most managed fish populations in the GOM are considered stable or recovering. Harvest is monitored and managed by NMFS and the Gulf of Mexico Fishery Management Council, and fish populations are not expected to be depleted to a point where benthic populations are impacted.

The recent invasion by lionfish is likely to alter some fish and invertebrate populations on topographic features over time (Johnston et al., 2015). The predatory nature of this fish, combined with its lack of natural predators in the GOM, suggests that a population explosion of lionfish could result in a trophic impact on benthic organisms. The result would be a decrease in biodiversity and abundance of many of the smaller organisms that use the seafloor habitats found on topographic features. Given the rapid spread of reported lionfish sightings across the GOM, it is possible that they are already present (if not yet documented) on portions of all of the topographic features. Therefore, the current impact level is not yet fully understood, but it seems likely to rise over time if lionfish populations continue to increase exponentially (Switzer et al., 2015).

Hurricanes are considered a rare event at any given location (refer to **Chapter 3.3.2.9.3**) but hurricane-associated water movement has the potential to cause localized impacts such as breaking branches of fragile shallow-water branching corals. Because hurricanes are a natural event that have regularly (if only intermittently) influenced environmental conditions surrounding topographic features, such impacts cannot be clearly distinguished from those of natural variation because benthic communities have adapted over millennia to deal with natural levels of severe weather.

Climate change-related effects have the potential to alter baseline environmental conditions throughout the GOM. An additional review of climate change is presented in the Five-Year Program EIS (USDOI, BOEM, 2016b), and there is extensive scientific literature available about climate change in general. Of particular note for benthic communities on topographic features are the potential negative consequences that may be caused by the dual mechanisms of ocean acidification and increasing ocean temperatures. Ocean acidification can reduce bioavailability of calcium carbonate and thereby inhibit normal rates of calcification by exoskeleton-building corals and other calcifying marine organisms. Decreased calcification rates have been observed in numerous shallow-water zooxanthellate corals (Hofmann et al., 2010) and can inhibit growth and reproductive fitness because of the additional energy expended. Sustained, unusually high water temperatures are documented to cause coral bleaching, in which symbiotic zooxanthellae are expelled from coral polyps. Over time, a permanent temperature baseline shift could allow the northward expansion of species adapted to warmer waters, potentially altering the current community structure at topographic features. Other potential climate change-driven alterations of baseline environmental conditions could also have additional, unpredictable effects on sessile benthic organisms. For example, changing climatic conditions that alter the frequency and/or severity of severe weather events could impact communities since severe weather can also have secondary, non-natural impacts such as causing movement of abandoned fishing gear and exaccerbating accidental losses of equipment overboard. At present, the overall impact of climate change-related effects on topographic features is likely negligible. However, over the next 50 years, this impact level could rise to higher levels, even as great as moderate**,** should the most extreme impacts possible as a result of projected climate change-associated factors come to pass.

Adherence to the restrictions specified in the Topographic Features Stipulation has minimized the potential for routine activities or accidental events to impact topographic features. Assuming continued application of the stipulation as a result of a proposed action, the probability of OCS oil- and gas-related activities increasing the overall cumulative impact level is expected to remain low, and the incremental contribution of a proposed lease sale is **negligible**. In contrast, non-OCS oil- and gas-related cumulative impacts could damage and disrupt topographic features. Some of those potential effects are highly variable and unpredictable, but certain non-OCS oil- and gas-related impacts such as lionfish expansion and climate change-related effects are expected to worsen over time.

Based on current conditions, the overall cumulative impact of everything (OCS and non-OCS oil- and gas-related impacts) is currently **negligible**, with almost all impacts coming from non-OCS oil- and gas-related factors. However, this total impact level has the potential to rise substantially over the next 50 years to higher levels, as high as **moderate**, should projected trends of non-OCS oil- and gas-related factors (particularly climate change) continue or worsen. However, given the negligible contribution of a proposed lease sale to the overall cumulative scenario, it is reasonable to conclude that a single proposed lease sale would have no discernible effect on increasing the overall cumulative impact level over the next 50 years.

4.6.1.2.4 Incomplete or Unavailable Information

BOEM recognizes that there is incomplete or unavailable information related to topographic features in general and specifically in relation to routine activities, accidental events, and cumulative impacts. However, the information that is known is adequate to come to a determination with respect to reasonably foreseeable impact-producing factors associated with a proposed action.

Research in offshore marine systems is logistically complex and requires substantial resources. As such, the total amount of research on these features and their communities is relatively limited, although BOEM and its predecessor agencies have funded numerous studies over the past 40 years. For example, our understanding of the possible impacts of surface oil spills to topographic features in the GOM was determined by combining research on the depth and concentration of the physical mixing of surface oil with the known depths of topographic features. Even though oil measurements were not collected at every feature under every condition, the available results suggest that, topographic features exist at depths deeper than lethal concentrations of oil would usually be expected (Lange, 1985; McAuliffe et al., 1975 and 1981a; Tkalich and Chan, 2002; Rezak et al., 1983; Wyers et al., 1986). Mixing to depth might occur, but it would be limited to unusual combinations of conditions such as when tropical storms pass directly over oiled surface waters (e.g., Silva et al., 2015). Moreover, the amount of oil/dispersant mixture in that catastrophic situation greatly exceeds the amounts considered in the “Accidental Events” analysis below. Given the geographic and temporal scope of a proposed action, it is believed that even impacts resulting from that particular scenario would still only have a slight impact on the overall status of the topographic features. However, the example demonstrates the point that the body of literature supporting the impact analysis is still growing and requires continual review by BOEM.

Since the 1970’s, BOEM and its predecessor agencies have supported continuous monitoring of the Flower Garden Banks for any impacts related to OCS oil- and gas-related activities. At the Flower Garden Banks, corals have generally flourished (refer to Johnston et al., 2015, and the references therein) even as OCS oil- and gas-related activities have occurred sometimes just outside of the No Activity Zone. Since corals are generally considered to be more fragile than most other types of organisms found on topographic features, it is also reasonable to conclude that topographic features with more resilient organisms have also not been negatively affected by OCS oil- and gas-related development in the GOM. However, given the ecological sensitivity of benthic communities on topographic features, continued research and monitoring efforts are necessary to maintaining a sufficient understanding of the various potential OCS oil- and gas-related and non-OCS oil- and gas-related impacts. A recent example illustrates how conditions could potentially change. In August 2016, a routine National Marine Sanctuary/BOEM long-term monitoring cruise in East Flower Garden Bank documented a mortality event affecting corals and other benthic organisms in a localized area. At the time of this writing, tissue and water quality samples have been collected but not yet analyzed, and no causes have been indicated. BOEM will continue cooperating with the Sanctuary and other partners to evaluate information as it becomes available and will update future Supplemental EISs as necessary.

Known information about potential impacts of a theoretical catastrophic spill is detailed in the *Catastrophic Spill Events Analysis* white paper (USDOI, BOEM, 2017) and further information was made available with the publication of the Trustees’ PDARP/PEIS in 2016 (Deepwater Horizon Natural Resource Damage Assessment Trustees, 2016). The content of that report was reviewed as part of this analysis. Some information related to impacts specific to the *Deepwater Horizon* explosion, oil, spill, and response, such as long-term monitoring results, is still incomplete or unavailable. BOEM has determined that such additional information could not be obtained within the timeline contemplated in the NEPA analysis for this Multisale EIS. However, the currently available body of evidence supports past analyses and does not indicate severe adverse impacts directly linked to the *Deepwater Horizon* explosion, oil spill, and response for topographic features. Impending reports are not expected to reveal additional significant effects that would alter the overall conclusions about reasonably foreseeable impact-producing factors associated with a proposed action.

BOEM will continue to analyze and support the collection and analysis of the best available scientific information related to topographic features. BOEM used reasonably accepted scientific methodologies to extrapolate from existing information in completing this analysis and formulating the conclusions presented here. As noted above, BOEM has determined that the incomplete or unavailable information is not essential to a reasoned choice among alternatives; there is sufficient information in the scientific literature to evaluate the potential impacts of a proposed action and its alternatives.

4.6.1.2.5 Alternative A—Regionwide OCS Lease Sale (The Preferred Alternative)

Adherence to the proposed Topographic Features Stipulation would prevent or at least minimize most of the potential impacts on topographic features and associated benthic communities from routine activities and accidental events. During an accidental event causing bottom disturbance, the size and scope of the impact would be directly proportional to the size of the accident and its vicinity to topographic features, but it would generally be very localized. In the case of an accidental oil spill, it would be expected that the majority of oil would rise to the surface and that the most heavily oiled sediments would likely be deposited before reaching the topographic features. Any contact with spilled oil would likely cause sublethal effects to benthic organisms because the distancing of activity would prevent contact with concentrated oil. In the unlikely event that oil from a subsurface spill reaches the biota of a topographic feature, the effects would be primarily sublethal and impacts would be localized. Most turbidity, sedimentation, and oil adsorbed to sediment particles would also be at low concentrations by the time the topographic features were reached, also likely resulting in primarily sublethal impacts. Impacts from an oil spill on topographic features are also reduced by the depth of the features and the currents that surround the features. Selection of this alternative would do little to change the overall cumulative impacts to topographic features. Overall, given adherence to the Topographic Features Stipulation (which is a required mitigation as a result of the Five Year Program's Record of Decision), reasonably foreseeable impacts to topographic features from routine activities, accidental events, and the cumulative impact of a proposed action in the GOM is expected to be **negligible**.

4.6.1.2.6 Alternative B—Regionwide OCS Proposed Lease Sale Excluding Available Unleased Blocks in the WPA Portion of the Proposed Lease Sale Area

Under Alternative B, BOEM would hold a lease sale excluding the available unleased blocks in the WPA and would offer all available unleased blocks in the CPA and a portion of the EPA. Alternative B would not fundamentally alter the conclusions reached under Alternative A. The impacts of routine activities to topographic features would remain the same in the CPA as under Alternative A, while any potential impacts to topographic features in the WPA could be reduced. Overall, there are 22 topographic features in the WPA, 16 in the CPA, and 0 in the EPA. Any impacts resulting from accidental events in the CPA and/or EPA would remain relatively localized, and the number of features affected would be directly proportional to the size of the accident. An accident along the CPA/WPA border has the possibility to impact features in either planning area. This alternative would do little to change the overall cumulative impacts to topographic features. Many OCS lease blocks near the features are already leased, and non-OCS oil- and gas-related impacts are not expected to decrease. Overall, given adherence to the Topographic Features Stipulation (which is a required mitigation in the Five-Year Program's Record of Decision), reasonably foreseeable impacts to topographic features from routine activities, accidental events and the cumulative impact of a proposed action in the GOM under Alternative B is expected to be **negligible**.

4.6.1.2.7 Alternative C—Regionwide OCS Proposed Lease Sale Excluding Available Unleased Blocks in the CPA/EPA Portions of the Proposed Lease Sale Area

Under Alternative C, BOEM would hold a lease sale excluding the available unleased blocks in the CPA/EPA and would offer all available unleased blocks in the WPA. Alternative C would not fundamentally alter the conclusions reached under Alternative A. The impacts of routine activities to topographic features would remain the same in the WPA while any potential impacts to topographic features in in the CPA/EPA could be reduced. Overall, there are 22 topographic features in the WPA, 16 in the CPA, and 0 in the EPA. Any impacts resulting from accidental events in the WPA would remain localized, and the number of features affected would be directly proportional to the size of the accident. An accident along the CPA/WPA border has the possibility to impact features in either planning area. This alternative would do little to change the overall cumulative impacts to topographic features. Many OCS lease blocks near the features are already leased, and non-OCS oil- and gas-related impacts are not expected to decrease. Overall, given adherence to the Topographic Features Stipulation (which is a required mitigation as a result of the Five-Year Program's Record of Decision), reasonably foreseeable impacts to topographic features from routine activities, accidental events, and the cumulative impact of a proposed action in the GOM under Alternative C is expected to be **negligible**.

4.6.1.2.8 Alternative D—Alternative A, B, or C, with the Option to Exclude Available Unleased Blocks Subject to the Topographic Features, Live Bottom (Pinnacle Trend), and/or Blocks South of Baldwin County, Alabama, Stipulations

Under Alternative D, BOEM could hold a lease sale excluding leasing on any and/or all blocks subject to the Topographic Features, Live Bottom (Pinnacle Trend), and Blocks South of Baldwin County, Alabama, Stipulations. Topographic features could experience fewer impacts through further distancing of the OCS oil- and gas-related activities, thereby reducing the probability of impacts. An accidental spill may still reach a feature, but it is expected that the increased distance would provide more dispersal time as the spill travels the additional distance across unleased blocks. This alternative would do little to change the overall cumulative impacts to topographic features. Many OCS lease blocks near the features are already leased, and non-OCS oil- and gas-related impacts are not expected to decrease. Blocks subject to the Topographic Features Stipulation include any available unleased block in which a No Activity Zone or shunting zone may be applied. A total of 207 blocks within the CPA and 160 blocks in the WPA are affected by the Topographic Features Stipulation. For additional information related to the specific blocks that would be excluded, refer to **Chapter 2.2.2.4**. The exclusion of any of the other blocks subject to either the Live Bottom (Pinnacle Trend) and/or Blocks South of Baldwin County, Alabama, Stipulations would not be expected to change the impacts to topographic features because of the small number of those blocks and their distance from identified topographic features. Overall, given adherence to the Topographic Features Stipulation (which is a required mitigation as a result of the Five-Year Program's Record of Decision), reasonably foreseeable impacts to topographic features from routine activities, accidental events, and the cumulative impact of a proposed action in the GOM under Alternative D is expected to be **negligible**.

4.6.1.2.9 Alternative E—No Action

Under Alternative E, a proposed lease sale would be cancelled. Therefore, the potential for new incremental impacts would be **none** because new impacts to topographic features related to the cancelled lease sale would be avoided entirely. Continuing OCS oil- and gas-related impacts to the communities would be limited to existing impacts resulting from routine activities and accidental events, and the cumulative impacts associated with previous OCS lease sales and development and other ongoing non-OCS oil- and gas-related activities. BOEM's existing stipulation and mitigation practices already regulate these activities and should continue to limit the associated ongoing impacts to the **negligible** level.

Ongoing non-OCS oil- and gas-related activities are difficult to accurately estimate since the spatial and temporal characteristics of some factors are rapidly changing and since the necessary baseline information is still being collected; however, at present, these non-OCS oil- and gas-related activities have **negligible** impacts on topographic feature communities. However, the level of cumulative impacts could potentially become greater, even rising to **moderate** over time, should current trends of these factors continue or worsen, regardless of whether or not a lease sale would take place.

4.6.2 Pinnacles and Low-Relief Features and Associated Communities

This analysis considers the impacts of routine activities, accidental events, and a proposed action's incremental contribution to cumulative impacts on GOM pinnacle and low-relief features and their associated benthic communities (hereafter referred to as "feature communities") over a 50-year period. This analysis is not exhaustive of all possible impacts of routine activities and accidental events; rather, it focuses on those related to a proposed action. A summary of the potential magnitude of impact for each of these impact-producing factors is provided in **Table 4-14** to help the reader quickly identify the level of potential impacts for each relevant impact-producing factor. The impact-level definitions and the analyses supporting these conclusions follow in this chapter. Because a catastrophic oil spill is not considered reasonably foreseeable, those potential impacts (including long-term recovery) are addressed in the *Catastrophic Spill Event Analysis* white paper (USDOI, BOEM, 2017). The impact significance criteria and resulting conclusions presented here (**Table 4-14**) focus on the overall functioning, resilience, and ecosystem level importance of live bottom pinnacles and low-relief feature communities throughout U.S. waters of the GOM. Postlease, site-specific analyses would focus more on the potential localized impacts of individual development activities (e.g., proposed drilling of a specific well) to individuals, discrete communities, and small patches of live bottom habitat. Those analyses would also detail site-specific protective mitigations required prior to approval of such activities. **Appendix B** provides detail on some of the potential site-specific mitigations that could be applied as necessary.

Table 4-14. Pinnacles and Low-Relief Features Impact-Producing Factors That Are Reasonably Foreseeable

Pinnacles and Low-Relief Features	Magnitude of Potential Impact[1]				
Impact-Producing Factors	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
Routine Impacts					
Bottom-Disturbing Activities and Drilling-related Sediment and Waste Discharges					
With Mitigation	Negligible	Negligible	Negligible	Negligible	None
Without Mitigation	Minor to Major	Minor to Moderate	Negligible to Minor	Negligible to Minor	None
Accidental Impacts					
Bottom-Disturbing Activities and Drilling-Related Sediment and Operational Waste Discharges					
With Mitigation	Negligible to Minor	Negligible to Minor	Negligible	Negligible	None
Without Mitigation	Minor to Major	Minor to Moderate	Negligible to Minor	Negligible to Minor	None
Oil Spills					
With Mitigation	Negligible to Minor	Negligible to Minor	Negligible	Negligible	None
Without Mitigation	Minor to Major	Minor to Moderate	Negligible to Minor	Negligible to Minor	None

Cumulative Impacts					
Incremental Contribution[2]	Negligible to Minor	Negligible to Minor	Negligible	Negligible	None
OCS Oil and Gas[3]	Negligible to Minor				
Non-OCS Oil and Gas[4]	Minor to Major				

[1] The analysis supporting these conclusions is discussed in detail in the "Environmental Consequences" chapter below.
[2] This includes all activities (i.e., routine activities projected to occur and accidental events that could occur) as a result of a single proposed lease sale in the 2017-2022 Five-Year Program.
[3] This includes all activities (i.e., routine activities projected to occur and accidental events that could occur) from past, proposed, and future lease sales.
[4] This includes other past, present, and reasonably foreseeable future activities occurring within the same geographic range and within the same timeframes as a proposed action, but they are not related to the OCS Oil and Gas Program.

Impact-Level Definitions

For this analysis, the definitions below were used to categorize impacts to pinnacles and low-relief features.

- **Negligible** – Impacts to pinnacle and low-relief feature communities are largely undetectable. There is some potential for even undetectable impacts to cause slight changes to a local community's species abundance and composition, community structure, and/or ecological functioning, but any such changes would be spatially localized, short term in duration, and would not alter the overall status of GOM pinnacle and low-relief feature communities.
- **Minor** – Impacts to pinnacle and low-relief feature communities are detectable but cannot be distinguished from natural variation. Such impacts could result in noticeable changes to a local community's species abundance and composition, community structure, and/or ecological functioning, but any such changes would be spatially localized, short term in duration, and would not alter the overall status of GOM pinnacle and low-relief feature communities.
- **Moderate** – Impacts to pinnacle and low-relief feature communities detectably cause substantial, population-level changes in species composition, community structure, and/or ecological functioning. These impacts would be expected to be spatially extensive, but they are expected to only temporarily alter the overall status of GOM pinnacle and low-relief feature communities such that long-term recovery to pre-impact levels is likely.
- **Major** – Impacts to pinnacle and low-relief feature communities detectably cause substantial, population-level changes in species composition, community structure, and/or ecological functioning. These impacts would be expected to be spatially extensive and to noticeably alter the overall status of GOM pinnacle and

low-relief feature communities such that long-term recovery to pre-impact levels is unlikely.

The primary relevant, reasonably foreseeable impacts of routine activities and accidental events to live bottom habitats described in this chapter can be grouped into the following three general categories:

(1) bottom-disturbing activities (routine and accidental);

(2) drilling-related sediment and waste discharges (routine and accidental); and

(3) oil spills (accidental).

These impacts are analyzed in detail under the “Routine Activities” and “Accidental Events” sections below. Cumulative impacts were also considered in two steps: cumulative impacts resulting from OCS oil- and gas-related activities and impacts resulting from non-OCS oil- and gas-related activities.

Some impact-producing factors relevant to pinnacle and low-relief feature communities are analyzed in detail in other chapters and need only be briefly summarized here. For example, **Chapter 4.7** (Fishes and Invertebrate Resources) details impacts from anthropogenic noise. Note that despite the growing body of information available for fishes, there is comparatively little information available on sound detection and sound-mediated behaviors for marine invertebrates. That said, the overall impacts on pinnacle and low-relief feature communities from anthropogenic noise are expected to be **negligible**. **Chapter 4.7** also details the impacts of routine activities and the cumulative impacts from OCS oil- and gas-related infrastructure presence, subsequent removal, and/or conversion to artificial reefs. While the total contribution of OCS infrastructure is still only a small percentage of natural hard bottoms (Gallaway et al., 2009) and is projected to further decrease throughout the period covered by this analysis (**Chapter 3.3.1.5**), the presence, removal, and/or conversion of artificial hard substrates colonized by sessile invertebrates are likely to result in localized community changes, such as changes in species diversity in an area (Schroeder and Love, 2004). While individual presence, removal, or conversion actions at specific locations do not cause more than negligible impacts when considered against the broader scope of this analysis, when the sum of such actions are considered cumulatively for all planning areas and over 50 years, such impacts could be greater for individual species. This is because select species commonly associated with OCS oil and gas platforms could be noticeably influenced over time by the overall presence (or removal) of OCS infrastructure. For example, a particular hermatypic coral species' Gulfwide spatial distribution may shift over time because of the presence or removal of structures in otherwise soft bottom-dominated areas. Such a change (were it to occur) could be considered a moderate level impact (for that species) if it represented a detectable change in the species' spatial distribution; such a range shift might have potential long-term effects related to dispersal and genetic connectivity to other populations of that species. Such potential impacts are not necessarily either positive or negative; that would be dependent on the species and a number of complex ecological factors. Some evidence of these types of changes (in particular, range expansion) has been documented for some shallow-water hermatypic species (Sammarco et al., 2012). More peer-reviewed literature about this topic is available for fish resources, as detailed in **Chapter 4.7** (Fishes and Invertebrate Resources).

Several additional impact-producing factors described in **Chapters 3.1 and 3.2** were evaluated for potential impacts on these live bottom communities. These impact-producing factors were not carried forward for full analysis because any potential effects were judged to be either not reasonably foreseeable or having such a miniscule impact that they would not rise to the level of **negligible** impact. These impact-producing factors include surface oil-spill response efforts (refer to **Chapter 4.6.1**, Topographic Features), impacts from G&G activities other than bottom disturbance (bottom disturbance is covered below), and potential impacts from a sinking vessel. A sinking vessel settling on a live bottom community is not a reasonably foreseeable impact-producing factor. Even if such an incident did occur, it would not have a population-level impact despite likely crushing or smothering live bottom organisms in the area of direct contact.

Some potential impact-producing factors are already regulated by other Federal agencies and/or international treaties. For example, the discharge of marine debris is subject to a number of laws and treaties. These include the Marine Debris Research, Prevention, and Reduction Act; the Marine Plastic Pollution Research and Control Act; and the MARPOL-Annex V Treaty. Regulation and enforcement of these laws is conducted by a number of agencies such as the U.S. Environmental Protection Agency, NOAA, and the U.S. Coast Guard. To further reduce potential impacts, the BSEE provides guidance on marine debris training of all OCS personnel through the "Marine Trash and Debris Awareness and Elimination" NTL (NTL 2015-BSEE-G03). Historically, this NTL has been made a binding part of leases through application of the Protected Species Stipulation. This NTL instructs OCS operators to post informational placards that outline the legal consequences and potential ecological harm of discharging marine debris. This NTL also states that OCS workers should complete annual marine debris prevention training; operators are also instructed to develop a certification process for the completion of this training by their workers. These various laws, regulations, and NTL would likely minimize any potential damage to live bottom resources from the discharge of marine debris related to OCS oil- and gas-related operations. Nonetheless, some accidental release of marine debris is still likely to occur as a result of OCS oil- and gas-related operations and could theoretically have limited effects on live bottom organisms (e.g., physical damage caused by strong currents pushing debris into fragile organisms or ingestion of plastics by invertebrates). However, the amount of debris in question would not suffice to cause even negligible impacts when considered at the scale of the overall population of live bottom communities in the GOM. One possible exception would be frequent accidental losses of very large items such as pipeline segments with the potential to crush or smother live bottoms. That impact-producing factor is briefly discussed under "Bottom-Disturbing Activities" in the "Accidental Events" section below, even though any such losses are expected to be very rare. In all cases, the likelihood of spatial overlap with debris from OCS vessels or infrastructure is inherently small due to the relatively rare and patchy distribution of live bottom communities in the GOM, particularly in areas of the western and northern GOM, which have the greatest amount of OCS oil- and gas-related operations.

Another potential impact-producing factor that is largely governed by (and potential impacts reduced by) external regulations is the potential presence of toxins in drilling muds and cuttings and/or produced waters. Because of the regulations issued by the USEPA and/or international treaties designed to keep toxins below harmful levels, hazardous levels of toxins are generally not expected to reach live bottom communities. Nonetheless, potential impacts from toxins are briefly discussed in the "Routine Activities" section below.

Historical Protections of Pinnacle and Low-Relief Features

Protective measures have been developed over time based on the nature and sensitivity of various live bottom habitats and their associated communities, as understood from decades of BOEM-funded and other environmental studies. These protections were developed into stipulations historically applied to OCS leases in areas with known concentrations of live bottom features. The Pinnacle Trend is a specific series of high- and low-relief hard/live bottom features occurring just east of the Mississippi River. BOEM has consistently applied the Live Bottom (Pinnacle Trend) Stipulation to 74 OCS lease blocks covering this area (which is a required mitigation as a result of the Five-Year Program's Record of Decision). The CPA blocks directly adjacent to low-relief blocks are included in a proposed action and some of the alternatives; therefore, the potential impacts of routine activities and accidental events originating in those adjoining blocks are analyzed here. A full list of the proposed stipulation blocks can be found in **Appendix D**.

Live bottom habitats are found outside the blocks where the Topographic Features and Live Bottom Stipulations have been historically applied (which is a required mitigation as a result of the Five-Year Program's Record of Decision). Such habitats are not specifically included in those stipulations but are still routinely given protections during NEPA reviews of site-specific development plans, as described in NTL 2009-G39, "Biologically-Sensitive Underwater Features and Areas." That NTL provides information and consolidates guidance to help operators understand BOEM's requirements related to sensitive benthic habitats.

Lessees must provide site-specific seafloor survey data and interpretive information (including about hard bottom features) with each EP, DOCD, and DPP. Site-specific NEPA reviews are conducted on these plans by BOEM's subject-matter experts on a case-by-case basis to determine whether a proposed operation could impact a live bottom feature. If an impact is judged likely based on site-specific information derived from BOEM's studies/databases, other published research, geohazard survey data, or another creditable source, the operator may be required to distance/relocate the proposed operation or undertake other mitigations to prevent an impact. This analysis assumes continuation of the protective measures outlined in NTL 2009-G39, as they are routinely applied (when and where appropriate) during all site-specific plan reviews. The Live Bottom Stipulation is applied to individual lease sales at the discretion of the Secretary and has been consistently applied to the same lease blocks for decades. The types of potential impacts to live bottom communities described in this chapter would become more likely and more severe without the continued application of these stipulations.

4.6.2.1 Description of the Affected Environment

The terms live bottom and hard bottom are often used interchangeably, but they are actually distinct since it is possible to have hard bottom that is not live bottom. Hard substrates can form crusts, pavements, pinnacles, ledges, outcrops, and other reefal features (Jenkins, 2011). These harder substrates may or may not be covered by a thin veneer of muddy or sandy sediments that can be deposited and removed over time by currents and storms. Hard substrates with the lowest vertical relief are the most likely to be routinely buried and exposed. Encrusting algae and sessile invertebrates regularly attach to and cover exposed hard substrates, creating live bottoms. For the purposes of the Live Bottom Stipulation, “live bottom areas” have been defined as communities or areas that contain biological assemblages consisting of sessile invertebrates such as sea fans, sea whips, hydroids, anemones, ascidians, sponges, bryozoans, or corals living upon and attached to naturally occurring hard or rocky formations with rough, broken, or smooth topography; or areas whose lithotope (substrate type) favors the accumulation of turtles, fishes, and other fauna.

Distribution of Hard/Live Bottoms in the Gulf of Mexico

The distribution of hard bottoms (and associated live bottom communities) in the GOM is not fully known, due in part to the patchy and ephemeral (temporary) nature of hard bottoms that do not have sufficient vertical relief to avoid intermittent sediment burial (Parker et al., 1983; Jenkins, 2011; Simmons et al., 2014; Jaap, 2015). Although accurate quantification is challenging and can quickly become outdated, Parker et al. (1983) illustrates a reasonable overall proportion and distribution of hard bottoms in U.S. portions of the GOM. The study extrapolated from 732 visual sampling stations to roughly approximate the amount of hard bottom habitat in a band of relatively shallow waters (18-91 m; 59-299 ft), estimating that about 94 percent (44,946 km^2; 17,354 mi^2) of the total lies between Key West and Pensacola, Florida, on the broad West Florida Shelf, and only about 6 percent (2,780 km^2; 1,073 mi^2) lies between Pensacola, Florida, and the Rio Grande River, where the continental shelf break is closer to shore. More recently, Jenkins (2011) interpolated a Gulfwide estimate of dominant surficial seafloor sediments.

Beyond direct sampling and visual observations, an evolving variety of geophysical techniques such as sidescan- and multibeam echo sounder-sonar (Hine et al., 2008; Mueller et al., 2014) and 3D seismic (USDOI, BOEM, 2015b; **Chapter 4.4**, Deepwater Benthic Communities) can also be used to estimate and map the distribution of hard bottom habitats. In the eastern GOM, far from the proposed EPA lease sale area and in parts of the EPA currently under a lease moratorium, there are several areas (including the Florida Middle Grounds, Madison-Swanson Marine Reserve, Steamboat Lumps, the Dry Tortugas Ecological Reserves, and Pulley Ridge, as shown in **Figure 4-17**) containing high concentrations of low-relief live bottom habitat. These and other areas have been designated by NMFS and GMFMC as marine reserves and/or EFH Habitat Areas of Particular Concern in recognition of the high ecological and socioeconomic (i.e., fisheries) value of live bottom habitat (Simmons et al., 2014; **Figure 4-17**). Designation is intended to encourage additional research and (in some but not all cases) implement fisheries management measures such as restrictions on gear types (Simmons et al., 2014). However, HAPC designation does not have direct bearing on nonfishing activities such as those regulated by BOEM. BOEM does consult with NMFS on EFH and HAPCs, including the above-named areas (*Essential Fish Habitat Assessment* white paper, USDOI, BOEM, 2016d).

Live Bottom Ecology

Live bottom communities are controlled by interconnected abiotic and biotic factors (Brooks, 1991; Weaver et al., 2002; Jaap, 2015). Physical conditions (e.g., light, sedimentation/turbidity, substrate type, temperature, salinity, prevailing currents, and the frequency and intensity of severe weather events) affect biological variables such as larval transport, settlement, and growth. For example, Lugo-Fernández et al. (2001) reported blockage of coral larval dispersal from the Flower Garden Bank area to the eastern GOM by the Mississippi River plume. In addition, biological controls, such as predation and trophic interactions, can affect epibenthic community development and disturbance response. The relative importance of each controlling factor varies for different types of epibenthos (Jaap, 2015).

A persistent nepheloid layer (a layer of suspended sediment-laden water of variable density and vertical size that persists above the seafloor) can be a controlling factor for live bottom species sensitive to turbidity (Rezak et al., 1990), exerting an influence on their bathymetric and geographic distribution, and thus is also relevant to impact-producing factors of some OCS oil- and gas-related activities. This layer reduces the light reaching hard bottoms, resulting in decreased species richness and abundance below 262 ft (80 m) (Dennis and Bright, 1988; Rezak et al., 1990). Some studies suggest that the Mississippi River plume influences the distribution and abundance of sessile invertebrates within 43 mi (70 km) of the river delta and may affect turbidity and sedimentation throughout the Pinnacle Trend (Gittings et al., 1992a; CSA and GERG, 2001). Nepheloid layers are less frequent in the eastern GOM, but they can occur when the Mississippi River plume and upwelling affect the area (CSA and GERG, 2001).

Large, shallow-water coral reefs created via biogenic deposition of calcium carbonate over time by hermatypic coral species (refer to Schumacher and Zibrowius [1985] for more information about theoretical and practical definitions of "hermatypic") are present only at the southern end of the EPA and on a few topographic features in the WPA and CPA (refer to **Chapter 4.6.1**, Topographic Features, for the impact analysis). While the general public often thinks of such biogenic coral reefs as the only natural habitat for corals, Jaap (2015) illustrates that, for most of their geological history, corals have existed in less elaborate epibenthic communities that are not built upon large biogenic reefs (Veron, 1995 and 2000). These types of corals and epibenthic communities are the focus of this chapter on pinnacles and low-relief features.

The Pinnacle Trend Area

Physical Characteristics

The Pinnacle Trend is an approximately 64 x 16 mi (103 x 26 km) area in water depths of about 200-650 ft (60-200 m). It is in the northeastern portion of the CPA portion of the proposed lease sale area at the outer edge of the Mississippi-Alabama shelf, between the Mississippi River and De Soto Canyon (**Figures 4-17 and 4-19A**).

Live bottoms within the Pinnacle Trend features consist of both high-relief outcroppings at the edge of the Mississippi-Alabama Shelf and low-relief hard bottoms on the inner and middle shelf. BOEM has sponsored numerous studies providing information about these features (Brooks, 1991; CSA, 1992; Thompson et al., 1999; CSA and GERG, 2001). A 2002 bathymetric survey by the USGS (Gardner et al., 2002) provided high-quality seafloor imagery that has become the baseline for this area (**Figure 4-19B**).

The eastern part of the Pinnacle Trend is covered with a thin, well-sorted layer of fine- to medium-grained quartzose sand originating from eastern continental rivers. The western portion is covered with fine silts, sands, and clays deposited by the Mississippi River (CSA, 1992). The linear orientation and distribution of some features correspond with depth contours and may represent historic shorelines and drowned calcareous biogenic reefs that developed prior to the most recent sea-level rise (Ludwick and Walton, 1957; Sager et al., 1992; Thompson et al., 1999).

The high-relief features are complex in shape and structure (e.g., **Figure 4-19A-C**) and provide varied zones of microhabitat for attached organisms. High-relief features consist of pinnacles, flat-top reefs, reef-like mounds, patch reefs, and ridges and scarps. Tall spire-like mounds are the historical “pinnacles” for which the region is named. The pinnacles rise up to 66 ft (20 m) in height and can be over 1,640 ft (500 m) in diameter (Thompson et al., 1999; Brooks, 1991). Other features in this area are smaller and have less vertical relief, but they are more numerous. Low-relief features include fields of small seafloor mounds that rise only a meter or two above the seafloor but still provide hard surfaces for attached epifauna. Fields of shallow depressions about 3-20 ft (1-6 m) across also add habitat complexity to the overall character of the Pinnacle Trend area.

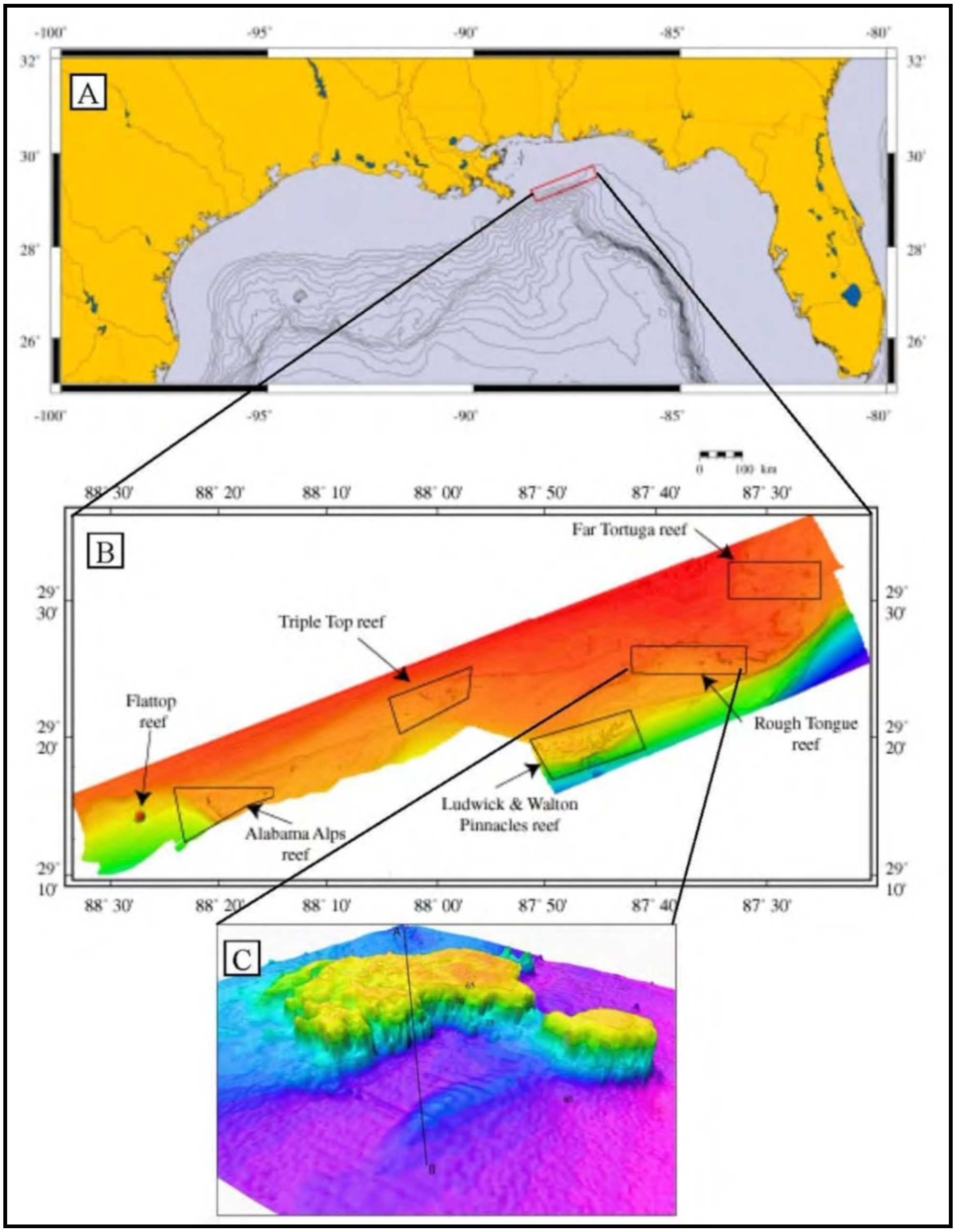

Figure 4-19. General Location of the Pinnacle Trend (A), Multibeam Bathymetry and Named Reef Areas (B), and an Exaggerated Vertical Relief Profile of Rough Tongue Reef (C). (Figure parts were excerpted and rearranged from Gardner et al., 2002).

Ecology of Live Bottom Communities in the Pinnacle Trend

The substantial amount of hard substrate in the Pinnacle Trend supports colonization by large numbers of suspension-feeding invertebrates, including octocorals, black corals, and sponges, and over 70 species of fish (Weaver et al., 2002). The Pinnacle Trend features are composed of carbonate reef material (Ludwick and Walton, 1957) and vary in shape, size, vertical relief, and overall complexity. These physical characteristics affect the composition (e.g., biodiversity, density, etc.) of the community associated with the substrate. Generally, the more complex the topographic shape of the substrate, the greater the variety of habitats for organisms and thus greater abundance and diversity of organisms.

Assemblages of coralline algae, sponges, octocorals, crinoids, and bryozoans are present at the tops of the shallowest features in water depths of less than 230 ft (70 m) (CSA, 1992). On the deeper features, as well as along the sides of the shallower pinnacles, ahermatypic corals may be locally abundant, along with octocorals, crinoids, and basket stars. The diversity and abundance of the associated species appear to be related to the size and complexity of the features, with the lower-relief outcrops typically having lower faunal densities and higher relief features having more diverse faunal communities (Gittings et al., 1992a; Thompson et al., 1999).

Low-Relief Live Bottoms

Outside of the Pinnacle Trend, low-relief live bottom features can and do occur in isolated locations in shallow waters (<984 ft; 300 m) throughout the GOM, wherever there is suitable hard substrate and other physical conditions (depth, turbidity, etc.) allow for epibenthic community development (Rezak et al., 1990). However, they are primarily known to be present in some locations on the Mississippi-Alabama Shelf and many more locations on the West Florida Shelf (**Figure 4-17**), far east of the proposed EPA lease sale area. None of the blocks with known concentrations of live bottom low-relief habitat are expected to be offered for lease; however, several live bottom low-relief areas are adjacent to blocks that would be offered for lease under a proposed action and could potentially be affected by impacts of routine activities and accidental events. Therefore, an analysis of the potential impacts is included in this Multisale EIS.

Ecology of Inner- and Middle-Shelf Live Bottoms of the Mississippi-Alabama Shelf

These nearshore, hard bottom areas are located in 60-130 ft (18-40 m) of water. A fine-grained quartz sand sheet covers most of the Mississippi-Alabama Shelf; however, numerous hard bottoms that are formed of sedimentary rock occur off the Mississippi River Delta and seaward of the Chandeleur Islands (Schroeder, 2000). These features include isolated low-relief, reef-like structures; rubble fields; low-relief flat rocks; limestone ledges; rocky outcrops off Mobile Bay; and clustered reefs (Schroeder et al., 1988; Schroeder, 2000). Hard bottom features on the Mississippi-Alabama-Florida Shelf typically provide reef habitat for tropical organisms, including sessile epifauna (i.e., soft corals, ahermatypic hard corals, sponges, bryozoans, and crinoids) and fish.

Various live bottom areas of the Mississippi-Alabama Shelf have been described in literature (Shipp and Hopkins, 1978, Schroeder et al., 1988; Schroeder et al., 1989, Brooks, 1991). These areas support a number of foundational species (including hard and soft corals, coralline algaes, and sponges) that are associated with larger, diverse communities of mobile invertebrates and fishes.

Ecology of Inner- and Middle-Shelf Live Bottoms of the West Florida Shelf

The majority of low-relief live bottom habitats in the GOM are found on the West Florida Shelf. The shelf is a relatively flat table of carbonate limestone that is largely covered with carbonate sand sheets. BOEM has designated blocks on the West Florida Shelf out to the 100-m (328-ft) isobath as Live Bottom (Low-Relief) Stipulation blocks (**Figure 4-17**) because live bottom communities are widely scattered across the West Florida Shelf on limestone ledges and outcrops (Jaap, 2015). In many places, the sand frequently shifts due to seasonal storms, occasionally uncovering patches of hard bottom. The nepheloid layer found throughout much of the northern CPA is not present to the same degree on the West Florida Shelf.

In addition to the smaller, widely distributed low-relief hard bottoms, there are also areas with permanently exposed, higher relief hard bottoms. In the southeastern portion of the GOM, shallow-water hermatypic corals are common throughout the Florida Keys reef tract, the Dry Tortugas, and Pulley Ridge (Jaap, 2015). To the north along the West Florida Shelf are several other important areas recognized by NMFS/GMFMC (Simmons et al., 2014). Some of these areas are thought to be relic reef formations that were "drowned" with historic sea-level rises.

Various sessile fauna and flora develop on exposed surfaces of low-relief hard substrates (Jaap, 2015). Some fauna, such as gorgonian soft corals, are flexible and tall enough to survive partial sediment burial. Many of the formations have deep reef communities with soft corals, black corals, sponges, sea whips/sea fans, anemones, and associated mobile echinoderms and crustaceans. Habitats that are sufficiently close to the water surface can support some hermatypic corals. Scleractinian and milleporian corals are common on rocky outcrops throughout the eastern GOM (Jaap, 2015).

Consultations

In 2014, 20 new coral species were listed as "threatened" under the ESA; all but 7 of these are found only in Indo-Pacific waters (*Federal Register*, 2014b). Three of the new species and two others that were previously listed (elkhorn and staghorn) are found in shallow waters of the GOM. Some are found on a few topographic features in the WPA/CPA and others in the Dry Tortugas and Florida reef tract. These coral species are further described in **Chapter 4.9.5**. The OCS lease blocks in the EPA near areas containing these species are not being offered in a proposed lease sale due to the current leasing moratorium and are therefore too distant to be reasonably affected by routine activities or accidental events occurring in leased areas. Currently, only staghorn and elkhorn coral have had critical habitat areas defined off the Florida Keys and Florida reef tract, neither of which are located in the proposed lease sale area. For ESA-listed coral found in the proposed lease sale area (specifically, on portions of the Flower Garden Banks) where accidental impacts might be possible, these coral species would be expected to experience the same types of impact-producing factors as other live bottom organisms. However, due to their relatively low population sizes, any impacts from accidental events on ESA-listed corals would have a magnified effect on each of those populations. BOEM consults on listed corals as part of the Section 7 consultation with NMFS. Adherence to recommendations resulting from this consultation and application of the Live Bottom Stipulation should prevent or minimize any impacts to these species.

4.6.2.2 Environmental Consequences

4.6.2.2.1 Routine Activities

A number of routine OCS oil- and gas-related impact-producing factors may cause adverse impacts on pinnacle and low-relief feature communities. As noted above, some factors with minimal impacts are presented in greater detail in other chapters and are not repeated here. The potential routine impact-producing factors on pinnacle and low-relief feature communities analyzed here are grouped into two main categories having similar impacts: (1) bottom-disturbing activities (e.g., anchoring, infrastructure emplacement and removal, and core sampling); and (2) drilling-related sediment and waste discharges (e.g., drilling muds and cuttings, and produced waters). These impact-producing factors have the potential to damage pinnacle and low-relief feature communities if not sufficiently distanced via mitigations.

Bottom-Disturbing Activities

Bottom-disturbing activities can be described as any activities that result in the physical disturbance of the seafloor during the exploration, production, or decommissioning phase of OCS oil- and gas-related operations. Anchoring, operational wastes produced during drilling, trenching, pipe-laying, and structure emplacement and removal are examples of OCS oil- and gas-related activities that disturb the seafloor (refer to **Chapter 3.1**). The spatial extent of the seafloor disturbance and the magnitude of the effect on benthic organisms would depend on the specific activity, local environmental conditions (e.g., currents, water depth, etc.), and species-specific behaviors and habitat preferences.

Turbidity from suspended sediments, along with sediment displacement resulting from routine, bottom-disturbing OCS oil- and gas-related activities generally have localized effects. In general, impacts to pinnacle and low-relief feature communities could include any or all of the following: reduced settlement and growth due to loss of available hard substrate; inhibited feeding leading to reduced reproductive fitness; and mortality of individuals (e.g., coral polyps) and groups (e.g., a coral colony). Reductions in overall biological cover could have secondary ecological effects on organisms that were using the complex structural microhabitats. Some mobile invertebrates (e.g., star fish) are expected to be able to move to avoid the heaviest sedimentation and highest suspended sediment loads within 33 ft (10 m) of a disturbance, while sessile invertebrates (e.g., corals) cannot. Both sessile and mobile invertebrate species adapted to living in turbid environments, such as those commonly found in the persistent nepheloid layer or otherwise adapted to occasional sediment inundation, may be less affected by increased turbidity. Such organisms may be adapted to remove some covering sediment via tentacle motion and mucus secretion (Shinn et al., 1980; Hudson and Robbin, 1980). Other species that typically inhabit less turbid waters would suffer greater impacts (Rogers, 1990; Gittings et al., 1992a). For example, zooxanthellate coral species are dependent on a continuous, unobscured light source to support the symbiotic photosynthetic algae (zooxanthellae) and may suffer coral bleaching if the water column becomes overly turbid. Solitary octocorals and gorgonians are generally more tolerant of sedimentation, partly because they grow tall and are flexible, reducing sediment accumulation and allowing for easier removal (Marszalek, 1981; Torres et al., 2001; Gittings et al., 1992a).

In addition to drilling activities, the process of installing and removing OCS oil- and gas-related infrastructure (i.e., pipelines, platforms, and subsea systems including cables) also has the potential to displace large volumes of sediment. The resulting localized increases in turbidity and sedimentation would have the same indirect impacts as those caused by drilling-related sediment discharges.

The OCS oil- and gas-related infrastructure/equipment also has the potential to damage or kill benthic organisms should the equipment itself make direct contact. Any object placed on or through a live bottom feature can cause partial or complete breakage, crushing, or smothering. In addition to mortality, there could be any or all of the potential sublethal impacts already described above in relation to sedimentation. The severity of impacts from direct physical contact would vary in direct proportion to the surface area and mass of the specific equipment. For example, the placement of a large bottom-founded platform on a live bottom would have a much greater impact than the placement of a small umbilical cable.

Similarly, anchor damage is one of the greatest threats to the biota of the offshore banks in the GOM (Rezak and Bright, 1979; Rezak et al., 1985; Gittings et al., 1992a; Hudson et al., 1982). Anchors may break, fragment, or overturn corals, sponges, and other benthic organisms, and the anchor chain or cable may drag across and shear organisms off the substrate (Dinsdale and Harriott, 2004). This would result in negative consequences ranging from increased stress to mortality (Dinsdale and Harriott, 2004). The impact of dragging an anchor across a live bottom would depend on the distance and duration of bottom contact, but it could be considerable due to the forces involved. Dragged anchors often leave seafloor scars noticeable on sidescan-sonar imagery years later. Damage to a coral community may take 10 or more years to recover (Fucik et al., 1984; Rogers and Garrison, 2001).

Drilling-Related Sediment and Waste Discharges

Drilling of new wells is one of the activities with the greatest impact potential, due to the associated sedimentation/turbidity caused by the drilling process and from the release of drilling cuttings and discharges. As noted in **Chapter 3**, drilling an exploratory well produces approximately 2,000 metric tons of combined drilling fluid and cuttings, though the total mass may vary widely for different wells (Neff, 2005). Cuttings discharged at the surface tend to disperse in the water column and are distributed at low concentrations (CSA, 2004a). In deep water, the majority of cuttings discharged at the sea surface are likely to be deposited within 250 m (820 ft) of the well (CSA, 2006). Cuttings shunted to the seafloor forms piles concentrated within a smaller area than when sediments are discharged at the sea surface (Neff, 2005).

Apart from turbidity and sedimentation, the chemical content of drilling muds and cuttings, and to a lesser extent produced waters, is another potential impact-producing factor since these may contain hydrocarbons, trace metals including heavy metals, elemental sulfur, and radionuclides (Kendall and Rainey, 1991; Trefry et al., 1995). Substances containing heavy metals and other potentially toxic compounds would have the potential to be moderately toxic to live bottom organisms, but only if they were to come into contact in undiluted strengths (CSA, 2004a). Although the literature has not reported impacts to corals as a result of exposure to contaminants in cuttings, infauna have shown effects at distances <100 m (<330 ft) from the discharge. These include reduced reproductive fitness, altered populations, and acute toxicity (Montagna and Harper, 1996; Carr et al., 1996; Kennicutt et al., 1996; Hart et al., 1989; Chapman et al., 1991; CSA, 2004a). Because of BOEM's distancing requirements for new wells, contact with concentrated (and potentially harmful) levels of any such toxins is not expected. Produced waters (refer to **Chapter 3.1.5.1.1** for more detail) are rapidly diluted with distance, and impacts are generally only observed within very close proximity of the discharge point (Gittings et al., 1992a; Neff, 2005). In addition to the protection offered by BOEM's distancing requirements, releases of toxic discharges are regulated by the USEPA through the issuance of NPDES permits. Adherence to NPDES permit requirements would help ensure that water quality is maintained at nontoxic levels.

As further detailed in other chapters, explosive severance methods used during decommissioning activities could result in damage or death to any organisms within the vicinity of the blast or associated sediment plume, although long-term turbidity is not expected from platform removal operations. The shockwave from the blast could also damage or destroy the underlying hard substrates required to support live bottoms. The BSEE Interim Policy Document 2013-07, "Rigs-to-Reefs Policy," specifies that the use of explosive severance methods will not be approved if analysis determines they would cause harm to established artificial reef sites and/or natural live bottoms.

Potential impacts resulting from all of the above routine activities are mitigated through the Live Bottom Stipulation and the protective measures summarized above and detailed in NTL 2009-G39. The site-specific survey information and distancing requirements described in NTL 2009-G39 would allow BOEM to identify and protect live bottom features from harm by proposed OCS oil- and gas-related activities during postlease reviews. If those protective measures are applied to identified pinnacle and low-relief feature communities as expected, at the scope of this analysis, impacts of routine activities would be expected to be **negligible**. These protective measures are now a required mitigation as a result of the Five-Year Program's Record of Decision.

Without adherence to the requirements of the stipulation and external regulatory restrictions on discharges, impacts to pinnacle and low-relief feature communities from the above routine activities could rise to minor, moderate, or even major, depending on the number and locations of specific activities. The highest impact levels are possible in the improbable (but theoretically possible) case that a large number of routine activity disturbances were to physically impact a large number of live bottom habitats. Even without mitigations, the likelihood is very low that a large number of OCS oil- and gas-related activities would occur in close proximity because the hard substrate habitats supporting pinnacle and low-relief feature communities are patchily distributed throughout the GOM and are relatively rare compared with soft bottom substrates. But this possibility cannot be definitively ruled out without knowing the precise spatial distribution of both future OCS oil- and gas-related activities and live bottom communities.

4.6.2.2.2 Accidental Events

The primary accidental impact-producing factors on pinnacle and low-relief feature communities analyzed here are grouped into two categories: (1) bottom-disturbing activities (e.g., anchoring and infrastructure emplacement and removal); and (2) oil spills (surface and subsurface) and associated cleanup responses. These impact-producing factors have the potential to damage pinnacle and low-relief feature communities if not sufficiently distanced or otherwise mitigated.

Bottom-Disturbing Activities

Impacts resulting from bottom-disturbing activities were detailed under "Routine Activities" and are largely the same for accidental events. There are only slight differencesrelated to mechanisms and potential severity. The primary, accidental bottom-disturbing activity is the inadvertent deposition or placement of equipment on live bottoms. Accidental loss of equipment could occur during transfer operations between vessels and platforms, during vessel transit, during an "on deck" accident, as a consequence of a severe storm, or if a structure, drill, or anchor is unintentionally placed in the wrong location during operations. During routine operations, distancing mitigations offer some protections against these types of impact, but those protections do not apply to accidents, other than to reduce the likelihood of routine activities occurring in pinnacle and low-relief feature areas in the first place. Any object placed on or through a pinnacle and low-relief feature can cause partial or complete breakage, crushing, or smothering of both substrate and organisms, and/or could cause increased sedimentation as equipment disturbs the seafloor. In addition to mortality, pinnacle and low-relief feature communities could experience any or all of the potential sublethal impacts already described in the "Routine Activities" section above. The severity of impacts from direct physical contact would vary in direct proportion to the surface area and mass of the specific equipment. Given the relative rarity of pinnacle and low-relief features and communities in the GOM, impacts from accidental bottom-disturbing equipment are expected to be infrequent and highly localized, with the likelihood of accidental contact further reduced by the expected distancing mitigations. However, because of the unplanned and potentially uncontrolled nature of accidental bottom-disturbing events, there exists greater uncertainty about their potential impact severity than exists for planned routine activities, and there is the potential for a minor level impact under the right combination of conditions. Therefore, at the scale of this analysis, impacts from accidental bottom-disturbing activity to pinnacle and low-relief features and associated communities could range from **negligible** to **minor**, depending on the overall frequency and severity of the accidental events.

Without the protective measures provided by the Live Bottom Stipulation (which is a required mitigation as a result of the Five-Year Program's Record of Decision) and by postlease reviews and distancing, the potential impacts of accidental bottom disturbances could rise to moderate or even major levels in the improbable (but theoretically possible) case that a large number of accidental disturbances were to physically impact a large number of pinnacle trend and low-relief features and if community-level impacts can be clearly distinguished from a natural variation. Even without mitigations, the likelihood is very low that a large number of OCS oil- and gas-related activities would occur in close proximity to the relatively rare hard substrate habitats supporting the communities, but this possibility cannot be definitively ruled out without knowing the precise spatial distribution of both future OCS oil- and gas-related activities and the features/communities.

Oil Spills and Associated Impacts

Oil spills, historic trends, the characteristics of oil, and factors affecting the fate of oil released into the marine environment are discussed in detail in **Chapter 3.2.1**, and the potential effects on water quality are analyzed in **Chapter 4.2** (Water Quality). For information on impacts specifically resulting from a catastrophic oil spill (beyond the scope of this analysis), refer to the *Catastrophic Spill Events Analysis* white paper (USDOI, BOEM, 2017).

Impacts related to an accidental release of oil or other contaminants could adversely affect pinnacle and low-relief feature communities. Potential impacts related to an accidental spill would depend on the combination of these various components: surface oil; subsurface oil; chemical dispersants and dispersed oil; sedimented oil (oil adsorbed to sediment particles, also known as “marine snow”); sedimentation caused by a loss of well control; and certain spill-response activities. Adherence to well-distancing requirements should serve to reduce such impacts.

Biological impacts resulting from exposure to accidentally released oil droplets and/or chemical dispersants are anticipated to be mostly sublethal. Sublethal impacts that may occur to exposed corals and similar benthic invertebrates may include reduced feeding, reduced photosynthesis, reduced reproduction and growth, physical tissue damage, and altered behavior. For example, short-term (24 hours) sublethal responses of one coral species included mesenterial filament extrusion, extreme tissue contraction, tentacle retraction, and localized tissue rupture after exposure to dispersed oil at a concentration of 20 ppm (Knap et al., 1983; Wyers et al., 1986). It is important to note that, generally, laboratory experimental concentrations are designed to discover toxicity thresholds (e.g., DeLeo et al., 2015) that exceed probable exposure concentrations in the field.

Oil spills originating at the surface, such as from a vessel or platform, have some potential to impact pinnacle and low-relief feature communities. The depth of the feature communities helps to buffer and protect them from most surface spills because their crests are generally deeper than the physical mixing ability of surface oil (Lange, 1985; McAuliffe et al., 1975 and 1981a; Tkalich and Chan, 2002; Thompson et al., 1999; Schroeder, 2000). Oil becomes diluted as it physically mixes with the surrounding water column. The shallowest known concentrations of pinnacle and low-relief features occur in the Live Bottom (Low Relief) Stipulation blocks within the EPA (**Figure 4-17**), and none of these blocks are expected to be offered for lease since they are under a Congressional leasing moratorium through 2022. In the Pinnacle Trend area, the largest features rise to within

40 m (130 ft) of the sea surface. In very unusual conditions, surface oil and/or surface dispersant could contact some of the shallower Pinnacle Trend features. Silva et al. (2015) documented acute lethal and sublethal impacts to gorgonians on Pinnacle Trend features caused by large amounts of *Deepwater Horizon*-sourced surface oil. A large volume of oil/dispersant mixture was submerged by unusually strong wave action associated with a tropical storm that passed directly over the oil. As a result, sizable amounts of the relatively undiluted oil/dispersant reached live bottom features. This contact, though demonstrably possible, required an unusual combination of atypical conditions, making it generally unlikely outside of a catastrophic spill situation, which is not part of a proposed action and not likely expected to occur.

In a subsurface spill or loss of well control situation, it is expected that the majority of released oil would rise quickly to the surface due the characteristics of northern GOM oil reserves, meaning most impacts would be similar to a surface-originating spill. However, if an oil spill/loss of well control occurs at great depths and released oil is subjected to higher water pressures, some oil droplets may emulsify and become entrained deep in the water column (Boehm and Fiest, 1982), creating a subsurface plume (Adcroft et al., 2010). In the PDARP/PEIS, such plumes were documented following the *Deepwater Horizon* oil spill (Deepwater Horizon Natural Resource Damage Assessment Trustees, 2016). If a concentrated plume came into contact with live bottom organisms, impacts could include mortality, failed reproductive success, reduced biodiversity, reduced coverage of fauna and flora on hard substrates, and changes in community structure (Reimer, 1975; Guzmán and Holst, 1993; Negri and Heyward, 2000; Silva et al., 2015). Exact impacts would depend on the location, age of the spill, and the hydrographic characteristics of the area (Bright and Rezak, 1978; Rezak et al., 1983; McGrail, 1982; Le Henáff et al., 2012). However, because shallow-water live bottom features are located on the shelf and upwelling events are limited to hurricanes, eddy formations, or when certain metrological conditions exist (Walker, 2001; Collard and Lugo-Fernandez, 1999; Zavala-Hidalgo et al., 2006), contact of a subsurface plume with a live bottom feature would only occur under the most unusual combination of conditions (e.g., Silva et al., 2015).

The USCG may allow the use of chemical dispersants in certain spill situations. Chemical dispersion of oil can help to break up concentrations of oil and accelerate natural weathering processes and bacterial biodegradation. Use of dispersants may, however, allow surface oil to penetrate to greater depths than normally expected from typical physical mixing, and dispersed oil might tend to remain further below the water's surface than undispersed oil (McAuliffe et al., 1981b; Lewis and Aurand, 1997). Reports about dispersant usage on surface plumes indicate that a majority of the dispersed oil remains in the top 10 m (33 ft) of the water column, which is generally shallower than the crests of OCS live bottom features; therefore, contact is generally not expected apart from highly unusual conditions such as those seen in Silva et al. (2015). If contact is made, impacts may differ somewhat between oil, oil/dispersant mixtures, and dispersant alone. DeLeo et al. (2015) demonstrated that concentrated amounts of dispersant and oil/dispersant mixtures caused more severe health declines to live bottom organisms than oil-only mixtures. One field study (Yender and Michel, 2010) indicated less severe impacts, possibly due to that study's (more realistic) application of dispersants in an open field system, although during the *Deepwater Horizon* oil spill, dispersants were also applied subsea at the source of the blowout. Stratified density layers of water allowed the oil/dispersant plume to remain at depth instead of dispersing up into the water column (Joint Analysis Group, 2010), and these concentrated plumes are thought to have caused serious but fairly localized damage to deepwater corals on the continental slope (White et al., 2012; Hsing et al., 2013; Fisher et al., 2014a). It is unlikely that concentrated oil/dispersant mixtures would be found near shallow-water live bottom features; therefore, lethal exposures to large numbers of shallow-water live bottom organisms are not anticipated.

For any accidental spill, it is expected that a certain quantity of oil may eventually settle on the seafloor through a binding process with suspended sediment particles (adsorption) or after being consumed and excreted by phytoplankton (Passow et al., 2012). The product of these processes is sometimes referred to as “marine snow.” It is expected that the greatest amount of adsorbed oil particles would occur close to the spill, with the concentration reducing over distance. If the spill occurs close to a live bottom feature, some underlying live bottom organisms may become smothered by the particles and experience long-term exposure to hydrocarbons. This was seen for some deepwater corals following the *Deepwater Horizon* oil spill and response (White et al., 2012; Hsing et al., 2013; Fisher et al., 2014a). Beyond the localized area of impact in that case, particles would become increasingly biodegraded and dispersed. Any localized impacts to pinnacle and low-relief feature communties would be expected to be largely sublethal and could include reduced recruitment success, reduced growth, and reduced biological cover as a result of impaired recruitment (Rogers, 1990; Kushmaro et al., 1997).

Sediments suspended or displaced as a result of a loss of well control could also impact pinnacle and low-relief feature communties. These impacts would be largely identical to those caused by sedimentation stirred up by bottom-disturbing equipment, with the possible addition of toxic hydrocarbons or drilling muds in the sediments (refer to “Routine Activities”). Because permitted wells would have been distanced from pinnacle and low-relief feature communties before installation, it is expected that the heaviest sediment concentrations would fall out of suspension and disperse before reaching the communities, preventing most impacts. Some live bottom organisms, such as flexible sea fans, are naturally adapted to turbid conditions and may not be as negatively affected. Outside of a catastrophic spill situation, a very substantial amount of sediment burial of organisms during an accidental spill event is not reasonably foreseeable (refer to the *Catastrophic Spill Events Analysis* white paper, USDOI, BOEM, 2017).

Finally, spill cleanup/response activities could themselves have negative impacts. During a response operation, the risk of accidental impacts of bottom-disturbing equipment is increased. There could be unplanned or emergency anchoring on live bottom features or accidental losses of heavy equipment from responding vessels. Response-related equipment such as seafloor-anchored booms may be used and could inadvertently contact live bottom organisms. In addition, drilling muds may be pumped into a well to prevent a loss of well control. It is possible that during this process, some of this mud may be forced out of the well and deposited on the seafloor near the well site. If this occurs, the impacts would be severe for any organisms buried; however, the impact beyond the immediate area would be limited and adherence to the original distancing requirements would prevent or reduce most impacts. Noncatastrophic accidental spills have historically been relatively small events (**Table 3-12**). While the total amount of hard/live bottoms in the GOM is small compared with soft bottoms, the habitats are widely distributed and a localized impact from one noncatastrophic accidental event would only impact a small fraction of the overall resource (McEachran, 2009).

All of the above impact-producing factors could lead to lethal or sublethal impacts on individual pinnacle and low-relief feature communities, with the range of impacts dependent on the quantity of spilled oil and proximity to habitats. While a spill resulting from a catastrophic-level blowout in deep water (such as the *Deepwater Horizon* oil spill) has the potential to seriously impact individual pinnacle and low-relief feature communities over a long time period, such a spill is not reasonably foreseeable as a result of a proposed action. Impacts from individual routine activities and reasonably foreseeable accidental events are usually temporary, highly localized, and expected to impact only small numbers of pinnacle and low-relief feature communties at a time. Some live bottom species possess natural adaptations to high-turbidity environments that could help remove spill-related sediments. Moreover, use of the expected site-specific plan reviews/mitigations would distance activities from identified pinnacle and low-relief feature communities, greatly diminishing the likelihood and severity of potential effects. Therefore, at the scale of this analysis, and with application of the expected mitigation practices, impacts on pinnacle and low-relief feature communities from accidental spills and associated impact-producing factors are expected to range from **negligible** to **minor**. This range of potential impact levels reflects the relative uncertainties associated with unplanned and potentially uncontrolled accidental spills and with the remote possibility of unusual weather conditions that could push surface oil/dispersant deeper than is typical, potentially leading to a minor level of impact. The exact impact would depend on the overall frequency and severity of accidental spills and their proximity to pinnacle and low-relief feature communities.

Without the protective measures provided by the Live Bottom Stipulation (which is a required mitigation as a result of the Five-Year Program's Record of Decision), and associated postlease reviews and distancing, the potential impacts of accidental spills could rise to moderate or even major levels, in the improbable (but theoretically possible) case that a large number of accidental spills were to occur at wells in close proximity to a large number of live bottom communities and if community-level impacts can be clearly distinguished from a natural variation. Even without mitigations, the likelihood is very low that a large number of accidental spills would occur in close proximity to the relatively rare hard substrate habitats supporting pinnacle and low-relief feature communities, but this possibility cannot be definitively ruled out without knowing both the precise distribution of such spills and the communities.

4.6.2.2.3 Cumulative Impacts

The following analysis considers whether the incremental impacts of routine activities and accidental events associated with the proposed OCS Oil and Gas Program-related operations, when added to or acting synergistically with existing non-OCS oil- and gas- related impact sources from the cumulative impacts scenario, may result in a significant collective impact.

OCS Oil- and Gas-Related Impacts

The OCS oil- and gas Program-related impacts include the long-term, incremental contribution of the routine and accidental bottom-disturbing activities outlined above: (1) bottom-disturbing activities (e.g., drilling, anchoring, infrastructure installation/removal, and associated sedimentation); (2) sediment and waste discharges (e.g., drilling muds and cuttings, and produced waters); and (3) oil spills (surface and subsurface and associated cleanup responses). As already detailed above, these impact-producing factors have the potential to damage individual pinnacle and low-relief feature communities , if insufficiently distanced or otherwise mitigated. Bottom-disturbing activities could result in the physical destruction of benthic habitat and organisms or the disturbance of sediments within the environment, resulting in burial and/or increased turbidity. Routine and accidental waste discharges could be toxic if contacted in undiluted form near the source. Oil spills and dispersants are known to have negative, acute effects on benthic organisms, and the cumulative, long term effects of persistent, low-level exposure to oil are not yet fully understood. All of these activities could lead to lethal or sublethal impacts on individual live bottom communities. However, impacts from individual events are usually temporary, highly localized, and expected to impact only small numbers of organisms and substrates at a time, particularly since live bottom habitats are relatively rare and distributed in only small patches of the OCS areas that are anticipated to be leased. Also, adherence to the expected Live Bottom Stipulation and site-specific plan reviews/mitigations would distance many of these activities, greatly diminishing potential effects. Therefore, the incremental cumulative contribution of the proposed OCS oil- and gas-related routine activities and accidental events is expected to have only **negligible** to **minor** impacts.

This range of potential impact levels reflects the relative uncertainties associated with unplanned accidental bottom disturbances and accidental spills, including the remote possibility of unusual weather conditions that could push surface oil/dispersant deeper than is typical, potentially leading to a minor level of impact. The exact impact would depend on the overall frequency and severity of accidental events and their proximity to pinnacle and low-relief feature communities.

Non-OCS Oil- and Gas-Related Impacts

The cumulative, long-term impact of reasonably foreseeable, non-OCS oil- and gas-related anthropogenic activities and influential environmental conditions on live bottoms could be considerable, although they are difficult to precisely quantify when projecting future conditions over the next 50 years. The primary anthropogenic activities with impact producing factors are vessel anchoring and fishing. The primary environmental factors are invasive species, hypoxia, severe weather, and climate change. There is extensive scientific literature readily available about all of these subjects; only a brief summary analysis is provided here. It should be noted that BOEM's stipulations and site-specific plan reviews/mitigations are not designed to mitigate against the potential impacts posed by these non-OCS oil- and gas-related anthropogenic activities and environmental factors. They are designed to protect live bottom resources from OCS oil- and gas-related activities within BOEM's jurisdiction and to mitigate against a proposed action's incremental cumulative impact contribution to the overall OCS and non-OCS cumulative impacts.

Certain fishing gear and overfishing can have long-term effects on benthic species and habitats. These effects can be caused both by the gear and through indirect trophic effects. Bottom-tending gear such as bottom trawls and bottom-contacting long lines could destroy or disturb hard/live bottoms such that species diversity and abundance are negatively affected (Wells et al., 2008; NRC, 2014; Pusceddu et al., 2014; Secor et al., 2014). Such gear may dislodge, entangle, or otherwise damage organisms inhabiting live bottoms. Large emergent sponges and corals may be particularly vulnerable to trawling activity, as these organisms grow above the substrate and can be caught and removed by trawling activity (Freese et al., 1999, Hourigan 2014). Because many hook-and-line fishermen target live bottom-associated reef fish, they may use bottom-contacting gear that can damage the tissues of benthic organisms, particularly when the line is snagged and abandoned. In addition, fishing pressure could selectively alter fish community structure and, over the long term, have a top-down trophic impact on fish populations that interact with live bottoms.

The impacts of vessel anchoring on live bottoms are similar to the other bottom-disturbing impacts described above. Of note in this section is that smaller vessels such as recreational fishing and diving boats are also included. Such vessels are more numerous than large vessels, though their individual anchors are much smaller and most recreational activities occur close to shore. The degree of potential damage is dependent on the size of the anchor and chain (Lissner et al., 1991). Anchor damages to benthic organisms such as corals may take more than 10 years to recover (Fucik et al., 1984; Rogers and Garrison, 2001).

The lionfish is an invasive species of concern that has been reported throughout the GOM (USDOI, GS, 2010 and 2015; Johnston et al., 2013; Aguilar-Perera and Tuz-Sulub, 2010). This fish is thought to drive down diversity and abundance of benthic organisms, especially crabs, demersal fishes, and shrimps (Green et al., 2012). The precise cumulative impact of invasive species on GOM live bottom features is still unknown at this time, but it is projected that negative impacts are likely to worsen over time as lionfish populations are increasing exponentially in both abundance and distribution (Switzer et al., 2015).

Depleted dissolved oxygen occurs seasonally in shelf waters of the northern GOM, including in areas with pinnacle and low-relief feature communties . Dissolved oxygen depletion is caused primarily by the decomposition of algae whose production is stimulated by excess nutrients delivered by the Mississippi River and other coastal rivers, the source of which can be traced back to onshore human activities such as fertilizer use. Hypoxic (dissolved oxygen ≤2.0 mg/L) conditions can have lethal and sublethal effects on aquatic organisms (refer to **Chapter 3.3.2.12** for more information on hypoxia). Although hypoxic conditions are mainly a characteristic of Louisiana-Texas shelf waters, negative effects could reach some pinnacle and low-relief feature communties in the northeast portion of the CPA. Dramatic changes in natural levels of dissolved oxygen over time could alter the composition and distribution of live bottom communities.

Severe weather events of sufficient magnitude (e.g., hurricanes) may also cause impacts. The force of currents and wave action can directly disturb sediments (Brooks, 1991; CSA, 1992), increasing turbidity and associated impacts. Severe weather can also have secondary impacts, such as causing movement of abandoned fishing gear and causing accidental losses of equipment overboard or even the toppling of entire platforms. In general, live bottom communities have adapted over millennia to deal with natural levels of severe weather, but changing climatic conditions that alter the frequency and/or severity of severe weather events could impact live bottom resources in unforeseen ways to which live bottoms may not be able to adapt.

Climate change-related effects have the potential to alter baseline environmental conditions throughout the GOM. An additional review of climate change is presented in the Five-Year Program EIS (USDOI, BOEM, 2016b). Of particular note for pinnacle and low-relief feature communties are the potential negative consequences that may be caused by the dual mechanisms of increasing ocean temperatures and ocean acidification. Sustained, unusually high water temperatures are documented to cause coral bleaching, in which symbiotic zooxanthellae are expelled from coral polyps. Ocean acidification can reduce the bioavailability of calcium carbonate and thereby inhibit normal rates of calcification by exoskeleton-building corals and other calcifying marine organisms. Decreased calcification rates have been observed in numerous shallow-water, zooxanthellate corals (refer to Hoffman et al., 2010). Both mechanisms can inhibit growth and reproductive fitness. Other potential climate change-driven alterations of baseline environmental conditions, such as sea-level rise, could also have additional, unpredictable effects on sessile benthic organisms.

The cumulative impact level of each of these individual factors is difficult to accurately estimate since the spatial and temporal characteristics of some factors are rapidly changing and necessary baseline information is still being collected. However, at present, the overall impact of these non-OCS factors is estimated to be **minor** to **moderate**, with individual species affected to different degrees by each factor. Over the next 50 years, the impact level from these non-OCS factors could potentially rise to higher levels, even possibly major, should current trends of these non-OCS oil- and gas-relatedactivities continue or worsen.

Weighed against these potential non-OCS oil- and gas-related impacts from anthropogenic activities and influential environmental conditions, the much smaller incremental cumulative impact of a proposed lease sale is expected to contribute only a **negligible** to **minor** amount to the total potential level of impacts. Based on current conditions, the overall cumulative impact of everything (OCS and non-OCS) is **minor** to **moderate**, with almost all of the impacts coming from non-OCS oil- and gas-related activities. This total impact level has the potential to rise over the next 50 years to higher levels, even possibly to major, should projected trends of non-OCS oil- and gas-related activities (particularly climate change) continue or worsen. Given the **negligible** to **minor** contribution of a proposed lease sale to this overall cumulative scenario, it is reasonable to conclude that a single proposed lease sale would not cause the overall cumulative impact level to rise over the next 50 years.

4.6.2.2.4 Incomplete or Unavailable Information

BOEM recognizes that there is incomplete or unavailable information related to GOM live bottom habitats in general and specifically in relation to routine activities, accidental events, and cumulative impacts for OCS oil- and gas-related activities and cumulative non-OCS oil- and gas-related activities. However, the information that is known is adequate to come to a determination with respect to reasonably foreseeable impact-producing factors associated with a proposed action.

Research in offshore marine systems is logistically complex and requires substantial resources to conduct. The total amount of research on live bottom habitats has therefore been limited, although BOEM and its predecessor agencies have funded numerous studies over the past 40 years. An example of incomplete knowledge about this resource would be that the exact distribution of GOM live bottom habitats at any given time is not perfectly understood. This is due in part to limits on data collection but also due to the frequent burial and exposure of low-relief hard bottoms. To help address this knowledge gap, BOEM requires operators to provide detailed, updated, site-specific survey information about potential live bottom habitats; this information is reviewed by subject-matter experts prior to approval of individual proposed activities, and appropriate protective mitigations are applied where appropriate.

Although BOEM has acquired and applies a large amount of knowledge about possible impacts to live bottom habitats, a perfect understanding of all conceivable impacts is unattainable. For example, only recently did a study (Silva et al., 2015) provide compelling evidence that mixing of a surface oil/dispersant mixture to the depths of the Pinnacle Trend live bottom features can actually occur, given an unusual combination of conditions, and could then have a localized impact. Given the geographic and temporal scope of a proposed action, it is believed that even impacts resulting from that particular scenario would still only have a slight impact on the overall status of GOM pinnacle and low-relief feature communities. Moreover, the amount of oil/dispersant mixture in that catastrophic situation greatly exceeded the amounts considered in the "Accidental Events" analysis. However, the example demonstrates the point that the body of literature supporting impact analysis is still growing and requires continual review by BOEM.

Known information about potential impacts of a theoretical catastrophic spill is detailed in the *Catastrophic Spill Events Analysis* white paper (USDOI, BOEM, 2017), and further information was made available with the publication of the Trustees' PDARP/PEIS in 2016 (Deepwater Horizon Natural Resource Damage Assessment Trustees, 2016). The content of that report was reviewed as part of this analysis. Some information related to impacts specific to the *Deepwater Horizon* explosion, oil, spill, and response, such as long-term monitoring results, is still incomplete or unavailable. BOEM has determined that such additional information could not be timely acquired and incorporated into the current analysis. However, based on the currently available evidence, impending reports are not expected to reveal additional significant effects that would alter the overall conclusions about reasonably foreseeable impact-producing factors associated with a proposed action.

BOEM will continue to analyze and support collection and analysis of the best available scientific information related to live bottom habitats. BOEM used reasonably accepted scientific methodologies to extrapolate from existing information in completing this analysis and formulating the conclusions presented here. BOEM has determined that the incomplete information is not essential to a reasoned choice among alternatives.

4.6.2.2.5 Alternative A—Regionwide OCS Lease Sale (The Preferred Alternative)

The activities proposed under Alternative A could directly impact live bottom pinnacle and low-relief features within the GOM. The primary, reasonably foreseeable, impact-producing factors for pinnacle and low-relief feature communities can be grouped into three main categories: (1) bottom-disturbing activities; (2) sediment and waste discharges; and (3) oil spills. The proposed Live Bottom Stipulation (which is a required mitigation as a result of the Five-Year Program's Record of Decision), along with site-specific reviews of permit applications and associated distancing requirements, would mitigate potential impacts to the communities as a result of both routine activities and accidental disturbances. Assuming adherence to all expected lease stipulations and other postlease protective restrictions and mitigations, the routine activities are expected to have mostly short-term, localized, and temporary effects on the communities that may not be clearly detectable. Therefore, at the regional, population-level scope of this analysis, the impacts of routine activities would be expected to be **negligible**.

Accidental events (below the threshold of a catastrophic spill, which is detailed in the *Catastrophic Spill Event Analysis* white paper [USDOI, BOEM, 2017]) have the potential to cause detectable, severe damage to specific pinnacle and low-relief feature communities. However, the number of such events is expected to be very small and localized, and impacts might not be clearly distinguishable from natural variation. Therefore, at the regional, population-level scope of this analysis, impacts from reasonably foreseeable accidental events are expected to be **negligible** to **minor**.

Proposed and existing OCS oil- and gas-related activities would also contribute incrementally, but only a **negligible** to **minor** amount, to the overall OCS oil- and gas-related and non-OCS oil- and gas-related cumulative effects experienced by pinnacle and low-relief feature communities. Absent the expected mitigations, the impacts resulting from both routine activities and accidental events of a proposed lease sale could be greater, with overall population-level impacts ranging from **minor** to **major** (in a theoretical, if improbable, worst-case scenario). The previous and continuing OCS oil- and gas-related cumulative impacts beyond the incremental contribution of a proposed action (a specific lease sale) are estimated to continue having only **negligible** to **minor** impacts, assuming continued adherence to all expected lease stipulations and other postlease protective restrictions and mitigations.

A variety of non-OCS oil- and gas-related activities, including fishing and anchoring, along with shifting natural conditions such as invasive species and climate change-related factors, seem likely to have a considerably greater impact on the communities; currently, that impact level is estimated as **minor** to **moderate**, but it could increase to as great as **major** over the next 50 years. Ongoing non-OCS oil- and gas-related activities are difficult to accurately estimate since the spatial and temporal characteristics of some factors are rapidly changing, and necessary baseline information is still being collected; however, at present, these non-OCS oil- and gas-related activities are having **minor** to **moderate** cumulative impacts on pinnacle and low-relief feature communities. These could potentially become greater over time, even rising to **major** over the next 50 years, should current trends of these activities continue or worsen, regardless of whether or not a proposed lease sale would be held. Weighed against these potential non-OCS oil- and gas-related impacts from anthropogenic activities and influential environmental conditions, the much smaller incremental cumulative impact of a proposed lease sale is expected to contribute only a **negligible** to **minor** amount to the total potential level of impacts.

4.6.2.2.6 Alternative B—Regionwide OCS Proposed Lease Sale Excluding Available Unleased Blocks in the WPA Portion of the Proposed Lease Sale Area

Under Alternative B, BOEM would hold a lease sale excluding the available unleased WPA blocks and would offer all available unleased blocks in the CPA and a portion of the EPA. Alternative B would not fundamentally alter the conclusions reached under Alternative A, but it would reduce the potential impacts of a proposed sale in the available unleased WPA blocks. The impacts from proposed activities to pinnacle and low-relief feature communities would remain the same in leased portions of the CPA/EPA. Impacts resulting from accidental events should remain relatively localized, with the number of features affected being directly proportional to the size of the accident. An accident along the CPA/WPA border has the possibility to impact features in either planning area. Pinnacle and low-relief feature communities are found throughout the GOM, and therefore, the impacts associated with Alternative B could still potentially cause some population-level effects.

At the regional, population-level scope of this analysis, the overall impact to the communities as a result of the activities proposed under Alternative B are expected to be the same as Alternative A, assuming the application of the Live Bottom (Pinnacle Trend) Stipulation (which is a required mitigation as a result of the Five-Year Program's Record of Decision), and continuation of expected mitigation practices. BOEM's mitigation practices would limit the potential impacts as a result of routine activities to **negligible** levels and would limit impacts from reasonably foreseeable accidental events to the range of **negligible** to **minor**. The OCS oil- and gas-related cumulative impacts of a proposed lease sale under Alternative B would be **negligible** to **minor** for a single proposed lease sale (the incremental contribution) and **negligible** to **minor** for the overall ongoing OCS oil and gas program.

However, absent the expected mitigations, the impacts resulting from both routine activities and accidental events of a proposed lease sale could be greater, with overall population-level impacts ranging from **minor** to **moderate** (in a theoretical, if improbable, worst-case scenario). This impact-level range is lower than the potential **minor** to **major** level impact range that would be possible (absent mitigations) under Alternative A. This difference is due to the reduced area available for new leasing under Alternative B, which would somewhat limit the number of potentially affected pinnacle and low-relief feature communities (including concentrations of such communities in the South Texas Banks) and increase the likelihood of eventual recovery to pre-impact levels, should impacts occur. However, it is believed that existing mitigation practices would continue to be applied to the proposed activities under all action alternatives.

The incremental cumulative impacts of proposed OCS oil- and gas-related activities of a single proposed lease sale under Alternative B would still add only a **negligible** to **minor** contribution to the overall cumulative impact, which includes the relatively greater influence of non-OCS cumulative impacts occurring throughout the GOM over the 50-year analysis period.

4.6.2.2.7 Alternative C—Regionwide OCS Proposed Lease Sale Excluding Available Unleased Blocks in the CPA/EPA Portions of the Proposed Lease Sale Area

Under Alternative C, BOEM would hold a lease sale excluding the CPA/EPA available unleased blocks and would only offer all available unleased blocks in the WPA. Alternative C would not fundamentally alter the conclusions reached under Alternative A, but it would reduce the potential impacts of a proposed lease sale of the available unleased CPA/EPA blocks, including known high concentrations of pinnacle and low-relief feature communities in the Pinnacle Trend blocks and other portions of the northeastern CPA (**Figure 4-17**). The impacts from proposed activities to the communities would remain the same in leased portions of the WPA. Impacts resulting from accidental events should remain relatively localized, with the number of features affected being directly proportional to the size of the accident. An accident along the CPA/WPA border has the possibility to impact features in either planning area. Live bottom communities are found throughout the GOM, not just in the CPA/EPA, and therefore, the impacts associated with Alternative C could still potentially cause some population-level effects.

At the regional, population-level scope of this analysis over the next 50 years, the potential impacts to pinnacle and low-relief feature communties as a result of the activities proposed under Alternative C are expected to be slightly reduced from the impact levels detailed in Alternatives A and B because such a large proportion of the Gulfwide population of pinnacle and low-relief feature communities are found within the CPA, especially within the Pinnacle Trend region. Therefore, the population would not be subjected to the same degree of potential accidental impacts theorized above, and the reduced theoretical impact would also increase the likelihood of eventual population recovery to pre-impact levels. BOEM's mitigation practices would further limit the potential impacts in leased areas. Under Alternative C, both routine activities and foreseeable accidental events are estimated to result in only **negligible** levels. The OCS oil- and gas-related impacts of a proposed lease sale under Alternative C would therefore be **negligible** for a single proposed lease sale (the incremental contribution) and **negligible** to **minor** for the overall ongoing OCS oil and gas program. Should Alternative C be selected for multiple subsequent proposed lease sales in the future, however, impacts from the cumulative OCS Oil and Gas Program could eventually be reduced to **negligible** as overall OCS oil- and gas-related activity in the CPA would begin to appreciably decline over time.

Absent these expected mitigations, the impacts resulting from routine activities and accidental events of a proposed lease sale could be greater, with overall population-level impacts ranging from **negligible** to **minor** for routine activities and from **negligible** to **minor** (in a theoretical, if improbable, worst-case scenario) for accidental events. These impact-level ranges are less than the potential impact-level ranges that would be possible (absent mitigations) under Alternatives A and B. This difference is due to the reduced area available for new leasing under Alternative C, which would somewhat limit the number of potentially affected pinnacle and low-relief feature communities (including large concentrations of known communities in the Pinnacle Trend blocks and other portions of the northeastern CPA) and increase the likelihood of eventual population recovery to pre-impact levels. However, the existing mitigation practices are now a required mitigation as a result of the Five-Year Program's Record of Decision and would continue to be applied to the proposed activities under all action alternatives, reducing the expected level of OCS oil- and gas-related impacts.

The incremental cumulative impacts of proposed OCS oil- and gas-related activities of a single proposed lease sale under Alternative C would likely add only a **negligible** contribution to the overall cumulative impact, which includes the relatively greater influence of non-OCS cumulative impacts occurring throughout the GOM over the 50-year analysis period.

4.6.2.2.8 Alternative D—Alternative A, B, or C, with the Option to Exclude Available Unleased Blocks Subject to the Topographic Features, Live Bottom (Pinnacle Trend), and/or Blocks South of Baldwin County, Alabama, Stipulations

Under Alternative D, BOEM could hold a lease sale excluding leasing on any and/or all blocks subject to the Topographic Features, Live Bottom (Pinnacle Trend), and Blocks South of Baldwin County, Alabama, Stipulations. Known pinnacle and low-relieft features in the Pinnacle Trend area would be further protected by the increased distancing of OCS oil- and gas-related activities. An accidental spill could still reach some Pinnacle Trend features, but if so, it is expected that oil from such a spill would be more dispersed and diluted due to it having to travel the additional distance across the areas not offered for lease.

Impacts resulting from accidental events should remain relatively localized, with the number of features affected being directly proportional to the size and location of the accident. An accident along the border of available unleased blocks subject to the Topographic Features and Live Bottom (Pinnacle Trend) Stipulations still has the possibility to impact features within those unleased blocks. Live bottom communities are found throughout the GOM, not just in the blocks subject to the Topographic Features and Live Bottom (Pinnacle Trend) Stipulations, and therefore, the impacts associated with Alternative D could still potentially cause some population-level effects. The exclusion of blocks subject to the Blocks South of Baldwin County, Alabama, Stipulations is not expected to change the impacts to pinnacles and/or low-relief features because of the small number of these blocks and their distance from known pinnacle and low-relief features.

At the regional, population-level scope of this analysis over the next 50 years, the potential impacts to pinnacle and low-relief feature communties as a result of the activities proposed under Alternative D are expected to be slightly reduced from the impact levels detailed in Alternatives A and B because such a large proportion of the Gulfwide population of pinnacle and low-relief feature communities are found within the CPA, especially within the Pinnacle Trend region. There are also a fair number of pinnacle and low-relief features within blocks subject to the Topographic Features Stipulation (specifically on the peripheral flanks of some of the much larger topographic features). Therefore, the Gulfwide population of pinnacle and low-relief feature communities would not be subjected to the same degree of potential accidental impacts theorized above for Alternatives A and B, and the reduced theoretical impact would also increase the likelihood of eventual population recovery to pre-impact levels. BOEM's mitigation practices would further limit the potential impacts in leased areas. Under Alternative D, both routine activities and foreseeable accidental events are estimated to result in only **negligible** levels. The OCS oil- and gas-related impacts of a proposed lease sale under Alternative D would therefore be **negligible** for a single proposed lease sale (the incremental contribution) and **negligible** to **minor** for the overall ongoing OCS oil and gas program. Should Alternative D be selected for multiple subsequent proposed lease sales in the future, however, impacts from the cumulative OCS Oil and Gas Program could eventually be reduced to **negligible** as overall OCS oil- and gas-related activity in the CPA would begin to appreciably decline over time. Absent these mitigations, the impacts resulting from routine activities and accidental events of a proposed lease sale under Alternative D could be greater. The overall population-level impact could range from **negligible** to **minor** for routine activities and from **negligible** to **minor** (in a theoretical, if improbable, worst-case scenario) for accidental events. This impact level is less than the potential **major** level impact that would be possible (absent mitigations) under Alternative A. These impact-level ranges are less than the potential impact-level range that would be possible (absent mitigations) under Alternatives A and B. This difference is due to the reduced area available for new leasing under Alternative D, which would limit the number of potentially affected pinnacle and low-relief feature communities (including large concentrations of known communities in the Pinnacle Trend blocks) and increase the likelihood of eventual population recovery to pre-impact levels. However, it is believed that existing mitigation practices would continue to be applied to the proposed activities under all action alternatives, reducing the expected level of OCS oil- and gas-related impacts.

The incremental cumulative impacts of proposed OCS oil- and gas-related activities of a single proposed lease sale under Alternative D would likely add only a **negligible** contribution to the overall cumulative impact, which includes the relatively greater influence of non-OCS cumulative impacts occurring throughout the GOM over the 50-year analysis period.

4.6.2.2.9 Alternative E—No Action

Under Alternative E, a proposed lease sale would be cancelled. Therefore, the potential for impacts would be **none** because new impacts to pinnacle and low-relief feature communities related to the cancelled lease sale would be avoided entirely. Continuing impacts to the communities would be limited to existing impacts resulting from routine activities and accidental events, and cumulative impacts associated with previous OCS lease sales. BOEM's current Live Bottom Stipulation and mitigation practices already regulate these activities and should continue to limit associated new impacts to the **negligible** level.

Ongoing non-OCS oil- and gas-related activities are difficult to accurately estimate since the spatial and temporal characteristics of some factors are rapidly changing, and necessary baseline information is still being collected; however, at present, these non-OCS oil- and gas-related activities are having minor to moderate cumulative impacts on live bottom communities. These could potentially become greater for some species, even rising to major over the next 50 years, should current trends of these factors continue or worsen, regardless of whether or not a proposed lease sale would be held.

4.7 FISHES AND INVERTEBRATE RESOURCES

Fish and invertebrate resources of the GOM comprise a large and diverse group of species (Felder et al., 2009). The distribution of fishes and invertebrates vary widely and species may be associated with different habitats at various life stages. This analysis highlights behaviors and habitat preferences, but it does not attempt to provide a comprehensive list of all potentially impacted fauna. For purposes of this analysis, habitat preferences can be divided into three broad categories: estuarine; coastal; and oceanic. Exposure to specific impact-producing factors generated by OCS oil- and gas-related routine activities and accidental events can vary among these categories. Coastal and oceanic resources are further broken into benthic and pelagic zones to address differences in potential exposure to impact-producing factors within a given habitat category. Ichthyoplankton bridges all three categories. Egg and larval stages of most fishes and invertebrates can be found in the upper layer of the water column, exposing these species' early life stages to similar impact-producing factors. For these reasons, the description of the affected environment for fish and invertebrate resources is broken into estuarine, coastal, and oceanic habitats, with ichthyoplankton being treated separately due to the potentially broader distribution of egg and larval lifestages across these habitats. A brief discussion of the federally managed species is provided at the end of the "Description of the Affected Environment" below (**Chapter 4.7.1**).

A full analysis of the "Environmental Consequences" is presented in **Chapter 4.7.2**. Analyses of the specific alternatives do not restate the full analysis of the impact-producing factors potentially affecting fishes and invertebrate resources; the analyses identify the potential impacts as a result of routine activities, accidental events, and cumulative impacts. This avoids excessive replication of the discussion of similar if not identical impacts for each alternative.

Preliminary analysis of routine OCS oil- and gas-related activities and reasonably foreseeable accidental events identified eight impact-producing factors with the potential to affect marine fishes and invertebrates and/or their habitat. Many OCS oil- and gas-related activities affect the environment similarly. For example, vessel traffic, exploratory drilling, geophysical activities, and offshore construction all produce sound. The impact-producing factor, "anthropogenic sound," was analyzed taking all sound-producing OCS activities into consideration. The following are impact-producing factors that were considered and analyzed in this resource analysis:

- anthropogenic sound (**Chapter 3.3.2.7**);
- bottom-disturbing activity (**Chapter 3.1.3.3.2**);
- habitat modification; and
- oil spills (**Chapter 3.2.1**).

Two of the eight impact-producing factors that were considered for fishes and invertebrate resources were determined to be insignificant under all reasonably foreseeable circumstances due to the limited exposure and/or response expected for fish and invertebrate resources and are, therefore, not analyzed in this chapter. These impact-producing factors are entrainment (**Chapter 3.1.5.1.6**) and offshore lighting (**Chapter 3.1.3.4.3**). A Joint Industry Biological Baseline Study was completed for USEPA Region 6 in June 2009 (LGL Ecological Research Associates, Inc., 2009), and an industry-wide cooling water intake structure entrainment monitoring study, approved by USEPA Region 6, was completed in 2014 (CSA and LGL Ecological Research Associates, Inc., 2014). The results of these two studies support BOEM's finding that entrainment is insignificant as an impact-producing factor for the purpose of this analysis. Analyses of two additional impact-producing factors that could potentially impact resources ecologically important to fishes and invertebrates were addressed in earlier chapters. Discussions of onshore construction and use of coastal support infrastructure (**Chapter 4.3**, Coastal Habitats) and regulated discharges (**Chapters 3.1.5 and 4.2**, Water Quality) were found to sufficiently address the potential for adverse impacts to fish and invertebrate habitats and are not duplicated in this chapter.

Analysis of potential impacts considered the estimated scale of source activities and used the best available science to evaluate how specific impact-producing factors could affect resources within the expected environment. Cumulative impacts (**Chapter 4.7.2.3**) were analyzed for OCS oil- and gas-related activities and for other sources that could affect fishes and invertebrates (e.g., coastal development, commercial shipping, fisheries, and environmental). Because of the diversity of fishes and invertebrates, detailed criteria for potential impact levels are not reasonable.

Impact-Level Definitions

For this analysis, the potential impact-level criteria can be described in terms of population-level effects.

- **Negligible** – localized and temporary impacts that are expected to be indistinguishable from natural variations in population distribution and abundance.
- **Minor** – localized and temporary impacts that are expected to be indistinguishable from natural variations in population distribution and

abundance. Community-level variations may be locally detectable, such as species mix and relative abundance following the removal of OCS oil- and gas-related infrastructure.

- **Moderate** – Impacts would be expected to exceed natural variations in population abundance or distribution, but not result in a long-term decline.
- **Major** – Impacts would be expected to exceed natural variations and inherently result in a long-term decline in populations.

Though two protected fish species (Gulf sturgeon [*Acipenser oxyrhynchus desotoi*] and smalltooth sawfish [*Pristis pectinata*]) are found near the area of interest, they inhabit and have critical habitat in onshore waters. A third protected species, Nassau grouper (*Epinephalus striatus*), has been documented as a transient or rarely occuring species in the area of interest. These species are not considered to be impacted by a proposed action because they are found away from activities that could cause an impact. The impact-producing factors analyzed and the impact-level conclusions reached from the analysis in this chapter are presented in **Table 4-15** to help the reader quickly identify the level of potential impacts for each relevant impact-producing factor. The analyses supporting these conclusions are then discussed in detail after a description of the relevant affected environment for fish and invertebrate resources in the GOM.

Table 4-15. Fish and Invertebrate Resources Impact-Producing Factors That Are Reasonably Foreseeable.

<table>
<tr><th>Fish and Invertebrate Resources</th><th colspan="5">Magnitude of Potential Impact[1]</th></tr>
<tr><th>Impact-Producing Factors</th><th>Alternative A</th><th>Alternative B</th><th>Alternative C</th><th>Alternative D</th><th>Alternative E</th></tr>
<tr><td colspan="6">Routine Impacts</td></tr>
<tr><td>Anthropogenic Sound</td><td>Minor</td><td>Minor</td><td>Minor</td><td>Minor</td><td>None</td></tr>
<tr><td>Bottom-Disturbing Activity</td><td>Negligible</td><td>Negligible</td><td>Negligible</td><td>Negligible</td><td>None</td></tr>
<tr><td>Habitat Modification</td><td>Negligible to Minor</td><td>Negligible to Minor</td><td>Negligible to Minor</td><td>Negligible to Minor</td><td>None</td></tr>
<tr><td colspan="6">Accidental Impacts</td></tr>
<tr><td>Oil Spills</td><td>Negligible</td><td>Negligible</td><td>Negligible</td><td>Negligible</td><td>None</td></tr>
<tr><td colspan="6">Cumulative Impacts</td></tr>
<tr><td>Incremental Contribution[2]</td><td>Minor</td><td>Minor</td><td>Minor</td><td>Minor</td><td>None</td></tr>
<tr><td colspan="6">OCS Oil and Gas[3]</td></tr>
<tr><td>Anthropogenic Sound</td><td colspan="5">Minor</td></tr>
<tr><td>Bottom-Disturbing Activity</td><td colspan="5">Negligible</td></tr>
</table>

Fish and Invertebrate Resources	Magnitude of Potential Impact[1]				
Impact-Producing Factors	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
Habitat Modification	Negligible to Moderate				
Non-OCS Oil and Gas[4]					
Anthropogenic Sound	Moderate				
Fisheries	Negligible to Moderate				
Habitat Modification	Minor				

[1] The analysis supporting these conclusions is discussed in detail in the “Environmental Consequences” chapter below.
[2] This includes all activities (i.e., routine activities projected to occur and accidental events that could occur) as a result of a single proposed lease sale in the 2017-2022 Five-Year Program.
[3] This includes all activities (i.e., routine activities projected to occur and accidental events that could occur) from past, proposed, and future lease sales.
[4] This includes other past, present, and reasonably foreseeable future activities occurring within the same geographic range and within the same timeframes as a proposed action, but they are not related to the OCS Oil and Gas Program.

4.7.1 Description of the Affected Environment

The ecological factors influencing the distribution of fish and invertebrate species include salinity, temperature, depth, primary productivity, and bottom type. These factors vary widely across the Gulf of Mexico and between inshore and offshore waters. Fish and invertebrate resources are associated with the various environments and are not randomly distributed. High densities of fish and invertebrate resources can be associated with particular habitat types; for detailed habitat information, distribution, potential impacts, and mitigations, refer to **Chapters 4.3** (Coastal Habitats), **4.4** (Deepwater Benthic Communities), **4.5** (*Sargassum* and Associated Communities), and **4.6** (Live Bottom Habitats), and to the *Essential Fish Habitat Assessment* white paper (USDOI, BOEM, 2016d). Because wide variations in habitat usage can occur throughout a species’ life history, potential impacts have been analyzed in three broad habitat categories (i.e., estuarine, coastal, and oceanic) and one life history category (i.e., ichthyoplankton). These categories are not divided by fixed boundaries but by generalized conditions and characteristics typical of the habitat where a fish or invertebrate may spend the bulk of its life, although individuals are likely to use multiple habitat types and/or move frequently through different areas of the water-column, including surface waters.

Estuarine

Estuaries are typically semi-enclosed areas where marine saltwater is diluted by freshwater and where salinity may vary widely from day to day. The freshwater input (e.g., bayou, stream, or river) delivers sediment and nutrients that result in turbid, productive environments. Estuaries include many important habitat types (e.g., wetlands, seagrasses, and mudflats) and are frequently areas with high biomass. However, these environments can also have high energetic costs for resident organisms due to the fluctuating conditions. Many of the fishes and invertebrates found in mid- or near-shelf waters are dependent on or opportunistically make use of estuaries at some point in their life cycle. For example, estuaries provide nursery habitat for Gulf menhaden (*Brevoortia patronus*), spotted sea trout (*Cynoscion nebulosus*), blue crab (*Callinectes sapidus*), brown shrimp (*Farfantepenaeus aztecus*), and gag (*Mycteroperca microlepis*). The eastern oyster (*Crassostrea viginica*) is an example of a species that both benefits from the environmental conditions in estuarine habitat and serves as an important substrate. Bull sharks (*Carcharhinus leucas*) opportunistically make use of estuarine habitat and are common in estuaries and coastal waters. Estuaries may be subject to extreme tidal exchange, strong currents, water-column stratification, and/or rapid fluctuations in dissolved oxygen.

Coastal

Coastal waters are defined here as those waters extending from the shoreline seaward over the continental shelf. These waters are enriched by organic material exported from the estuaries and rivers of the GOM and support the greatest biomass of the three categories. Many species in the coastal waters of the GOM exploit the entire water column; the following subcategories are used to distinguish between zones in which species are predominantly found.

Coastal Pelagics

Pelagic fishes are primarily found in waters associated with neither the shore nor the seafloor. Commercial fishery landings are one of the best sources of information for coastal pelagic fishes because these species are an important component of regional fisheries. Coastal pelagic species traverse shelf waters of the region throughout the year. Major coastal pelagic families occurring in the region include

- Carcarhinidae (requiem sharks),
- Elopidae (ladyfish),
- Engraulidae (anchovies),
- Clupeidae (herrings),
- Scombridae (mackerels and tunas),
- Carangidae (jacks and scads),
- Mugilidae (mullets),
- Pomatomidae (bluefish), and
- Rachycentridae (cobia).

The distribution of most species depends upon water-column characteristics that vary spatiotemporally. Coastal pelagic species with an affinity for vertical structure are often observed around topographic features and offshore platforms, where they are best classified as transients rather than resident fishes. Spawning typically occurs over the mid- or inner-continental shelf, eggs and larvae are pelagic, and juveniles are common in estuaries and coastal waters. Coastal pelagic fishes can be divided into two general groups: large predatory species (e.g., Spanish mackerel, cobia, and coastal sharks); and smaller, omnivorous and herbivorous species, such as Gulf menhaden and striped mullet (*Mugil cephalus*). Members of both groups may form large schools. The predatory species typically undergo migrations, grow rapidly, mature early, and exhibit the ability to produce a large number of eggs, while the latter group includes many estuarine-dependent species that are frequently preyed upon by members of the first group. These fishes are ecologically important to energy transfer in the nearshore environment and, in many cases, are subject to significant fishing pressure. Large schools of squid (e.g., *Doryteuthis pealeii* and *Lolliguncula brevis*) can also be found over the continental shelf, and many less well-known cephalopods inhabit the GOM, ranging from nearshore waters to oceanic waters (Voss and Brakoneicki, 1985; Felder et al., 2009).

Coastal Demersal

Most of the benthic habitat in the northern GOM can be described as low-relief soft bottom habitat (i.e., mud, clay, and sand). Demersal fish and benthic invertebrates live and forage at the seafloor. White shrimp (*Litopenaeus setiferus*), hardhead catfish (*Arius felis*), Atlantic croaker (*Micropogonias undulatus*), and cownose rays (*Rhinoptera bonasus*) are common to inshore soft bottom habitat. Over the inner- and mid-shelf, and in association with deeper topographic features, red snapper (*Lutjanus campechanus*) provide an example of an opportunistic fish. This species feeds on the bottom and throughout the water column. Older and larger fish inhabit open bottom and habitat with vertical structure, whereas young adults tend to recruit to habitat with vertical structure (Gallaway et al., 2009). Scattered low-relief hard bottom features and several significant higher relief features are located on the shelf. Thirteen banks have been identified by the Gulf of Mexico Fisheries Management Council (GMFMC) as being important features in the northwestern GOM, and these banks are designated as habitat areas of particular concern (HAPCs). More information on HAPCs is available in the *Essential Fish Habitat Assessment* white paper (USDOI, BOEM, 2016d). Where hard bottom occurs, demersal species and opportunistic reef fish species more commonly associated with the mid- or inner-shelf may also be found. Species particularly adapted for deeper hard bottom areas include snowy grouper (*Epinephelus niveatus*), yellowedge grouper (*Epinephelus flavolimbatus*), and gag. Outer shelf demersal assemblages (approximately 656- to 984-ft [200- to 300-m] water depth) might include three-eye flounder (*Ancylopsetta dilecta*), deepbody boarfish (*Antigonia capros*), and armored searobins (*Peristedion miniatum*).

Oceanic

For purposes of this impact analysis, oceanic waters are generally defined as those waters seaward of the continental shelf, although oceanographic features and storms can cause these waters to intrude over the mid- or inner-shelf. Information on the distribution and abundance of oceanic species comes from commercial longline catches, recreational fishing surveys, and relatively few independent research efforts. Pelagic fishes occur throughout the water column in the open ocean. Within this vast habitat, water-column structure (i.e., temperature, salinity, and turbidity) is the primary means of partitioning for analyses. In general, pelagic fishes recognize different watermasses based upon physical and biological characteristics. The following subcategories are used to distinguish among assemblages based on predominant depth inhabited: epipelagic – extends from the surface to a depth of 656 ft (200 m); mesopelagic – extends from 656 to 3,281 ft (200 to 1,000 m); and bathypelagic – includes depths greater than 3,281 ft (1,000 m). The demersal category is also included and encompasses those species associated with the deep seafloor.

Epipelagic

Oceanic epipelagic species occur throughout the GOM, especially at or beyond the shelf edge. Epipelagics are reportedly associated with mesoscale hydrographic features such as fronts, eddies, and discontinuities. Many of the oceanic fishes also associate with drifting *Sargassum*, which provides forage areas and/or nursery refugia (**Chapter 4.5,** *Sargassum* and Associated Communities). Common fishes in this zone include halfbeaks and flying fishes (Exocoetidae), and early life stage driftfishes (Ariommatidae). Several well-known large predators are also epipelagic species, including bluefin tuna (*Thunnus thynnus*), swordfish (*Xiphias gladius*), dolphinfish (*Coryphaena hippurus*), wahoo (*Acanthocybium solanderi*), and shortfin mako (*Isurus oxyrinchus*). The lower section of this epipelagic zone has a distinct fauna, consisting of the poorly known oarfishes and its relatives, in addition to fishes with great depth ranges such as tunas (Scombridae) and swordfishes (Xiphiidae) (McEachran and Fechhelm, 1998). Adult driftfishes are generally found at depths bridging the lower epipelagic and upper mesopelagic zones.

Mesopelagics

The mesopelagic realm is below the photic zone and below the permanent thermocline. 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; 656-3,281 ft) to feed in higher, food rich layers of the water column (McEachran and Fechhelm, 1998). Mesopelagic fishes are ecologically important because they transfer substantial amounts of energy between mesopelagic and epipelagic zones over each diel cycle.

Bathypelagics

The deeper dwelling bathypelagic fishes inhabit the water column at depths >1,000 m (3,281 ft) and seldom migrate into shallower waters. This zone receives no sunlight and temperatures range from 4 °C to 10 °C (39 °F to 50 °F). Numerous species of gonostomatids (bristlemouths or lightfishes) and scaleless black dragonfishes (Melanostomiidae) are found in the bathypelagic of the GOM. Like mesopelagic fishes, most species are capable of producing and emitting light (bioluminescence) to aid in communication in an environment devoid of sunlight (Snyder, 2000).

Demersal

Three major deep-sea studies have collected demersal fish throughout the depth range of the GOM's continental slope between the 1960's and as recently as 2003. The families Macrouridae (grenadiers or rattails), Ophidiidae (cuskeels), and Alepocephalidae (slickheads) dominated the samples (Rowe and Kennicutt, 2009). Analysis of the data suggested an upper slope assemblage between 1,033 and 2,575 ft (315 and 785 m), a mid-slope assemblage between 2,251 and 4,491 ft (686 and 1,369 m), and a deep assemblage between 5,030 and 10,089 ft (1,533 and 3,075 m) (Rowe and Kennicutt, 2009). Shelf edge and upper slope species include tilefish (*Lopholatilus chamaeleonticeps*) and snowy grouper (*Epinephelus niveatus*).

Ichthyoplankton

Most fishes inhabiting the GOM, whether benthic or pelagic as adults, have pelagic larval stages. For the duration of this stage, these eggs and larvae 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). In general, the distribution of fish larvae depends on the spawning behavior of adults, hydrographic structure and transport at a variety of scales, duration of the pelagic period, behavior of larvae, larval mortality, and growth (Leis, 1991). Larval fishes are highly dependent on zooplankton until they can feed on larger prey.

Two important hydrographic features in the GOM are the Mississippi River discharge plume and the Loop Current. Combined with wind regimes in the region, these features strongly influence the transport and distribution of pelagic eggs and larvae. Water from the Mississippi River exits from several passes, delivering approximately one-third its volume to the Mississippi-Alabama shelf and two-thirds to the Texas-Louisiana shelf. The convergence and mixing of this many plumes is associated with continually reforming turbidity fronts and an accumulation of larvae at the plume boundary (Wiseman and Sturges, 1999). Planktonic eggs and larvae also become concentrated at the frontal boundaries of the Loop Current, shed rings, and gyres. Entrained *Sargassum* provides nursery habitat and refuge for many of these early life stage fish, and upwelling at the edges of the Loop Current and rings delivers nutrient-enriched waters to the surface, increasing primary production. Frontal waters of both the river plume and eddy boundaries provide feeding and growth opportunities for larvae.

Managed Species

For purposes of this analysis, managed species are those identified in a fishery management plan by a regional fishery management council or as a federally managed species. These species are subject to monitoring and management regulations. Fish species currently managed in the GOM are listed in Table D-1 of the *Essential Fish Habitat Assessment* white paper (USDOI, BOEM, 2016d). Detailed descriptions 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) and updated in the "Essential Fish Habitat Generic Amendment 3" (GMFMC, 2005).

Information on federally managed species and EFH is provided in the Consolidated Atlantic Highly Migratory Species Fishery Management Plan and amendments. These fishes and invertebrates are included in the preceding categories and are considered in the respective analyses for impacts below. Increased susceptibility to potential impacts as a result of fishing pressures will be discussed in the "Cumulative Impacts" section below.

4.7.2 Environmental Consequences

This chapter provides detailed information regarding the impact-producing factors from routine activities, accidental events, and cumulative impacts described in **Chapter 3** and their potential effects on fish and invertebrate resources that would potentially result from a proposed action or the alternatives. This analysis applies to all considered alternatives. While the WPA is a smaller area with less projected activity than is proposed for the CPA/EPA (refer to **Chapter 3**), the distribution of fishes and invertebrate species is nonrandom and species are associated with habitat preferences. However, within the Gulf of Mexico, distribution of species may generally be even throughout their range of habitat within the planning areas. As such, the potential for impacts to populations is independent of the planning area(s) analyzed. Differences in the specific populations potentially exposed to impact-producing factors and the potential impacts may be more easily estimated as specific sites and activities become known. Therefore, because of the diversity and distribution of species in the Area of Interest, the level of impacts would be the same for Alternatives A, B, C, and D. However, Alternative E would have no impacts as a proposed action would not be implemented; therefore, the only impacts would be those associated with the continuing effects from past lease sales and non-OCS oil- and gas-related activities. Following this environmental consequences chapter, there will be a summary of the potential impacts as they relate to the action alternatives.

4.7.2.1 Routine Activities

Routine OCS oil- and gas-related activities that take place on the OCS as a result of a proposed action and that produce sound, disturb the seafloor, or otherwise modify the habitat, could impact fish and invertebrate resources. A full list of impact-producing factors and scenarios for routine activities can be found in **Chapter 3.1**.

Anthropogenic Sound

Natural background noise in a marine environment is the result of physical processes (i.e., wind, wave action, tidal movement, and geological activity) and bioacoustic signals (Wysocki and Ladich, 2005; Hildebrand, 2009; Radford et al., 2010; Ladich, 2013). Acoustic signaling in the marine environment is extremely efficient, so marine species have evolved several mechanisms for producing and receiving sound. Important sound-mediated behaviors can include spawning aggregations, larval settlement, territorial disputes, and predator-prey detection (Radford et al., 2010 and 2014; Slabbekoorn et al., 2010). Despite the growing body of information on fishes, there is comparatively little information available on sound detection and sound-mediated behaviors for marine invertebrates (Mooney et al., 2012; Normandeau Associates, 2012; de Soto et al., 2013;

Popper et al., 2014; Samson et al., 2014). The diversity of marine fishes and invertebrates suggests the small number of studied species may not be representative of the full range of auditory sensory mechanisms and hearing capabilities. Therefore, caution was used in extrapolating potential impacts to fishes and invertebrate resources from documented behavioral responses and physiological impacts resulting from exposure to anthropogenic sound sources. For purposes of this analysis, it was deemed reasonable to use observed results as an indication of the types of impacts that may occur as a result of expected discrete and cumulative exposures to anthropogenic sound produced by routine OCS oil- and gas-related activities.

All routine OCS oil- and gas-related activities have some element of sound generation. Common sound sources include propeller cavitation, rotating machinery, and reciprocating machinery, which are associated with routine OCS oil- and gas-related activities such as vessel traffic, drilling, construction, and oil and gas production, processing, and transport. Sound introduced into the marine environment as a result of human activities has the potential to affect marine organisms by stimulating behavioral response, masking biologically important signals, causing temporary or permanent hearing loss (Popper et al., 2005; Popper et al., 2014), or causing physiological injury (e.g., barotrauma) resulting in mortality (Popper and Hastings, 2009). The potential for anthropogenic sound to affect any individual organism is dependent on the proximity to the source, signal characteristics, received peak pressures relative to the static pressure, cumulative sound exposure, species, motivation, and the receiver's prior experience. In addition, environmental conditions (e.g., temperature, water depth, and substrate) affect sound speed, propagation paths, and attenuation, resulting in temporal and spatial variations in the received signal for organisms throughout the ensonified area (Hildebrand, 2009).

Sound detection capabilities among fishes vary. All fishes are able to detect low-frequency particle motion at short ranges by means of the otolith and lateral line organs (Popper et al., 2003). Detection of the particle velocity and the ability to determine the position of the source is only possible over distances of 1-2 body lengths, but it is important for orientation in flowing water and maneuvering in close proximity to other organisms (Popper et al., 2014). Species with a swim bladder and accessory structure close to or in contact with the inner ear have increased hearing sensitivity and a wider range of detectable frequencies than do fishes with a swim bladder only or fishes with no gas-filled structure (Popper et al., 2003). For most fish species, it is reasonable to assume hearing sensitivity to frequencies below 500 Hertz (Hz) (Popper et al., 2003 and 2014; Popper and Hastings, 2009; Slabbekoorn et al., 2010; Radford et al., 2014). Ambient noise may be divided into three general frequency bands (i.e., low, medium, and high), each dominated by different sound sources (Hildebrand, 2009). The band of greatest interest to this analysis, low-frequency sound (30-500 Hz), has come to be dominated by anthropogenic sources and includes the frequencies most likely to be detected by most fish species. For example, the noise generated by large vessel traffic typically results from propeller cavitation and falls within 40-150 Hz (Hildebrand, 2009; McKenna et al., 2012). This range is similar to that of fish vocalizations and hearing, and could result in a masking effect.

Masking occurs when background noise increases the threshold for a sound to be detected; masking can be partial or complete. If detection thresholds are raised for biologically relevant signals, there is a potential for increased predation, reduced foraging success, reduced reproductive success, or other effects. However, fish hearing and sound production may be adapted to a noisy environment (Wysocki and Ladich, 2005). There is evidence that fishes are able to efficiently discriminate between signals, extracting important sounds from background noise (Popper et al., 2003; Wysocki and Ladich, 2005). Sophisticated sound processing capabilities and filtering by the sound sensing organs essentially narrows the band of masking frequencies, potentially decreasing masking effects. In addition, the low-frequency sounds of interest propagate over very long distances in deep water, but these frequencies are quickly lost in water depths between ½ and ¼ the wavelength (Ladich, 2013). This would suggest that the potential for a masking effect from low-frequency noise on behaviors occurring in shallow coastal waters may be reduced by the receiver's distance from sound sources, such as busy ports or construction activities.

Pulsed sounds generated by OCS oil- and gas-related activities (e.g., impact-driven piles and airguns) can potentially cause behavioral response, reduce hearing sensitivity, or result in physiological injury to fishes and invertebrate resources. Impact pile-driving during OCS construction and on-lease seismic activity are both temporally and spatially limited activities. The effects of these sound-producing activities would extend only to communities of fishes and invertebrates within a relatively small area. Benthic fishes and invertebrates could receive sound waves propagated through the water and sound waves propagated through the substrate. However, Wardle et al. (2001) found that, although fishes and invertebrates associated with a reef exhibited a brief startle response when exposed to pulsed low-frequency signals, disruption of diurnal patterns was not observed. Fishes disturbed by the noise were observed to resume their previous activity within 1-2 seconds and only exhibited flight response if the airguns were visible when discharged (Wardle et al., 2001). Other studies of fishes exposed to pulsed anthropogenic sound signals in natural environments have produced a wide range of results suggesting that species, experience, and motivation are very important factors, and indicating that habituation may occur (Engås et al., 1996; Løkkeborg et al., 2012; Popper et al., 2014). Organisms in close proximity to a pulsed sound source are at increased risk of barotrauma. A signal with a very rapid rise and peak pressures that vary substantially from the static pressure at the receiver's location can cause physiological injury or mortality (Popper et al., 2014). However, the range at which physiological injury may occur is short (<10 m; <33 ft) and, given fish avoidance behavior, the potential for widespread impacts to populations as a result of physiological injury is **negligible**.

Despite the importance of many sound-mediated behaviors and the potential biological costs associated with behavioral response to anthropogenic sounds, many environmental and biological factors limit potential exposure and the effects that OCS oil- and gas-related sounds have on fishes and invertebrate resources. The overall impact to fishes and invertebrate resources due to anthropogenic sound introduced into the marine environment by OCS oil- and gas-related routine activities is expected to be **minor**.

Bottom-Disturbing Activities

For the purpose of this analysis, bottom-disturbing activities are distinguished from habitat modification by the relatively short period of time over which disturbances occur. Anchoring, drilling, trenching, pipe-laying, and structure emplacement are examples of OCS oil- and gas-related activities that disturb the seafloor. The specific activity, ocean currents, and water depth can affect the extent of the water column and seafloor disturbance, and the magnitude of the effect. For example, drilling an exploratory well produces approximately 2,000 metric tons (2,205 tons) of combined drilling fluid and cuttings, though the total mass may vary widely for different wells (Neff, 2005). Cuttings discharged at the surface tend to disperse in the water column and are distributed at low concentrations (CSA, 2004b). In deep water, cuttings discharged at the sea surface may spread 3,280 ft (1,000 m) from the source, with the majority of the sediment deposited within 820 ft (250 m) of the well (CSA, 2006). Drilling mud plumes may be visible 0.6 mi (1 km) from the discharge point, but the plumes rapidly become diluted (Shinn et al., 1980; Hudson et al., 1982; Neff, 2005). Cuttings shunted to the seafloor form piles concentrated within a smaller area than that affected by sediments discharged at the sea surface (Neff, 2005). Emplacement of infrastructure (i.e., pipelines, platforms, and subsea systems) can also displace large volumes of sediment, resulting in increased turbidity and sedimentation (**Chapter 3.1.3.3**).

Turbidity and sedimentation resulting from routine OCS oil- and gas-related activities are short term and have localized effects (**Chapter 3.1.3.3.3**). The potential impacts to fishes and invertebrates (e.g., reduced feeding efficiency, decreased predator avoidance, and behavioral responses) may be related to species-specific behaviors and habitat preference (Minello et al., 1987; Benfield and Minello, 1996; Chesney et al., 2000; de Robertis et al., 2003; Jönsson et al., 2013; Lunt and Smee, 2014). Mobile fishes and invertebrates are expected to avoid the heaviest sedimentation and highest suspended sediment loads within 33 ft (10 m) of a disturbance. Icthyoplankton cannot avoid sediment plumes at or near the surface and may be exposed for longer durations than adults. However, evidence suggesting increased turbidity, which may reduce hatching success or delay larval development, is limited, and other studies have shown larval foraging success and growth may benefit from nutrient-rich plumes (Wenger et al., 2014; Gray et al., 2012). Coastal fishes and invertebrate species adapted to turbid environments, such as shallow bays, estuaries, and coastal habitat influenced by the Mississippi River plume, may be less affected by increased turbidity than species typically inhabiting less turbid environments.

Due to a combination of the spatiotemporally limited nature of suspended sediment plumes resulting from bottom-disturbing activities, avoidance behaviors, and a range of tolerances for various environmental conditions, the overall impact to fishes and invertebrate resources as a result of bottom disturbances associated with OCS oil- and gas-related routine activities is expected to be **negligible**.

Habitat Modification

For purposes of this analysis, the installation of platforms, pipelines, and subsea systems, or the construction of other facilities within a marine environment constitutes habitat modification.

Although these structures are temporary (refer to **Chapter 3.1.6**, Decommissioning and Removal Operations; **Chapter 3.1.6.2**, Artificial Reefs; and **Chapter 3.3.2.1.2**, Artificial Reefs, for more information), the operational life is long term and may impact the distribution of species in an area (Carr and Hixon, 1997; Gallaway et al., 2009; Shipp and Bortone, 2009). It is generally assumed that artificial structures serve as both fish-attracting and production-enhancing devices, depending upon the species (Carr and Hixon, 1997; Gallaway et al., 2009; Shipp and Bortone, 2009). The resulting assemblages frequently include commercially and recreationally valuable coastal and oceanic fishes. The well-known association with OCS oil- and gas-related structures attracts fishermen targeting these species and may subject some fishes to locally increased fishing pressure (Dance et al., 2011; Addis et al., 2013). However, infrastructure or pipeline removal also impacts fishes and invertebrates associated with the substrate. Removal of the structure is necessary to restore the seafloor to the original soft bottom habitat, but it would likely result in an altered community as the restored site is recolonized. The removal of hard substrate may result in community-level changes, such as an overall reduction in species diversity of epifaunal organisms, fishes, and invertebrates (Schroeder and Love, 2004).

Fish mortality can occur as a result of decommissioning operations using explosive severance methods; however, a study of the associated mortality for three commercially important fishes indicated that the level of explosive severance activity in the GOM did not significantly alter stock assessments (Gitschlag et al., 2001). To account for inherent variations in species composition and abundance among platforms (e.g., Stanley and Wilson, 1997; Gitschlag et al., 2001; Stanley and Wilson, 2000; Wilson et al., 2003), mortality estimates were doubled and stock estimates were recalculated. Although the study was limited and cannot be directly applied to all species or habitats, it is reasonable to assume that other represented fish populations would respond similarly. Impacts to sessile benthic organisms (e.g., barnacles and bivalves) and many mobile invertebrates (e.g., shrimp and crabs) that do not possess swim bladders are expected to be minimal (Keevin and Hempen, 1997; Schroeder and Love, 2004) because it is typically the rapid expansion and contraction of gas-filled spaces in response to pressure changes that results in the greatest physiological injury. Larvae and small juvenile fishes have been found to be more susceptible to injury from shock waves than large juveniles or adults (Govoni et al., 2008). At the projected rate of removal, these activities are not expected to have a substantial negative impact on stocks of managed fishes or other fishes and invertebrates associated with OCS oil- and gas-related infrastructure.

Some structures may be converted to artificial reefs. If portions of a platform were permitted to be reefed in place, the hard substrate and encrusting communities would remain part of the benthic habitat. The diversity of the community would change due to the reduced presence in the water column, but some associated fish species would be expected to continue use of the structure. Structures removed and redeployed as artificial reef substrate at another location may support substantially different communities, depending on the environmental characteristics of the reef site and other factors. The plugging of wells and other decommissioning activities that disturb the seafloor would impact benthic communities as discussed above.

Some ichthyoplankton studies have been conducted, focusing specifically on the influence of offshore platforms. The first of these projects investigated the potential role of platforms as nursery habitat for larvae or refugia for postlarval and juvenile fish (Hernandez et al., 2001). A follow-up study by Shaw et al. (2002) used data collected at several platforms both east and west of the Mississippi River Delta to examine the significance of platforms to larval and juvenile fishes. Both Hernandez et al. (2001) and Shaw et al. (2002) found highest taxonomic richness and diversity at mid-shelf platforms. Results indicated the distribution of larval and juvenile life stages is influenced by across-shelf gradients of increasing depth, similar to the distribution of adult fishes. Differences observed in the abundance of certain taxa in larval and juvenile fish assemblages across longitudinal gradients may reflect differences in the hydrographic conditions and/or habitat availability (Shaw et al., 2002). These results indicate the predominant factors influencing the distribution of larvae and juvenile life stages are environmental conditions and the distribution of adult conspecifics. Therefore, emplacement and/or removal of OCS oil- and gas-related infrastructure as the result of a proposed action is expected to have a **negligible** impact on the distribution or abundance of ichthyoplankton.

Although fish and invertebrate resources may be affected by habitat modifications due to routine OCS oil- and gas-related activities, there is no evidence suggesting that population-level impacts would occur as a result of a proposed activity. Due to the localized nature of the effects and limited number of structure installations and removals anticipated, impacts to fishes and invertebrate resources as a result of routine OCS oil- and gas-related activities are expected to range from **negligible** for most species to **minor** for species most commonly associated with OCS oil- and gas-related platforms (e.g., sharpnose puffer [*Canthigaster rostrate*], gray triggerfish [*Balistes capriscus*], great barracuda [*Sphyraena barracuda*], and red snapper).

4.7.2.2 Accidental Events

Accidental events resulting in a release of oil or other contaminants ("spills") could adversely affect fish and invertebrate resources. Although an unlikely occurrence, a subsea loss of well control would also suspend large amounts of sediment. For the reasons stated above ("Bottom-Disturbing Activities"), the potential effects of suspended sediments would be **negligible**. This section will address the potential effects to fishes and invertebrate resources resulting from direct and indirect exposure to spilled oil. Oil spills, historic trends, the characteristics of oil, and factors affecting the fate of oil released into the marine environment are discussed in **Chapter 3.2.1**, and the potential effects on water quality are analyzed in **Chapter 4.2** (Water Quality).

The effects of spills in open waters of the OCS proximate to mobile adult fishes would likely be sublethal; potential effects would be reduced because adult fish have the ability to avoid adverse conditions, metabolize hydrocarbons, and excrete metabolites and parent compounds. However, dispersal and emulsification of spilled oil can increase bioavailability to fishes and invertebrates throughout the water column. Some filter feeders, such as Gulf menhaden, may have an increased risk of exposure due to the likelihood of ingesting high levels of dispersed oil. Increased contaminant exposure could result in a higher incidence of chronic sublethal impacts (Millemann et al., 2015). Similarly, adsorption of oil to suspended particulate matter and subsequent sedimentation increases the potential for chronic exposure of demersal fishes and benthic invertebrates to oil (Murawski et al., 2014; Baguley et al., 2015; Snyder et al., 2015). Long-term impacts to fish and invertebrate populations in the GOM have not been identified, but studies suggest short-term impacts, including increased metabolic costs, immunosuppression, and histological lesions (Carls et al., 1998; Brewton et al., 2013). As a result of these effects, fitness and productivity of affected individuals may be decreased.

Oil floating on the surface could directly contact ichthyoplankton found at or near the surface, coating eggs and larvae. Most ichthyoplankton would be unable to avoid spills and the affected individuals may be at risk of death, delayed development, abnormalities, endocrine disruption, or other effects, resulting in decreased fitness and reduced survival rates (Incardona et al., 2014; Mager et al., 2014; Brown-Peterson et al., 2015; Snyder et al., 2015). In general, early life stages are more sensitive to acute oil exposure than adults, but some research indicates that embryos, depending on the developmental stage, may be less sensitive to acute exposure than larval stages (Fucik et al., 1995). Spills reaching estuarine habitat or overlapping spatiotemporally with a spawning event have the greatest potential for affecting the early life stages of fishes and invertebrates.

Effects from an accidental event would be expected to be localized; accidental spills have historically been small and are low-probability events (**Tables 3-12 and 3-17**). Most fishes and invertebrates in the GOM are broadly distributed throughout one or more regions of the GOM and, typically, only a small portion of a population would be impacted (McEachran, 2009). Studies indicate that the impacts of previous accidental spills have not resulted in population-level effects (Fodrie and Heck, 2011; Moody et al., 2013; Rooker et al., 2013; Murawski et al., 2014; Fry and Anderson, 2014). However, long-term impacts could be masked by many factors (e.g., natural population variability, natural and anthropogenic disturbances, and compensatory processes) and may not be observed for several years (Fodrie et al., 2014). Therefore, the overall impact to fishes and invertebrate resources due to reasonably foreseeable accidental spills resulting from routine OCS oil- and gas-related activities is expected to be **negligible**.

4.7.2.3 Cumulative Impacts

The OCS oil- and gas-related activities resulting from a lease sale are assumed to occur over a period of 50 years. However, available information is insufficient to conduct an analysis of impact-producing factors potentially affecting fish and invertebrate resources over the same period. The unknown influence of changing environmental, biological, and anthropogenic factors over such an extended period could exceed that of analyzed impact-producing factors. Therefore, this section assumes an analysis of reasonably foreseeable cumulative impacts to encompass a period of approximately 20 years. This cumulative analysis considers the effects on fishes and invertebrate resources of the Gulf of Mexico as a result of the OCS Program, State oil and gas activity, recreational and commercial fishing (**Chapters 4.11 and 4.10**, respectively), and habitat availability. The incremental impact of a single proposed lease sale combines the effects of the associated routine activities and accidental events described in **Chapters 4.7.2.1 and 4.7.2.2**, respectively. The expected incremental contributions (**Table 4-15**) are incorporated into this cumulative analysis. Potential degradation of specific habitats is analyzed in **Chapters 4.3** (Coastal Habitats), **4.4** (Deepwater Benthic Communities), **4.5** (*Sargassum* and Associated Communities), and **4.6** (Live Bottom Habitats). The direct and/or indirect impacts from cumulative OCS oil- and gas-related and non-OCS oil- and gas-related activities on essential fish habitat are considered and summarized in the *Essential Fish Habitat Assessment* white paper (USDOI, BOEM, 2016d).

OCS Oil- and Gas-Related Impacts

As discussed in the analysis of routine activities, OCS oil- and gas-related activities produce some level of anthropogenic sound, though signal characteristics vary widely. Geological and geophysical surveys, construction of new facilities, and decommissioning are episodic acoustic events and do not contribute to long-term changes in the soundscape. The OCS oil- and gas-related support vessel traffic, drilling, production facilities, and other sources of continuous sounds contribute to a chronic increase in background noise, with varying areas of effect that may be influenced by the sound level, frequencies, and environmental factors (Hildebrand, 2009; Slabbekoorn et al., 2010; McKenna et al., 2012). These sources have a low potential for causing physiological injury or injuring hearing in fishes and invertebrates (Popper et al., 2014). However, continuous sounds have an increased potential for masking biologically relevant sounds than do pulsed signals. The potential effects of masking on fishes and invertebrates is difficult to assess in the natural setting for communities and populations of species, but evidence indicates that the increase to background noise as a result of the OCS Program would be relatively minor. Therefore, it is expected that the cumulative impact to fishes and invertebrate resources in the GOM would be **minor** and would not extend beyond localized disturbances or behavioral modification. The incremental impact of a single proposed lease sale would be **minor**.

Sediment suspended by bottom-disturbing activities settles rapidly to the seafloor. Impacts from individual events are temporary, highly localized, and expected to impact small numbers of organisms. In nearshore and estuarine waters, the effects of temporarily increased turbidity would be indistinguishable from background conditions. Bottom-disturbing activities in outer-shelf and oceanic waters may temporarily affect fishes and invertebrates in the water column or bury sessile benthic organisms near the disturbance. The cumulative contribution to adverse impacts on these resources would be **negligible** due to the transient nature of the disturbance and the limited area affected. The incremental impact of a single proposed lease sale would be **negligible**.

Cumulative habitat modification as a result of OCS oil- and gas-related activities is spatially extensive and long term in nature. It has been hypothesized that the network of OCS oil- and gas-related infrastructure has resulted in changes in the distribution of some species (Shipp and Bortone, 2009; Gallaway et al., 2009). However, the total contribution of OCS oil- and gas-related infrastructure to hard substrate in the Gulf is small and is projected to decrease throughout the period covered by this analysis (Gallaway et al., 2009). Exceptions to the removal requirement may be permitted under specific circumstances; for more information, refer to **Chapters 3.1.6.2** (Artificial

Reefs) and **3.3.2.1.2** (Artificial Reefs). The cumulative impact of OCS oil- and gas-related habitat modification on fishes and invertebrate resources may be extensive for some species; therefore, cumulative impacts may range from **negligible** for most species to **moderate** for those species associated with OCS oil- and gas-related platforms (i.e., distribution and abundance may vary from historical values). The incremental impact of a single lease sale would be **negligible** to **minor**.

Non-OCS Oil- and Gas-Related Activities

Commercial shipping is the greatest anthropogenic source of low-frequency sound in the marine environment and, combined with many other sources (e.g., State oil- and gas-related activities, coastal construction, and recreational boating), contributes to increased background noise levels (Hildebrand, 2009; McKenna et al., 2012; Hawkins et al., 2014). As a result of increasing background noise, fishes and invertebrates may modify behaviors and biologically relevant sounds could be masked, but the effects are difficult to assess in the natural setting. Marine organisms evolved in a noisy environment and available information suggests that at least some fishes and invertebrates may have the capacity to adapt to increasing noise levels (Wardle et al., 2001; Wysocki and Ladich, 2005; Purser and Radford, 2011; Radford et al., 2014). However, even organisms adapted to increasing background noise could incur consequences from remaining in an environment continuously exposed to sound energy from anthropogenic sources. Potential effects would vary among species and across a range of environmental factors but may include reduced hatching rates, delayed development, or decreased reproductive potential (Slabbekoorn et al., 2010; Hawkins et al., 2014). The overall contribution of non-OCS oil- and gas-related anthropogenic sound sources to increasing background noise levels in the marine environment is expected to **moderately** impact fishes and invertebrate resources because increased background noise levels affect broad areas and can be reasonably assumed to have limited population-level impacts, but they would not be expected to result in a long-term decline in population.

The NMFS is responsible for implementing fisheries regulations and managing commercial and recreational fisheries, with advice from the regional fisheries management councils. Commercial and recreational fishing have been a factor in the decline of several fish populations in the GOM (Shipp, 1999; USDOC, NMFS, 2015a; NRC, 2014). Although several stocks are rebuilding or have been rebuilt, certain fishing practices and overfishing can have long-term effects on target species and the ecosystem. For example, the structure of a rebuilt stock may differ from historic demographics, resulting in a less resilient population, or habitat could be altered such that species diversity and abundance are affected (Wells et al., 2008; NRC, 2014; Pusceddu et al., 2014; Secor et al., 2014). The cumulative impact of long-term, large-scale fisheries activity on fishes and invertebrate resources in the GOM is not known, but NMFS has determined that assessed fish stocks are predominantly healthy (USDOC, NMFS, 2015a). Thus, it is expected that impacts to fishes and invertebrate resources as a result of commercial and recreational fisheries would range from **negligible** for most nontargeted species to **moderate** for species that are overfished or experiencing overfishing (e.g., hogfish spp., gray triggerfish, and greater amber jack [*Seriola dumerili*]).

The conversion or modification of wetlands as a result of agricultural, residential, and commercial development in the GOM has been substantial (USEPA, 2012b; Greene et al., 2014). The trend for coastal development is projected to continue into the future, although at a slower rate because of regulatory pressures (refer to **Chapter 4.3**, Coastal Habitats, for detailed information on these habitats, potential impacts, and mitigations). The conversion of habitat from one form to another (e.g., wetlands to open water) would typically result in community-level changes in biodiversity and abundance compared with communities in unmodified habitat (Lowe and Peterson, 2014; USDOC, NMFS, 2010a). Although changes to habitat may benefit some species while adversely impacting others, it is generally accepted that the quality (i.e., the ecological services provided) of modified habitat is not equivalent to natural habitat (Peterson and Lowe, 2009; Scyphers et al., 2015). Therefore, the continued loss or modification of wetlands could ultimately result in decreased recruitment for some estuarine-dependent species, adversely impacting stocks within the region (Levin and Stunz, 2005; Jordan et al., 2012). The current lack of a meaningful baseline makes it extremely difficult to estimate cumulative impacts to fishes and invertebrate resources at a regional scale. However, coastal zone management efforts increasingly incorporate the responses of fishes and invertebrates into analyses of development activities (Peterson and Lowe, 2009; Greene et al., 2014). The Federal, State, and local agencies jointly responsible for managing estuarine habitats, permitting development, and mitigating impacts ensure that sustainable development practices are implemented. Therefore, the cumulative adverse impact of coastal development on fishes and invertebrate resources is expected to be **minor**.

Additional pressures potentially contributing to cumulative effects on fishes and invertebrate resources in the GOM include increasing invasive species populations and climate change. These factors are currently negligible but could have increasingly substantial impacts in the future. Invasive species, such as the lionfish, have the potential to out-compete and displace some indigenous species of ecological, commercial, and/or recreational importance (Morris and Akin, 2009; Dahl and Patterson, 2014; Raymond et al., 2014). Although severe weather events are part of the natural environment and are not considered in an analysis of impact-producing factors, changing conditions that alter the frequency and/or severity of weather events or that accelerate sea-level rise could impact fishes and invertebrate resources in an unforeseen manner. A review of climate change is presented in Chapter 4.2.1 of the Five-Year Program EIS (USDOI, BOEM, 2016b).

The cumulative effect of combined past, present, and reasonably foreseeable future OCS oil- and gas-related activities and non-OCS oil- and gas-related activities on fishes and invertebrate resources of the Gulf of Mexico is expected to vary spatiotemporally. The incremental contribution of OCS oil- and gas-related activities to the combined cumulative impacts is generally **minor** in comparison with all other human activities affecting the resources. Impacts to fish and invertebrate populations are expected to be in proportion to the fraction of a population exposed to an impact-producing factor. Therefore, OCS oil- and gas-related habitat modification is likely to have a greater impact than other oil- and gas-related impact-producing factors of a more limited scale and duration. However, impacts are not universally adverse and some habitat modification may benefit particular species or communities. Commercial and recreational fishing are expected to have the greatest direct impact on fishes and invertebrate resources. Although NMFS manages fisheries, populations are affected by many biological and environmental factors. Fluctuations in populations of fisheries-affected species are expected. Increased background noise levels due to anthropogenic sources, such as commercial shipping, are also likely to affect deep waters of the GOM (Hildebrand, 2009). Although the effects are currently unknown, no impacts to fish and invertebrate populations in the GOM have been quantified. International efforts to develop and implement ship-quieting technologies may mitigate future increases in shipping capacity. As a result of these impact-producing factors, the overall cumulative impact on fishes and invertebrate resources may range from **minor** to **moderate** for different species throughout the period analyzed.

4.7.2.4 Incomplete or Unavailable Information

BOEM identified incomplete or unavailable information related to impacts to fishes and invertebrate resources resulting from OCS oil- and gas-related activities and non-OCS oil- and gas-related activities in the GOM. Anthropogenic sound and habitat modification directly or indirectly affect large areas of the GOM and potentially impact thousands of species. However, the response of individuals, groups of conspecifics (members of the same species), and communities are highly variable and inconsistent. In addition, BOEM recognizes that there is incomplete information with respect to potential long-term effects resulting from exposure to spilled oil. Although additional information on these impact-producing factors may be relevant to the evaluation of impacts to fishes and invertebrate resources, BOEM has determined that the incomplete information is not essential to a reasoned choice among alternatives. Analyses of routine activities, accidental events, and cumulative impacts drew upon the most current and best available research to assess the potential effects on many species and habitats. The findings collectively indicate that impacts are likely, but limited, and are not expected to induce a population-level response. BOEM recognizes the potential that populations with spatially limited distributions or increased sensitivity to an impact-producing factor may be more severely impacted than current research suggests. However, sufficient data to conduct a thorough assessment of all potentially affected species are not available or obtainable within the timeline contemplated in the NEPA analysis of this Multisale EIS. BOEM used the best available science to determine the range of reasonably foreseeable impacts and applied accepted scientific methodologies to integrate existing information and extrapolate potential outcomes in completing this analysis and formulating the conclusions presented here.

4.7.2.5 Alternatives A, B, C, and D

With respect to fishes and invertebrate resources, the effects associated with selection of any of the proposed action alternatives would be equivalent because of the diversity and distribution of fish and invertebrate species throughout the potential area of interest. The preceding analyses assumed a nonrandom distribution of species (i.e., distribution is associated with habitat preference and habitat availability) and considered impacts to fishes and invertebrate resources occurring in a wide range of habitats across all planning areas. While the WPA is a smaller area with less projected activity than is proposed for the CPA/EPA (refer to **Chapter 3**), the distribution of fishes and invertebrate species is nonrandom and generally even throughout their range of habitat within the planning areas. As such, the potential for impacts to populations is independent of the planning area(s) analyzed. Differences in the specific populations potentially exposed to impact-producing factors and the potential impacts may be more easily estimated as specific sites and activities become known. Therefore, at a planning area scale, it is expected that a similar mix of species would be exposed to the analyzed impact-producing factors, regardless of the specific action alternative selected. The analysis of routine activities and accidental events indicates that the incremental contribution to the overall cumulative impacts on fishes and invertebrate resources as a result of a single proposed lease sale would be **minor**. The activities proposed under Alternatives A, B, C, and D would directly impact fishes and invertebrate resources within the GOM and would contribute incrementally to the cumulative effects on these resources. Routine activities, excluding infrastructure emplacement, would be expected to have short-term and/or localized effects. The installation of OCS oil- and gas-related infrastructure constitutes a long-term modification of the local habitat. Individually, these modifications have small-scale (e.g., community-level) effects on the distribution and abundance of species; cumulatively, OCS oil- and gas-related infrastructure is hypothesized to have moderately impacted the distribution of some fishes and invertebrates, exceeding natural variations. Although this effect is not necessarily adverse and infrastructure is expected to be decommissioned and sites restored to natural habitat, the cumulative impact over the life of the OCS Program is spatiotemporally extensive with species-specific effects. Accidental spills are considered low-probability events, but they have the potential to produce localized impacts on fishes and invertebrate resources if coinciding with a spawning event. Mobile adults are expected to avoid adverse conditions, limiting exposure to spilled oil. The cumulative, long-term effects of exposure to oil are unknown, but available information suggests that the effects have been minor. The cumulative effects of habitat loss and increasing background noise levels are unknown, but the OCS oil- and gas-related contribution is small, relative to non-OCS oil- and gas-related impact-producing factors. Therefore, the analysis of routine OCS oil- and gas-related activities, accidental events, and the cumulative impacts of OCS oil- and gas-related and non-OCS oil- and gas-related activities indicates the expected overall impact to fishes and invertebrate resources, depending upon the IPF and the affected species, would range from **negligible** to **moderate** for the period analyzed. For example, muds and cuttings discharged at the surface for a well drilled at a water depth of 5,000-ft (1,524 m) would have a negligible impact on coastal species, such as menhaden, whereas a small spill in coastal waters and subsequent response activities could disrupt a spawning event or temporarily displace coastal fishes from the affected area (minor). Moderate impacts would only be expected if impact-producing factors affected habitat or populations to an extent that would be expected to exceed natural variations in population abundance or distribution but not result in a long-term decline.

4.7.2.6 Alternative E—No Action

Under Alternative E impacts on fishes and invertebrate resources within the Gulf of Mexico would be **none**. However, cumulative impacts would be unchanged from the conclusions reached for the other alternatives.

4.8 BIRDS

The analyses of the potential impacts of routine activities and accidental events associated with a GOM proposed action and a proposed action's incremental contribution to the cumulative impacts to coastal and migratory birds are presented in this chapter. The approach of the analysis is to focus on the potential impact-producing factors from OCS oil- and gas-related routine activities (i.e., exploration, development, and production), as well as accidental events and cumulative impacts, and to define the impact levels for each impact-producing factor. The impact-producing factors considered and analyzed include discharges and wastes, noise, platform severance with explosives, geophysical surveys with airguns, platform presence and lighting, emergency air emissions, platform or pipeline oil spills, spill response, oil- and gas-related activities in State waters, the hypoxic "dead zone" of the Mississippi River, net coastal wetland gain or loss, urbanization, a large tanker spill, military activities, recreation, boat traffic, impacts on bird habitat, collisions with vehicles and buildings, predation by domestic cats, commercial fishing, climate change, and wetland subsidence. The potential magnitude of impact for each of these impact-producing factors is provided in **Table 4-16** to help the reader quickly identify the level of potential impacts for each impact-producing factor. The impact-level definitions and the analyses supporting these conclusions are then discussed in detail in this chapter.

Impact-producing factors considered but not analyzed include obstruction lighting, which is under the jurisdiction of the USCG. Other impact-producing factors that were not analyzed because they do not apply to birds include geological ancillary activities, all onshore infrastructure emplacement and presence, offshore platform emplacement, other commissioning activities, and onshore waste disposal.

Seven species found in the area of interest are listed under the ESA, and BOEM has initiated formal consultation with FWS for those species. Those species have life histories that are similar to those of the birds covered in this chapter, but the cumulative impact could be greater. BOEM recognizes this, consults on these species, and requires mitigations that would decrease the potential for greater impacts due to small population size. For more information on the listed bird species, refer to **Chapter 4.9.4** (Protected Birds).

Table 4-16. Birds Impact-Producing Factors That Are Reasonably Foreseeable.

Birds	Magnitude of Potential Impact[1]				
Impact-Producing Factors	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
Routine Impacts					
Discharges and Wastes	Negligible	Negligible	Negligible	Negligible	None
OCS Oil- and Gas-Related Noise and Disturbance	Negligible	Negligible	Negligible	Negligible	None
Platform Severance and Rigs-to-Reefs	Minor	Minor	Minor	Minor	None
Geophysical Surveys with Airguns	Minor	Minor	Minor	Minor	None
Platform Presence and Lighting	Minor	Minor	Minor	Minor	None

Birds	Magnitude of Potential Impact[1]				
Impact-Producing Factors	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
Accidental Impacts					
Oil Spills	Moderate	Moderate	Moderate	Moderate	None
Oil-Spill Response	Minor	Minor	Minor	Minor	None
Emergency Air Emissions	Minor	Minor	Minor	Minor	None
Cumulative Impacts					
Incremental Contribution[2]	Moderate	Moderate	Moderate	Moderate	None
OCS Oil and Gas[3]	Moderate				
Non-OCS Oil and Gas[4]	Major				

[1] The analysis supporting these conclusions are discussed in detail in the "Environmental Consequences" chapter below. Moderate impact levels could be possible but only if a large oil spill were to occur.
[2] This impact level is the incremental contribution of a single proposed lease sale to all cumulative impacts in the GOM.
[3] This impact level is the cumulative impacts of all past, present, and reasonably forseeable OCS oil- and gas-related activities in the GOM.
[4] This impact level is the cumulative impacts of all past, present, and reasonably foreseeable activities in the GOM.

Impact-Level Definitions

Two concepts important in the impact-level definitions below are populations and population sizes. In ecology, a population is often defined as a group of individuals with similar genes (i.e., species and subspecies). Such a population lives in one or more natural geographic areas where its habitats are located. Human-made areas (e.g., the planning areas) are also important to the analysis. Natural areas overlap with the planning areas. Bird species described in this chapter are considered to have large populations and to be widely distributed. Flock size and population, mentioned below in the impact-level definitions, have ranges of impacts that can vary by bird species. Examples of flock sizes and population sizes are given in the "Description of the Affected Environment" chapter. Abundance, as used in this chapter, means the number or biomass (total weight) of a particular species in a general area (this definition is taken from Krebs [2009]). Chronic, as used in this chapter, means of indefinitely high frequency or of indefinitely long duration.

The impact-level definitions for birds are as follows:

- **Negligible** – Impacts would not affect a substantial abundance of birds. Impacts would especially not affect species with low abundances prior to impacts. Estimates of continued population viability, including predicted annual rates of recruitment or survival, would not change. Any impacts would be acute and reversible. Further, no injury to or mortality of a small number of individuals or a small flock would occur.

- **Minor** – Impacts would not affect a substantial abundance of birds. Impacts would especially not affect species with low abundances prior to impacts. Estimates of continued population viability, including predicted annual rates of recruitment or survival, would not change. Additionally, one or both of the two following conditions must be met: (1) small numbers of individuals or small flocks of birds would experience chronic impact-producing factors and would be chronically disturbed or affected, resulting in chronic but reversible behavioral changes; and/or (2) one or more incidents would occur where small numbers of individuals or small flocks of birds would experience injury or mortality, but with no measurable impact on a population.
- **Moderate** – Impacts would affect a substantial abundance of birds. Estimates of continued population viability, including predicted annual rates of recruitment or survival, would not change. Additionally, one or both of the two following conditions must be met: (1) a large flock of birds (e.g., a shorebird flock of 500 or 1,000 birds) would experience chronic impact-producing factors and would be chronically disturbed or affected, resulting in chronic behavioral changes or mortality over time; and/or (2) one or more incidents would occur where substantial numbers of individuals, including large flocks, would experience chronic behavior changes or mortality that would affect a large flock but with no measurable impact on a population.
- **Major** – Impacts would affect a substantial abundance of birds. Estimates of continued population viability, including predicted annual rates of recruitment or survival, would change. Additionally, one or both of the two following conditions must be met: (1) At least one large population of birds would have a reduction in the estimates of continued population viability, including predicted annual rates of mortality, recruitment or survival, some or all of which would seriously decline (causing sublethal impacts to be irreversible); and/or (2) one or more incidents would occur where at least one large population would experience chronic behavior changes or mortality that would affect a large population and with measurable impact on a population.

4.8.1 Description of the Affected Environment

This description of birds focuses on the factors that control the relative vulnerability of different bird groups to impacts. Passerines, or songbirds, represent many of the breeding and wintering birds within the Gulf Coast States. They are only found offshore when migrating across the Gulf of Mexico, and they cannot stop and rest or feed on the water. Some species of birds (some seabirds) live primarily offshore except when breeding and, therefore, are rarely observed in the nearshore environment. More information about seabirds is provided in the Five-Year Program EIS (USDOI, BOEM, 2016b). The remaining species are found within coastal and inshore habitats and may be more susceptible to potential deleterious effects resulting from OCS oil- and gas-related activities because many of these species largely overlap spatially and temporally with OCS oil- and gas-related activities, because of their abundance or density, and because of the potential of spilled oil impacting their habitat or food resources. A detailed analysis of the impacts to birds is presented in the chapters below.

Feeding Habits

A bird's feeding method is one of the important determinants of a bird's habitat choice. Bird species feed either in the water (aquatic feeders) or terrestrially. Aquatic bird species that feed by wading include some shorebirds and other waders such as herons. Some species have comparatively short legs and wade in relatively shallow water or walk on beaches to feed; other species feed in somewhat deeper as well as shallow water and have longer legs. Shorebirds are adapted to take advantage of tidally-influenced habitat. Their diurnal movements and habitat use appears to be closely linked to tidal advances and recessions, i.e., lunar, solar, or wind-driven tides. Shorebirds and other wading species feed on invertebrates and fish. Aquatic bird species, including some ducks, may feed by dabbling at the water surface. Many aquatic bird species, including some ducks and many seabirds, feed by diving into the water from the air or water surface for either plant or animal food. Some seabirds aggregate at patches of floating macroalgae *Sargassum* to feed or rest, at least in tropical waters (Haney, 1986). A list of examples of marine and coastal birds can be found in the Five-Year Program EIS (USDOI, BOEM, 2016b).

Oil from reasonably foreseeable spills is not expected to be very commonly encountered by birds. Still, birds are a relatively vulnerable resource because feeding habits may result in encounters between birds and OCS oil- and gas-related activity. For example, waders feed in shallow water, which is important because oil from previous spills that happened to reach the sediment may accumulate in the sediment, where birds may encounter it. Diving birds can encounter an oil slick either if they begin their dive in the air and pass across the water surface or if they begin their dive floating on the water surface. Birds may feed and roost in the water or at or near the water's edge, where they may be impacted by an oil spill. Marsh birds feed in or at the water's edge of marshes, where oil may accumulate in the sediment. Also, platforms may represent profitable foraging areas for seabirds, raptors, and potentially passerines (Wiese et al., 2001; Russell, 2005). More information about raptors and passerines is provided in the Five-Year Program EIS (USDOI, BOEM, 2016b).

Habitat

The open Gulf (including blue water [off the continental shelf], shelf, and inshore open water) is used by terrestrial birds (including passerines), shorebirds, long-legged wading birds, and raptors for trans-Gulf migration (Russell, 2005). More information on shorebirds is provided in the Five-Year Program EIS (USDOI, BOEM, 2016b). The open GOM is used by seabirds for feeding and roosting, and some seabirds never come ashore in the Gulf of Mexico. Wetlands (consisting of trees, shrubs, marshes, and/or unvegetated flats) (refer to **Chapter 4.3**, Coastal Habitats) are used by waterfowl, shorebirds, long-legged wading birds, secretive marsh birds (e.g., rails), raptors, and terrestrial birds (including passerines) for feeding, roosting, and/or nesting (Portnoy, 1978 and 1981; Hunter et al., 2006; Brown et al., 2001; and North American Waterfowl Management Plan, 2004). More information on waterfowl is provided in the Five-Year Program EIS (USDOI, BOEM, 2016b). Beaches and dunes are used by seabirds and shorebirds for feeding, roosting, and/or nesting (Portnoy, 1978 and 1981; Hunter et al., 2006). Coastal forests are used by trans-Gulf migrant terrestrial birds for feeding, roosting, and/or nesting. Several species breed along the coastline of the Gulf of Mexico (where spilled oil may travel and persist) and, therefore, may be especially vulnerable to the impacts of an oil spill. Previous surveys indicate that Louisiana, Texas, and Florida are among the primary states in the southern and southeastern U.S. for both nesting colonies and the total number of breeding coastal and marine birds (Portnoy, 1978 and 1981; Hunter et al., 2006). All avian species show varying levels of fidelity to both breeding and wintering areas. The global Important Bird Areas Program was developed by the National Audubon Society to identify and conserve areas that are vital to birds and other biota. More information on the program is provided in the Five-Year Program EIS (USDOI, BOEM, 2016b).

Population Ecology

The level of any impact to different species of birds depends on its population ecology, including the age or life stages and sex that are impacted. For example, relevant population ecology factors for seabirds includes delayed maturity, low reproductive potential, periodic nonbreeding, low first-year survival, and small clutch size. These factors can make them the most vulnerable to impacts. Relevant population ecology is not always available to explain oiling mortality from an oil spill because the sex and life stage of recovered oiled birds is not always known or recorded. For example, for the *Deepwater Horizon* explosion, oil spill, and response, only the species information was available, not the age, life stage, or sex of oiled birds. The location, magnitude, and other conditions of an impact-producing factor that may seem to have relatively low contact with and relatively reduced mortality for one species may in fact cause other bird species increased mortality and long-term impacts. Populations appear to be most sensitive to changes (even small decreases) in adult survival, particularly female survival because adult female survival appears to be the driver for these populations (Russell, 1999).

Migration

Some birds that utilize the GOM are year-round resident species. These species may be exposed to impacts during any time of the year. However, most of the bird species that utilize the GOM are migratory. They may breed or overwinter in the GOM, or stop over on the northern Gulf Coast while migrating. For example, some birds may breed on the coast and depart during the winter months. However, some birds breed in the northern United States or the Caribbean and overwinter offshore the GOM and never come ashore. As an example, the brown booby breeds in the Caribbean, Mexico, and Central America, while the white-tailed tropicbird breeds in the Caribbean. Some birds of both species overwinter in the pelagic GOM, but little is known about where they are located then in the GOM (Schreiber and Norton, 2002; Lee and Walsh-McGehee, 1998). All avian species show varying levels of fidelity to both breeding and wintering areas. Birds may be present in the Gulf of Mexico only during one or two of the following seasons: breeding and/or overwintering and/or migrating. Therefore, seasonal timing of an impact helps determine which species would be affected.

Each spring, vast numbers of birds migrate northward across the GOM enroute to breeding habitats in the United States and Canada from their wintering quarters in the neotropics. They depart in large numbers from the Yucatan Peninsula and the Isthmus of Tehuantepec (Russell, 2005). The path they take depends on supporting tail wind direction, which depends, in turn, on the presence of an East Continental High Pressure synoptic weather pattern over the continental United States or a Bermuda High Pressure synoptic weather pattern over the Atlantic Ocean around Bermuda (Russell, 2005). The East Continental Highs move east and become Bermuda Highs. During an East Continental High in spring, the birds may migrate especially from the east-southeast to the northwest Gulf of Mexico (**Figure 4-20**). During a Bermuda High in spring, the birds may migrate especially from the south-southeast to the northcentral Gulf of Mexico (**Figure 4-21**). They are mostly seed eaters and insectivores and, therefore, may stop over and feed on available insects but mostly not on aquatic organisms. An example of a spring migration corridor is for wood thrush, which migrates most densely from the Yucatan Peninsula across the central Gulf of Mexico (**Figure** 4-22). Synoptic weather patterns were not specified for this migration corridor. Following a short breeding season in the north, most of these birds return southward across the GOM; their numbers are then augmented by offspring produced over the summer (Russell, 2005). During an East Continental High in fall, an example of a fall migration route that could initiate in the north central Gulf of Mexico and terminate on the eastern Bay of Campeche, the Yucatan Peninsula, western Cuba, and northern Honduras is shown in **Figure 4-20**. In fall, few birds migrate during a Bermuda High. An example of a fall migration corridor is for wood thrush, which migrates most densely from Florida across the eastern Gulf of Mexico (**Figure 4-23**). Synoptic weather patterns were not specified for this migration corridor. Migrating songbirds may stop over on offshore platforms. Platform density with respect to migratory routes is shown in **Figure 4-24**, and its high spatial variability at a large scale suggests that the probability of a bird encountering one or more platforms is also highly variable for routes at a large scale. Migratory birds may also stop over on boats, other vessels, and coastal terrestrial habitat when crossing the GOM in the spring or fall. Three of the four migratory flyways in the United States depend on the GOM as part of their route. Executive Order 13186 protects migratory birds and emphasizes species of conservation concern. It requires analyses of birds in NEPA documents and a Memorandum of Understanding between the action agency (BOEM and BSEE) and FWS. Also, all migratory birds are protected under the Migratory Bird Treaty Act. The Act provides limits on when migratory birds can be taken, killed, possessed, transported, or imported.

For some bird species, both spring and fall migrations take place in a series of stops among various staging areas. At these staging areas, birds spend time primarily feeding to recover reserves necessary for the sustained flight to the next staging area (Norris, 2005; Krapu et al., 2006; Skagen, 2006). Many coastal habitats along the GOM are critical for such purposes.

More information on bird migration is provided in the Five-Year Program EIS (USDOI, BOEM, 2016b).

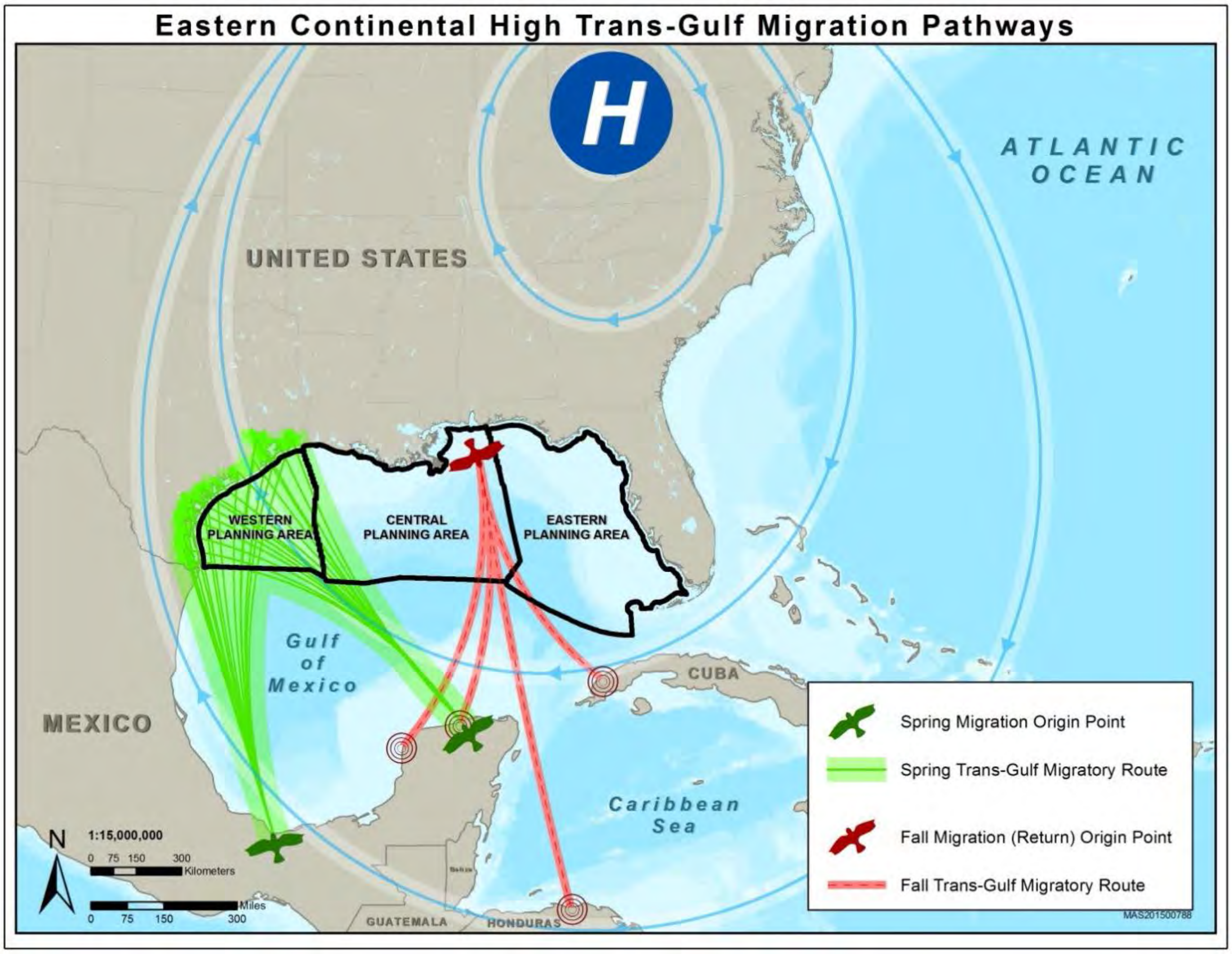

Figure 4-20. Migration Routes for Trans-Gulf Migratory Birds in the Presence of an Eastern Continental High. (The Eastern Continental High is indicated by the letter "H," and the corresponding clockwise somewhat concentric synoptic wind patterns are indicated by lines and arrows.)

Figure 4-21. Migration Routes for Trans-Gulf Migratory Birds in the Presence of a Bermuda High. (The Bermuda High is indicated by the letter "H," and clockwise somewhat concentric synoptic wind patterns are indicated by lines and arrows.)

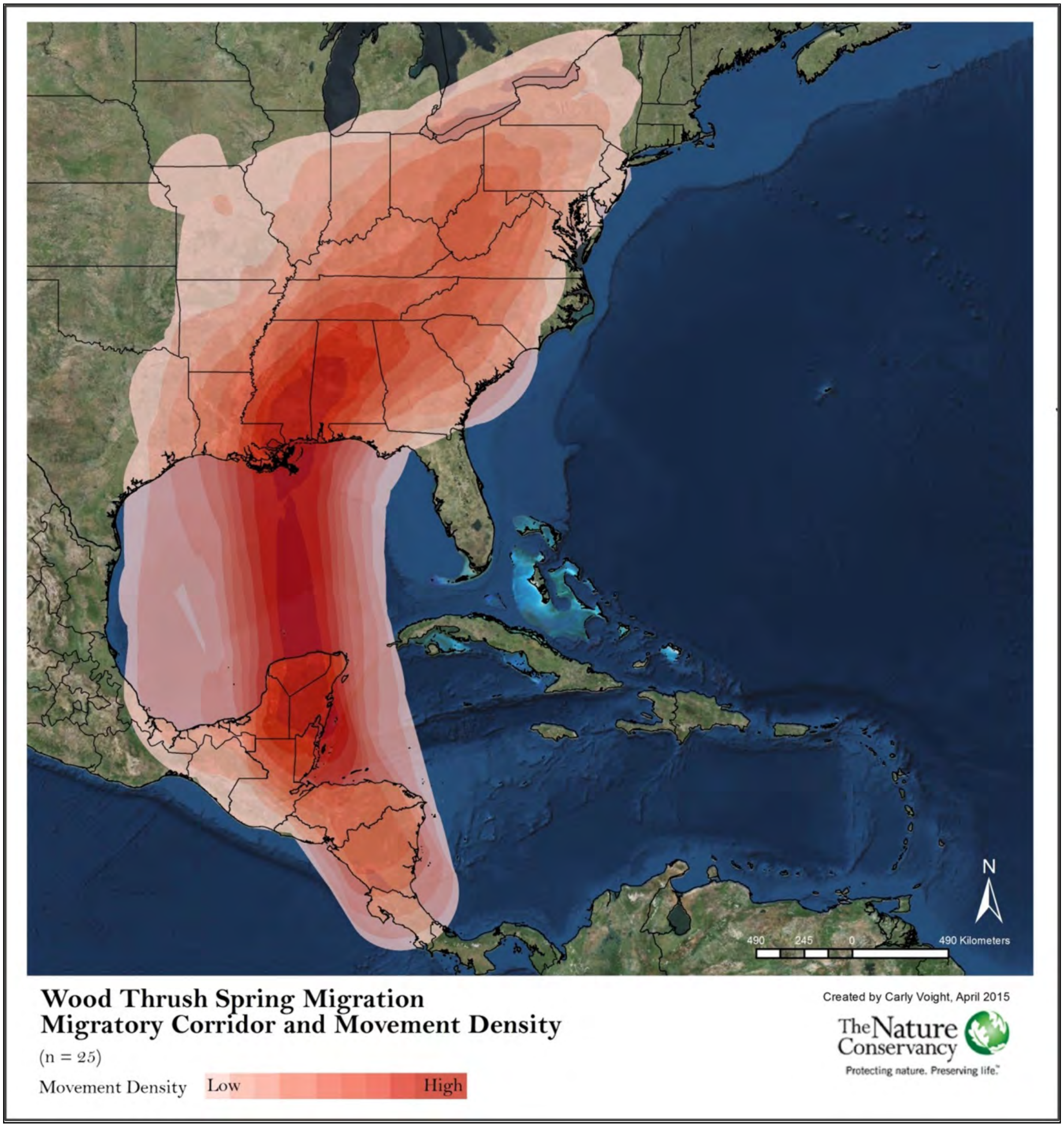

Figure 4-22. Spring Wood Thrush Partial Migratory Corridor in North America (reprinted with permission from Brenner et al., 2016; movement data for this map was provided to The Nature Conservancy by Bridget Stutchbury and collaborators).

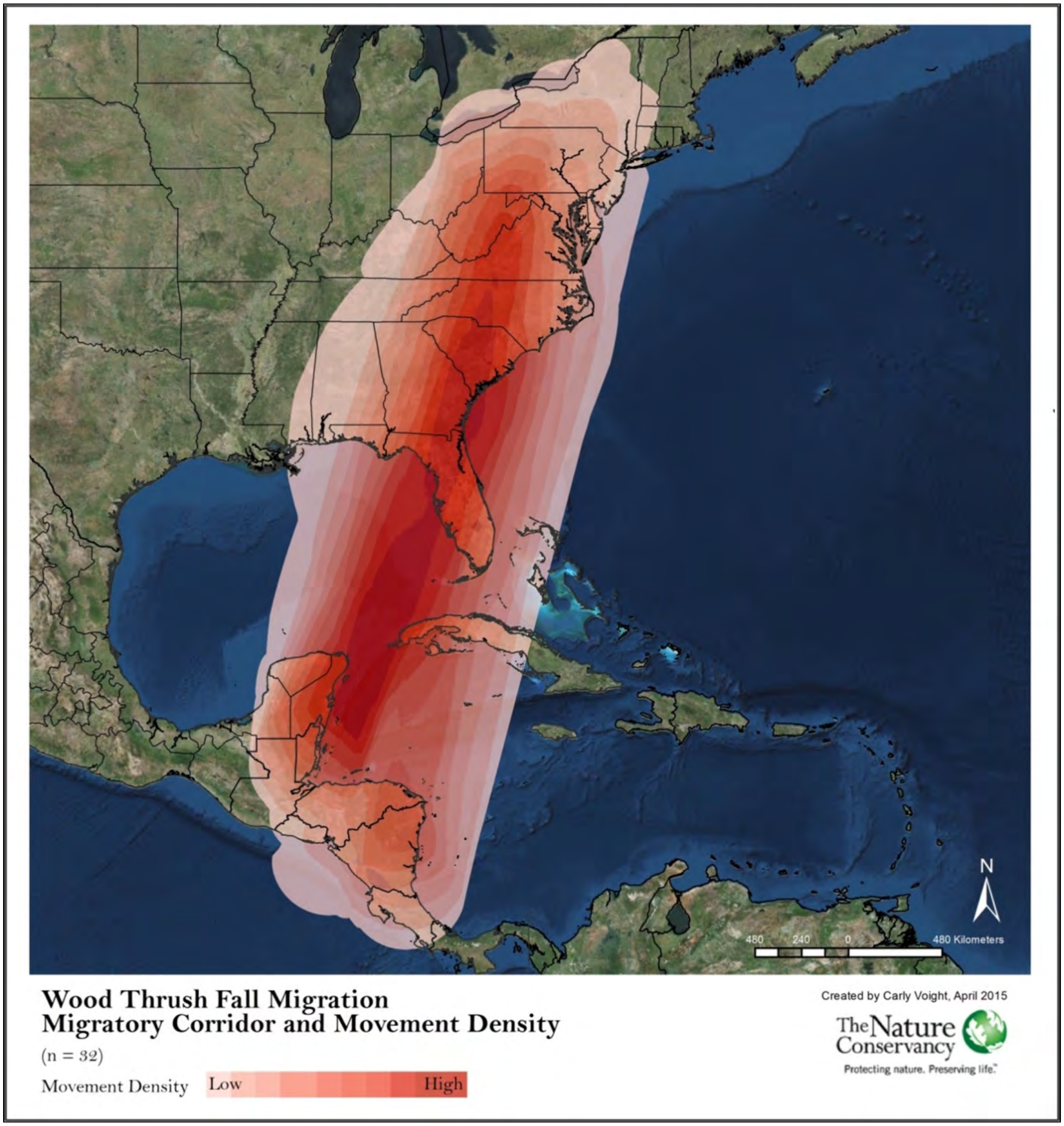

Figure 4-23. Fall Wood Thrush Partial Migratory Corridor in North America (Reprinted with permission from Brenner et al., 2016; movement data for this map was provided to The Nature Conservancy by Bridget Stutchbury and collaborators).

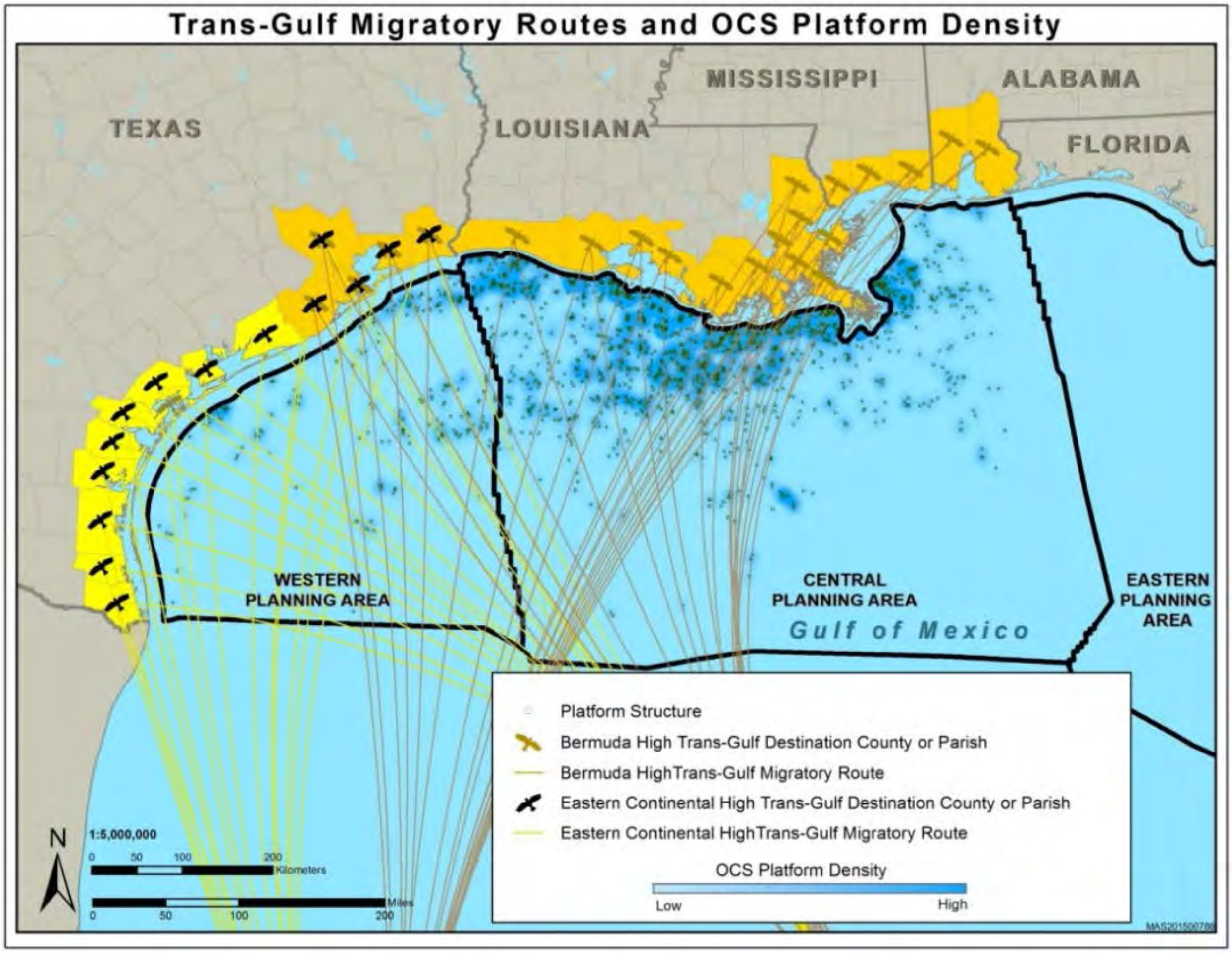

Figure 4-24. Platform Density and Spring Migration Routes for Trans-Gulf Migratory Birds.

Baseline Populations

Baseline populations of birds have been affected by recent events, including hurricanes and the *Deepwater Horizon* explosion, oil spill, and response. However, no species or subspecies of birds that has been listed as federally endangered or threatened, of conservation concern to the U.S. Fish and Wildlife Service, State listed, or of State conservation concern has been reported in sharp decline or otherwise harmed by either recent hurricanes or the *Deepwater Horizon* explosion, oil spill, and response. Definitions for the impact levels used above in this analysis (**Table 4-16**) use concepts of flock or colony size affected. For two examples of flock size, royal terns have compact flocks up to several thousands (Buckley and Buckley, 2002), while dunlin (a shorebird) has flocks of 10-100 (Buchanan et al., 1988). For examples of colony size, in Louisiana, which takes up much of the CPA, in 2001, brown pelican colonies consisted of about 8,484 breeding pairs and royal terns consisted of about 12,500 breeding pairs (Michot et al., 2003). Only about two seabird colonies in Lousiana in 2001 had >10,000 breeding pairs. In 2001, the total numbers of seabird colonies in Louisana were 158, composing 101,957 breeding pairs (Michot et al., 2003). No hurricanes have made baseline changes since the 2012-2017 WPA/CPA Multisale EIS, which was published in 2012

(USDOI, BOEM, 2012b). There is new information on baseline changes resulting from the *Deepwater Horizon* explosion, oil spill, and response, as described below.

Hurricane-related flooding can drown nests, and associated winds can kill birds due to impact with objects like trees. In addition, hurricane impacts to coastal ecosystems can have deleterious effects to foraging and nesting birds that utilize those habitats. However, no surveys of mortality from such impacts related to Hurricane Katrina and other storms were located.

The following information is relevant to evaluating reasonably foreseeable significant adverse impacts on the human environment but not essential to a reasoned choice among alternatives. Mortality from the *Deepwater Horizon* explosion, oil spill, and response was sufficient to cause a small negative shift in baseline abundances for seabirds. Total seabird mortality seaward of 25 mi (40 km) from shore due to the *Deepwater Horizon* explosion, oil spill, and response was estimated at 200,000 birds (Haney et al., 2014a). Estimates of breeding population sizes were 60,000-15,000,000 for four procellariiform (shearwaters and related) species, 9,000 for one pelecaniform (pelican and related) species, and 96,000-500,000 for three charadriiform (gulls and related) species (Haney et al., 2014a). Total bird mortality landward of 25 mi (40 km) from shore was estimated as 600,000 birds using one model and 800,000 birds using another (Haney et al., 2014b). In perspective, in three analyzed species of seabirds, estimated losses due to the *Deepwater Horizon* explosion, oil spill, and response were 12 percent or more of the total population estimated present in the northern GOM (Haney et al., 2014b). Because the effect was on the total populations, the impact was major. This new information estimates a small negative shift in baseline numbers. Incremental impacts caused by the negative shift in baseline numbers were not sufficient to change the conclusions for the impact analysis of a proposed action. The shift was extrapolated from the increased mortality due to the *Deepwater Horizon* explosion, oil spill, and response. However, these changes to the baseline did not identify any species whose population was likely to be impacted by a proposed action or alternatives.

The following information is relevant to evaluating reasonably foreseeable significant adverse impacts on the human environment but not essential to a reasoned choice among alternatives. Recovery (NRDA) data have become available since the analyses by Haney et al. (2014a and 2014b). Total nearshore mortality was determined in six recent NRDA final reports on the *Deepwater Horizon* explosion, oil spill, and response as 54,099-100,134 waterbirds (USDOI, FWS, 2015a, 2015b, 2015c, 2015d, and 2015e; Industrial Economics, Inc., 2015a Total offshore mortality was determined in one NRDA final report on the *Deepwater Horizon* explosion, oil spill, and response as 2,317-3,141 birds (Industrial Economics, Inc., 2015b). These NRDA reports did not include estimates of lost bird-years used in NRDA's reports of some previous spills, as discussed in Zafonte and Hampton (2005). New information is also provided by two articles (not funded by NRDA) on the *Deepwater Horizon* explosion, oil spill, and response. Franci et al. (2014) found no confirmed impacts of oil on the endocrine status and no evidence of exposure to oil of northern gannets that migrated to eastern Canada after overwintering in the northern Gulf of Mexico in the winter of 2010-2011. Seegar et al. (2015) found evidence in the fall of 2010 of polycyclic aromatic hydrocarbon (PAH) contamination of blood of migrant tundra Peregrine Falcons that probably were exposed to *Deepwater Horizon* PAHs in oil. However, blood of migrant tundra peregrine falcons found in the spring of 2011 had a small amount of PAHs that were not from the *Deepwater Horizon* oil. Finally, blood in migrants in the fall of 2011 could have had moderate levels of PAHs from a petroleum source, but it was probably not *Deepwater Horizon* oil (Seegar et al., 2015).

Mortality can indicate substantial impacts from an oil spill even when sharp declines or other impacts on population size have not been measured. No reports of the impact levels of hurricane on the rates of population decline or any other impacts on population size were located.

4.8.2 Environmental Consequences

This chapter provides detailed information regarding the impact-producing factors from the routine activities, accidental events, and cumulative impacts described in **Chapter 3** and their potential effects on birds that would potentially be impacted by a proposed action or the alternatives. This analysis would apply to all alternatives considered; however, the level of impacts would be different for each alternative, as discussed below in **Chapters 4.8.2.5-9**.

4.8.2.1 Routine Activities

Impacts from routine activities to coastal, marine, and migratory birds include impacts from routine discharges and wastes, noise, platform severance with explosives (barotrauma), geophysical surveys with airguns, platform presence and lighting, construction of OCS-related onshore facilities, and pipeline landfalls. For marine and coastal birds, more information on impact-producing factors of routine activities can be found in the Five-Year Program EIS (USDOI, BOEM, 2016b). In that document, noise from seismic sources, vessels, aircraft, drilling, trenching, production, and platform removal is discussed.

Discharges and Wastes. These include produced waters, drilling muds and cuttings, and routine air emissions. Routine discharges and wastes affecting air and water quality (**Chapter 4.1**, Air Quality, and **Chapter 4.2**, Water Quality) are under the jurisdiction of USEPA (including NPDES) or BOEM, and regulations assure that impacts on birds are **negligible** because USEPA's and BOEM's regulations protect against the unreasonable degradation of the marine environment.

Helicopters and Vessels. The OCS oil- and gas-related helicopters and vessels have the potential to cause noise and disturbance. However, flight altitude restrictions over sensitive habitat, including that of birds, may make serious disturbance unlikely. Birds are also known to habituate to noises, including airport noise. It is an assumption that the OCS oil- and gas-related vessel traffic would follow regular routes; if so, seabirds would find the noise to be familiar. Therefore, the impact of OCS oil- and gas-related noise from helicopters and vessels to birds would be expected to be **negligible**.

Platform Severance and Rigs-to-Reefs. These activities are discussed in *Structure-Removal Operations on the Gulf of Mexico Outer Continental Shelf: Programmatic Environmental Assessment* (USDOI, MMS, 2005). Refer to **Chapter 3.1.6** for more information on platform removal. Platform severance with explosives may potentially kill one or more birds from barotrauma if a bird (or several birds because birds may occur in a flock) is present at the location of the severance. For the impact of underwater sound, a threshold of 202 dB sound exposure level (SEL) for injury and 208 dB SEL for barotrauma was recommended for the *Brahyramphus marmoratus*, a diving seabird (USDOI, FWS, 2011). Platform relocation in the Rigs-to-Reefs program would potentially provide foraging habitat for birds, which would be a positive impact. The overall impact of severance and rigs-to-reefs would be **minor** because positive impacts do not completely counteract barotrauma, for which possible lethality would offset expected low frequency.

Geological and Geophysical (G&G) Surveys. These are discussed in the *Atlantic OCS Proposed Geological and Geophysical Activities: Mid-Atlantic and South Atlantic Planning Areas; Final Programmatic Environmental Impact Statement* (USDOI, BOEM, 2014a) and Five-Year Program EIS (USDOI, BOEM, 2016b). Refer to **Chapter 3.1.2.1** for more information on G&G information in the GOM. Geological and geophysical surveys with airguns may kill one bird (or a small number of individuals occurring in a flock) from barotrauma in one or more incident. This impact would be **minor**.

Platform Lighting and Nocturnal Circulation. Potential impacts of platform lighting can be dependent on spectra, intensity, and weather conditions (refer to **Chapter 3.1.3.4.3** of this Multisale EIS and to the Five-Year Program EIS [USDOI, BOEM, 2016b] for more information on platform lighting). Obstruction lighting is considered under cumulative impacts because it is under the jurisdiction of the USCG and not likely subject to change. Obstruction lighting on proposed platforms could attract trans-Gulf migrant birds during low-visibility conditions because it is white, and so it includes spectral red. Birds may have the following behaviors in any combination, any order, any frequency, and any duration at platforms: resting; feeding; collision with platforms; and nocturnal circulation (Russell, 2005). In nocturnal circulation, birds fly around the lit platforms. Nocturnal circulation may be brief with little impact or may be long term and burn up energy reserves (Russell, 2005). The number of times a bird stops at platforms is unknown. Birds would likely stop over on platforms with lights with spectral red or with high intensity during overcast, rainy, or foggy conditions at night (Marquenie et al., 2013). The potential range of a songbird adapted to fatten up enough to cross the GOM is approximated by data on shorebirds. The computed maximum non-stop range of a bar-tailed godwit (a shorebird) leaving Alaska (based on a model of fuel load) was to the South Pole (Pennycuick and Battley, 2003). It is about 739 mi (1,189 km) from Galveston, Texas, to the Yucatan Peninsula, Mexico; it is about 10,156 mi (16,344 km) from Alaska to the South Pole. Populations of birds may be affected if many of them do not make it across the GOM because of stopping at platforms, which may affect species richness. That may, in turn, affect bird watching and bird hunting. Full or almost full population recovery means that impacts to trans-Gulf migrants would be **minor**.

Platform Lighting and Collisions. **Minor** impacts would result partly because total estimated annual mortality from collisions due to structure presence has been estimated at 200,000-321,000 birds of the up to 316 million birds that migrate (Russell, 2005). Those numbers are of the same order of magnitude as overall mortality from the *Deepwater Horizon* explosion, oil spill, and response. Nonlethal (e.g., reproductive) impacts of collisions are not expected but they are expected for nocturnal circulation. Impacts on trans-Gulf migrants from platform presence and particularly light spectra (Marquenie et al., 2013) need further study. More information on the impact of platform presence is provided in the Five-Year Program EIS (USDOI, BOEM, 2016b).

Platform Presence, Produced Waters, and Seabirds. Seabirds are attracted to structures and may benefit from underwater reef organisms associated with the structure. Neither toxicological effects of produced waters on seabirds nor the possible attraction of seabirds to the plumes of discharged produced water have been studied at all. However, USEPA mandates testing the toxicity of produced waters to other organisms, which may sufficiently protect birds, resulting in **negligible** impacts. There is a short delay between taking produced-water samples and getting them tested in laboratories, during which seabirds could be exposed. The study of toxicology in birds has been proposed.

Construction of Onshore Facilities. The OCS oil- and gas-related construction of onshore facilities would require obtaining permits for any projects that could harm wetlands or any other habitats protected by conservation laws and regulations. For example, construction in a wetland area would require a COE permit under Section 404 of the Clean Water Act; this would include mitigations and monitoring of the activities. Further reinforcement of wetland protection is expected because of the long-standing goal of no net wetland loss. As a result, **negligible** impacts are expected from OCS oil- and gas-related construction of onshore facilities and consequent habitat loss.

Pipeline Landfall: Impacts from a pipeline landfall could disturb shoreline or wetland habitat that is utilized by birds. Up to one pipeline landfall is projected. The resulting habitat loss to birds from the installation method of directional drilling is expected to result in a **negligible** impact.

4.8.2.2 Accidental Events

Impacts for accidental events to birds are caused by oil spills, spill cleanup, and emergency air emissions. Impacts of hydrocarbons from oil spills depend on the hydrocarbons' ultimate destination, i.e., in the air (from evaporation), in the water, or in the sediment. Birds may be affected by hydrocarbons through means of inhalation or ingestion when eating oiled benthic, planktonic, or pelagic prey; preening oiled plumage; or drinking hydrocarbons in water (Leighton, 1993). Birds (Leighton, 1993) and prey may be killed by toxic oiling. Oiled plumage can also be lethal because it causes loss of insulation, ability to fly, and buoyancy; also, oil can be transferred from such plumage to egg shells during incubation and can cause embryo mortality (Leighton, 1993). While some birds can be rehabilitated after contamination by oil or dispersants, others may sustain injuries or die. Oil and dispersants can affect birds at the small population level. Birds that feed aquatically are vulnerable to oil, and migrants or residents that occur in the GOM when oil from a spill is present are also vulnerable. These circumstances are discussed in detail in **Chapter 4.8.1**. Impacts on long-lived seabirds may last longer because generation time is longer, and they may also be delayed. For an example of the latter, a delay on first-breeders would have a delayed reduction in recruitment, which would go unnoticed until years after exposure. Therefore, detection would not occur without long-term studies. In addition, oiling may sometimes be more severe in shallow water, wetlands, both bayside and gulfside intertidal shorelines (including beaches), and dunes where avian diversity and abundance, as well as hydrocarbon accumulation and persistence, may be high. Barrier islands may be composed of all of these component habitats, and the islands give important support to breeding and wintering waterbirds (Curtiss and Pierce, 2016; Selman et al., 2016). The islands are also important migratory stopovers. Refer to **Chapter 4.3** (Coastal Habitats) for a discussion of the fate of oil in wetlands. Sometimes, because of lack of adequate personnel training or the sheer scale of activity, shoreline cleanup (**Chapter 3.2.8**) may disturb nesting birds and have a **minor** impact. Disturbance to GOM nonnesting shorebirds from the *Deepwater Horizon* oil-spill cleanup may have affected bird conditions later on the northern breeding grounds (Henkel et al., 2014). An oil-spill sublethally affecting birds that migrate may have carry-over impacts to one or migratory destinations, including the ecosystems at those destinations.

Combined probabilities of occurrence and contact of an oil spill with shoreline bird species and nearshore bird species can be found in **Figures E-2 through E-7 and Figure E-20**, respectively. Seabirds may take longer to recover from the impacts of an oil spill than other bird groups because of their unique population ecology (demography), regardless of the intensity of the initial impacts on a population. Long-term impacts are possible to seabirds (with long generation time) that delay first breeding (and hence impacts on first breeders would have a delayed reduction in recruitment) (Dunnet et al., 1982). Long-term impacts also occur when local colony or flock extirpation occurs, resulting in loss of species richness (community structure) until a colony or flock can recover from extirpation. Refer to **Chapter 4.12** (Recreational Resources) for a discussion of the socioeconomics of wildlife tourism. Finally, long-term impacts occur when oil persists (sometimes for years) in sediment and may contact seafloor organisms or be resuspended and contact organisms in the water column. Resuspended oil may then be transported to other areas and settle out where it could be encountered by birds. The impact level from oil spills would depend on the combined result of the effects on habitat (sediment oiling in shallow water) and abundance (effect on small or large populations) of affected birds, as well as long-term persistence of oil in some habitats. A minor offshore spill (<1,000 bbl) could disappear even before a crew could arrive and clean it up; however, because the spill would be so small, impacts would be **negligible**. A minor inshore spill (e.g., <1,000 bbl spilled during vessel refueling) could be completely cleaned up right away; therefore, impacts would be **negligible**. Impacts of a large spill (≥1,000 bbl) associated with a proposed action under Alternative A, B, C, or D would be expected to be **moderate** because a large population of birds could be chronically disturbed or affected, because of the size and persistence of the oil spill.

Emergency air emissions may cause various toxic effects to a bird or flock of birds exposed to the discharge. An example would be a hydrogen sulfide leak from a pipe. A single incident of toxic effects could affect nothing more than a flock. On the basis of the frequency of such events, impacts from emergency air emissions would be **minor**.

4.8.2.3 Cumulative Impacts

OCS Oil- and Gas-Related Impacts

Baseline populations are discussed in **Chapter 4.8.1** (Description of the Affected Environment). Routine OCS oil- and gas-related impacts that could add to the cumulative impacts to coastal and marine birds are effects to air and water quality, noise, platform severance with explosives (barotrauma), geophysical surveys with airguns (barotrauma), platform presence and lighting, and construction. They are discussed in detail in the “Routine Activities” section above. Accidental events are oil spills, cleanup, and emergency air emissions, which are discussed in the “Accidental Events” section above. Cumulative OCS oil- and gas-related impacts are presented briefly here.

Impacts from routine air and water discharges are discussed in **Chapters 4.1** (Air Quality) and **4.2** (Water Quality). As a result of these discharges, impacts on birds would be expected to be **negligible**. Drilling discharges, produced waters, and the discarding of marine trash and debris would have **negligible** impacts on birds. Impacts of aircraft and vessel noise would be expected to be **negligible**. Impacts of severance with explosives during platform decommissioning and of geophysical surveys with airguns would have **minor** impacts. Structure presence would possibly result in collision of birds with a structure, nocturnal circulation, or an opportunity to rest and/or feed. It may have a net beneficial or a net negative impact on birds (Ramirez et al., 2014; Marquenie et al., 2013). Structure presence is discussed in the “Incomplete or Unavailable Information” section below. Impacts of coastal OCS oil- and gas-related facility construction would be expected to be **negligible**. More information on all of the routine impacts discussed above (including all types of noise and routine discharges, except for produced waters) is provided in the Five-Year Program EIS (USDOI, BOEM 2016c).

A large oil spill (≥1,000 bbl) could **moderately** impact coastal and marine birds, and oil-spill response and emergency air emissions could have **minor** impacts on them; refer to the “Accidental Events” section above for more details. Modeling shows that, without a thorough understanding of a species’ habitat use and preferences, a species’ ability to locate and colonize alternative habitat, and the population structure, it is difficult to make inferences regarding the ability of individual birds or groups to successfully emigrate and colonize novel, undisturbed habitat (assuming it is available) (Fahrig, 1997, 1998, and 2001). BOEM used scientific reasoning about habitat in lieu of empirical studies to help understand the impacts of oil spills on colonial nesting birds. Habitat may be occupied at or below carrying capacity, or it may not be occupied at all, so it may have various amounts of room for immigrant birds (and various sources of mortality or depression of realized reproductive rate) when immigrants are escaping disturbance or an oil spill. For habitat that is occupied, any single patch or group of patches of habitat may change periodically in the resource or resources (which could include the amount of the habitat itself) that are limiting to its occupants. The impact of an area of major degradation of habitat quality (with no change in total habitat area) can be more or less important than the impact of complete loss of a large area of habitat. For purposes of this discussion, habitat availability is defined as presence of unoccupied habitat. The following statement applies only if birds are able to move into habitat that is occupied below carrying capacity.

Habitat does not become limiting until it is filled up (completely occupied), so habitat availability is not itself limiting. Filled habitat (habitat limitation) can be ideal for birds if that is the pervasive condition of a bird population. Filled habitat only becomes a problem when no extra space is available for immigrants trying to escape a major event such as an oil spill or when the amount of filled habitat is so small that a bird is listed as threatened, endangered, or of conservation concern. Unoccupied habitat for colonial nesting birds is likely pervasive because periodic surveys of bird colonies in the northern Gulf of Mexico show regular formation of completely new bird colonies. Therefore, impacts of an oil spill on colonial nesting birds are expected to be **negligible**. Impacts from pipeline landfalls are expected to be **negligible**.

Non-OCS Oil- and Gas-Related Impacts

All OCS oil- and gas-related impact-producing factors and their impact levels also hold for State oil- and gas-related activities. The **moderate** impacts from State oil and gas activities include a large oil spill (≥1,000 bbl). Impact levels for collision of trans-Gulf migrants with platforms, and possibly nocturnal circulation of trans-Gulf migrants, need further study. Impacts are expected to be **minor**. A large tanker spill (≥1,000 bbl) would have the same impact (**moderate**) as a similar sized OCS oil- and gas-related spill or State oil- and gas-related spill discussed above. Impacts to birds would be expected to be **moderate**.

A source of cumulative impacts is obstruction lighting on platforms in State waters or on the OCS; obstruction lighting is under the jurisdiction of the USCG and is not likely to be changed by mitigations to protect birds. The impact level of obstruction lighting would need further study.

In addition to the OCS oil- and gas-related discharges discussed above, other regulated discharges include the discharge of bilge or ballast water from ships, runoff to waters, and industrial discharges into the coastal atmosphere, all of which are regulated by the USEPA. Also, agricultural nutrient (fertilizer) and pesticide runoff occurs. For more information and impact levels for runoff, other discharges into waters, and discharges into the atmosphere, refer to **Chapter 4.1** (Air Quality) and **Chapter 4.2** (Water Quality). Pollutants are expected to be diluted to a level below that which is harmful to birds or otherwise safely disposed of, and effects are not expected at a population level.

Discard of trash and debris from non-OCS oil- and gas-related sources (e.g., from State oil- and gas-related activities, recreational fishing boats, and land-based sources; refer to **Chapter 3.3.2.3.7**) is prohibited; however, despite regulation, unknown quantities of plastics and other materials are discarded and lost in the marine environment and remain a threat to individual birds. Many species readily consume plastic debris, either intentionally or incidental to consuming prey, and can become trapped or entangled in discarded fishing line or nets. Although the short-term prognosis suggests that plastic impacts are increasing significantly, analyses also suggest that reductions in exposure would result in reduced ingestion (Wilcox et al., 2015). Seabirds are sometimes caught in commercial fishermen's gear. Seabird bycatch numbers in the GOM (Hale et al., 2009) indicated that the pelagic and bottom longline fisheries had **negligible** impacts on seabirds. Discarded bycatch of fishes and invertebrates would benefit seabirds. Impacts to birds from trash and debris as a whole are expected to be **moderate** in the short term but **negligible** with forecasted reductions in exposure (Wilcox et al., 2015).

The Mississippi River watershed contributes nutrients causing a seasonal population explosion of phytoplankton, which decomposes to create a hypoxic or anoxic “dead zone” over the continental shelf (**Chapter 3.3.2.12**). Aquatic food for coastal waterbirds could be decimated in places in the hypoxic zone. No massive phytoplankton blooms have been reported to produce massive mortality to seabirds and other waterbirds in the zone. It is possible that birds are able to move from impacted areas with no food to patches of sufficient food; doing so would make the effects short term. Impacts on a whole population are expected to be **minor**.

Historical wetland loss due to Mississippi River hydromodification (**Chapter 3.3.2.10**) would be at least somewhat ameliorated by wetland creation from Atchafalaya River sediments and coastal restoration and hurricane protection programs. Also Louisiana’s Master Plan, which was partly designed for maximizing coastal wetlands, would likely increase habitat for four selected waterbird species and for neotropical birds over the next 50 years (refer to **Chapter 4.3**, Coastal Habitats). These predictions are based on Habitat Suitability Index models and were controlled for other, non-habitat environmental variables (Nyman et al., 2013). Therefore, wetland loss would probably not be an issue that would exacerbate other impacts of a proposed action and other cumulative impacts for coastal and marine birds. For these reasons, impacts on whole populations are expected to be **negligible**.

In addition to impacts to habitat from Mississippi River hydromodification, impacts to habitat could also be due to urbanization, or they could be rural. Habitat (e.g., wetland) loss, alteration, and fragmentation associated with building, factory, and road construction is kept from harming sensitive bird habitat by standard mitigating measures required by COE and State wetland permitting regulations. A major policy goal (not yet fully reached) is “no net loss” of wetlands. However, Ward et al. (2010) indicates that urbanization may alter wetland hydrology rather than destroy wetlands and that may cause a reduction in abundance of wetland birds. Such impacts would probably be avoided by protection or active management of wetland hydrology regimes (Ward et al., 2010). When such procedures and a no-net-loss policy are in place, impacts to birds would be expected to be **negligible**.

Military activities, including training overflights and sonic booms, would occur in special areas offshore in seabird habitat. Military operations in the Gulf of Mexico are undertaken primarily by the U.S. Air Force and the U.S. Navy within federally designated areas for the purposes of training personnel, as well as research, design, testing, and evaluation activities. There are 18 U.S. military bases along the northern Gulf of Mexico. The greatest impacts would come from sonic booms, which would likely cause a short-term behavioral change such as flushing of a flock resting on the water or cessation of feeding by a flock. No individual or group of individuals would be injured or killed. Impacts would be expected to be **negligible**.

Nonconsumptive recreation includes recreational boating; it also involves beach use during bird-watching activities, riding in all-terrain vehicles, and walking and jogging with pets. All forms of beach use may cause birds to become stressed and fly away, possibly with no possible destinations with habitat of equal value for feeding, nesting, roosting, or sleeping. Stress and ejection from habitat on a large scale may cause sublethal depression of reproductive productivity, which in turn may result in population decline that may exceed decline resulting from mortality. For economic impacts, refer to **Chapter 4.12** (Recreational Resources). In most cases, recreational boats are subject to strict speed and wake restrictions. Disturbances of an area could be regular but impacts would be benign and direct (limited to the time period of disturbance); therefore, they would be **minor**.

Consumptive recreation (hunting game birds) is regulated. Each state and Canadian province in each flyway, along with FWS, are the source for waterfowl hunting regulations. Usually, total mortality of hunted species does not increase because of hunting—it remains the same because the overall carrying capacity of a species does not change with hunting. However, some species of game birds have experienced hunting-related mortality impacts at the population level, a **major** impact that would be mitigated to a net **negligible** impact by adjustments in hunting regulations.

Use of navigable waters by vessels may cause erosion of banks by vessel wakes, causing wetland habitat loss. The impacts to wetlands from non-OCS oil- and gas-related vessel traffic is expected to be **moderate** to **major** (**Chapter 4.3.1.2.3**, Estuarine Habitats, Cumulative Impacts). Because wetland habitat loss would be **moderate** to **major**, the potential impacts on birds would be **moderate** to **major** also.

There are a myriad of anthropogenic avian mortality sources, including collisions and predation by domestic cats. No GOM regional estimates are available for annual mortality rates for collisions with vehicles, collisions with buildings, or predation by domestic cats. However, recent quantitative national estimates allow for a qualitative extrapolation to the GOM. An estimated range of national annual mortality from collision with vehicles is 62-275 million birds per year (Loss et al., 2014a). An estimate of national annual mortality from collision with buildings is 599 million birds per year (Loss et al., 2014b). Finally, an estimate of annual mortality from predation by free-ranging domestic cats is 1.4-3.7 billion birds per year (Loss et al., 2013). Cat predation would predominantly affect small birds like songbirds. The mortality estimates are nationwide and not just for the northern GOM, where impacts would be much less. Impacts of collisions with vehicles and buildings and predation by domestic cats are expected to be **moderate** (chronic but not causing steady declines in whole large populations).

Emerging infectious diseases include West Nile virus. LaDeau et al. (2007) stated that "Emerging infectious diseases present a formidable challenge to the conservation of native species in the twenty-first century." The population responses of bird species to the virus was complex (LaDeau et al., 2007). Of 20 selected avian species across North America that were potential hosts to the West Nile virus, 7 species (35%) exhibited negative changes at the population level that were attributed to the virus, and only 2 of the 7 recovered to pre-West Nile virus levels by 2005 based on 26 years of data (LaDeau et al., 2007). These continental estimates were meant to be qualitatively extrapolated to other species and can also be qualitatively extrapolated to the smaller area of the northern Gulf of Mexico (like the collision mortality estimates above). Impacts of the West Nile virus are at the population level and are expected to be **major**.

Impacts of climate change (from global warming; refer to the Five-Year Program EIS (USDOI, BOEM, 2016b) and ocean acidification could eventually be expected to decline because, in April 2016, the United States joined a United Nations brokered agreement to keep the global temperatures within 2 °C (36 °F) of the pre-industrial climate, and preferably below 1.5 °C (35 °F). However, this might not occur if various positive feedbacks on global warming, such as a decrease in albedo of ice and snow shift to become irreversibly uncontrollable. Impacts on birds from greenhouse gases could be either beneficial or negative according to the Five-Year Program EIS (USDOI, BOEM, 2016b). Sea-level rise is discussed in **Chapter 4.3** (Coastal Habitats). A recent comprehensive meta-analysis was completed on the impacts of ocean acidification on sea taxa (Kroeker et al., 2013). Some of the taxa are related to important prey for birds or are related to organisms that support ecosystems important to those birds. Of taxa related to organisms important to birds, some features of some of them are expected to be impacted negatively by ocean acidification, some positively impacted, and some not affected at all (Kroeker et al., 2013). Ocean acidification and changed nutrient supply into the continental shelf with eutrophication or de-eutrophication (the latter owing to pollution control) have clear scope to alter phytoplankton succession, control phytoplankton, and support higher trophic levels (Flynn et al., 2015; Cripps et al., 2016). Those levels could include secondary production mediated by copepods, future trophic dynamics, and probably positively or (more likely) negatively altered fisheries (Flynn et al., 2015; Cripps et al., 2016) and, therefore, perhaps altered waterbirds. Copepods could be affected indirectly through phytoplankton or directly by reduced pH (Cripps et al., 2016). Forecasted impact levels of climate change and ocean acidification from burning the hydrocarbons produced by a proposed action cannot be determined at this time. If not curtailed, climate change could possibly result in a decline in biodiversity that is vital to the ecosystems that support all bird life (McDaniel and Borton, 2002), and impacts could be as great as **major**; however, there is still a need for research on this. Global climate change may increase the frequency and intensity of hurricanes, which can cause spills from Gulf of Mexico OCS oil and gas facilities. Increases in the intensity, frequency, duration, and strength of Atlantic hurricanes are projected (USEPA, 2016d) but these might eventually respond to greenhouse gas control.

Cumulative incremental impacts to birds, when taking into consideration the potential impacts of OCS oil- and gas-related impacts, would be expected to be **moderate** as a result of a proposed action because of a possible large (e.g., ≥1,000 bbl) oil spill. This Multisale EIS does not consider a catastrophic spill. For a discussion of a low-probability catastrophic spill, refer to the *Catastrophic Spill Event Analysis* white paper (USDOI, BOEM (2017). Cumulative incremental impacts to birds, when taking into consideration the potential impacts of non-OCS oil- and gas-related impacts, would be expected to be **major** as a result of a proposed action. This is because of emerging non-native infectious diseases. Cumulative impacts could more likely have a

major impact on a particular bird species with a low population level, dependent upon the level of impact and the number of individuals affected by it (e.g., if an impact to the federally listed red knot or piping plover were to result in substantial mortality, it would diminish the continued viability of the population, including the annual rates of recruitment or survival).

4.8.2.4 Incomplete or Unavailable Information

BOEM has identified incomplete or unavailable information related to impacts on birds resulting from OCS oil- and gas-related activities and non-OCS oil- and gas-related activities in the GOM. BOEM's subject-matter experts have used the available scientifically credible evidence presented below and applied accepted scientific methodologies to integrate existing information and extrapolate potential outcomes in completing this analysis and formulating the conclusions presented here.

The impact of artificial light along the coast on birds has not been studied and is unkown but is relevant to evaluating whether adverse impacts on the human environment are significant, but it is not essential to a reasoned choice among alternatives. BOEM used available information to fill the data gap. Existing information (Longcore and Rich, 2004) shows that outdoor lights at night can have both lethal impacts from collisions and sublethal impacts from a variety of mechanisms on birds. The impact level of obstruction lighting located on platforms would also need further study. The best available information was obtained from a study done by observers on platforms, from a model of energy reserves of migratory birds, and from several studies of the effect of light on birds. This scientific information presented in the "Routine Activities" section and under State oil and gas activities in the "Cumulative Impacts" section was used to conclude that platform lighting, in general, has **minor** impacts.

4.8.2.5 Alternative A—Regionwide OCS Lease Sale (The Preferred Alternative)

This chapter summarizes the potential impacts of routine activities, accidental events, and cumulative impacts associated with Alternative A on birds. Under Alternative A, BOEM would hold a regionwide lease sale comprised of the WPA, CPA, and a portion of the EPA.

Birds overlap with the proposed action area throughout their various life history stages. Different species have different feeding behaviors for different habitats. Many migrate seasonally and seabirds sometimes come to shore only to breed.

For impacts from routine activities, the effects from discharges and wastes, air and water quality, and noise would be **negligible** to coastal and migratory birds. Impacts of barotrauma from seismic airguns and platform severance with explosives would be **minor**. Impacts on trans-Gulf migrants from platform presence and lighting are tentatively **minor** but need further study of both positive and negative effects to be precisely assessed. For marine and coastal birds, more information on impact-producing factors for routine activites can be found in the Five-Year Program EIS (USDOI, BOEM, 2016b).

An accidental event that may be associated with a proposed action and that has the largest impact on coastal and migratory birds is a large oil spill (≥1,000 bbl). Seabirds (compared with other bird groups) may not always experience the greatest impacts from a spill but may take longer to recover because of their unique population ecology (demography).

State oil- and gas-related activities would have the same impact-producing factors and expected impact levels as OCS oil- and gas-related activities. Discarding trash and debris would be a negligible impact. The hypoxic "dead zone" of the Mississippi River would have a minor impact. Net impacts of historic wetland loss and coastal wetland creation would be negligible. A large tanker spill (≥1,000 bbl) would have **moderate** impacts. Military activities would have minor impacts. Nonconsumptive recreation would have minor impacts. Consumptive recreation with any hunting regulation mitigation would have **negligible** impacts. Boat traffic would have a negligible impact on wetland bird habitat. Impacts of collisions with vehicles and buildings as well as predation by domestic cats would be **moderate**. Impacts of the West Nile virus and future emerging infectious diseases are at the population level. Partly because of this, the impacts, including the incremental contribution of a proposed lease sale, are expected to be **major**. Impacts of commercial fishing are expected to be positive for discarded fish and invertebrate bycatch and **negligible** for seabird bycatch. Impacts of climate change and ocean acidification cannot be determined at this time. Finally, impacts of wetland subsidence are expected to be **moderate**. The overall impacts from a proposed action on coastal and migratory birds are **moderate**. The incremental contribution of a proposed action to the overall cumulative impacts is considered **moderate**, but only because of the potential impacts of a large oil spill (≥1,000 bbl). However, the combined probabilities of a large oil spill for occurrence and also contact with shoreline birds and nearshore waterbirds under Alternative A are small (<0.5-20% after 10 days and <0.5-25% after 30 days) (refere to **Chapter 3.2.1.4.8 and Appendix E**). These probabilities are for the high case for projected resource estimates (billions of barrels of oil). The overall cumulative impacts to non-OCS oil- and gas-related anthropogenic events and natural processes are considered **major**, but only because of the impact of non-native infectious diseases.

From a bird perspective, since Alternative A is regionwide, which includes the WPA, CPA, and EPA portions of the proposed lease sale area, it would have more of all of the types of OCS oil- and gas-related activities; therefore, it would have more potential for impacts. Impacts from the other alternatives would follow in a graded fashion. For platforms, the number of spills between 1,000 and 10,000 bbl that has been forecasted to potentially occur is <1 spill for Alternatives A, B, and C (i.e., spill); also for platforms, the number of spills ≥10,000 bbl has also been estimated to be <1 spill for Alternatives A, B, and C. For pipelines, the number of spills between 1,000 and 9,999 bbl has been estimated to be <1 to 1 spill for Alternative A; also for pipelines, the number of spills ≥10,000 bbl has been estimated to be <1 spill for Alternative A.

4.8.2.6 Alternative B—Regionwide OCS Proposed Lease Sale Excluding Available Unleased Blocks in the WPA Portion of the Proposed Lease Sale Area

Under Alternative B, BOEM would hold a lease sale excluding the WPA available lease sale blocks and offer all available blocks in the CPA and a portion of the EPA. The impacts to birds from Alternative B are similar to those from Alternative A since a majority of the activity is projected to occur in the CPA, as described in **Chapter 3.1**, and since overall routine and accidental impacts are considered **moderate**, but only because of the impacts of a large oil spill (≥1,000 bbl). The combined probabilities for occurrence and contact with shoreline birds and nearshore waterbirds are small. The incremental cumulative impacts of Alternative B to OCS oil- and gas-related impacts are considered **moderate**, but only because of the impacts of a large oil spill (≥1,000 bbl).

The following description of migratory routes applies to Alternatives A, B, and C and refers to adult trans-Gulf migrant birds stopping over on platform and drilling vessels. In spring, under East Continental High synoptic wind conditions, the migrant birds mostly follow a northward migratory route that crosses the western GOM, especially in the WPA (refer to **Figure 4-20**). In spring, under Bermuda High synoptic wind conditions, the migrant birds follow a northern migratory route that crosses the north-central GOM across both the WPA and EPA (refer to **Figure 4-21**). In fall, under East Continental High synoptic wind conditions, such birds mostly follow a fall southward migratory route that crosses mostly outside the western GOM, especially outside the WPA (refer to **Figure** 4-20). During Bermuda High wind conditions, birds mostly do not migrate in the fall (Russell, 2005).

Migrant birds stop over on GOM offshore structures in fall, collide with the structures, and exhibit nocturnal circulation just like in the spring (Russell, 2005), even though they are just beginning their nonstop flight in the fall. Drilling vessels and new platforms under Alternative B would be entirely outside the western Gulf. Therefore, under Alternative B, both positive and negative impacts from offshore structures on trans-Gulf migrants migrating during an East Continental High in spring would be less than under Alternative C, and in fall, the impacts would be more than under Alternative C (refer to **Figure 4-20**). Under Alternative B, both positive and negative impacts from offshore structures on trans-Gulf migrants migrating during a Bermuda High in spring would be about the same as under Alternative C (refer to **Figure 4-21**). Under Alternative B, juvenile trans-Gulf southward fall migration often differs from adult migration in that it often hugs the Texas coast. It is possible that juveniles lack the reserves for nonstop overwater flight. In any case, they would possibly stop over on platforms on the OCS near the Texas coast, and the leasing area under Alternative C (i.e., the WPA) is off the Texas coast. The leasing area for Alternative B is the CPA/EPA. Therefore, both positive and negative impacts on juveniles would occur under Alternative C but not under Alternative B. The overall cumulative impacts to non-OCS oil-and gas-related anthropogenic events and natural processes are considered **major**, but only because of the anthropogenic impact of non-native infectious diseases. The significance of impact-producing factors on birds would be the same for Alternative B as for Alternative A. The degree of impacts as a result of Alternative B would be somewhat less than Alternative A since a majority of the routine activities and impact-producing factors from a proposed lease sale would occur in the CPA/EPA, as projected in the scenario in **Chapter 3.1.1**. For platforms, the number of spills between 1,000 and

9,999 bbl has been estimated to be <1 spill for Alternative B; also for platforms, the number of spills ≥10,000 bbl has also been estimated to be <1 spill for Alternative B. For pipelines, the number of spills between 1,000 and 9,999 bbl has been estimated to be <1 spill for Alternative B. Therefore, the overall impacts of Alternative B on coastal and migratory birds would also be **moderate** and the incremental contribution to the overall cumulative impacts would also be **moderate**, but only because of the potential impacts a potentially forecasted to occur large oil spill (≥1,000 bbl). However, under Alternative B ,the combined probabilities of a large oil spill for occurrence and also contact with shoreline birds and nearshore waterbirds are small (<0.5-20% after 10 days and <0.5-25% after 30 days) (refer to **Chapter 3.2.1.4.8 and Appendix E**). These probabilities are for the high case for projected resource estimates (billions of barrels of oil).

4.8.2.7 Alternative C—Regionwide OCS Proposed Lease Sale Excluding Available Unleased Blocks in the CPA/EPA Portions of the Proposed Lease Sale Area

Under Alternative C, BOEM would hold a lease sale excluding the CPA/EPA available lease blocks and offer all available blocks in the WPA. The impacts to birds from OCS oil-and gas-related activities are similar in the WPA or wherever they may occur in the GOM, and overall routine and accidental impacts from Alternative C are considered **moderate**, but only because of the impacts of a large oil spill (≥1,000 bbl).

While the WPA is a smaller area with less projected activity than is proposed for the CPA/EPA (refer to **Chapter 3**), offshore pelagic seabird habitat is distributed throughout the planning areas. Therefore, activities isolated to specific planning areas pose similar potential impacts to offshore pelagic seabird populations as do activities occurring in all planning areas. Therefore, because of the diversity and distribution of offshore pelagic seabird species in the Area of Interest, the level of impacts would be the same for Alternatives A, B, C, and D.

Trans-Gulf migrant birds stopping over on platforms and drilling vessels follow the migratory routes described in **Chapter 4.8.2.2** (Alternative B) and as shown in **Figures 4-20**, **4-21, and 4-24**. Migrant birds stop over on GOM offshore structures in fall, collide with the structures, and exhibit nocturnal circulation just like in the spring (Russell, 2005), even though they are just beginning their nonstop flight in the fall. Drilling vessels and new platforms under Alternative C would be entirely outside the eastern and central GOM; therefore, both positive and negative impacts from offshore structures on trans-Gulf migrants migrating during an East Continental High in spring would be more than under Alternative B, and in fall, the impacts would be less than under Alternative B (refer to **Figure 4-20**). However, under Bermuda High synoptic wind conditions in spring, migration would be mostly across the north-central GOM, overlapping both the WPA and CPA (refer to **Figure 4-21**); therefore, both the favorable and unfavorable impacts to trans-Gulf migrants extant under Alternative C under Bermuda High conditions in spring would be about the same as under Alternative B. Juvenile trans-Gulf southward fall migration often differs from adult migration in that it often hugs the Texas coast. It is possible that juveniles lack the reserves for nonstop overwater flight. In any case, they would possibly stop over on platforms on the OCS near the Texas coast, and the leasing area under Alternative C (i.e., the WPA) is off the Texas coast; therefore, both positive and negative impacts on juveniles would occur under Alternative C. For platforms, the number of spills between 1,000 and 9,999 bbl has been estimated to be <1 for Alternatives C; also for platforms, the number of spills ≥10,000 bbl has also been estimated to be <1 for Alternative C.

Alternative C would have the same potential for impact as Alternative A or B, even though the level of projected OCS oil- and gas-related activities and impact-producing factors are less in the WPA, but these are still substantial. For example, a range of 11-67 production wells are projected to be drilled and developed under Alternative C, whereas 58-464 production wells are projected to occur under Alternative B. The incremental cumulative impacts of Alternative C to OCS oil- and gas-related anthropogenic events are considered **moderate**, but only because of the impacts of a large oil spill (≥1,000 bbl) potentially forecasted to occur. However, under Alternative C, the combined probabilities of a large oil spill for occurrence and also contact with shoreline birds and nearshore waterbirds are small (<0.5-5% after 10 days and <0.5-7% after 30 days) (refer to **Chapter 3.2.1.4.8 and Appendix E**) These probabilities are for the high case for projected resource estimates (billions of barrels of oil).

The significance of impact-producing factors on birds would be somewhat the same for Alternative C as for Alternative A. Alternative C would have a somewhat less impact than Alternatives A and B since the geographical planning area is smaller and less activity is projected to occur in the WPA under the scenario in **Chapter 3.1.1**.

4.8.2.8 Alternative D—Alternative A, B, or C, with the Option to Exclude Available Unleased Blocks Subject to the Topographic Features, Live Bottom (Pinnacle Trend), and/or Blocks South of Baldwin County, Alabama, Stipulations

Under Alternative D, the impacts to birds are similar wherever they may occur in the GOM, and overall routine and accidental impacts are considered **moderate**, but only because of the impacts of a large oil spill (≥1,000 bbl). The incremental cumulative impacts of Alternative D to OCS oil- and gas-related anthropogenic events are considered **moderate**, but only because of the impacts of a large oil spill (≥1,000 bbl). Also, the incremental impacts of Alternative D on other non-OCS oil-and gas-related anthropogenic events and natural processes are considered **major**, but only because of the anthropogenic impact of non-native infectious diseases. The significance of impact-producing factors on birds could be somewhat less for Alternative D than for Alternative A, B, or C since a few blocks and associated activities would be removed from the proposed lease sale area. However, since there are so few unleased blocks subject to the Topographic Features, Live Bottom, and Blocks South of Baldwin County, Alabama, Stipulations, this would be a small incremental change compared with the other action alternatives. The impacts under Alternative D would not be much different and likely not even measurable when compared with the other action alternatives.

4.8.2.9 Alternative E—No Action

Alternative E would offer no new lease blocks for exploration and development; therefore, no impacts from a proposed lease sale would occur. However, there would be continuing impacts associated with the existing oil and gas activities from previously permitted activities and previous lease sales.

Overall, cumulative impacts on birds are as much as **major** and would result in social endpoints of take under the Migratory Bird Treaty Act and impacts on bird watching and hunting. There would consequently be fewer consumers in the supply chain and reduced spending. Hunting results in additional negative feedback loops for economic factors.

4.9 PROTECTED SPECIES

The Endangered Species Act of 1973 (ESA), as amended, establishes a national policy designed to protect and conserve threatened and endangered species and the ecosystems upon which they depend. In fulfilling these requirements, each agency must use the best scientific and commercial data available. The FWS and NMFS share responsibility for implementing the ESA.

The Marine Mammal Protection Act of 1972 (MMPA) prohibits, with certain exceptions, the "take" of marine mammals in U.S. waters and by U.S. citizens on the high seas and the importation of marine mammals and marine mammal products into the U.S. The NMFS and FWS are also responsible for the MMPA.

For the GOM, NMFS is charged with protecting all cetaceans while manatees are under the jurisdiction of FWS. Details on BOEM's consultations and coordination are presented in **Chapter 5.7** (Endangered Species Act).

Protected species for the purposes of this Multisale EIS include ESA- and MMPA-listed species and associated designated critical habitat under the ESA. The species considered in this chapter, pursuant to our consultations and coordination, and within **Table 4-17** are those that could be affected within the GOM Area of Interest and that are subject to the proposed activities under the alternatives. For those species not considered further because they are unlikely to be affected by the proposed activities, refer to **Appendix F**. Critical habitats noted within the GOM Area of Interest are shown in **Figure 4-25** and are mentioned in this chapter, but comprehensive details on many of these habitats can be found in **Chapters 4.3** (Coastal Habitats), **4.5** (*Sargassum* and Associated Communities), and **4.6** (Live Bottom Habitats).

Table 4-17. Species within the Gulf of Mexico That Are Protected Under the Endangered Species Act and/or the Marine Mammal Protection Act.

Common Name	Scientific Name		Common Name	Scientific Name
Marine Mammals			Sea Turtles	
Atlantic spotted dolphin*	*Stenella frontalis**		Green sea turtle[2]	*Chelonia mydas*[2]
Blainville's beaked whale*	*Mesoplodon densirostris**		Hawksbill sea turtle[3]	*Eretmochelys imbricata*[3]
Bottlenose dolphin*	*Tursiops truncatus**		Kemp's ridley sea turtle[3]	*Lepidochelys kempii*[3]
Bryde's whale*	*Balaenoptera edeni**		Northwest Atlantic Ocean loggerhead sea turtle[2]	*Caretta caretta*[2]

Clymene dolphin*	*Stenella clymene**
Cuvier's beaked whale*	*Ziphius cavirostris**
Dwarf sperm whale*	*Kogia sima**
False killer whale*	*Pseudorca crassidens**
Fraser's dolphin*	*Lagenodelphis hosei**
Gervais' beaked whale*	*Mesoplodon europaeus**
Killer whale*	*Orcinus orca**
Melon-headed whale*	*Peponocephala electra**
Pantropical spotted dolphin*	*Stenella attenuate**
Pygmy killer whale*	*Feresa attenuata**
Pygmy sperm whale*	*Kogia breviceps**
Risso's dolphin*	*Grampus griseus**
Rough-toothed dolphin*	*Steno bredanensis**
Short-finned pilot whale*	*Globicephala macrorhynchus**
Sperm whale[1]	*Physeter macrocephalus*[1]
Spinner dolphin*	*Stenella longirostris**
Striped dolphin*	*Stenella coeruleoalba**
West Indian manatee[1]	*Trichechus manatus*[1]

Leatherback sea turtle (Atlantic Northwest)[3]	*Dermochelys coriacea*[3]
Beach Mice	
Alabama beach mouse[3]	*Peromyscus polionotus ammobates*[3]
Choctawhatchee beach mouse[3]	*Peromyscus polionotus allophrys*[3]
Perdido Key beach mouse[3]	*Peromyscus polionotus trissyllepsis*[3]
St. Andrew beach mouse[3]	*Peromyscus polionotus peninsularis*[3]
Birds	
Cape Sable Seaside Sparrow[3]	*Ammodramus maritimus mirabilis*[3]
Mississippi Sandhill Crane[3]	*Grus canadensis pulla*[3]
Piping Plover[2]	*Charadrius melodus*[2]
Rufa Red knot[2]	*Calidris canutus rufa*[2]
Roseate Tern[2]	*Sterna dougallii dougallii*[2]
Whooping Crane[3]	*Grus americana*[3]
Wood Stork[2]	*Mycteria americana*[2]
Corals	
Elkhorn coral[2]	*Acropora palmata*[2]
Staghorn coral[2]	*Acropora cervicornis*[2]
Boulder star coral[2]	*Orbicella franksi*[2]
Lobed star coral[2]	*Orbicella annularis*[2]
Mountainous star coral[2]	*Orbicella faveolata*[2]

* This species is protected under the Marine Mammal Protection Act (MMPA).

[1] This species/subspecies is listed under the Endangered Species Act (ESA) as "endangered" and is also protected under the MMPA.

[2] This species/subspecies is listed under the ESA as "threatened."

[3] This species/subspecies is listed under the ESA as "endangered."

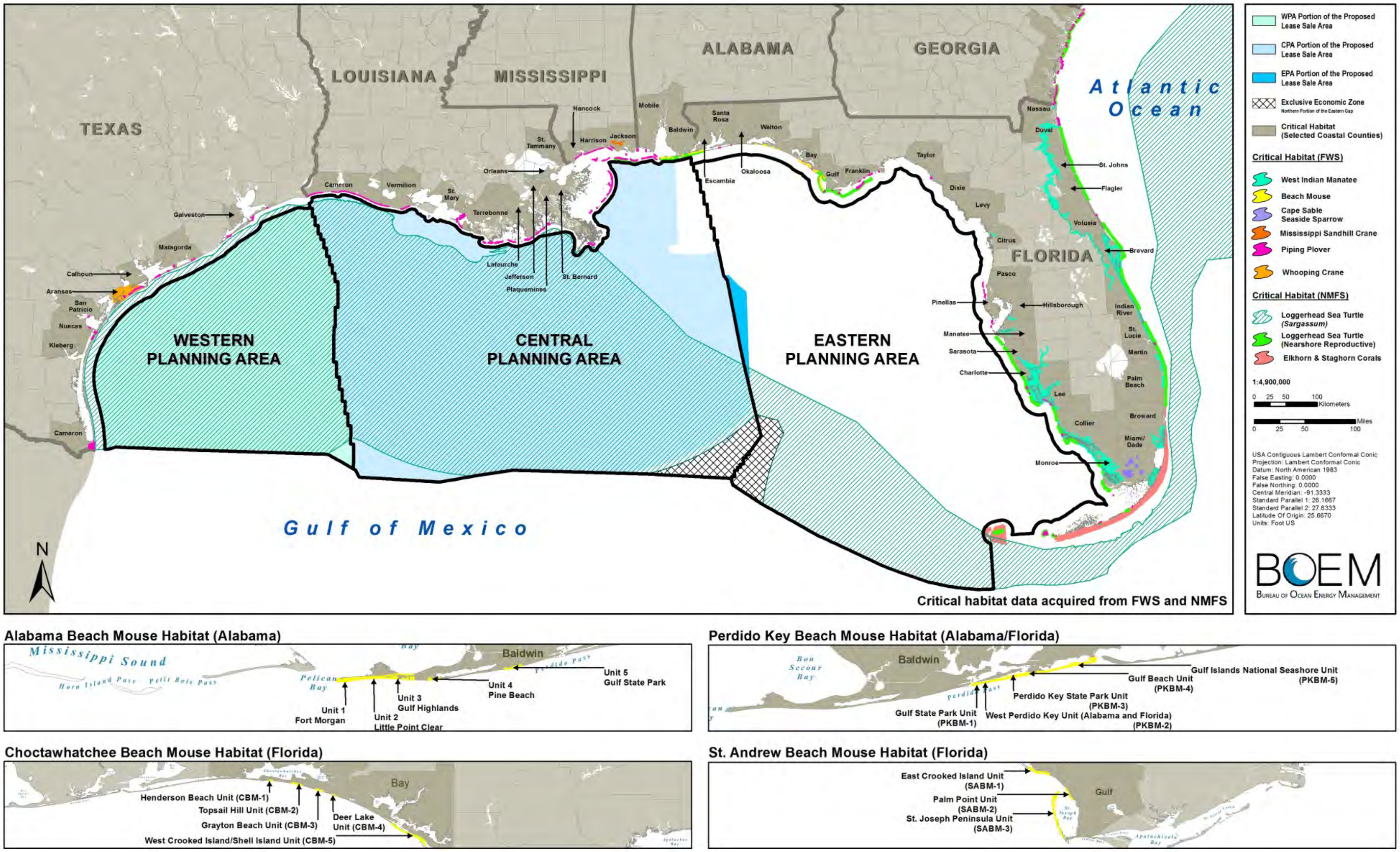

Figure 4-25. Gulf of Mexico Protected Species' Critical Habitats.

Impact-Level Definitions

As the routine activities, accidental events, and cumulative impacts are considered for specific listed species, each is given criteria per level of impact represented below.

- **Negligible** – An individual or group of animals would be subject to nominal to slight measurable impacts. No mortality or injury to any individual would occur, and no disruption of behavioral patterns would be expected. The disturbance would last only as long as the human-caused stimulus was perceptible to the individual or group.
- **Minor** – An individual or group of animals would be subject to a human-caused stimulus and be disturbed, resulting in an acute behavioral change. No mortality or injury to an individual or group would occur.
- **Moderate** – An individual or group of animals would be subject to a human-caused stimulus and be disturbed, resulting in a chronic behavioral change. Individuals may be impacted but at levels that do not affect the fitness of the population. Some impacts to individual animals may be irreversible.
- **Major** – An individual or group of animals would be subject to a human-caused stimulus, resulting in physical injury or mortality, and would include sufficient numbers that the continued viability of the population is diminished, including annual rates of recruitment or survival. Impacts would also include permanent disruption of behavioral patterns that would affect a species or stock.

The analyses of the reasonably foreseeable potential impacts of routine activities and accidental events associated with a GOM proposed action and a proposed action's incremental contribution to the cumulative impacts are presented in detail within the chapters below. The approach of the analysis is to focus on the potential impact-producing factors from OCS oil- and gas-related routine activities (i.e., exploration, development, and production), as well as accidental events and cumulative impacts, and to define impact-level measures for each impact-producing factor for protected species, as summarized in **Table 4-18**. These impacts are across all action alternatives (i.e., Alternatives A, B, C, and D) except for beach mice and protected corals. Beach mice are not found in the WPA; therefore, they are not relevant for Alternative B, and the ranges given for potential impacts to protected corals are based on whether or not stipulations are placed on leases.

Table 4-18. Protected Species Impact-Producing Factors That Are Reasonably Foreseeable.

Protected Species	Magnitude of Potential Impact[1]				
Impact-Producing Factors	Marine Mammals	Sea Turtles	Beach Mice[2]	Protected Birds	Protected Corals[3]
Routine Impacts					
Geological and Geophysical Activities	Negligible to Moderate	Negligible to Moderate	N/A*	N/A	N/A
Transportation (vessel strikes)	Negligible	Negligible	N/A	N/A	N/A
Discharges (air and water quality degradation)	Negligible	Negligible	N/A	Negligible	N/A
Decommissioning (explosive severance)	Negligible to Minor	Negligible to Moderate	N/A	N/A	Negligible
Noise	Negligible to Minor	Negligible to Minor	N/A	Negligible	N/A
Drilling and Exploration (bottom-disturbing activities)	N/A	N/A	N/A	N/A	Negligible
Offshore Lighting/Platform Presence	N/A	N/A	N/A	Negligible	N/A
Vessel Operation (bottom-disturbing activities)	N/A	N/A	N/A	N/A	Negligible
Accidental Impacts					
Oil Spills[4]	Negligible to Moderate	Negligible to Moderate	Negligible	Negligible to Moderate	Negligible
Oil-Spill Response Activities	Negligible to Minor	Negligible to Minor	Negligible	Negligible to Minor	Negligible
Marine Trash and Debris	Negligible	Negligible	Negligible	Negligible	Negligible
Cumulative Impacts					
Incremental Contribution[5]	Negligible	Negligible	Negligible	Negligible	Negligible
OCS Oil and Gas[6]	Negligible to Moderate	Negligible to Moderate	Negligible	Negligible to Moderate	Negligible
Non-OCS Oil and Gas[7]	Negligible to Major				

* N/A represents those impact-producing factors that are not applicable to that protected species group.

1 The analysis supporting these conclusions are discussed in detail in the analysis chapter for each species.

2 Beach mice are not found in the WPA; therefore, they are not likely to be impacted by Alternative B.

3 Ranges for the potential impacts to protected corals are based on whether or not protected stipulations are placed on leases.

4 Accidental oil spills are those <10,000 bbl.

[5] This includes all activities (i.e., routine activities projected to occur and accidental events that could occur) as a result of a single proposed lease sale in the 2017-2022 Five-Year Program.
[6] This includes all activities (i.e., routine activities projected to occur and accidental events that could occur) from past, proposed, and future lease sales.
[7] This includes other past, present, and reasonably foreseeable future activities occurring within the same geographic range and within the same timeframes as a proposed action, but they are not related to the OCS Oil and Gas Program.

For protected coral impact-producing factors, refer to **Table 4-11** in **Chapter 4.6.1** (Topographic Features) since coral impact-producing factors are covered in detail there and would apply to protected corals as well. For protected birds impact-producing factors, refer to **Table 4-16** in **Chapter 4.8** (Birds) since the impact-producing factors that impact coastal, marine, and migratory birds (the listed birds are either found in coastal areas or are migratory and utilize coastal areas as part of their life history) are covered in detail there. For beach mice, the most relevant impact-producing factors are those causing harm to the populations by affecting their habitat (beaches). **Table 4-10** in **Chapter 4.3.2** (Coastal Barrier Beaches and Associated Dunes) covers the impact-producing factors that affect beaches and dunes, and details about those impacts to beach mouse habitat can be found there.

BOEM understands that mitigations greatly reduce the likelihood of an impact-producing factor, but mitigations do not guarantee that a protected species would not be impacted. There is a very low probability that a protected species may not be sighted despite all of the mitigative precautions taken to reduce impact. Unlikely scenarios such as these may cause major impacts to a protected species with a very low population because some impact-producing factors may negatively impact the reproductive success of an individual and, therefore, the continued viability of the population. However, based on credible scientific research and that within the GOM, there is a long-standing and well-developed OCS Program (more than 60 years), and scenarios such as these are highly speculative. There are no data to suggest that activities from the previous OCS Programs are significantly impacting protected species populations. Therefore, for purposes of this analysis, BOEM has considered the potential effects of impact-producing factors that are reasonably foreseeable to occur.

Current baselines (including past and present events) are described for all protected species under their respective "Description of the Affected Environment" chapters. The altered baseline includes individual species directly affected by this unexpected unique catastrophic event. BOEM understands that each oil-spill event is unique and that its outcome depends on several factors, including the time of year and location of the release relative to winds, currents, land, and sensitive resources, as well as specifics of the well and response effort. Specific to the *Deepwater Horizon*, the Trustees have completed the PADARP/PEIS (Deepwater Horizon Natural Resource Damage Assessment Trustees, 2016), which has the purpose and need of assessing and creating restoration plans to relieve injuries from the to natural resourses and services. The injuries assessed within the PDARP/PEIS do not necessarily equate the baseline as defined by NEPA. BOEM continues to analyze the *Deepwater Horizon* explosion, oil spill, and response *Deepwater Horizon* explosion, oil spill, and response as information becomes available, and it was evaluated as part of the baseline for resources in this Multisale EIS.

BOEM analyzed a low-probability catastrophic event (USDOI, BOEM 2017) in conjunction with its analysis of the potential effects, as requested by CEQ pursuant to its regulation at 40 CFR § 1502.22. The CEQ (2010) recommended that BOEM should "ensure that NEPA documents provide decision makers with a robust analysis of reasonably foreseeable impacts, including an analysis of reasonably foreseeable impacts associated with low probability catastrophic spills for oil and gas activities on the Outer Continental Shelf." A low-probability catastrophic spill is, by definition, *not* reasonably certain to occur. The return period of a catastrophic oil spill in OCS areas is estimated to be 165 years, with a 95 percent confidence interval between 41 years and more than 500 years (Ji et al., 2014). Other methods of analysis are significantly limited in their applicability and availability, and they would not provide any meaningful or useful information to be used to assess the risk of a catastrophic oil-spill occurrence at this programmatic level of oil and gas activities in the GOM.

4.9.1 Marine Mammals

The Gulf of Mexico marine mammal community is diverse and distributed throughout the GOM, including northern U.S. waters. The GOM's Cetacea include the suborders Mysticeti (i.e., baleen whales) and Odontoceti (i.e., toothed whales), and the order Sirenia, which includes the West Indian manatee. Most marine mammal distributions vary widely across the northern GOM with very little known about their respective breeding and calving grounds, as well as any potential migratory routes. While all marine mammals are protected under the MMPA, two species (i.e., the sperm whale and West Indian manatee) are listed as endangered under the ESA due to various factors, which are described in this chapter. For the Gulf of Mexico, NMFS is charged with protecting all cetaceans, while manatees are under the jurisdiction of FWS. Details on BOEM's consultations and coordination are presented in **Chapter 5.7** (Endangered Species Act).

The analyses of the reasonably forseeable potential impacts of routine activities and accidental events associated with a proposed lease sale and a proposed lease sale's incremental contribution to the cumulative impacts to marine mammals are presented in this chapter. Potential impact-level criteria are defined in **Chapter 4.9** (Protected Species) and apply to marine mammal species described in this chapter. The approach of the analysis is to focus on the potential impact-producing factors from OCS oil- and gas-related routine activities (i.e., exploration, development, and production), as well as accidental events and cumulative impacts, and to define impact-level measures for each impact-producing factor in relation to the best available population estimates (refer to **Table 4-18** in **Chapter 4.9**). Some impact-producing factors may have different potential impact levels to different marine mammal species due to their various population sizes, as well as their wide-ranging behavior; thus, some potential impact-producing factors are described in a range. Throughout this chapter, where information was incomplete or unavailable, BOEM complied with its obligations under NEPA to determine if the information was relevant to reasonably foreseeable significant adverse impacts. Refer to **Chapter 4.9.1.2.4** for a more detailed discussion.

4.9.1.1 Description of the Affected Environment

Twenty-one species of cetaceans and one species of sirenian (West Indian manatee) regularly occur in the GOM and are identified in NMFS' Gulf of Mexico Stock Assessment Reports (Jefferson et al., 1992; Davis et al., 2000; Waring et al., 2016). Along with stock assessment reports, NMFS also calculates the Potential Biological Removal (PBR) for cetaceans, which is defined under the MMPA as the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population (USDOC, NMFS, 2007b). The PBR is the product of the minimum population estimate of the stock, one-half the maximum theoretical or estimated net productivity rate of the stock at a small population size, and a recovery factor of between 0.1 and 1.0 (USDOC, NMFS, 2007b). The PBR can be used as a conservative tool, most often for commercial fisheries, to help with management of the different marine mammal stocks because a potential impact-producing factor may have a more serious impact on a marine mammal stock that has a lower PBR and a less serious impact to a marine mammal stock with a higher PBR.

There are species that have been reported from GOM waters either by sighting or stranding that, due to their rarity, are not considered in this Multisale EIS (Wursig et al., 2000; Mullin and Fulling, 2004). These species include the following: the blue whale (*Balaenoptera musculus*), North Atlantic right whale (*Eubalaena glacialis*), and Sowerby's beaked whale (*Mesoplodon bidens*), all of which are considered extralimital in the Gulf of Mexico; and the humpback whale (*Megaptera novaeangliae*), fin whale (*Balaenoptera physalus*), sei whale (*Balaenoptera borealis*), and minke whale (*Balaenoptera acutorostrata*), all of which are considered rare occasional migrants in the Gulf of Mexico (Wursig et al., 2000; Mullin and Fulling, 2004). Because these species are uncommon in the GOM and because they are not included in the most recent NMFS Gulf of Mexico Stock Assessment Reports, BOEM did not consider them for this analysis as they are unlikely to be impacted by OCS oil- and gas-related activities.

Population estimates for marine mammals in the GOM, as well as the PBR for cetaceans, are represented in **Table 4-19**. A recent study analyzed past cetacean survey data and environmental variables related to cetacean habitat (e.g., sea-surface temperature and bathymetry) to produce cetacean density models for the Gulf of Mexico (Roberts et al., 2016). However, because NMFS is charged with protecting cetaceans in the GOM waters, BOEM used NMFS' Stock Assessment Reports for this analysis. The most recent abundance estimates available for all cetacean species mentioned in this Multisale EIS can be found on NMFS's website (USDOC, NMFS, 2015b). and estimates for manatees can be found on the Florida Fish and Wildlife Conservation Commission's website (State of Florida, Fish and Wildlife Conservation Commission, 2015a).

Table 4-19. Best Available Population Estimates for Marine Mammal Species in the Northern Gulf of Mexico.

Species	Population Estimate	PBR*
Bryde's Whale (*Balaenoptera brydes*)	33	0.03
Sperm Whale (*Physeter macrocephalus*)	763	1.1
Pygmy Sperm Whale (*Kogia breviceps*)	186[a]	0.9
Dwarf Sperm Whale (*Kogia sima*)	186[a]	0.9
Gervais' Beaked Whale (*Mesoplodon europaeus*)	149[b]	0.8
Blainville's Beaked Whale (*Mesoplodon densirostris*)	149[b]	0.8
Cuvier's Beaked Whale (*Ziphius cavirostris*)	74	0.4
Bottlenose Dolphin (*Tursiops truncatus*)		
Oceanic waters	5,806	42
Northern Coastal Stock	7,185	60
Eastern Coastal Stock	12,388	111
Western Coastal Stock	20,161	175
Continental Shelf Stock	51,192	469
Bay, Sound, and Estuary (27 stocks)	Unknown for all but 6 stocks	Undetermined for all but 6 stocks
Barataria Bay Estuarine System	Unknown	Undetermined
Mississippi Sound, Lake Borgne, and Bay Boudreau	901	5.6
Clymene Dolphin (*Stenella clymene*)	129	0.6
Pantropical Spotted Dolphin (*Stenella attenuata*)	50,880	407
Atlantic Spotted Dolphin (*Stenella frontalis*)	Unknown	Undetermined
Risso's Dolphin (*Grampus griseus*)	2,442	16
Rough-toothed Dolphin (*Steno bredanensis*)	624	3
Spinner Dolphin (*Stenella longirostris*)	11,441	62
Striped Dolphin (*Stenella coeruleoalba*)	1,849	10
False Killer Whale (*Pseudorca crassidens*)	Unknown	Undetermined
Fraser's Dolphin (*Lagenodelphis hosei*)	Unknown	Undetermined
Killer Whale (*Orcinus orca*)	28	0.1
Melon-headed Whale (*Peponocephala electra*)	2,235	13
Pygmy Killer Whale (*Feresa attenuata*)	152	0.8
Short-finned Pilot Whale (*Globicephala macrorhynchus*)[c]	2,415[c]	15[c]
West Indian Manatee (*Trichechus manatus latirostris*)	2,730[d]	Not Applicable[e]

Species	Population Estimate	PBR*

* Potential Biological Removal (PBR) estimates from Waring et al., 2016.
[a] This estimate includes both the dwarf and pygmy sperm whales.
[b] This estimate includes Gervais' beaked whales and Blainville's beaked whales in the GOM.
[c] This estimate includes all *Globicephala* sp., though it is presumed that only short-finned pilot whales are present in the Gulf of Mexico.
[d] This estimate includes the west coast of Florida.
[e] West Indian manatees are under the jurisdiction of FWS. The NMFS PBR estimate is not applicable.

Sources: State of Florida, Fish and Wildlife Conservation Commission, 2015a.
Waring et al., 2016.

Threatened or Endangered Species

Currently, the sperm whale (*Physeter macrocephalus*) and the West Indian manatee (*Trichechus manatus*) are the only ESA-listed marine mammals that regularly occur in the GOM. The sperm whale is common in oceanic waters of the northern GOM and appears to be a resident species (Mullin et al., 1991; Davis and Fargion, 1996; Jefferson and Schiro, 1997). The West Indian manatee is commonly found along the coast of Florida in the winter and may migrate as far as Texas in the warmer seasons, typically inhabiting only shallow coastal marine, brackish, and freshwater areas (O'Shea et al.,1995; Fertl et al., 2005). The FWS provided notice of the petition on January 8, 2016, to reclassify the West Indian manatee from endangered to threatened (*Federal Register*, 2016d). If this petition becomes a final rule and the West Indian manatee meets the requirements to be reclassified as threatened, it would still have protection under the ESA because it would still be an ESA-listed species. On December 8, 2016, NMFS announced a 12-month finding on a petition to list the GOM Bryde's whale (*Balaenoptera edeni)* and proposed that it be listed as endangered under the ESA (*Federal Register*, 2016e). If NOAA issues a final rule listing the Bryde's whale as endangered, the species will receive additional protections and Federal agencies will be required to consult under Section 7 for Federal actions that may affect the species.

Cetaceans—Odontocetes

The sperm whale was listed as endangered in 1970 (*Federal Register*, 1970a). It is found worldwide in deep waters between approximately 60° N. and 60° S. latitude (Whitehead, 2002), although generally only large males venture to the extreme northern and southern portions of their range (Jefferson et al., 1993). Females and juveniles form pods that are found mainly at tropical and temperate latitudes (between 50° N. and 50° S. latitude), while the solitary adult males can be found at higher latitudes (between 75° N. and 75° S. latitude) (Reeves and Whitehead, 1997). In the western North Atlantic, they range from Greenland to the Gulf of Mexico and the Caribbean Sea. As deep divers, sperm whales generally inhabit oceanic waters at depths greater than 591 ft (180 m), but they do come close to shore where submarine canyons or other geophysical features bring deep water near the coast (Jefferson et al., 1993). Sperm whales prey on cephalopods, demersal fishes, and benthic invertebrates (Rice, 1989; Jefferson et al., 1993).

The NMFS considers sperm whales in the GOM as a distinct stock in the Marine Mammal Stock Assessment Report (Waring et al., 2016), and research supports this distinction from the Atlantic and Caribbean stocks (Engelhaupt et al., 2009; Gero et al., 2007; Jaquet, 2006; Jochens et al., 2008). Consistent sightings, satellite tracking, strandings, historical whale catches, and recent research indicate that sperm whales occupy the northern GOM throughout all seasons and that aggregations are commonly found in waters over the shelf edge in the vicinity of the Mississippi River Delta, which are 1,641-6,562 ft (500-2,000 m) in depth, and represent a resident population (Mullin et al., 1994a; Davis and Fargion, 1996; Sparks et al., 1996; Jefferson and Schiro, 1997; Davis et al., 2000; Jochens et al., 2008). Seasonal aerial surveys confirmed that sperm whales sightings are more common during summer (Mullin et al., 1991 and 1994a; Mullin and Hoggard, 2000; Mullin and Fulling, 2004), but this may be an artifact of movement patterns of sperm whales associated with reproductive behavior, hydrographic features, or other environmental or seasonal factors. Because of the lack of adult males observed in the GOM, it is not known whether females leave the GOM to mate or whether males sporadically enter the area to mate with females, which would make this a very important area for sperm whale reproduction.

While they may be encountered almost anywhere on the high seas, their distribution shows a preference for continental margins, sea mounts, and areas of upwelling, where food is abundant (Leatherwood and Reeves, 1983). The low-salinity, nutrient-rich water from the Mississippi River contributes to enhanced primary and secondary productivity in the north-central GOM and may explain the presence of sperm whales in the area (Würsig et al., 2000; Davis et al., 2000 and 2002; Jochens et al., 2008). The continental margin in the north-central GOM is only 12 mi (20 km) wide at its narrowest point, and the ocean floor descends quickly along the continental slope, reaching a depth of 3,281 ft (1,000 m) within 25 mi (40 km) of the coast. This unique area of the GOM brings deepwater organisms within the influence of coastal fisheries, contaminants, and other human impacts on the entire northern GOM (Davis et al., 2000). Sperm whales are noted for their ability to make prolonged deep dives and are likely the deepest and longest diving mammal. Typical foraging dives last approximately 40 minutes and descend to about 1,312 ft (400 m), followed by approximately 8 minutes of resting at the surface (Papastavrou et al., 1989). However, dives of over 2 hours and deeper than 2.1 mi (3.3 km) have been recorded (Clarke, 1976; Watkins et al., 1985 and 1993), and individuals may spend extended periods of time at the surface to recover.

Evidence suggests that the disproportionately large head of the sperm whale is an adaptation to produce vocalizations (Norris and Harvey, 1972; Cranford, 1992). This suggests that vocalizations are extremely important to sperm whales. The function of vocalizations is relatively well-studied (Weilgart and Whitehead, 1997; Goold and Jones, 1995). Long series of monotonous, regularly spaced clicks are associated with feeding and are thought to be produced for echolocation. Sperm whales also use unique stereotyped click sequence “codas” (Mullins et al., 1988; Watkins and Scheville, 1977; Watkins et al., 1985), according to Weilgart and Whitehead (1988), to possibly convey information about the age, sex, and reproductive status of the sender. Groups of closely related females and their offspring have group-specific dialects (Weilgart and Whitehead, 1997). Sperm whale vocalization and audition are important for echolocation and feeding, social behavior and intragroup interactions, and maintaining social cohesion within the group. Further detailed information on sperm whale hearing may be found in BOEM's *Atlantic OCS Proposed Geological and Geophysical Activities: Mid-Atlantic and South Atlantic Planning Areas, Final Programmatic Environmental Impact Statement* (USDOI, BOEM, 2014a).

The age distribution of the GOM sperm whale population is unknown, but they are believed to live at least 60 years. Potential sources of natural mortality in sperm whales include killer whales and a papilloma virus (Lambertsen et al., 1987). Little is known of recruitment and mortality rates; however, recent abundance estimates based on surveys indicate that the population appears to be stable, but NMFS believes that there is insufficient data to determine population trends in the GOM for this species at this time (Waring et al., 2016).

Cephalopods (i.e., squid, octopi, cuttlefishes, and nautilus) are the main dietary component of sperm whales (Davis et al., 2002). Other sperm whale populations are known to also take significant quantities of large demersal and mesopelagic fishes, especially the mature males in higher latitudes (Clarke, 1962 and 1979). Postulated feeding and hunting methods include lying suspended and relatively motionless near the ocean floor and ambushing prey, attracting squid and other prey to the white lining of their mouths by disturbing bioluminescent organisms around them to make their mouths more visible, or stunning prey with ultrasonic sounds (Norris and Mohl, 1983; Würsig et al., 2000). However, a recent study found that sperm whales produce powerful biological sounds in order to echolocate prey at long ranges but reduce acoustic outputs by several orders of magnitude when they are about their own body length from their prey (Fais et al., 2016a). This behaviour is inconsistent with the hypothesis that sperm whales stun their prey with ultrasonic sounds because the lowest outputs of sound are used in close proximity to their prey and are not at a magnitude that could stun their prey (Fais et al., 2016a). Evidence of ingested stones, sand, sponges, and other non-food items suggests they forage on or near the bottom (Rice, 1989) and may occasionally drown after becoming entangled in deep-sea cables that wrap around their lower jaw (Würsig et al., 2000).

The primary factor for the population decline was commercial whaling in the 18th, 19th, and 20th centuries. A commercial fishery for sperm whales operated in the GOM during the late 1700's to the early 1900's, but the exact number of whales taken is not known (Townsend, 1935). The overharvest of sperm whales resulted in their alarming decline in the last century. The total take of sperm whales worldwide between 1800 and 1909 has been estimated as close to 700,000 and between 1910 and 1973 as close to 605,000 (Best et al., 1984). Sperm whales have been protected from commercial harvest by the International Whaling Commission since 1981, although the Japanese continued to harvest sperm whales in the North Pacific until 1988 (Reeves and Whitehead, 1997). Since the ban on nearly all hunting of sperm whales, there has been little evidence that direct effects of anthropogenic causes of mortality or injury (e.g., vessel strikes, commercial fishing, entanglements, etc.) are significantly affecting the recovery of sperm whale stocks (Perry et al., 1999), yet the effects of these activities on the behavior of sperm whales has just recently begun to be studied. Sperm whales are also protected by the Convention on International Trade in Endangered Species of Wild Flora and Fauna and the Marine Mammal

Protection Act of 1972. As of 2002, the global population of sperm whales is estimated to be at 32 percent of its pre-whaling number (Whitehead, 2002).

Since sperm whales were listed under the ESA, a concern for the impacts of anthropogenic activities on the physiology and behavior of marine mammals has received much attention. The NMFS published a final recovery plan for the sperm whale (USDOC, NMFS, 2010b), and current threats to sperm whale populations worldwide are discussed. Threats are defined as "any factor that could represent an impediment to recovery" and include fisheries interactions, anthropogenic noise, vessel interactions, contaminants and pollutants, disease, injury from marine debris, research, predation and natural mortality, direct harvest, competition for resources, loss of prey base due to climate change and ecosystem change, and cable laying. In the GOM, the impacts from all of these threats are identified as either low or unknown (USDOC, NMFS, 2010b).

The commercial fishery, which potentially could interact with the GOM sperm whale stock, is the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico large pelagic longline fishery (Waring et al., 2016). There have been no reports of mortality or serious injury to sperm whales by this fishery (Waring et al., 2016), although one sperm whale was released alive with no serious injury after an entanglement interaction with the pelagic longline fishery in 2008 (Garrison et al., 2009).

In regards to the impacts of anthropogenic noise, the Five-Year Review of NMFS' recovery plan recognizes that there is a concern, but additional research is needed to fully understand possible injury and behavior changes (USDOC, NMFS, 2015c). Anthropogenic sources from vessel noise, noise associated with oil production, seismic surveys, and other sources have the potential to impact sperm whales. Little is known about sperm whale reactions to seismic exploration, and available studies provide inconsistent results. Further discussion of seismic exploration and marine mammals can be found in the "Routine Activities" section below (**Chapter 4.9.1.2**).

BOEM has completed the "Sperm Whale Seismic Study in the GOM," and a synthesis report was published in 2008 (Jochens et al., 2008). The principle conclusions from this multiyear research effort were as follows:

- the data support the conservation of sperm whales in the northern GOM as a discrete stock;
- sperm whales are present year-round in the GOM, with females generally having significant site fidelity and with males and females exhibiting significant differences in habitat usage;
- the sperm whale population off the Mississippi River Delta likely has a core size of about 140 individuals;
- GOM sperm whales seem to be smaller in individual size than sperm whales in some other oceans;

- some groups of sperm whales in the GOM were mixed-sex groups of females/immatures and others were groups of bachelor males and typical group size for mixed groups was 10 individuals, which is smaller than group sizes in some other oceans;
- the typical diving and underwater behaviors of the GOM's sperm whales are similar to those of animals in other oceans;
- the typical feeding and foraging behaviors of the GOM's sperm whales are similar to those of animals in other oceans, although differences in defecation rates suggest possible differences in feeding success;
- in the otherwise oligotrophic Gulf of Mexico, the eddy field contributes to the development of regions of locally high surface productivity that, in turn, may create conditions favorable for the trophic cascade of surface production to the depths where GOM sperm whales dive to forage;
- there appeared to be no horizontal avoidance to controlled exposure of seismic airgun sounds by sperm whales in the main "Sperm Whale Seismic Study" area;
- data analysis suggests it is more likely than not that some decrease in foraging effort may occur during exposure to full-array airgun firing as compared with the post-exposure condition, at least for some individuals; and
- knowledge of the acoustic propagation and airgun sound characteristics is critical to developing the capability for accurate predictions of exposures and the modeling of potential resulting effects.

Recommendations from the "Sperm Whale Seismic Study" included continued conservation of GOM sperm whales as a separate stock, implementation of a long-term monitoring program, continued controlled exposure experiments, investigation into sperm whale prey fields, continued development of tagging sensor and instrument capabilities, and continued development of passive acoustic monitoring techniques.

In 2009, BOEM entered into an Interagency Agreement with NMFS' Southeast Fisheries Science Center for the "Sperm Whale Acoustic Prey Study." Study objectives include quantitative sampling of the mid-water pelagic community within the foraging depths of sperm whales, examination of the relationships between acoustic backscatter and prey taxonomic composition, and comparison of sperm whale distribution and prey composition across habitats of the northern GOM. Field work is complete and sample analyses and data synthesis are ongoing.

Sirenians

The West Indian manatee typically inhabits only coastal marine, brackish, and freshwater areas of the southeastern U.S., the GOM, and the Caribbean Sea (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. The Florida manatee was listed as endangered in 1967 (*Federal Register*, 1967) and is the subspecies considered for this impact analysis. On January 8, 2016, FWS proposed that the manatee be downlisted from endangered to threatened as a result of improvements in its population and habitat conditions, and reductions in threats (*Federal Register*, 2016d); however, this proposal will not affect Federal protections currently in place by the ESA.

Manatees are generalist feeders and are known to consume more than 60 species of aquatic vegetation in marine, estuarine, and freshwater habitats (USDOI, FWS, 2001). Manatees primarily use open coastal areas and estuaries, and they are also found far up in freshwater tributaries. Shallow grassbeds with access to deep channels are their preferred feeding areas in coastal and riverine habitats (near the mouths of coastal rivers), and sloughs are used for feeding, resting, mating, and calving (USDOI, FWS, 2001).

Florida manatees have been divided into four distinct regional management units:

- the Atlantic Coast Unit that occupies the east coast of Florida, including the Florida Keys and the lower St. Johns River north of Palatka, Florida;
- the Southwest Unit that occurs from Pasco County, Florida, south to Whitewater Bay in Monroe County, Florida;
- the Upper St. Johns River Unit that occurs in the river south of Palatka, Florida; and
- the Northwest Unit that occupies the Florida Panhandle south to Hernando County, Florida (USDOI, FWS, 2014). Manatees from the Northwest Unit are more likely to be seen in the northern GOM, and they can be found as far west as Texas; however, most sightings are in the eastern GOM (Fertl et al., 2005).

During warmer months (June to September), manatees are common along the Gulf Coast of Florida from the Everglades National Park northward to the Suwannee River in northwestern Florida. Although manatees are less common farther westward, manatee sightings increase during the warmer summer months. Winter habitat use is primarily influenced by water temperature as animals congregate at natural (springs) and/or artificial (power plant outflows) warm water sources (Alves-Stanley et al., 2010). The most recent count of Florida manatees is 6,063 individuals (2,730 individuals on the west coast of Florida and 3,333 individuals on the east coast) based on a February 2015 synoptic aerial survey of warm-water refuges (State of Florida, Fish and Wildlife Conservation Commission, 2015a). These synoptic surveys are performed each winter to get a count of manatees, and the most recent results may be found on the Fish and Wildlife Conservation Commission's website (State of Florida, Fish and Wildlife Conservation Commission, 2016a). Although these surveys provide a recent count of Florida manatees, the techniques are not the best for accurate abundance estimates. Thus, a statewide survey was performed in 2011 and 2012 using a different sampling method and produced a more accurate abundance estimate of 6,350 individuals for the State of Florida (Martin et al., 2015).

Per the guidance of NTL 2016-BOEM-G01, "Vessel Strike Avoidance and Injured/Dead Protection Species Reporting," an operator is to report an observation of an injured or dead protected species, though many operators also report live animals. Recently, three live manatees have been spotted offshore. The first sighting was on March 20, 2013, in Green Canyon Block 653 in 4,356 ft (1,328 m) of water; another was on March 27, 2013, next to a drillship in approximately 6,000 ft (1,829 m) of water; and the third was on December 18, 2013, about 16 ft (5 m) off a seismic vessel's port stern in 466 ft (142 m) of water. These sightings at these depths are uncommon, and these are the only reports of a manatee sighted by seismic observers in the GOM.

Manatees are vulnerable to various natural and anthropogenic threats. In 2013, a red-tide event in southwest Florida produced a brevetoxin that was ingested by manatees and that claimed a total of 277 individuals. This is the highest number of red-tide-related deaths in a single calendar year on record. State and Federal scientists are monitoring and responding to manatees affected by red-tide blooms along the southwest Florida coast (State of Florida, Fish and Wildlife Conservation Commission, 2015b). Research into the causes of death is currently ongoing and undetermined for the No. 58 Florida unusual mortality event (UME). A previous UME in 2011 (No. 52) was determined to have been caused by ecological factors (USDOC, NMFS, 2015d). While pathogens or toxins such as brevtoxin may cause a high number of mortalities to manatees in a relatively short timeframe, they are not known to occur on a regular basis.

The most common major threats to the Florida manatee are cold stress and watercraft collisions. When manatees experience prolonged exposure to water temperatures below 68 °F (20 °C), they can develop a condition called cold-stress syndrome, which can be fatal (State of Florida, Fish and Wildlife Conservation Commission, 2016b). Chronic cold-stress syndrome is a complex disease process that involves metabolic, nutritional, and immunologic factors. Some parts of south Florida experienced the coldest temperatures on record from January 2-13, 2010, with temperatures at,or below 45 ºF (7.2 ºC). A total of 503 manatee carcasses were verified in State waters from January to April 2010, which surpassed the record high annual carcass count of 429 in 2009 (State of Florida, Fish and Wildlife Conservation Commission, 2016b).

Manatees share the waterways with watercraft and have historically sustained injuries due to interactions with vessels (Lightsey et al., 2006). As much as 24 percent of dead manatees recovered in the State of Florida between 1993 and 2003 were killed by watercraft-induced trauma, making it a significant contributor to Florida manatee mortality. The State of Florida's Fish and Wildlife Conservation Commission analyzes manatee mortality statistics every year and have found similar trends with manatees and water-craft collisions (State of Florida, Fish and Wildlife Conservation Commission, 2015c). Yearly mortality summaries can be found on the Fish and Wildlife Conservation Commission's website (State of Florida, Fish and Wildlife Conservation Commission, 2016c).

Other Protected Marine Mammal Species

One baleen cetacean (Bryde's whale) and 19 toothed cetaceans (including beaked whales and dolphins, but excluding the sperm whale since they are already discussed above) occur in the Gulf of Mexico. None of these species are protected under the ESA; however, all marine mammals are protected under the Marine Mammal Protection Act (1972).

Cetaceans—Mysticetes

The only commonly occurring baleen whale in the northern GOM is the Bryde's whale (*Balaenoptera edeni*). The Bryde's whale is found in tropical and subtropical waters throughout the world. They feed on small pelagic fishes and invertebrates (Leatherwood and Reeves, 1983; Cummings, 1985; Jefferson et al., 1993). Bryde's whales in the northern GOM, with few exceptions, have been sighted along a narrow corridor near the 100-m (328-ft) isobath (Davis and Fargion, 1996; Davis et al., 2000). Most sightings have been made in the De Soto Canyon region and off western Florida, although there have been some in the west-central portion of the northeastern GOM.

A recent study from NMFS' Southeast Fisheries Science Center (Rosel and Wilcox, 2014) evaluated genetic diversity and phylogenetic distinctiveness of this population to determine how unique it is in comparison to other Bryde's whales worldwide. The study found that the Gulf of Mexico Bryde's whale population has little genetic diversity, suggesting a small population size and a history of isolation; and that the population is evolutionarily distinct from all other Bryde's whales examined to date. The scientists conclude that the level of divergence suggests a unique evolutionary lineage for this population that is equivalent to currently recognized subspecies and species within the Bryde's complex, and among species and subspecies of certain other baleen whales. The small population in the Gulf of Mexico, which is also morphologically and behaviorally distinct from others in the complex, constitutes the only known members of this unique lineage.

The GOM population is considered a separate stock (northern GOM) for management purposes by NMFS (Waring et al., 2016). The status of Bryde's whales in the northern GOM is unknown, as there are insufficient data to determine the population trends for this stock. On December 8, 2016, however, NMFS announced a 12-month finding on a petition to list the GOM Bryde's whale as endangered under the Endangered Species Act (*Federal Register*, *2016e*). If this listing becomes final, the Bryde's whale would be recognized as an ESA-listed species, which would most likely encourage more research to aid in a recovery plan for the species. Preparation of a recovery plan would commence and Section 7 consultation requirements would apply.

Cetaceans—Odontocetes

Family Kogiidae: The pygmy sperm whale (*Kogia breviceps*) and dwarf sperm whale (*Kogia sima*) have a worldwide distribution in temperate to tropical waters (Caldwell and Caldwell, 1989). They feed mainly on squid but they would also eat crabs, shrimp, and smaller fishes (Würsig et al., 2000). In the GOM, they occur primarily along the continental shelf edge and in deeper waters off the continental shelf (Mullin et al., 1991). At sea, it is difficult to differentiate dwarf sperm whales from pygmy sperm whales, and sightings are often grouped together as "*Kogia* spp." Very little is known about the species except from studies on stranded individuals.

Family Ziphiidae (Beaked Whales): Beaked whales in the GOM are identified either as Cuvier's beaked whales or are grouped into an undifferentiated complex (*Mesoplodon* spp.) because of their similarity in appearance and potential identification errors. In the northern GOM, they are broadly distributed in waters >3,281 ft (1,000 m) over lower slope and abyssal landscapes (Davis et al., 1998 and 2000). Beaked whales were seen in the GOM in all seasons during GulfCet aerial surveys (Mullin and Hoggard, 2000). Beaked whale species that may occur within the GOM are usually observed singly or in small groups of individuals (Jefferson et al., 2008). As a group they are poorly known but are thought to be deep-diving animals. They feed at depth on deepwater cephalopods and fishes (Mead, 2002).

Three species of *Mesoplodon* are known to occur in the GOM based on sighting and stranding data and are considered provisional stocks (Wursig et al., 2000; Waring et al., 2014). The Gervais' beaked whale (*Mesoplodon europaeus*) appears to be widely but sparsely distributed worldwide in temperate to tropical waters (Leatherwood and Reeves, 1983). Stranding records suggest that this is probably the most common mesoplodont in the northern GOM (Jefferson and Schiro, 1997). The Blainville's beaked whale (*Mesoplodon densirostris*) is distributed throughout temperate and tropical waters worldwide, but it is not considered common (Würsig et al., 2000). Cuvier's beaked whale (*Ziphius cavirorostris*) is widely (but sparsely) distributed throughout temperate and tropical waters worldwide (Würsig et al., 2000). They are sighted in the GOM in all seasons in water depths typically >1,640 ft (500 m) (Maze-Foley and Mullin, 2006). Sightings data indicate that Cuvier's beaked whale is probably the most common beaked whale in the GOM (Jefferson and Schiro, 1997; Davis et al., 1998 and 2000).

Family Delphinidae (Dolphins): Fourteen members of the dolphin family are known to occur in the GOM. Dolphins are often gregarious and commonly form aggregations that can range from a few to several thousand individuals depending on the species (Jefferson et al., 2008; Würsig et al., 2000).

Of the 14 members, the bottlenose dolphin (*Tursiops truncatus*) is the most common inhabitant of the continental shelf and upper slope waters of the northern GOM. Bottlenose dolphins are opportunistic feeders, taking a wide variety of fishes, cephalopods, and shrimp (Davis and Fargion, 1996; Jefferson and Schiro, 1997; Wells and Scott, 1999). There appears to be two ecotypes of bottlenose dolphins, a coastal form (52-210 ft;16-67 m) and an offshore form (about 820 ft; 250 m) (Hersh and Duffield, 1990; Mead and Potter, 1990; Baumgartner, 1995). The coastal or inshore stocks are genetically isolated from the offshore stock (Curry and Smith, 1997). Inshore stocks are further provisionally delineated into 31 bay, sound, and estuarine stocks (Waring et al., 2016).

Species endemic to tropical and subtropical waters of the Atlantic Ocean include the Clymene dolphin (*Stenella clymene*) (Perrin and Mead, 1994) and pantropical spotted dolphin (*Stenella attenuata*) (Perrin and Hohn, 1994). The Clymene dolphin is thought to feed on fishes and cephalopods (Leatherwood and Reeves, 1983; Jefferson et al., 1993; Mullin et al., 1994b). Sightings in the GOM are relatively common and suggest a primary range offshore of the 100-m (328-ft) isobath (Davis et al., 2000; Würsig et al., 2000). The pantropical spotted dolphin feeds on epipelagic fishes and cephalopods (Leatherwood and Reeves, 1983; Jefferson et al., 1993). It is the most common cetacean in the oceanic northern GOM (Mullin et al., 1994a) and is found in the deeper waters off the continental shelf between the 100-m and 2,000-m (328- and 6,565-ft) depth contours (Mullin et al., 1994a; Davis et al., 1998 and 2000; Würsig et al., 2000).

The Atlantic spotted dolphin (*Stenella frontalis*), Risso's dolphin (*Grampus griseus*), rough-toothed dolphin (*Steno bredanensis*), spinner dolphin (*Stenella longirostris*), striped dolphin (*Stenella coeruleoalba*), and the false killer whale (*Pseudorca crassidens*) are found in tropical to temperate waters (Jefferson and Schiro, 1997; Leatherwood and Reeves, 1983; Miyazaki and Perrin, 1994; Perrin and Gilpatrick, 1994; Perrin et al., 1994a and 1994b). Another species, the Fraser's dolphin (*Lagenodelphis hosei*), has a worldwide distribution in tropical waters (Perrin et al., 1994c). These dolphin species are known to feed on a wide variety of fishes, cephalopods, crustaceans, and benthic invertebrates (Leatherwood and Reeves, 1983; Jefferson et al., 1993; Jefferson and Schiro, 1997; Perrin et al., 1994a). In the GOM, they occur primarily along the continental shelf and continental slope (Mullin and Fulling, 2004). The rough-toothed dolphin, striped dolphin, spinner dolphin, and false killer whale can occur in deeper waters off the continental shelf (Davis and Fargion, 1996, Mullin and Fulling, 2004).

The killer whale (*Orcinus orca*) has a worldwide distribution from tropical to polar waters (Dahlheim and Heyning, 1999). They feed on marine mammals, marine birds, sea turtles, cartilaginous and bony fishes, and cephalopods (Leatherwood and Reeves, 1983; Jefferson et al., 1993). In the GOM, they occur primarily in the deeper waters off the continental shelf (Davis and Fargion, 1996).

The melon-headed whale (*Peponocephala electra*) and pygmy killer whale (*Feresa attenuata*) have worldwide distributions in subtropical to tropical waters (Jefferson et al., 1992; Ross and Leatherwood, 1994), feeding on cephalopods and fishes (Mullin et al., 1994a; Jefferson and Schiro, 1997). In the GOM, they occur in the deeper waters off the continental shelf (Mullin et al., 1994a).

The short-finned pilot whale (*Globicephala macrorhynchus*) is distributed worldwide in tropical to temperate waters (Leatherwood and Reeves, 1983). They feed predominantly on squid, with fishes being consumed occasionally (Würsig et al., 2000). Aggregations of short-finned pilot whales are commonly associated with other cetacean species (Jefferson et al., 2008). In the GOM, they are most frequently sighted along the continental shelf and continental slope.

Factors Influencing Cetacean Distribution and Abundance

The distribution and abundance of cetaceans within the northern GOM is strongly influenced by various mesoscale oceanographic circulation patterns. These patterns are primarily driven by river discharge (primarily the Mississippi River), wind stress, and the Loop Current and its derived circulation phenomena. Approximately once or twice a year, the Loop Current sheds anticyclonic eddies (also called warm-core rings), which, in turn, spawn cyclonic eddies (also called cold-core rings) during interaction with one another and upon contact with topographic features of the continental slope and shelf edge. These cyclonic eddies contain and maintain high concentrations of nutrients and stimulate localized production of phytoplankton (Davis et al., 2000), which, in turn, provides various food resources for various predators. The Loop Current and its associated eddies can occur throughout the GOM region, including south of the U.S. Exclusive Economic Zone limits, but this area is very poorly studied with little to no information on cetacean distributions. River outflow also may be entrained within the confluence of a cyclone-anticyclone eddy pair and transported beyond the continental slope. Marine mammals may focus their foraging efforts on these abundant prey locations to improve overall efficiency and reduce energy costs (Bailey and Thompson, 2010). Other than factors influencing feeding behaviors, very little is known about other factors that may influence marine mammal distribution in the northern GOM because there are few studies that examine them.

Critical Habitat

Critical habitat is designated if specific areas of habitat occupied by a species listed as endangered or threatened under the ESA may contain physical or biological features essential to the species' conservation, and may require special management considerations or protection. The only marine mammal that has critical habitat currently listed within the GOM is the West Indian manatee; this is illustrated in **Figure 4-25** (50 CFR § 17.95).

4.9.1.2 Environmental Consequences

This chapter provides detailed information regarding the impact-producing factors from routine activities, accidental events, and cumulative impacts from activities described in **Chapter 3** and the potential impacts that could result from a single lease sale. As mentioned earlier in **Chapter 4.9,** BOEM has considered the potential effects of impact-producing factors that are reasonably foreseeable to occur based on credible scientific research and past data for the following analysis. This analysis applies to all alternatives analyzed in **Chapter 4**. While a proposed WPA lease sale (Alternative C) would be in a smaller area with less projected activity than a regionwide (Alternative A) or CPA/EPA lease sale (Alternative B), as described in **Chapter 3**, marine mammal species are widely distributed throughout the planning areas. As such, activities isolated to specific planning areas pose similar potential impacts to populations as do activities occurring in all planning areas. For example, if a marine mammal species were to be accidentally struck by an OCS vessel, it would have the same impact to that individual and its respective population estimate in the WPA as it would in the CPA or EPA. Although it can be speculated that a smaller leased area resulting in less projected OCS oil- and gas-related activity would decrease the likelihood of OCS oil- and gas-related activities impacting marine mammal populations, there are not enough conclusive data on the density and distribution of marine mammal populations in the GOM throughout the year to conclude that speculation. Therefore, because of the diversity and wide distribution of species in the Area of Interest, the level of impacts would be the same for Alternatives A, B, C, and D. Under Alternative E, there would be no new activities associated with a proposed lease sale; however, activities associated with past lease sales and non-OCS oil- and gas-related activities would continue. Following this discussion of environmental consequences, there is a more detailed summary of the potential impacts as they relate to the action alternatives.

As mentioned earlier in **Chapter 4.9.1.1**, the PBR of a marine mammal species plays an important role in marine mammal management due to the fact that the same impact-producing factor may have a more serious impact on a marine mammal stock that has a lower PBR and a less serious impact to a marine mammal stock with a higher PBR. In other words, if an impact-producing factor were to negatively affect a number of individuals of a marine mammal stock that exceeds its respective PBR estimate, it could possibly diminish the continued viability of the stock, including the annual rates of recruitment or survival. BOEM understands that the PBR is a very conservative estimate and that the abundance estimates used in estimating the PBR may not accurately reflect the actual abundances of marine mammal stocks. The following evaluation considers how the impact-producing factors from routine activities, reasonably foreseeable accidental events, and cumulative impacts from activities described in **Chapter 3** may potentially impact a marine mammal species based on its respective PBR (refer to **Table 4-19** for list of marine mammal species and their respective PBR). BOEM has made conscientious efforts to comply with the spirit and intent of NEPA and to be comprehensive in its analyses of potential environmental impacts to marine mammals, including species that are poorly studied.

4.9.1.2.1 Routine Activities

Potential impacts on marine mammal species may occur from routine activities associated with a proposed lease sale. As a result of OCS oil- and gas-related routine activities in the GOM, the major impact-producing factors affecting marine mammals include geological and geophysical activities, transportation, operational discharges, decommissioning, and noise.

Geological and Geophysical Activities

Geophysical (seismic) exploration is an integral part of oil and gas discovery, development, and production in the GOM (refer to **Chapter 3.1.2.1**). With technical advances that now allow extraction of petroleum from the ultra-deep areas of the Gulf, seismic surveys are routinely conducted in virtually all water depths of the GOM, including the deep habitat of the endangered sperm whale. As discussed in **Chapter 3.1.9**, acoustic sources are described by their sound characteristics and are generally divided into impulsive noise and nonimpulsive noise for the regulatory process. Underwater noise sources from G&G activities include impulsive sound sources such as airguns, boomers, subbottom profilers, multibeam echosounders, and side-scan sonars, as well as continuous sources such as vessel and aircraft noise. Overall, the potential for noise impacts from these sound sources on marine mammals is highly variable and depends on the specific circumstances of a given situation. Furthermore, the same sound source can propagate differently depending on the physical environment. How a sound from a specific source propagates through a particular environment depends on a variety of factors, including physical environmental factors (e.g., salinity, temperature, bathymetry, seafloor type, and tow depth), sound characteristics associated with different sources (e.g., source level, directionality, source type, and duration for both impulsive or continuous signals), frequency (i.e., higher frequencies dissipate faster and lower frequencies may travel farther depending on water depth), and intensity (i.e., decibel level).

With the growing number of studies assessing the potential impacts of sound on marine mammal species, NMFS recently announced the availability of the *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing—Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts*, which provides updated acoustic thresholds, above which individual marine mammals are predicted to experience changes in their hearing sensitivity (either temporary or permanent) for all underwater anthropogenic sound sources (USDOC, NMFS, 2016a).

The impacts of noise from G&G activities could include one or more of the following: masking of natural sounds, which could reduce an individual's ability to effectively communicate, detect predators or prey, and detect important environmental features (Clark et al., 2009); behavioral disturbance (e.g., changes in feeding or mating behaviors); tolerance; and temporary or permanent hearing impairment, or nonauditory physical or physiological impacts (Richardson et al., 1995; Nowacek et al., 2007; Southall et al., 2007). Given that mysticetes produce calls that span a low-frequency range (20 Hertz-30 kilohertz) with their best hearing abilities presumably falling into this range as well, they would be most likely to experience impacts from the low-frequency sounds produced by seismic surveys (Richardson et al., 1995). In contrast, odontocetes produce calls and hear best at mid to high frequencies (Richardson et al., 1995) and appear less vulnerable to low-frequency sound sources than mysticetes. Permanent hearing impairment would constitute injury; however, temporary threshold shift is not considered an injury (Southall et al., 2007). More detailed information on the seismic surveying technology and techniques that could be used is provided in BOEM's *Atlantic OCS Proposed Geological and Geophysical Activities: Mid-Atlantic and South Atlantic Planning Areas—Final Programmatic Environmental Impact Statement*. BOEM's Atlantic G&G Activities Programmatic EIS also includes appendices on marine mammal hearing and sensitivity to acoustic impacts which, although emphasizes species specific to the Atlantic OCS, a majority of the species found in the GOM were included in the analysis and would be expected to respond in a similar manner to G&G activities in the GOM (USDOI, BOEM, 2014a). As of this Multisale EIS, BOEM, with BSEE and NMFS as cooperating agencies, prepared the *Gulf of Mexico OCS Proposed Geological and Geophysical Activities: Western, Central, and Eastern Planning Areas; Draft Programmatic Environmental Impact Statement* (Gulf of Mexico G&G Programmatic EIS) to evaluate the potential environmental impacts of multiple G&G activities within Federal waters of the Gulf of Mexico's OCS and adjacent State waters, and is currently in the process of evaluating public comments. This Gulf of Mexico G&G Programmatic EIS evaluates all G&G activities in the GOM (for oil and gas, marine minerals, and renewable activities) over a 10-year period, including a small subset of reasonably foreseeable postlease G&G activities that may occur as a result of a proposed lease sale being evaluated in this Multisale EIS.

As mentioned in **Chapter 4.9.1.1**, Description of the Affected Environment, the only regularly occurring mysticete in the GOM is the Bryde's whale, which is currently proposed to be listed as endangered under the ESA in the GOM (*Federal Register, 2016e)*. Based on this proposal's comprehensive status review and after considering the Status Review Team's threats assessment, NMFS concluded that energy exploration and development is one of many contributing factors adding to the GOM Bryde's whale's risk of extinction. However, both NMFS and the Status Review Team stated that this conclusion took into account the possibility that the EPA, which is currently under moratorium, would become available for energy exploration in the year 2022 (Rosel et al., 2016) and that the potential oil- and gas-related activities would commence there. This area encompasses the Bryde's whale current primary habitat in the GOM. Currently, there are few seismic surveys occurring in the EPA, and it is expected that nearby noise from seismic surveys occurring in the CPA are limited in impacts to the Bryde's whale primary habitat (Rosel et al., 2016). As this Multisale EIS only relates to lease sales through 2022, during the period that much of the EPA remains under Congressional moratorium, any postlease activities related to a proposed action in the Bryde's whale habitat in the EPA would likely be related to transporation. No postlease G&G activities as a result of a proposed lease sale evaluated in this Multisale EIS would occur in the area of the EPA under moratorium.

Another impact-producing factor to marine mammals that is associated with G&G activities is the potential for gear interaction. Marine mammals and other various marine life can become entangled in some types of lines associated with G&G activities; this has occurred in the past with ocean bottom cable/ocean bottom node surveys and other activities where rope tethers were used (e.g., anchors and buoys). The deployment of nodes and cables is accomplished by a remotely operated vehicle, by dropping nodes on a tether, or by laying cables off the back of a layout boat. The G&G permit applications are reviewed by BOEM and NMFS to set conditions of approval with each activity that would minimize impacts caused by gear interactions which are expected to be rare.

The NTL 2016-BOEM-G02, "Implementation of Seismic Survey Mitigation Measures and Protected Species Observer Program," provides guidance to protect marine mammals and sea turtles during seismic operations. This NTL clarifies how operators should implement seismic survey mitigating measures, including ramp-up procedures, the use of a minimum sound source, airgun testing, shutdowns, and protected species observation and reporting. The Protected Species Stipulation, if applied, would make compliance with the guidance identified in the NTL mandatory for lessee activities. In addition, NMFS, BOEM, and BSEE collaborated to publish the technical memorandum "National Standards for a Protected Species Observer Program" in order to provide guidance on how to reduce impacts to protected species from G&G activities by standardizing the variation in and improving the management of the program (Baker et al., 2013).

Without implementation of BOEM's mitigations, marine mammals would be vulnerable to impacts from the noise produced from airguns, vessel strikes, and entanglement from gear interaction. The impacts from these factors with mitigations mentioned above would be expected to be **negligible** to **moderate** when considering that the increasing number of studies analyzing the effects of G&G activities on marine mammals have found no evidence of mortality and variable results in behavioral changes and possible hearing impairment as a result of exposure to these activities. An example of a moderate impact would be if an individual oceanic bottlenose dolphin (PBR 42 individuals) would become entangled from gear interaction, resulting in physical injury or mortality that would have a localized impact on that individual, but it would not diminish the continued viability of the population. However, with the use of ramp-up procedures, minimum sound sources, airgun testing, and protected species observation and reporting, and limited seismic surveys in the EPA, it is reasonably foreseeable that most marine mammals would be detected and that proper procedures, including shutdowns, would be used to avoid any impacts, making them **negligible**.

Transportation

The oil and gas industry uses a variety of vessels running from shore bases to offshore OCS oil and gas structures (refer to **Chapter 3.1.4.3**). Increased traffic from service and support vessels would increase the probability of collisions between vessels and marine mammals. These collisions can cause major injuries and/or fatalities (e.g., the sperm whale [Waring et al., 2013] and bottlenose dolphin [Fertl, 1994]). Slow-moving cetaceans or those that spend extended periods of time at the surface might be expected to be the most vulnerable (Vanderlaan and Taggert, 2007). Smaller delphinids often approach vessels that are in transit to bow-ride; however, vessel strikes are less common for these faster moving mammals or are underreported (Wells and Scott, 1997). Nowacek and Wells (2001) found that bottlenose dolphins had longer interbreath intervals during boat approaches compared with control periods (no boats present within 100 m [328 ft]) in a study conducted in Sarasota Bay, Florida. They also found that dolphins' decreased interanimal distance, changed heading, and increased swimming speed significantly more often in response to an approaching vessel than during control periods. Behavioral changes such as these could stress and disorient individuals, which could then result in an accidental vessel collision.

Collisions of vessels with marine mammals are not uncommon (Laist et al., 2001). Vanderlaan and Taggert (2007) examined the literature for large whale species and reported that the probability for vessel strikes is largely a function of vessel speed. Data compiled by Laist et al. (2001) indicate that relatively large (>80 m; 262 ft) and fast-moving vessels (>14 kn; 16 mph) are most commonly involved in collisions with marine mammals. They also conclude that the majority of collisions appear to occur over or near the continental shelf and that the whales usually are not seen beforehand or are seen too late to be avoided. The rapid increase in exploration and development of petroleum resources in deep oceanic waters of the northern Gulf has increased the risk of OCS vessel collisions with sperm whales and other deep-diving cetaceans (e.g., Kogia and beaked whales). Deep-diving whales may be more vulnerable to vessel strikes because of the extended surface period required to recover from extended deep dives (Fais et al., 2016b). Sperm whales have been shown to be unable to outmaneuver a fast vessel approaching under stratified water conditions (Gannier and Marty, 2015). Although the sperm whale is the most likely large whale to be struck by a vessel in the GOM, there is only evidence of one mortality due to a vessel strike in 1990, as documented as of 2013 (Waring et al., 2016). The whale was found with a cut in the vicinity of Grand Isle, Louisiana, so the origin of the vessel that possibly struck it is unknown. Since the implementation of the vessel strike NTL, there have been no reports of any vessel strikes on marine mammals.

Florida manatees are commonly found in shallow coastal waters of Florida, but they have been found along the entire northern GOM from Florida to Texas (Fertl et al., 2005), though some recent deepwater sightings have occurred. Vessel strikes are the most common cause of human-induced mortality for manatees (State of Florida, Fish and Wildlife Conservation Commission, 2015c), and most manatees bear prop scars from contact with vessels. The vast majority of strikes result from recreational and fishing vessels, not those related to oil and gas activities. Service and support vessels traveling through coastal areas to and from oil and gas structures have the rare potential to impact manatees by vessel collisions. In 1995, for example, an oil crew workboat struck and killed a manatee in a canal near coastal Louisiana (Fertl et al., 2005). Inadequate hearing sensitivity at low frequencies (Gerstein et al., 1999), slow movement, and use of shallow and surface waters are contributing factors to their vulnerability to vessel strike impacts. While manatees are less common in the western Gulf, they are being seen more frequently, and increased sightings indicate that there is a potential for risks to this species from OCS vessel traffic. There is the possibility of short-term disruption of movement patterns and/or behavior caused by vessel noise and disturbance; however, these are not expected to impact survival and growth of manatees in the GOM.

Expected industry service trip numbers as a result of Alternative A, B, C, or D are described in **Chapter 3.1.4.3** (**Table 3-2**). BOEM issued NTL 2016-BOEM-G01, "Vessel Strike Avoidance and Injured/Dead Protected Species Reporting," which explains how operators must implement measures to minimize the risk of vessel strikes to protected species and to report observations of injured or dead protected species. The Protected Species Stipulation, if applied, would make compliance with the guidance identified in the NTL mandatory for lessee activities. Adherence to the NTL protocols is expected to reduce but not eliminate the risk of potential vessel strikes with marine mammals.

Without implementation of mitigations, marine mammals would be vulnerable to direct impacts from OCS oil- and gas-related vessel strikes. The impacts from these factors with mitigations are expected to be **negligible** to **minor** when considering the high probability of detecting a marine mammal while in transit. An example of a minor impact would be if a group of 20 rough-toothed dolphins (PBR 3 individuals) were to change their course to avoid an OCS vessel. However, with the use of vessel strike avoidance guidelines, it is reasonably foreseeable that marine mammals would be detected and that proper procedures, including reduced speed, change in course, or shutdown, would be used to avoid impacts to marine mammals, which would be **negligible**.

Discharges and Wastes

The primary operational waste discharges generated during offshore oil and gas exploration and development are drilling fluids, drill cuttings, produced water, deck drainage, sanitary wastes, and domestic wastes (refer to **Chapter 3.1.5**). During production activities, additional waste streams include well treatment, workover, and completion fluids. Minor additional discharges occur from numerous sources; these discharges may include desalination unit discharges, blowout preventer fluids, boiler blowdown discharges, excess cement slurry, and uncontaminated freshwater and saltwater. Discharges are regulated by the USEPA through the issuance of NPDES permits. Pollutants discharged into navigable waters of the U.S. are regulated by the USEPA under the Clean Water Act of 1972 and subsequent provisions (33 U.S.C. §§ 1251 *et seq*.). Specifically, an NPDES permit must be obtained from the USEPA under Sections 301(h) and 403 (*Federal Register*, 1980) of the Clean Water Act (refer to **Chapter 4.2**, Water Quality).

Heavy metal accumulations in marine mammal tissues are of concern worldwide (Bossart, 2006). Trace metals, including mercury, in drilling discharges have been a particular concern. However, Neff et al. (1989) concluded that metals associated with drilling fluid were virtually nonbioavailable to marine organisms. Marine mammals generally are inefficient assimilators of petroleum compounds in prey (Neff, 1990). Analyses of samples from live GOM and Atlantic bottlenose dolphins showed high levels of polyfluoroalkyl compounds (Houde et al., 2005). Recent work by Kucklick et al. (2011) in the GOM identified a number of persistent organic pollutants in bottlenose dolphins, and Fair et al. (2010) documented unusually high levels of organic chemicals in bottlenose dolphins in Atlantic populations. Adequate baseline data are not available to determine the significant sources of contaminants that accumulate in GOM cetaceans or their prey, due in no small part to the fact that contaminants are introduced into the GOM from a variety of national watersheds. Many cetaceans are wide-ranging animals, which also compounds the issue. Coastal cetacean species tend to have higher levels of metals than those frequenting oceanic waters (Johnston et al., 1996). Oceanic cetaceans feeding on cephalopods have higher levels of cadmium in their tissues than comparable fish-eating species (Johnston et al., 1996). There also is, in many cases, a striking difference between the relatively high mercury levels in the toothed whales and the lower levels found in baleen whales, which is probably attributable to the different prey species consumed by baleen whales, as well as differences in the habitat (Johnston et al., 1996).

Most operational discharges are diluted and dispersed when released in offshore areas, and they are not expected to directly affect any marine mammal species (Kennicutt, 1995). Any potential impacts from drilling fluids would be indirect, either as a result of impacts to prey species or possibly through ingestion via the food chain (Neff et al., 1989). 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. Releases of toxic discharges are regulated by the USEPA through the issuance of NPDES permits to keep contaminants below harmful levels. These regulations and permit provisions are designed to prevent unreasonable degradation of the marine environment, and adherence to these requirements by industry would be expected to result in limited impacts to water quality, and therefore, indirect impacts to marine mammals would likewise be small. Without implementation of requirements, marine mammals would be vulnerable to direct and indirect impacts from operational discharges. The impacts from these factors are, therefore, expected to be **negligible** given assumed compliance with existing regulations and permit requirements.

Decommissioning

The use of explosives is one of industry's preferred methods for the severance of structures from their foundations in the GOM (refer to **Chapter 3.1.6**). It has been demonstrated that nearby underwater blasts can injure or kill marine mammals (Richardson et al., 1995). Injuries from high-velocity underwater explosions result from two factors: (1) the very rapid rise time of the shock wave; and (2) the negative pressure wave generated by the collapsing bubble, which is followed by a series of decreasing positive and negative pressure pulses (USDOI, MMS, 2004b). The extent of injury largely depends on the intensity of the shock wave and the size and depth of the animal at the time of the detonation (Yelverton et al., 1973).

BOEM (then BOEMRE) issued "Decommissioning Guidance for Wells and Platforms" (NTL 2010- BSEE-G05) to offshore operators; it provides clarification and interpretation of regulations regarding decommissioning, as well as guidance to operators proposing to use explosives to perform well/casing severance. These guidelines specify and reference mitigation, monitoring, and reporting requirements. As noted in **Chapter 3.1.6**, decommissioning for wells and platforms are site specific and are reviewed by BSEE and BOEM.

Expected numbers of production structures to be removed using explosives as a result of Alternative A, B, C, or D are reported in **Chapter 3.1.6**. Explosive severance could moderately impact marine mammals; however, with implementation of the Bureau of Safety and Environmental Enforcement's NTL guidelines and regulations, and NMFS's Observer Program for explosive removal, impacts to marine mammals from explosive severance are expected to be **negligible** to **moderate**. Although the NTL's guidelines and regulations, along with NMFS' Observer program for explosive removal, would greatly reduce impacts of decommissioning activities to marine mammals, they may not be completely eliminated. To date, there are no documented "takes" of marine mammals resulting from explosive removals of offshore structures. Decommissioning activities and their potential impacts to different marine mammal species are described further in the *Structure-Removal Operations on the Gulf of Mexico Outer Continental Shelf: Programmatic Environmental Assessment* (USDOI, MMS, 2005), as well as in **Chapter 3**. In addition, a site-specific NEPA analysis, in the form of an EA or EIS, is completed for all structure removals that propose explosive severance methods and/or site-clearance trawling. Without implementation of mitigations, marine mammals would be vulnerable to direct impacts from explosive charges used for the removal of production structures. The impacts from these factors with mitigations are expected to be **negligible** to **minor** when considering that there have been no "takes" of marine mammals due to decommissioning activities. An example of a minor impact would be if a group of 10-15 pantropical spotted dolphins (PBR 407 individuals) were outside of the impact zone prior to a detonation and swam away after the explosives were detonated. It would have a localized behavioral impact on that group of individuals, but it would not diminish the continued viability of the population. However, with the use of decommissioning guidelines, as well as the fact that there have been no documented “takes” of marine mammals from explosive removal activities, it is reasonably foreseeable that decommissioning activities would have a **negligible** impact.

Noise

As discussed in **Chapter 3.1.9**, acoustic sources are described by their sound characteristics and are generally divided into impulsive noise and nonimpulsive noise for the regulatory proceess. Impulsive noises (e.g., impact pile drivers) are generally considered powerful sounds with relatively short durations, broadband frequency content, and rapid rise times to peak levels. Nonimpulsive noise generally includes all other noise (e.g., sonars and vibratory pile drivers) and includes continuous anthropogenic noise (e.g., vessel noise). Overall, the potential for noise impacts from these sound sources on marine mammals is highly variable and depends on the specific circumstances of a given situation.

Aircraft overflights (either helicopter or fixed-wing) in close proximity to marine mammals may elicit a startle response due to either the increasing noise as the aircraft approaches or due to the physical presence of the aircraft in the air. Refer to **Chapter 3.1.9** for more information on OCS oil- and gas-related noise. With more than 1 million helicopter take offs/landings expected per year from activity related to past, proposed, and future lease sales, the OCS industry’s activity contributes greatly to this noise source. Although air traffic offshore is limited, the military maintains 11 military warning areas and 6 water test areas in the GOM (Error! Reference source not found.). Some commercial fisheries include aerial surveillance. Scientific research aerial surveys are occasionally scheduled over the GOM. Commercial and private aircraft also traverse the area.

Marine mammals often react to aircraft overflights by hasty dives, turns, or other abrupt changes in behavior. Responsiveness varies widely depending on factors such as species, the activity the animals are engaged in, and water depth (Richardson et al., 1995). Marine mammals engaged in feeding or social behavior are often insensitive to overflights, while those in confined waters or those with calves may be more responsive. The impacts appear to be transient, and there is no indication that long-term displacement of marine mammals occurs. However, the absence of conspicuous response does not show that the animals are unaffected; it is not known whether these subtle impacts are biologically significant (Richardson and Würsig, 1997).

Aircraft noise is generally short in duration and transient in nature, although it may ensonify large areas. Much of the noise from a passing aircraft is reflected and does not penetrate the water (Urick, 1972). Helicopter noises contain dominant tones (resulting from rotors) generally below 500 Hz (Richardson et al., 1995). The Federal Aviation Administration’s Advisory Circular 91-36D (2004) encourages pilots to maintain an altitude of higher than 610 m (2,000 ft) over noise-sensitive areas. Corporate helicopter policy states that helicopters should maintain a minimum altitude of 231 m (700 ft) while in transit offshore and 152 m (500 ft) while working between platforms. It is unlikely that marine mammals would be affected by routine OCS helicopter traffic operating at these altitudes. Routine overflights may elicit a startle response from and interrupt marine mammals nearby (depending on the activity of the animals), possibly causing temporary displacement from feeding, mating, or traveling activities. This temporary disturbance to marine mammals may occur as helicopters approach or depart OCS oil- and gas-related facilities if animals are near the facility. Without implementation of guidelines and regulations by NMFS under the authority of the MMPA, marine mammals would be vulnerable to direct impacts from routine overflights. The impacts from these factors with these guidelines and mitigations are expected to be **negligible**.

The dominant source of human noise in the sea is ship noise (Tyack, 2008). 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). The intensity of noise from service vessels is roughly related to ship size and speed. 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 unladed vessels. For a given vessel, relative noise also tends to increase with increased speed. The ambient noise environment in the GOM is filled with ship "noise" associated with oil- and gas-related activities, shipping, and recreational vessels, raising concerns that elevated levels of noise may interfere with the behavior and physiology of marine mammals (Tyack, 2008). Many of the industry-related noises are believed to be out of, or on the limits of, marine mammal hearing, and the sounds are also generally temporary. Impacts from vessel noise could disturb animals in the immediate vicinity of the vessel; however, the noise would be transitory in nature. Further detailed information on marine mammal hearing and sensitivity to acoustic impacts may be found in BOEM's *Atlantic OCS Proposed Geological and Geophysical Activities: Mid-Atlantic and South Atlantic Planning Areas, Final Programmatic Environmental Impact Statement*, which can be found on BOEM's website (USDOI, BOEM, 2014a). The aforementioned Gulf of Mexico G&G Programmatic EIS, for which is currently in the process of evaluating public comments, also includes more detailed information on marine mammal hearing and sensitivity to acoustic impacts within the Federal waters of the Gulf of Mexico's OCS and adjacent State waters.

Andrew et al. (2002) reported that, over a 33-year period, increases in shipping noise levels in the ocean may account for a 10-decibel (dB) increase in ambient noise between 20 and 80 Hz and between 200 and 300 Hz, and a 3-dB increase in noise at 100 Hz on the continental slope of Point Sur, California. Although comparable baseline data are not available for the GOM, it is likely that similar ambient noise increases have occurred. Much of the change is expected to be attributable to commercial shipping (greater numbers of ships in the GOM and larger ship size are both factors). However, the expansion of oil and gas industry activities, including more structures, more exploration (seismic surveys) and drilling, a larger service boat fleet, and much greater distances to travel to deepwater installations, has also contributed to more noise in GOM waters.

The continued presence of various cetacean species in areas with heavy vessel traffic suggests a considerable degree of tolerance to vessel noise and disturbance. Evidence suggests, however, that some whale species 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. Vessel noise could interfere with marine mammal communication either by masking important sounds from conspecifics, masking sounds from predators, or by forcing animals to alter their vocalizations (Tyack, 2008). There is the possibility of short-term disruption of movement patterns and/or behavior caused by vessel noise and disturbance; however, these are not expected to impact survival and growth of any marine mammal populations in the GOM. BOEM issued NTL 2016-BOEM-G01, "Vessel Strike Avoidance and Injured/Dead Protected Species Reporting," explains how operators must implement measures to minimize the risk of vessel strikes to protected species and report observations of injured or dead protected species. This guidance should also minimize the chance of marine mammals being subject to the increased noise level of a service vessel in very close proximity. The Protected Species Stipulation, if applied, would make compliance with the guidance identified in the NTL mandatory for lessee activities.

Without implementation of the guidance mentioned above to avoid marine mammals, marine mammals would be vulnerable to direct noise impacts from routine vessel traffic, resulting in short-term disruptions of movement patterns or behaviors. However, with the use of the guidelines mentioned above to minimize the chance of marine mammals being subjected to increased noise levels from service vessels, the impacts are expected to be **negligible**.

Drilling and production activities, which include operating platforms and drillships, produce underwater noise that may be detected by marine mammals. The OCS industry's drilling and production impacts are discussed in **Chapters 3.1.2.2 and 3.1.3.1**. Noises produced by these types of activities, including pile driving, are generally low frequency and have the potential to mask cetaceans' reception of sounds produced for echolocation and communication. Most species of marine mammals in the GOM (except the Bryde's whale) use sounds at frequencies that are generally higher than the dominant noise generated by offshore drilling and production activities. Baleen whales use low-frequency sounds that overlap broadly with the dominant frequencies of many industrial sounds, and there are indications that baleen whales are sensitive to low- and moderate- frequency sounds (Richardson et al., 1995). However, all baleen whale species, except for the Bryde's whale, are considered extralimital or rare in the GOM. It is expected that noise from drilling activities would be relatively constant during the temporary duration of drilling. Drilling noise from conventional metal-legged structures and semisubmersibles is not particularly intense and is strongest at low frequencies, averaging 5 Hz and 10-500 Hz, respectively (Richardson et al., 1995). 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 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 drilling and production operations may impact marine mammals similarly to other anthropogenic sounds in the ocean. Noise can mask important sounds from conspecifics (a member of the same species), mask sounds from predators, or force animals to alter their vocalizations. Noises may frighten, annoy, or distract marine mammals and lead to physiological and behavioral disturbances (Southall et al., 2007). The response threshold may depend on whether habituation (gradual waning of behavioral responsiveness) or sensitization (increased behavioral responsiveness) occurs (Richardson et al., 1995). Noises can cause reactions that might include the 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. Some demographic groups may be more vulnerable to noise impacts, including females in late pregnancy or lactating. Human-made noise may cause temporary or permanent hearing impairment in marine mammals if the noise is strong enough (Southall et al.,2007). Such impairment would have the potential to diminish the individual's chance for survival. Tolerance of noise is often demonstrated, but marine mammals may be affected by noise in difficult-to-observe ways. 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 it is little studied in marine mammals. Tyack (2008) suggests that a more significant risk to marine mammals from sound are these less visible impacts of chronic exposure. Drilling and production noise would contribute to increases in the ambient noise environment of the GOM, but they are not expected in amplitudes sufficient to cause either hearing or behavioral impacts. Expected numbers of exploration and delineation wells, as well as development wells, projected to be drilled as a result of Alternative A, B, C, or D can be found in **Chapters 3.1.2.2 and 3.1.3.1**.

The temporary and transient noise associated with drilling and production is not expected to produce more than **negligible** to **minor** impacts on marine mammals since they are not expected in amplitudes sufficient to cause hearing behavioral effects and due to the wide-ranging behavior of marine mammal species.

Although there would always be some level of incomplete information on the impacts from routine activities under a proposed action on marine mammals, there is credible scientific information, applied using acceptable scientific methodologies, to support the conclusion that any realized impacts would be sublethal in nature and not in themselves rise to the level of reasonably foreseeable significant adverse (population-level) effects. There are no data to suggest that routine activities from the preexisting OCS Program are significantly impacting marine mammal populations.

4.9.1.2.2 Accidental Events

Accidental, unexpected events reasonably foreseeable as a result of a proposed lease sale could negatively impact marine mammals. Such impacts would primarily be the result of oil spills, spill-response activities, and marine trash and debris.

Oil Spills

Improperly balanced well pressures that result in sudden, uncontrolled releases of fluids from a wellhead or wellbore could occur during any phase of development, i.e., exploratory drilling, development drilling, production, completion, or workover operations. In the event of an accidental spill, the eruption of gases and fluids may generate significant pressure waves and noise that may harass, injure, or kill marine mammals, depending on their proximity to the accident. The probability that a marine mammal would be in the vicinity of a loss of well control at the exact moment it occurs is relatively small due to the wide-ranging behavior of marine mammal species, along with the low probability of a loss of well control (refer to **Chapter 3.2.1** for more information on oil spills). There are relatively few studies assessing the physiological impacts of oil spills on marine mammals because laboratory experiments present ethical concerns. Most of the information on the potential impacts of oil on marine mammals comes as a result of the *Exxon Valdez* oil spill in Alaska and some limited exposure experiments (Geraci and St. Aubin, 1990).

The impacts of an oil spill on marine mammals depend on many variables, such as location and size of the spill, oil characteristics, weather and water conditions, time of year, and types of habitats, as well as the behavior and physiology of the marine mammals themselves (Johnson and Ziccardi, 2006). The oil from a spill can adversely affect marine mammals by causing soft-tissue irritation, fouling of baleen plates, respiratory stress from the inhalation of toxic fumes, food reduction or contamination, direct ingestion of oil and/or tar, and temporary displacement from preferred habitats. The long-term impacts to marine mammal populations are poorly understood but could include decreased survival and lowered reproductive success (Matkin et al., 2008). An oil spill may physiologically stress an animal (Geraci and St. Aubin, 1980), making it more vulnerable to disease, parasitism, environmental contaminants, and/or predation. In any case, the impact could negatively impact a marine mammal population or stock.

The resident marine mammal species in the GOM include a baleen whale, toothed whales, delphinids, and a sirenian. Baleen whales are particularly vulnerable to direct impacts from oil causing fouling of baleen plates, which could impact feeding behavior (Geraci and St. Aubin, 1990). Marine mammals may have direct contact with oil by swimming through oil on the surface and/or subsurface. Surfacing behavior exposes skin, eyes, nares, and other mucus membranes to volatile hydrocarbons. This contact with oil could cause soft-tissue damage to eye tissues, potentially leading to ulcers, conjunctivitis, or blindness.

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) may reach critical levels for the first few hours after a spill, prior to evaporation and dispersion of volatile aromatic hydrocarbons and other light components (Geraci and St. Aubin, 1982).

Studies by Geraci and St. Aubin (1982 and 1985) have shown that the cetacean epidermis functions as an effective barrier to many of the toxic substances found in petroleum. The cetacean epidermis is nearly impenetrable, even to the highly volatile compounds in oil, and when skin is breached, exposure to these compounds does not impede the progress of healing (Geraci and St. Aubin, 1985). Marine mammals are more likely to have dermal contact with weathered oil, which is more persistent but contains fewer of the toxic compounds found in fresh oil (Geraci and St. Aubin, 1990). Dolphins maintained at a captive site that were exposed to petroleum products initially exhibited a sharp decrease of food intake, along with excited behavior, eye inflammation, and changes in hemoglobin as well as erythrocyte content (Lukina et al., 1996). Prolonged exposure to oil led to a decrease of those blood parameters, changes in breathing patterns and gas metabolism, depressed nervous functions, and the appearance of skin injuries and burns (Lukina et al., 1996).

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). Studies of captive dolphins also showed that they completely avoided surfacing in slick oil after a few brief, initial tactile encounters. Reactions of free-ranging dolphins to spilled oil appear varied, ranging from avoidance to apparent indifference (reviewed by Geraci, 1990; Smultea and Würsig, 1991). In contrast to captive dolphins, bottlenose dolphins were observed off Galveston, Texas, during the *Mega Borg* oil spill in the summer of 1990 and did not consistently avoid entering the 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 GOM (Smultea and Würsig, 1995). After the *Exxon Valdez* spill, killer whales did not appear to avoid oil; however, none were observed in 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 impacts 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).

Manatees concentrate their activities in coastal waters, often resting at or just below the surface, which may bring them in contact with spilled oil (St. Aubin and Lounsbury, 1990). Types of impacts to manatees from contact with oil include (1) asphyxiation due to inhalation of hydrocarbons, (2) acute poisoning due to contact with fresh oil, (3) lowering of tolerance to other stress due to the incorporation of sublethal amounts of petroleum components into body tissues, (4) nutritional stress through damage to food sources, and (5) inflammation or infection and difficulty eating due to oil sticking to the sensory hairs around their mouths (Preen, 1989, in Sadiq and McCain, 1993). Direct contact with discharged oil likely does not impact adult manatees' thermoregulatory abilities because they use blubber for insulation. Also, they exhibit no grooming behavior that would contribute to ingestion (USDOI, FWS, 2006). Manatees are nonselective, generalized feeders that might consume tarballs along with their normal food, although such occurrences have been rarely reported (review in St. Aubin and Lounsbury, 1990). A manatee might also ingest fresh petroleum, which some researchers have suggested might interfere with the manatee's secretory activity of their unique gastric glands or harm intestinal flora vital to digestion (Geraci and St. Aubin, 1980; Reynolds, 1980). Spilled oil may also affect the quality or availability of aquatic vegetation, including seagrasses, upon which manatees feed.

There have been no experimental studies and only a few observations suggesting that oil has harmed any manatees (St. Aubin and Lounsbury, 1990), although for a population under pressure from other mortality factors (e.g., vessel strikes), even a localized incident could be significant (St. Aubin and Lounsbury, 1990). Oil spills that may occur from OCS energy-related activities that reach the coast or the confines of preferred river systems and canals, particularly during winter (when the animals are most vulnerable physiologically), could further endanger local populations. The physiological costs of animals moving to colder waters to escape oiled areas may result in thermal stress that would exacerbate the impacts of even brief exposure to oil (St. Aubin and Lounsbury, 1990).

Indirect consequences of oil pollution on marine mammals include those impacts that may be associated with changes in the availability or suitability of food resources (Hansen, 1992). Spilled oil can lead to the localized reduction, disappearance, or contamination of some prey species. Prey species such as zooplankton, crustaceans, mollusks, and fishes may become contaminated by direct contact and/or by ingesting oil droplets and tainted food. Marine fishes are known to take up petroleum hydrocarbons from both water and food, although apparently do not accumulate high concentrations of hydrocarbons in tissues, and may transfer them to predators (Neff, 1990). In general, the potential for ingesting oil-contaminated prey organisms with petroleum-hydrocarbon, body-burden content is highest for benthic-feeding whales, which are not common in the GOM. The potential is reduced for plankton-feeding whales and is lowest for fish-eating whales (Würsig, 1990). Depending on the spatial scale and magnitude of an oil spill, diminished prey abundance and availability may cause marine mammal predators to move to less suitable areas and/or consume less suitable prey.

Several factors increase the probability of marine mammal/oil-spill contact, including (1) marine mammals often travel long distances in the GOM, increasing the geographic areas of potential impact; (2) marine mammals are relatively long-lived and have many years during which they may be exposed; (3) the life of a proposed action also means many years for an impact to occur; and (4) some spills would be larger, increasing the area of potential impact. It is impossible to know precisely which cetacean species, population, or individuals would be most impacted, to what magnitude, or in what numbers since each species has unique distribution patterns in the GOM and because of difficulties attributed to predicting when and where oil spills would occur over the 50-year lifetime of a proposed action. The potential impacts associated with an accidental spill may be more severe depending on the size of the reasonably foreseeable accidental spill. The impact from a reasonably foreseeable, higher volume accidental spill could potentially contribute to more significant and longer-lasting impacts that could include mortality and longer-lasting chronic or sublethal impacts.

Given the distribution of available leases and pipelines associated with a proposed lease sale and the distribution of marine mammals in the northern GOM, the fate of an oil spill must be considered relative to the region and period of exposure. Spills of any size can degrade water quality at least locally (**Chapter 4.2**, Water Quality), and residuals become available for bioaccumulation within the food chain. Slicks may spread at the sea surface or may migrate underwater from the seafloor through the water column and never broach the sea surface. Regardless, a slick is an expanding but aggregated mass of oil that, with time, would disperse into smaller units as it evaporates (if at the sea surface) and weathers. As the slick breaks up into smaller units (e.g., slickets) and soluble components dissolve into the seawater, tarballs may remain within the water column. Tarballs may subsequently settle to the seafloor or attach to other particles or bodies in the sea. As residues of an oil spill disperse, marine mammals may be exposed via the waters that they inhabit, as well as via the prey they consume. For example, tarballs may be consumed by marine mammals and by other marine organisms that are eaten by marine mammals. Although marine mammals may (or may not) avoid oil spills or slicks, it is highly unlikely that they are capable of avoiding spill residuals in their environment at some point in their lifetime. Consequently, the probability that a marine mammal is exposed to hydrocarbons resulting from a spill extends well after the oil spill has dispersed from its initial aggregated mass. Populations of marine mammals in the northern GOM would likely be exposed to residuals of spilled oil throughout their lifetime.

OSRA Modeling

The OSRA modeling results, which show the probabilities of a large spill (≥1,000 bbl) occurring in Federal offshore waters making contact with State offshore waters, are provided in **Figure E-20**. In general terms, coastal waters of the area may be contacted by many, frequent, small spills (≤1 bbl); few, infrequent, moderately-sized spills (>1 and <1,000 bbl); and a single large spill (≥1,000 bbl) as a result of a proposed lease sale. Pipelines pose the greatest risk of a large spill occurring in coastal waters compared with platforms and tankers. Spill estimates over a 50-year time period are indicated in **Table 3-18**. According to **Table 3-18**, the majority of estimated spills would be small (<10 bbl). The actual number of spills that may occur in the future could vary from the estimated number. A spill size group for ≥10,000 bbl was not included in **Table 3-18** because the catastrophic *Deepwater Horizon* oil spill (4.9 MMbbl released from the well) was the only spill in this size range during 1996-2010 and such a spill is not reasonably foreseeable in the future; thus, limited conclusions can be made from a single data point. For more information on OSRA, refer to **Chapter 3.2.1.4** (Analysis of Offshore Spills ≥1,000 bbl). Given the distribution of available leases and pipelines associated with a proposed lease sale and the distribution of marine mammals in the northern GOM, the fate of an oil spill must be considered relative to the region and period of exposure. Projected oil production is 0.211-1.118 BBO and 0.547-4.424 Tcf of gas over 50 years. **Chapter 3.2.1** details the persistence, spreading, and weathering process for offshore spills.

Depending on the timing of a spill's occurrence in coastal waters, its impact and resulting cleanup activities may interrupt marine mammal migration, feeding, mating, and/or calving activities for extended periods (i.e., days, weeks, or months). Spills originating in or migrating through coastal waters of Florida may impact any marine mammal species inhabiting the area, including the West Indian manatee, which commonly inhabits Florida's coastal waters. However, it is highly unlikely that any spill occurring in Federal offshore waters would make contact with coastal waters in Florida (<0.5%) where manatees are commonly found. Aside from the acute impacts noted earlier, if marine mammals encounter an oil slick, the displacement of marine mammals to less suitable habitats from habitual feeding areas impacted by oil spills may increase vulnerability to predators, disease, or mortality from anthropogenic causes.

The likelihood that individuals of a marine mammal population may encounter an oil slick resulting from a single spill during a 50-year period is greater than that of a single individual encountering a slick during its lifetime. It is impossible to estimate precisely what marine mammal species, populations, or individuals would be impacted, to what magnitude, or in what numbers, since each species has unique distribution patterns in the GOM and because of difficulties attributed to estimating when and where oil spills would occur over a 50-year period. For example, if a reasonably foreseeable accidental oil spill were to occur in close proximity to State waters, coastal species, such as manatees and some stocks of bottlenose dolphins, would most likely experience the impacts from this spill. If a reasonably foreseeable accidental spill were to occur in offshore Federal waters such as the Mississippi Canyon area, offshore species, such as sperm whales, would most likely experience the impacts from the potential spill since the possibility of the potential spill reaching coastal waters is very low.

Depending on the spill location, the species of marine mammals present, the distance of marine mammals in relation to the spill, and if the marine mammal accidentally ingests oil while feeding, impacts may be **negligible** to **moderate** when considering the probability of a marine mammal coming into contact with an oil spill. An example of a **negligible** impact would be if a group of oceanic bottlenose dolphins were traveling in an area where a reasonably foreseeable small accidental spill occurred at a well, but the group of bottlenose dolphins never encountered the oil and continued traveling. An example of a **moderate** impact would be if an individual melon-headed whale (PBR 13 individuals) were to ingest fresh crude oil while feeding and the impacts resulted in physical injury or mortality.

Recently, NMFS announced a proposed rule to list the Gulf of Mexico Bryde's whale as endangered under the ESA (*Federal Register, 2016e*). Impacts to the Gulf of Mexico Bryde's whales' habitat or to individual Bryde's whales exposed to an oil spill or associated spill-response activities would increase the risk of extinction of this distinct population segment, which would elevate the impact for this analysis to major. For purposes of this Multisale EIS, BOEM has analyzed the impacts of reasonably foreseeable activities that could occur as part of a proposed action. Although there is limited activity in the EPA, both the habitat or individual Gulf of Mexico Bryde's whales could be exposed to an accidental spill depending on the timing, size, and proximity of the oil spill to the primary habitat, as well as various factors that influence the fate and transport of spilled oil (e.g., oil characteristics, weather and water conditions, time of year, etc.). Although the possibility of Gulf of Mexico Bryde's whales being exposed to an oil spill exists, the probability of an oil spill occurring and contacting the Gulf of Mexico Bryde's whale's primary habitat as part of a proposed action is low. Based on this low probability, along with the best science available for the Gulf of Mexico Bryde's whale distribution, and considering the current moratorium in the EPA, it is not likely that a Bryde's whale would be exposed to an accidental oil spill as part of a proposed action.

Spill-Response Activities

Spill-response activities that may impact marine mammals include increased vessel traffic, the use of dispersants, and remediation activities (e.g., controlled burns, skimmers, boom, etc. [refer to **Chapter 3.2.8**]). The increased human presence after an oil spill (e.g., vessels) would likely add to changes in behavior and/or distribution, thereby potentially stressing marine mammals further and perhaps making them more vulnerable to various physiologic and toxic effects of spilled oil. In addition, the large number of response vessels could place marine mammals at a greater risk of vessel collisions, which could cause fatal injuries. Manatees are particularly vulnerable to vessel collisions that may result from increased vessel traffic. Vessel noise would also increase as a result of increased vessel activity and could result in behavioral changes in some individuals.

Spill-response activities could also include the application of dispersants to the affected area. Dispersants are designed to break oil on the water's surface into minute droplets, which then break down in seawater (refer to **Chapter 3.2.8.2.2**). Essentially little is known about the impacts of oil dispersants on cetaceans, except that removing 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). A laboratory experiment by Wise et al. (2014) found that chemical dispersants used during the *Deepwater Horizon* oil-spill response were cytotoxic to sperm whale cells and could lead to fibrosis and impaired organ function. However, it is difficult to determine how these exposures relate to the actual exposures in the GOM since there is no known accurate method to measure the amount of whale exposure to dispersants (Wise et al., 2014). The acute toxicity of most oil dispersant chemicals is considered to be low relative to the constituents and fractions of crude oil and refined products, and a study by Wells (1989) showed that the rate of biodegradation of dispersed oil is equal to or greater than that of undispersed oil. Varieties of aquatic organisms readily accumulate and metabolize surfactants from oil dispersants; however, metabolism of surfactants is thought to be rapid enough that there is little likelihood of food chain transfer from marine invertebrates and fish to predators, including marine mammals (Neff, 1990). Impacts from dispersants are unknown but may be irritants to tissues and sensitive membranes (NRC, 2005). One assumption concerning the use of dispersants is that the chemical dispersion of oil would considerably reduce the impacts to marine mammals, primarily by reducing their exposure to petroleum hydrocarbons (French-McCay, 2004; NRC, 2005). However, the impacts to marine mammals from chemical dispersants could include nonlethal injury (e.g., tissue irritation and inhalation), long-term exposure through bioaccumulation, and potential shifts in distribution from some habitats.

Some remediation activities that could impact marine mammals include the use of skimmers, booms, and controlled burns. Impacts from skimmers could be through capture and/or entrainment. Booming operations could potentially impact marine mammals, particularly manatees, as they are close to shore and known to explore and interact with objects in their environment (Hartman, 1979). Lines used to anchor booms are more likely than the boom itself to impact manatees, by entanglement. Controlled burns could impact marine mammals if they were in the burning oil; however, it is expected that animals would avoid the area once it is ignited. In both skimming and controlled burning activities, the use of trained observers is common and reduces the likelihood of impacts to marine mammals. Because of the low probability of marine mammals being in the vicinity of an OCS oil- and gas-related, oil-spill response activity due to their wide-ranging behavior as well as the likelihood of having trained observers looking for marine mammals, impacts are expected to be **negligible** to **moderate**. An example of a **negligible** impact would be if a small group (5-8 individuals) of Atlantic spotted dolphins was traveling in an area where remediation activities are being conducted to control an oil spill, but the group of Atlantic spotted dolphins never encountered the remediation activities and continued traveling. An example of a **moderate** impact would be if a small group (5-8 individuals) of spinner dolphins (PBR 62 individuals) encountered dispersants while traveling and experienced a nonlethal injury via inhalation at the water-surface interface. Although it may have a localized impact on that particular group of spinner dolphins, it would not diminish the continued viability of the population, including the annual rates of recruitment or survival.

Marine Trash and Debris

Marine mammal ingestion of, and entanglement in, accidentally released industry debris is a concern (refer to **Chapter 3.2.7**). A marine mammal could suffer reduced feeding and reproductive success, and potential injury, infection, and death from entanglement in marine debris. 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 from a variety 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); however, ingestion of net materials can also be fatal (Jacobsen et al., 2010). Sheavely (2007) reports that as much as 49 percent of marine debris is considered land based. There are many types of materials used in offshore energy production, and some of this material is accidentally lost overboard from service vessels or OCS structures where marine mammals could ingest it or become entangled in it. The offshore oil and gas industry was shown to contribute 13 percent of the debris found at the Padre Island National Seashore (Miller et al., 1995). Many of the plastics used by industry could withstand years of saltwater exposure without disintegrating or dissolving.

To address the potential impacts of marine debris, BSEE issued NTL 2015-BSEE-G03, “Marine Trash and Debris Awareness and Elimination,” which provides information on the marine trash and debris awareness training video and slide show, and both postal and email addresses for submitting annual training reports. The information provided is intended to greatly minimize the amount of debris that is accidentally lost overboard by offshore personnel; however, these directives do not eliminate the accidental release of debris, which could impact an individual or group of individuals if they become entangled in or accidentally ingest released debris. The Protected Species Stipulation, if applied, would make compliance with the guidance identified in the NTL mandatory for lessee activities.

Without implementation of mitigations, marine mammals would be vulnerable to direct impacts from entanglement in or ingestion of OCS marine debris. The impacts from OCS marine debris with marine trash and debris guideline mitigations are expected to be **negligible**.

4.9.1.2.3 Cumulative Impacts

The cumulative analysis considers past, present, and foreseeable future human and natural activities that may occur and adversely affect marine mammals in the same general area that may be affected by a proposed action.

The major impact-producing factors relative to a proposed action are described in **Chapter 4.9** (Protected Species) above in **Table 4-18**. Chapters providing supportive material for the marine mammals analysis include **Chapters 4.9.1** (Marine Mammals, Description of the Affected Environment), **3.3.1.3** (Cumulative Exploration and Delineation), **3.3.1.4** (Cumulative Development and Production Drilling), **3.3.1.7** (Transport), **3.3.1.8** (Discharges and Wastes), **3.1.9** and **3.3.2.7** (Noise and Noise from Non-OCS Oil- and Gas-Related Sources), **3.3.1.10** (Coastal Infrastructure), **3.3.1.9** (Decommissioning and Removal Operations), and **3.2.1** (Oil Spills).

OCS Oil- and Gas-Related Impacts

The major potential impact-producing factors affecting marine mammals in the GOM as a result of cumulative past, present, and reasonably foreseeable OCS energy-related activities are described under the "Routine Activities" and "Accidental Events" sections above and include the following: decommissioning; operational discharges; G&G activities; noise; transportation; marine debris; and accidental oil spill and spill-response activities. The cumulative impact of these ongoing OCS energy-related activities on marine mammals is expected to result in a number of chronic and sporadic sublethal effects (i.e., behavioral effects and nonfatal exposure to or intake of OCS oil- and gas -related contaminants or discarded debris) due to the fact that these activities may stress and/or weaken individuals of a local group or population and may predispose them to infection from natural (e.g., bacteria) or anthropogenic (e.g., marine debris) sources.

As previously discussed in **Chapter 4.9.1.2.1** (Routine Activities), the use of explosives is the preferred method for the severance of structures from their foundations in the GOM. Explosive structure removals put loud but temporary noise into the ocean, and these can occur in Federal or State waters. The shock wave and blast noise from explosions are of most concern to marine mammals. Depending on the intensity of the shock wave and size and depth of the animal, an animal can be injured or killed. Farther from the blast, an animal may suffer nonlethal physical impacts. Outside of these zones of death and physical injuries, marine mammals may experience hearing-related impacts with or without behavioral responses. A limited amount of information is available on the impacts of explosions on marine mammals (O'Keeffe and Young, 1984; Ketten, 1998). However, BOEM (then BOEMRE) issued "Decommissioning Guidance for Wells and Platforms" (NTL 2010-G05), which specifies and references mitigation requirements in the current ESA and MMPA guidance and which should minimize the chance of a marine mammal being impacted from explosive severance activities. "Decommissioning Guidance for Wells and Platforms" (NTL 2010-G05) is discussed in **Chapter 4.9.1.2.1** (Routine Activities).

Industry noise sources include seismic operations, fixed platforms and drilling rigs, drilling ships, low-flying aircraft, vessel traffic, and explosive operations, particularly for structure removal.

Chapter 3.1 describes the offshore infrastructure and activities (impact-producing factors) associated with a proposed lease sale. A discussion of all activities that are projected from past, present, and future lease sales during a 70-year activity period (2017-2086) can be found in **Chapter 3.3.1**.

Accidental events related to a proposed action, as discussed above, have the potential to have adverse, impacts to marine mammal populations in the GOM.

Oil spills may cause chronic (long-term lethal or sublethal oil-related injuries) and acute (spill-related deaths occurring during a spill) impacts on marine mammals. Long-term impacts include (1) decreases in prey availability and abundance because of increased mortality rates, (2) change in age-class population 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). The impacts of cleanup activities are unknown, but increased human presence (e.g., vessels) could add to changes in marine mammal behavior and/or distribution, thereby additionally stressing animals, and perhaps making them more vulnerable to various physiologic and toxic impacts. However, there is no supporting evidence that marine mammal populations of the GOM are impacted by the cumulative OCS oil-and-gas related activities. Therefore, the incremental cumulative contribution of OCS- oil and gas-related activities is expected to have **negligible** to **moderate** impacts.

Non-OCS Oil- and Gas-Related Impacts

Non-OCS energy-related activities that may affect marine mammal populations include pollution, marine debris, explosive severance of structures in non-OCS State waters as part of State oil- and gas-related activities, vessel traffic and related noise (e.g., from military operations, commercial shipping, and research vessels); commercial and recreational fishing (**Chapters 4.10 and 4.11**), scientific research, diseases, UMEs, and natural phenomena. Specific types of impact-producing factors considered in this cumulative analysis include noise from numerous sources, pollution, ingestion and entanglement in non-OCS marine debris, and vessel strikes.

Pollution in the ocean comes from many point (e.g., non-OCS discharges, factories, wastewater treatment facilities) and nonpoint (e.g., drainage, precipitation, land runoff) sources, and the GOM is certainly no exception. The drainage of the Mississippi River results in massive amounts of chemicals and other pollutants being constantly discharged into the GOM. The zone of hypoxia on the Louisiana-Texas shelf is one of the largest areas of low oxygen in the world's coastal waters (Murray, 1997) and does not support adequate food resources due to its low oxygen levels (refer to **Chapter 3.3.2.12**). Primarily, bottlenose dolphins and manatees are most at risk for nearshore pollution. Bottlenose dolphins have been reported having very high levels of contaminants, including heavy metals, in tissue samples (Borrell, 1993). Since other marine mammals are not commonly found in coastal waters, they are less likely to be impacted by nearshore pollution. Prey species also affect the influence of pollution on marine mammals. Biomagnification in fish results in the generally higher contaminant levels in fish-eating marine mammals (Gray, 2002). Manatees are herbivores, but pollution and habitat degradation may impact the manatee. Manatees are exposed to herbicides by ingesting aquatic vegetation containing concentrations of these compounds (O'Shea et al., 1984). The propensity of manatees to aggregate at industrial and municipal outfalls also may expose them to high concentrations of contaminants (Stavros et al., 2008). Antifouling bottom paint on the hulls of boats has been linked to the release of contaminants (Schiff et al., 2004). For coastal dolphins and especially manatees that are very well known to frequent marinas and that scratch on the hulls of vessels, areas with high concentrations of vessels may have extremely polluted waters. However, there are non-OCS regulations that limit the discharge of pollutants in State waters (e.g., NPDES). Although there are a number of studies assessing the impacts of chemicals and pollutants on marine mammals, there is no conclusive evidence that these impacts are affecting marine mammals on a population level. Therefore, impacts to marine mammals from non-OCS pollutants would be **negligible** to **minor**.

Ingestion of, or entanglement in, non-OCS marine debris is a global concern for marine organisms. Estimates indicate that approximately 6.4 million tons of marine litter is dumped in oceans every year, resulting in an estimated 13,000 pieces of litter per square kilometer of ocean (United Nations Environment Programme, 2005). There is general consensus that land-based sources are the dominant origin of marine debris, contributing up to 49 percent, with marine or undetermined sources contributing the remainder (Sheavly and Register, 2007). 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); however, ingestion of net materials can also be fatal (Jacobsen et al., 2010). Plastics are very persistent, yet they are not immune to degradation. Microplastics, or microscopic plastic particles, may be ingested by a wide range of organisms, and there are indications that microplastics are propagated over trophic levels of the marine food web (Farrell and Nelson, 2013; Setälä et al., 2014). Therefore, marine mammals may be ingesting plastic particles through consumption of various prey sources.

Entanglement in marine debris can cause decreased swimming ability, disruption in feeding, life-threatening injuries, and death. 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 from a variety of vessels. Impacts from non-OCS marine debris are expected to be **negligible** to **major**. An example of a negligible impact would be if small pieces of marine debris were ingested by a marine mammal species and then later passed through their digestive tract with no complications. An example of a major impact would be if a discarded monofilament fishing net were to cause physical injury or mortality to a marine mammal species with a low population estimate (e.g., Bryde's whale).

Structure removals that take place in GOM State waters are under the jurisdiction of the COE. Impacts to marine mammals from these activities are similar to the impacts discussed in the "OCS Oil- and Gas-Related Impacts" section in **Chapter 4.9.1.2**, and they may potentially include injury or death from shockwave depending on the intensity of the shock wave and size and depth of the animal; nonlethal physical effects; and hearing-related effects with or without behavioral responses.

Numerous sources of aircraft fly over the coastal and offshore areas. The air space over the GOM is used extensively by DOD for conducting various air-to-air and air-to-surface operations. Eleven military warning areas and six water test areas are located within the GOM, as stated in NTL 2009-G06, "Military Warning and Water Test Areas" (**Figure 2-7**). Additional activities, including vessel operations and ordnance detonation, also may impact marine mammals. Subject to Federal Aviation Administration guidelines, private and commercial air traffic further traverse these areas and have the potential to cause impacts to marine mammals.

Commercial fishery interactions are a concern for marine mammals because they may be injured or killed by commercial fishing gear. Marine mammals can either get caught on longline hooks or can be entrained into a net by a shrimp boat or groundfish vessel. There is also the chance of entanglement by lines from crab traps to buoys. Gillnets, which have now been banned in many places around the GOM, have been reported to take marine mammals. However, recent reports of these impacts are uncommon. Depending on the type of fishing gear and the number of marine mammals affected by the interaction with the fishing gear, impacts would be **negligible** to **major**. An example of a negligible impact would be if a marine mammal species observed fishing activities, made no behavior change, and ultimately had no interaction with the fishing gear or activities. An example of a major impact would be if a commercial fishing net were to cause physical injury or mortality to a marine mammal species with a low population estimate (e.g., killer whale).

All manner of commercial shipping vessels, commercial fishing vessels, military ships, research ships, recreational craft, and others are always present in the GOM and increases the possibility of vessel collisions between vessels and marine mammals. Slow-moving marine mammals or those that spend extended periods of time at the surface might be expected to be the most vulnerable (Vanderlaan and Taggert, 2007). In 2014, approximately 85 percent of human-caused manatee mortalities in Florida were attributed to collisions with watercraft (State of Florida, Fish and Wildlife Conservation Commission, 2015c). Noise from various non-OCS vessels could interfere with marine mammal communication either by masking important sounds from conspecifics, masking sounds from predators, or by forcing animals to alter their vocalizations (Tyack, 2008).

Some factions of the boating public, mainly recreational fishermen and boaters, create adverse impacts by paying too much attention to marine mammals. Reports of harassment, inappropriate feeding, and even attempting to swim with marine mammals are common. Dolphins have been injured and killed after becoming accustomed to being fed by humans. Animals become sick from eating the "food" that people throw. Very close approaches by boats are likely major causes of stress in marine mammals, as is chasing and following.

Scientific research can impact marine mammal species. Numerous marine mammal research cruises have been conducted, and permitted activities have included tagging and biopsy sampling. The U.S. protocols are always in place to keep the mammals safe, but some of the research techniques do involve harassment and possible stress to the animal. Scientific seismic studies often use the same tools and techniques as industry seismic work, which could have the same impacts to marine mammals. Scientific groundfish or shrimp cruises can entrap a dolphin in a net just as commercial fisheries can. In 2011, a scientific cruise that was associated with NRDA killed six dolphins while sampling fish with nets. Scientific aerial surveys are also periodically conducted in the GOM, and aircraft can startle marine mammals. Circling pods for identification may stress multiple individuals in a pod. Such marking techniques as freeze branding were used in the past to do mark-recapture studies. This required the live capture and branding of dolphins. Both the Navy and the public-display industry took bottlenose dolphins from the GOM in years past. A moratorium on live captures has been in effect for several years, as captive breeding programs have become successful enough to provide dolphins for aquariums and zoos.

Occasionally, numbers of marine mammals strand, either alive or already dead. Die-offs happen infrequently but can seriously deplete small, discrete stocks. The causes of die offs are not always well known and vary by event. Some appear to be triggered by natural events (i.e., unusually cold weather) but others are suspected to at least be indirectly caused by pollution of various contaminants. Exposure to certain compounds may weaken the natural immunity of marine mammals and make them susceptible to viruses and diseases that would normally not affect them. Certain viruses, such as morbilliviruses, which affect the lungs and brain in cetaceans, are being observed more frequently than in the past (USDOC, NMFS, 2015e). A red-tide event that began in southwest Florida in late September 2012 claimed the highest number of red-tide-related manatee deaths in a single calendar year on record (State of Florida, Fish and Wildlife Conservation Commission, 2015c). The NMFS may declare a large die-off to be an UME, which is defined under the MMPA as "a stranding that is unexpected; involves a significant die-off of any marine mammal population; and demands immediate response" (USDOC, NMFS, 2015e). The causes for nearly 20 UMEs that have been declared by NMFS in the GOM region since 1991 have either been due to infectious diseases or biotoxins, ecological factors, or were declared undetermined. However, some strandings become available. The most recent information for UMEs in the GOM can be found on NMFS' website (USDOC, NMFS, 2015f).

Impacts from climate change to marine mammals have become a concern, and responses both at the individual and population level of marine mammal species to climate change are poorly understood (Evans and Bjørge, 2013). Making predictions about future impacts becomes even more speculative. In the last 15 years, a number of marine mammal scientists have attempted to do this (Tynan and DeMaster, 1997; International Whaling Commission, 1997; Würsig et al., 2002; Learmonth et al., 2006; Simmonds and Isaac, 2007; Huntington and Moore, 2008; Kovacs and Lyderson, 2008; Laidre et al., 2008; International Whaling Commission, 2009; MacLeod, 2009; Evans et al., 2010; Kaschner et al., 2011). Some of the major hypothesized impacts to marine mammals from climate change are changes in water temperatures, which may result in distribution changes, changes to physical habitat, changes to the food web, thermal Intolerance (e.g., heat stress), and susceptibility to increased diseases and contaminants (Evans and Bjørge, 2013). There is also concern that ocean acidification from rising carbon dioxide levels will decrease sound absorption in oceans, thereby causing amplified levels of ambient noise (Gazioglu et al., 2015), which would negatively affect marine mammals. Further, increased sea-surface temperatures likely enhance the magnitude and frequency of harmful algal blooms and their associated toxins, which have shown to negatively impact ecosystem health (O'Neil et al., 2012).

Lastly, tropical storms and hurricanes are normal occurrences in the GOM and along the Gulf Coast. Generally, the impacts have been localized and infrequent. However, the GOM has been hit extremely hard by very powerful hurricanes. Few areas of the coast have not suffered some damage in 2004 and 2005, and activities in the GOM have also been severely impacted. In 2004, Hurricane Ivan took a large toll on oil and gas structures and operations in the GOM and caused widespread damage to the Alabama-Florida Panhandle coast. In 2005, Hurricanes Katrina, Rita, and Wilma reached Category 5 strength in the GOM, and these hurricanes were followed in 2008 by Hurricane Gustav and by Hurricane Isaac in 2012. These storms caused damage to all five of the Gulf Coast States and damage to structures and operations both offshore and onshore. The actual impacts of these storms on marine mammals in the GOM have not yet been determined and, for the most part, may remain very difficult to quantify.

The impacts of such natural disasters on marine mammal populations are poorly understood and difficult to assess due to the limited predictability of storm occurrence, course, strength, and location of impact. Some immediate and direct impacts of hurricanes on marine mammals have been documented, such as the temporary displacement or stranding of individuals (e.g., dugongs [*Dugong dugon*; Marsh, 1989]; pygmy killer whales [*Feresa attenuata*; Mignucci-Giannoni et al., 1999]; and bottlenose dolphins [*Tursiops truncatus*; Rosel and Watts, 2008]). Under some circumstances, hurricanes can cause massive mortalities of fish and destruction of their habitats in coastal and estuarine ecosystems (Tabb and Jones, 1962) causing dolphins to be temporarily displaced when seeking new foraging areas.

Evaluation of long-term impacts of severe storms to marine mammals requires multi-year studies to be in place prior to a disaster to adequately measure the impacts (Smith et al., 2013), in which there are few. Langtimm et al. (2006) found that the destruction of habitat in important foraging areas following severe tropical systems may have indirectly increased mortality in Florida manatees (*Trichechus manatus latirostris*) (Langtimm et al., 2006). However, some evaluations of long-term impacts to coastal marine mammals have documented their resilience and adaptability. Miller et al. (2010) investigated the impacts of Hurricane Katrina on bottlenose dolphin reproduction in the Mississippi Sound area. The study reported an increase in reproduction, which was attributed, in part, to a potential increase in prey abundance in the area following a widespread decrease in annual fisheries landings in the area during the year following the storm (Miller et al., 2010). A similar study in the same area by Smith et al. (2013) also found that bottlenose dolphin foraging activity increased significantly following the passage of Hurricane Katrina, suggesting that there may have been an increase in feeding opportunity, prey abundance, and/or a need for increased food consumption likely attributed to the same decrease in annual fisheries landings.

Cumulative incremental impacts to marine mammals from a proposed lease sale, when taking into consideration the potential impacts of the *Deepwater Horizon* explosion, oil spill, and response, non-OCS oil- and gas-related factors, the minimization of OCS oil- and gas-related impacts through lease stipulations and regulations, and the wide-ranging behavior of marine mammals, would be expected to be **negligible** with no anticipated population-level impacts.

4.9.1.2.4 Incomplete or Unavailable Information

Throughout this chapter, where information was incomplete or unavailable, BOEM complied with its obligations under NEPA to determine if the information was relevant to reasonably foreseeable significant adverse impacts; if so, whether it was essential to a reasoned choice among alternatives; and, if it was essential, whether it can be obtained and whether the cost of obtaining the information is exorbitant, as well as whether credible scientific information applied using generally accepted scientific methodologies can be used in its place (40 CFR § 1502.22). BOEM has made conscientious efforts to comply with the spirit and intent of NEPA and to be comprehensive in its analyses of potential environmental impacts.

BOEM has identified incomplete information regarding impacts of the *Deepwater Horizon* explosion, oil spill, and response on marine mammals in the GOM. This incomplete information may be relevant to the evaluation of adverse impacts because it could provide changes in the baseline environmental conditions for marine mammals in the affected environment from the *Deepwater Horizon* oil spill and response, exacerbating any impacts from a proposed action. In NEPA, the term "baseline" usually consists of the pre-project environmental conditions. For the purpose of this Multisale EIS, the baseline is the condition of resources in the vicinity of the project as they exist at the time this environmental analysis began. The injuries assessed within the PDARP/PEIS do not necessarily equate to the current baseline as defined in NEPA. Quantification of a new baseline has several difficulties, including the lack of pre-spill data, the interpretation of post-spill data, and other potential parameters that may have contributed to the quantification of the new baseline. The difference between the state of the resources in an earlier injury assessment and in a current baseline assessment equals any recovery that may have occurred. In addition, the injury assessment reviews a worst-case impact scenario while a baseline assessment determines a reasonable understanding of the current state of the resource.

On December 13, 2010, NMFS declared a UME for cetaceans (whales and dolphins) in the Gulf of Mexico that was later closed in May 2016. Evidence of the UME was first noted by NMFS as early as February 2010, before the *Deepwater Horizon* explosion, oil spill, and response. During this UME, spatial and temporal boundaries of stranded cetaceans were defined as far as the Florida Panhandle and west to the Louisiana-Texas border (USDOC, NMFS, 2015f). However, these boundaries were redefined by NOAA, based upon analysis of stranding data, to include all cetaceans that stranded in Alabama, Mississippi, and Louisiana from March 2010 through July 2014 and all cetaceans other than bottlenose dolphins that stranded in the Florida Panhandle (Franklin County through Escambia County) from March 2010 through July 2014. The NOAA has claimed that these boundaries could be adjusted in the future based upon the availability of new results or analyses (USDOC, NMFS, 2016b). As of May 2016, a total of 1,141 cetaceans (5% stranded alive and 95% stranded dead) stranded during the UME between Franklin County, Florida, and the

Louisiana/Texas border. These stranding numbers are significantly greater than reported in past years; ,though it should be further noted that stranding coverage (i.e., effort in collecting strategies) has increased considerably due to the *Deepwater Horizon* explosion, oil spill, and response (USDOC, NMFS, 2016b).

The UME investigation and the Trustees determined that the *Deepwater Horizon* explosion, oil spill, and response resulted in the death of marine mammals and is the most likely explanation of the persistent, elevated stranding numbers in the northern Gulf of Mexico after the spill. Data have supported that the adrenal and lung disease observed in dolphins was most likely due to exposure to petroleum products from the oil spill. This has resulted in both dolphin mortalities, which peaked from March 2010 through July 2014, and fetal loss. Research, while ongoing, suggests that the effect on these populations has not ended, with evidence of failed pregnancies found in 2015 (USDOC, NMFS, 2016b).

Although data have suggested that exposure to petroleum products may result in reproductive failure, other factors have the potential to affect marine mammal reproduction and were also observed during the timeframe of this UME. In addition to investigating all other potential causes, scientists are still investigating what role *Brucella* plays in the northern Gulf of Mexico UME. *Brucella* is a gram-negative, intracellular bacterium that has been isolated from many marine mammal species globally (Nymo et al., 2011; Guzmán-Verri et al., 2012; Hernández-Mora et al., 2013) and that may cause placentitis and sporadic late-term abortion (Miller et al., 1999; Dagleish et al., 2008; Guzmán-Verri et al., 2012; Hernández-Mora et al., 2013). As of October 27, 2015, 68 out of 210 dolphins tested were positive or suspected positive for *Brucella*. More detail on *Brucella* and its role in the UME can be found on NMFS' website (USDOC, NMFS, 2016b). Future investigations on immune function in Gulf of Mexico dolphins are needed to determine whether exposure to hydrocarbons during the *Deepwater Horizon* oil spill or other environmental stressors may have caused an increased susceptibility to infectious agents that affect the fetal-placental unit or other conditions leading to late-term fetal loss (Colegrove et al., 2016). Furthermore, a study by Carmichael et al. (2012) suggested that natural stressors combined with the *Deepwater Horizon* explosion, oil spill, and response may have created a "perfect storm" for bottlenose dolphins in the northern Gulf of Mexico. Many coastal species in the northern Gulf of Mexico, including dolphins, experienced unusually harsh winter conditions in early 2010, which were followed by the *Deepwater Horizon* explosion, oil spill, and response. A third potential stressor was introduced in January 2011 when large volumes of cold freshwater, associated with melt water from an unusually large winter snowfall near the Mobile Bay watershed, entered the nearshore coastal systems very rapidly. This event happened days prior to the start of unusually high numbers of perinatal (near term to neonatal) bottlenose dolphin mortalities in the northern Gulf of Mexico from January to April 2011.

Various environmental stressors that are known to cause death to marine mammals were also present during the *Deepwater Horizon* explosion, oil spill, and response, but it is unclear at this time what level of impact these stressors contributed to the increase in strandings (Carmichael et al., 2012). According to NMFS' website referenced above, evidence of the UME was first documented by NMFS as early as March 2010, a month prior to the *Deepwater Horizon* explosion and oil spill.

The NMFS has also documented an additional 12 UMEs that have been previously declared in the GOM for cetaceans (an additional 7 specific to manatees only) since 1991 (USDOC, NMFS, 2015d). However, studies published from the NRDA process evaluating the possible impacts of the *Deepwater Horizon* explosion, oil spill, and response on bottlenose dolphins exposed to oiling have shown overall poor health and prevalence of poor body condition, disease, and abnormalities as compared with bottlenose dolphins in the Gulf of Mexico that were not exposed to oiling (Schwacke et al., 2013; Venn-Watson et al., 2015). Bacterial pneumonia was also identified from dolphins before and during the UME but it was detected more in the UME dolphins (Venn-Watson et al., 2015). While this information may ultimately be useful in expanding the available knowledge on baseline environmental conditions following the *Deepwater Horizon* explosion, oil spill, and response, it remains difficult to draw specific conclusions regarding the current overall bottlenose dolphin population in the GOM.

Even with recent publications, such as the Venn-Watson et al. (2015) marine mammal study, the best available information on impacts to GOM marine resources does not yet provide a complete understanding of the impacts of the oil spill and active response/cleanup activities from the *Deepwater Horizon* explosion and oil spill on marine resources as a whole in the GOM. Relevant data on the status of marine mammal populations after the UME and *Deepwater Horizon* explosion, oil spill, and response may take years to acquire and analyze, and impacts from the *Deepwater Horizon* explosion, oil spill, and response may be difficult or impossible to discern from other factors. For example, even 20 years after the *Exxon Valdez* spill, the long-term impacts to marine mammal populations are still being investigated (Matkin et al., 2008). Therefore, it is not possible for BOEM to obtain this information within the timeline contemplated for analysis in this Multisale EIS, regardless of the cost or resources needed.

Unavailable information provides challenges in understanding the baseline conditions and changes within marine mammal populations. The impacts of tropical storms and hurricanes in the GOM have never been determined and the impacts remain very difficult to quantify. The impacts associated with the *Deepwater Horizon* explosion, oil spill, and response makes an understanding of the cumulative impacts less defined. The process, timeline, and determination of NMFS' proposal to list the Bryde's whale as endangered is unknown, but it is not essential to a reasoned choice among alternatives because, if listed, BOEM would need to consult under ESA Section 7 (refer to **Chapter 5.2**). BOEM used existing information and reasonably accepted scientific methodologies to extrapolate from publicly available information on marine mammals in completing the relevant analysis of marine mammal populations. There are existing leases in the GOM with ongoing or the potential for exploration, drilling, and production activities. In addition, non-OCS oil- and gas-related activities would continue to occur in the GOM irrespective of a proposed action (e.g., fishing, military activities, and scientific research). Therefore, BOEM concludes that the unavailable information from these events may be relevant to foreseeable significant adverse impacts to marine mammals because the full extent of impacts on marine mammals is not known. However, BOEM has determined that the information is not essential to a reasoned choice among alternatives for this Multisale EIS (including the No Action and Action Alternatives) because none of the sources reveal reasonably foreseeable significant adverse impacts to marine mammals not otherwise considered in this Multisale EIS.

4.9.1.2.5 Alternatives A, B, C, and D

With respect to marine mammal species, the effects associated with selection of any of the alternatives would be equivalent because of the diversity and distribution of marine mammal species throughout the potential areas of interest. The preceding analyses assumed a wide distribution of species and considered impacts to marine mammal species occurring in a wide range of habitats across all planning areas. While a proposed WPA lease sale (Alternative C) would be in a smaller area with less projected activity than a proposed regionwide (Alternative A) or proposed CPA/EPA lease sale (Alternative B) as described in **Chapter 3**, marine mammal species are widely distributed throughout the planning areas and may travel great distances across the GOM. As such, activities isolated to specific planning areas pose similar potential impacts to individuals as do activities occurring in all planning areas. Therefore, a similar mix of species would be exposed to the analyzed impact-producing factors, regardless of the specific action alternative selected. For example, if a marine mammal species were to be accidentally struck by an OCS vessel, it would have the same impact to that individual and its respective population estimate in the WPA as it would if it were struck in the CPA or EPA. Although it can be speculated that a smaller leased area resulting in less projected OCS oil- and gas-related activity would decrease the likelihood of OCS oil- and gas-related activities impacting marine mammal populations, there are not enough conclusive data on the density and distributions of marine mammal populations in the GOM throughout the year to support that speculation. Because this information is not available and because marine mammals have exhibited wide-ranging behaviors in the GOM, it is very difficult to predict where in the GOM a particular marine mammal species will be throughout the year. For instance, the Florida manatee has been known to occur mostly in the State waters of Florida in the EPA, which has very little OCS oil- and gas-related activity. However, there have been multiple manatee sightings in deep water from OCS oil- and gas-related activities occurring in the CPA.

The activities proposed under Alternatives A, B, C, and D could directly impact marine mammal species within the GOM and contribute incrementally to the cumulative effects on these species. Although there would always be some level of incomplete information on the impacts from routine activities under a proposed action on marine mammals, there is credible scientific information, applied using acceptable scientific methodologies, to support the conclusion that any realized impacts would be sublethal in nature and not in themselves rise to the level of reasonably foreseeable significant adverse (population-level) impacts. Also, routine activities would be ongoing in the proposed action area as a result of active leases and related activities. There are no data to suggest that routine activities from the previous OCS Program are significantly impacting marine mammal populations. The net result of any disturbance would depend upon the size and percentage of the population likely to be affected, the ecological importance of the disturbed area, the environmental and biological parameters that influence an animal’s sensitivity to disturbance and stress, or the accommodation time in response to prolonged disturbance (Geraci and St. Aubin, 1980). Accidental events that involve large spills, particularly those continuing to flow fresh hydrocarbons into oceanic and/or outer shelf waters for extended periods (i.e., days, weeks, or months), pose an increased likelihood of impacting marine mammal populations inhabiting these waters.

The effects of a proposed action, when viewed in light of the impacts associated with other past, present, and reasonably foreseeable future activities, may result in greater impacts to marine mammals than before the *Deepwater Horizon* explosion, oil spill, and response; however, the magnitude of those impacts cannot yet be determined. Nonetheless, operators are required to follow all applicable lease stipulations and regulations, as clarified by NTLs, to minimize these potential interactions and impacts. The operator's reaffirmed compliance with NTL 2016-BOEM-G01 ("Vessel Strike Avoidance and Injured/Dead Protected Species Reporting") and NTL 2015-BSEE-G03 ("Marine Trash and Debris Awareness and Elimination"), as well as the limited scope, timing, and geographic location of a proposed lease sale, would result in negligible impacts from the proposed activities on marine mammals. In addition, NTL 2012-JOINT-G02, "Implementation of Seismic Survey Mitigation Measures and Protected Species Observer Program," minimizes the potential for injury from seismic operations to marine mammals. These mitigations include onboard observers, airgun shut-downs for whales in the exclusion zone, ramp-up procedures, and the use of a minimum sound source. The Protected Species Stipulation, if applied, requires compliance with any terms and conditions from past and future biological opinions from NMFS and FWS.

Cumulative impacts on marine mammals are expected to result in a number of chronic and sporadic sublethal impacts (i.e., behavioral effects and nonfatal exposure to or intake of OCS oil- and gas-related or non-OCS oil- and gas-related contaminants or discarded debris) that may stress and/or weaken individuals of a local group or population and predispose them to infection from natural or anthropogenic sources (Harvey and Dahlheim, 1994). Disturbance (i.e., noise from vessel traffic and drilling operations) and/or exposure to sublethal levels of toxins and anthropogenic contaminants may stress animals, weaken their immune systems, and make them more vulnerable to parasites and diseases that normally would not be fatal (Harvey and Dahlheim, 1994). There is potential for impacts from routine activities or accidental events to be greater on individuals or populations already impacted by other OCS oil- and gas-related or non-OCS oil- and gas-related impact-producing factors. However, within the GOM, there is a long-standing and well-developed OCS Program (more than 50 years) and there are no data to suggest that activities from the previous OCS Program are significantly impacting marine mammal populations.

The incremental contribution of a proposed lease sale (Alternative A, B, C, or D) to cumulative impacts to marine mammal populations, depending upon the affected species and their respective population estimate, even when taking into consideration the potential impacts of the *Deepwater Horizon* explosion, oil spill, and response; non-OCS oil- or gas-related factors; and the minimization of OCS oil- or gas-related impacts through lease stipulations and regulations, would be expected to be **negligible** as a result of a proposed action (Alternative A, B, C, or D) and the period analyzed.

4.9.1.2.6 Alternative E—No Action

If selected, Alternative E would not contribute to impacts on marine mammal species within the GOM. However, cumulatively, the impacts resulting from the routine activities and accidental events and the cumulative impacts from previously permitted activities and prior lease sales would continue and be unchanged from the conclusion reached for the action alternatives because of existing oil and gas activities. Therefore, the significance of impact-producing factors on marine mammals would be the same for Alternative E as the impacts discussed in **Chapter 4.9.1.2** for previously permitted activities and prior lease sales.

4.9.2 Sea Turtles

Five species of sea turtles are known to inhabit the GOM (Pritchard, 1997): green (*Chelonia mydas*); hawksbill (*Eretmochelys imbricata*); Kemp's ridley (*Lepidochelys kempii*); leatherback (*Dermochelys coriacea*); and loggerhead (*Caretta caretta*). All five species are highly migratory with individuals migrating into nearshore waters as well as other areas of the GOM, North Atlantic Ocean, and the Caribbean Sea, and all five species use beaches along the coasts during nesting season. These sea turtles are protected under the Endangered Species Act of 1973. The FWS and NMFS share Federal jurisdiction for sea turtles. The FWS has responsibility for monitoring and managing sea turtles (i.e., nesting turtles, eggs, and hatchlings) on the beaches, and NMFS has jurisdiction for sea turtles in the marine environment. Refer to **Chapter 4.9** above for general information regarding protected species. The approach of this analysis is to focus on the potential impact-producing factors for sea turtles from OCS oil- and gas-related routine activities (i.e., exploration, development, and production), as well as reasonably foreseeable accidental events and cumulative impacts, and to define impact-level measures for each impact-producing factor under a proposed action (refer to **Table 4-18** in **Chapter 4.9**).

4.9.2.1 Description of the Affected Environment

General information relevant to all five species is discussed in the introduction for **Chapter 4.9**. Species-specific information regarding mating/nesting, foraging, habitat use, conservation status, and threats is discussed in the chapters below.

In 2009, NMFS completed a status review of loggerhead sea turtles, and on September 22, 2011, and issued a final rule to list nine Distinct Population Segments (DPSs) of loggerhead sea turtles under the ESA and designated the GOM population under the Northwest Atlantic Ocean DPS (*Federal Register*, 2011b). The Kemp's ridley 5-year review was completed in July 2015 and the status remains unchanged (USDOC, NMFS and USDOI, FWS, 2015). In 2016, NMFS and FWS completed a status review of green sea turtles, designating the status of 11 DPSs across the species global distribution. The Gulf of Mexico population is included in the designated North Atlantic DPS and is considered threatened (*Federal Register*, 2016f). In 2013, the 5-year reviews for leatherback and hawksbill sea turtles were updated and all retained endangered status (USDOC, NMFS and USDOI, FWS, 2013a and 2013b).

Nesting on the U.S. Gulf Coast has been documented for the five species of sea turtles. Loggerheads and Kemp's ridleys are the most common, followed by green sea turtles, and finally leatherback and hawksbill sea turtles; however, the latter two species rarely nest in the GOM (USDOC, NMFS and USDOI, FWS, 2007a-c, 2013a, and 2013b). Data can be found for sea turtle nesting through different websites, including the National Park Service who has data for Texas (USDOI, NPS, 2016), Alabama's Sea Turtle Conservation Program (Share the Beach, 2015), and the State of Florida, Fish and Wildlife Conservation Commission's websites (State of Florida, Fish and Wildlife Conservation Commission, 2016d).

Sea turtles are protected by the Endangered Species Act due to their low population numbers and habitat loss. Existing threats to sea turtles include both natural and human-influenced impacts that are discussed under the individual species descriptions. Natural phenomena, such as tropical storms and hurricanes, occur in the GOM and may impact nesting beaches (Dewald and Pike, 2013), depending on timing, size, and location of the storm. Storm impacts to nesting activity can be difficult to assess, but beach erosion has been shown to be one of the major factors affecting turtle hatchling success (Brost et al., 2015). Although the use of turtle excluding devices has reduced interactions, fisheries' impacts remain the greatest threat to sea turtles (Lewison et al., 2013).

Sea turtle strandings can be used as an index of their habitat conditions; an increase in strandings indicates a change that negatively impacts sea turtles resulting in impairment or mortality as identified by recovered stranded turtles or may also be reflective of increased surveillance or detection of stranded turtles. Sea turtle strandings along the Gulf and Atlantic Coasts are documented and monitored by the Sea Turtle Stranding and Salvage Network and includes Federal, State, and private partners. The NMFS provides stranding data for the GOM (i.e., Texas, Louisiana, Mississippi, and Alabama) through its Office of Protected Resources site. These data are updated regularly when NMFS obtains the data from the Sea Turtle Stranding and Salvage Network members. Because this information is routinely updated and can change at any time, BOEM refers the reader to NMFS's website for the most current information (USDOC, NMFS, 2015g). Florida is not included in NMFS' Gulf of Mexico stranding data; however, Florida-specific stranding information can be found on the State of Florida, Fish and Wildlife Conservation Commission's Florida Sea Turtle Stranding and Salvage Network website (State of Florida, Fish and Wildlife Conservation Commission, 2016e). Stranding data are not indicative of population status because there are many variables associated with the data (Epperly et al., 1996; Nero et al., 2013). Stranding data indicate the presence of species, which is important particularly regarding populations or species thata are rare or uncommon.

Green Sea Turtle (*Chelonia mydas*)

Federal listing of the green sea turtle occurred on July 28, 1978 (*Federal Register*, 1978a). All green sea turtle populations are listed as threatened except for the breeding populations of Florida and the Pacific Coast of Mexico, which are endangered. The NMFS and FWS finalized a rule (*Federal Register*, 2016f) to remove the current range-wide listing for green sea turtles, to replace it with eight DPSs as threatened and three as endangered, and to include application of existing protective regulations to the DPSs. Green sea turtles that use the GOM are designated as part of the threatened North Atlantic DPS (*Federal Register*, 2016f).

Green sea turtle mating occurs in the waters off the nesting beaches, and nesting is typically associated with the female's hatching beach. In a study conducted off the coast of southern Florida, each female deposited up to six clutches during the breeding season at 9- to 18-day intervals (Hart et al., 2013a). Mean clutch size is highly variable among populations but averages about 110 eggs. The complete nesting range of the green sea turtle includes sandy beaches of mainland shores and barrier islands between Texas and North Carolina and at the U.S. Virgin Islands and Puerto Rico (USDOC, NMFS and USDOI, FWS, 1991). Principal U.S. nesting areas for green sea turtles are in eastern Florida (Ehrhart and Witherington, 1992).

After hatching, green sea turtles go through a post-hatchling pelagic stage where they move offshore and are associated with drift lines of algae, *Sargassum*, and other debris. The post-hatchlings are believed to remain tightly associated with these drift lines for several years, feeding close to the surface on a variety of pelagic plants and animals. The post-hatchling, pelagic-stage individuals are assumed to be omnivorous, but little data are available. Once the juveniles reach a certain age/size range, they leave the pelagic habitat and travel to nearshore foraging grounds. Once they move to these nearshore benthic habitats, adult green turtles are almost exclusively herbivores, feeding on seagrass and algae. Age at sexual maturity is estimated to be between 20 and 40 years (USDOC, NMFS and USDOI, FWS, 2007c). Adult females migrate from foraging areas to mainland or island nesting beaches and may travel hundreds or thousands of kilometers each way (USDOC, NMFS and USDOI, FWS, 2007c).

Foraging areas along the northern GOM include shallow, coastal waters with sufficient benthic vegetation such as seagrass. Direct destruction or degredation of these areas from bottom disturbance due to dredging, boat anchorage, deposition of spoil, and siltation (Coston-Clements and Hoss, 1983; Williams, 1988) influence the distribution of foraging green sea turtles. Eutrophication, heavy metals, radioactive elements, and hydrocarbons all may reduce the extent, quality, and productivity of foraging grounds (Frazier, 1980; USDOC, NMFS and USDOI, FWS, 2007c).

The principal cause of past declines and extirpations of green sea turtle assemblages has been the over exploitation of eggs and meat. Significant threats on green sea turtle nesting in the region include beach armoring and erosion control, artificial lighting, and general disturbance from human activity, such as trampling. Armoring of beaches (e.g., seawalls, revetments, rip-rap, sandbags, and sand fences) in Florida for protecting developed property by reducing coastal erosion is increasing and has been shown to deter nesting, even when armoring structures do not completely block access to nesting habitat (Mosier, 1998). Marine debris is a threat to the pelagic habitat of juvenile green sea turtles as well, and older juvenile green turtles have been found dead after ingesting seaborne plastics (Balazs, 1985). Another issue regarding manmade debris in the marine or coastal environment is entanglement of turtles in discarded monofilament fishing line and abandoned netting (Balazs, 1985).

Ongoing threats to green sea turtles include the occurrence of green sea turtle fibropapillomatosis disease, which was originally reported in the 1930's (Smith and Coates, 1938). This disease is globally widespread and has been found to affect large numbers of animals in some areas, including Hawaii and Florida (Herbst, 1994; Jacobson, 1990; Jacobson et al., 1991). Gillnets, trawl nets, pound nets (Crouse, 1982; Hillestad et al., 1982; NRC, 1990), and any abandoned nets (Balazs, 1985; Ehrhart et al., 1990) are known to kill sea turtles as bycatch. To address interactions between marine turtles and trawl fishing gear, NOAA worked cooperatively with the commercial shrimp trawl industry to develop sea turtle excluder devices (*Federal Register*, 2015g). Green sea turtles are also threatened and taken by hook-and-line fishing. Collisions with power boats and encounters with suction dredges have resulted in the mortality of green sea turtles along the U.S. coast and may be common elsewhere where boating and dredging activities are frequent.

Hawksbill Sea Turtle (*Eretmochelys imbricata*)

The hawksbill sea turtle was listed as endangered on December 2, 1970 (*Federal Register*, 1970b). They were once abundant in tropical and subtropical regions and are highly migratory, using a wide range of habitats during their lifetime. In the continental U.S., hawksbills have been documented along the east coast as far north as Massachusetts and in all Gulf Coast States, but they are found primarily along Florida and Texas.

Reproductive females undertake periodic (usually non-annual) migrations to their natal beach to nest. Movements of reproductive males are less well known, but they are presumed to involve migrations to the nesting beach or to courtship stations along the migratory corridor. Immature hawksbills tagged at St. Thomas during long-term, in-water studies appeared to be resident for extended periods (Boulon, 1994). Tag returns were recorded from St. Lucia, the British Virgin Islands, Puerto Rico, U.S. Virgin Islands, and the Dominican Republic (Boulon, 1989; Meylan, 1999; USDOC, NFMS and USDOI, FWS, 2013b). While nesting occurs along the beaches throughout the world's oceans with the most nesting occurring on beaches of the Caribbean Sea; hawksbill nesting on northern GOM beaches, including Florida, is rare (Mays and Shaver, 1998; USDOI, FWS, 2015f). The Atlantic Coast of Florida is the only area in the U.S. where hawksbills nest on a regular basis, but the maximum number of nests documented in any year during 1979-2000 was only four. Females nest an average of 3-5 times per season, and the mean clutch size is 130 eggs (USDOC, NMFS and USDOI, FWS, 2013b).

The life history of hawksbills consists of a pelagic stage that lasts from the time they leave the nesting beach as hatchlings until they are approximately 7-12 in (20-30 cm) in straight carapace length (Meylan, 1988; Bell and Pike, 2012), followed by residency in developmental habitats (foraging areas where immature individuals reside and grow) in coastal waters. As with most sea turtle species, hatchlings and early juveniles are often found in association with oceanic *Sargassum* floats. As older juveniles, they move nearshore for feeding habitat and may associate with the same feeding locality for more than a decade (Musick and Limpus, 1997).

Adult foraging habitat, which may or may not overlap with developmental habitat, is typically coral reefs, although other hard bottom communities and occasionally mangrove-fringed bays may be occupied. Hawksbills show fidelity to their foraging areas over periods of time as great as several years (van Dam and Diez, 1998). The diet is highly specialized and consists primarily of sponges and macroalgae, although other food items have been documented to be important in some areas of the Caribbean (USDOC, NMFS and USDOI, FWS, 2013b). The lack of sponge-covered reefs and the cold winters in the northern GOM may prevent hawksbills from establishing a strong population in this area.

The majority of hawksbill sightings are reported from the Sea Turtle Stranding Network. Hawksbills undertake developmental migrations (movements as immature turtles) and reproductive migrations over long distances (Meylan, 1999).

The primary cause of hawksbill decline has been attributed to historical overexploitation for tortoise shell, the patterned scales that cover the turtle's shell (Parsons, 1972; Mortimer and Donnelly, 2008). International trade in tortoiseshell is now prohibited among all signatories of the Convention on International Trade in Endangered Species (CITES); however, some illegal trade continues.

In addition to the factors threatening all marine turtles (described in the sea turtle introduction above), hybridization with other species has also been identified as a concern for maintaining the genetic integrity of hawksbills (USDOC, NMFS and USDOI, FWS, 2013b). Hybridization occurs more often for small populations with low densities as the chance of finding a mate is reduced. Globally, the decline of hawksbills has been influenced by impacts to foraging areas and nesting beaches by climate change and fisheries bycatch (USDOC, NMFS and USDOI, FWS, 2013b).

Kemp's Ridley Sea Turtle (*Lepidochelys kempii*)

The Kemp's ridley sea turtle was listed as endangered on December 2, 1970 (*Federal Register*, 1970b). On September 22, 2011, a final bi-national (Mexico and U.S.) recovery plan for Kemp's ridleys was released. The 5-year review for Kemp's ridleys was released on August 21, 2015, and the classification did not change. This species was given higher recovery priority from NMFS due to the potential for future extinction, while priority from FWS remained the same (USDOC, NMFS and USDOI, FWS, 2015). Internationally, the Kemp's ridley sea turtle is considered the most endangered sea turtle throughout its range.

The Kemp's ridley turtle has a more restricted distribution through all of its life stages relative to other sea turtle species. Data suggest that Kemp's ridley turtles are found mainly in coastal areas of the GOM and northwestern Atlantic Ocean; sea-water temperature influences the distribution of this species as this species is not tolerant to cold waters (Ogren, 1989; Renaud, 1995; Renaud and

Williams, 2005). The nearshore waters of the GOM are believed to provide important developmental habitat for juvenile Kemp's ridley and loggerhead sea turtles. Ogren (1989) suggested that the Gulf Coast, from Port Aransas, Texas, through Cedar Key, Florida, represents the primary habitat for subadult Kemp's ridleys in the northern GOM. Juvenile/subadult Kemp's ridleys have been found along the Eastern Seaboard of the U.S. (Epperly et al., 2007) and in the GOM. Atlantic juveniles/subadults travel northward with spring warming to feed in the productive, coastal waters of Georgia through New England, returning southward with the onset of winter to escape the cold (Ogren, 1989; USDOC, NMFS and USDOI, FWS, 2015). Along the coast of Louisiana, immature Kemp's ridleys migrated to warmer nearshore waters during winter months (Coleman et al., 2016).

Kemp's ridleys nest in daytime aggregations, arribada, from April to July primarily at Rancho Nuevo, a stretch of beach in Mexico, Tamaulipas State (USDOC, NMFS and USDOI, FWS, 2015). Remigration of females to the nesting beach varies from annually to every 4 years, with a mean of 2 years (Turtle Expert Working Group, 1998). The mean clutch size for Kemp's ridley turgles is 100 eggs per nest, with an average of 2.5 nests per female per season. According to the 2011 bi-national recovery plan, nests in and surrounding Rancho Nuevo exceeded 20,000, thereby representing 8,000 females for 2009 (Secretariat of Environment & Natural Resources et al., 2011). Kemp's ridley sea turtle nests have increased in recent years along the South Padre Island National Seashore in Texas (USDOI, NPS, 2016).

In the GOM, juvenile/subadult Kemp's ridleys occupy shallow, coastal regions. Little is known of the movements of the post-hatching, planktonic stage within the GOM, although model predictions suggest that they mostly remain in waters offshore of Tamaulipas, Mexico (Putman et al, 2013). Studies have shown the post-hatchling pelagic stage varies from 1 to 4 years, and the benthic immature stage lasts 7-9 years (Schmid and Witzell, 1997). Benthic immature turtles with an 8- to 24-in (20- to 60-cm) straight-line carapace length are found in nearshore coastal waters, including the estuaries of the GOM and Atlantic, although adult-sized individuals sometimes are found on the eastern seaboard of the U.S.

The post-pelagic stages are commonly found dwelling over crab-rich sandy or muddy bottoms. Juveniles frequent bays, coastal lagoons, and river mouths. Adults of this species are usually confined to the GOM but occasionally swim into the Atlantic along the east coast of the U.S. The Turtle Expert Working Group (1998) estimated the age at sexual maturity to be 7-15 years.

Pelagic-stage, neonatal Kemp's ridleys presumably feed on the available *Sargassum* and associated infauna or other epipelagic species found in the GOM (USDOI, FWS, 2015g). Shaver et al. (2013) described the Kemp's ridley turtle nearshore foraging habitat "hotspots" in the northern GOM and, in another study, rehabilitated juveniles that were released showed similar foraging areas in coastal areas of Louisiana and Florida (Lyn et al., 2012). Stomach contents of Kemp's ridley turtles along the lower Texas coast consisted of a predominance of nearshore crabs and mollusks, as well as fish, shrimp, and other foods considered to be shrimp fishery discards (Shaver, 1991).

Of the five species in the GOM, the Kemp's ridley has suffered the greatest population decline; and historically, that decline was caused by commercial and local exploitation. Many natural and anthropogenic threats to the future of the species remain, including interactions with fisheries gear, dredging, marine pollution, foraging habitat destruction, entrainment in power plant cooling system intake structures, illegal poaching of nests, water temperature changes, and threats to nesting beaches from such sources as rising sea levels and coastal development (USDOC, NMFS and USDOI, FWS 2015).

Leatherback Sea Turtle (*Dermochelys coriacea*)

The leatherback sea turtle was listed as endangered on December 2, 1970 (*Federal Register*, 1970b). The leatherback is the largest and most pelagic of sea turtles. The average curved carapace length for adults is 61 in (155 cm) and weights from global populations range from 441 to 1,543 lb (200 to 700 kg).

Leatherback distribution and nesting grounds are found around the world in waters of the Atlantic, Pacific, and Indian Oceans; the Caribbean Sea; and the Gulf of Mexico (Ernst et al., 1994; USDOC, NMFS and USDOI, FWS 2013a). The leatherback is the most abundant sea turtle in waters over the northern GOM continental slope (Mullin and Hoggard, 2000). Leatherbacks appear to use continental shelf and slope habitats in the GOM (Collard and Ogren, 1990; Davis and Fargion, 1996). Surveys indicate that the region from Mississippi Canyon to De Soto Canyon, especially near the shelf edge, appears to be an important habitat for leatherbacks in the northern GOM (Mullin and Hoggard, 2000). Leatherbacks have been frequently sighted in the GOM during summer and winter (Mullin and Hoggard, 2000). Stranding data from 1986 through 2016, as reported by NOAA's Sea Turtle Stranding Network, indicated leatherback strandings in all states within the northern GOM. The current estimate of the northern Atlantic population, which includes the GOM, is 34,000-94,000 adults (USDOC, NMFS and USDOI, FWS, 2013a). Leatherbacks are a long-lived species (>30 years), with an estimated age of sexual maturity reported at about 3-19 years (Zug and Parham, 1996).

Historically, the largest concentrations of nesting females were found along the Pacific Coast of Mexico, but this population has been declining (Pritchard, 1982; Sarti et al., 1996). Also associated with the Pacific, nesting has been reported from China, Southeast Asia, Indonesia, and Australia. In the western Atlantic, female leatherbacks nest from the southeastern U.S. (east coast of Florida) to southern Brazil and from Mauritania to Angola in the eastern Atlantic Ocean (USDOC, NMFS and USDOI, FWS, 2013a; USDOI, FWS, 2015h). They nest frequently with up to 7 nests per year during a nesting season (March-July) and nest about every 2-3 years, although nesting is rare on GOM beaches (State of Florida, Fish and Wildlife Conservation Commission, 2016d). During each nesting, females may produce 100 eggs or more in each clutch (Schultz, 1975); however, leatherback clutches recorded at Buck Island, U.S. Virgin Islands, in 2014 ranged from 48 to 72 (Pollock et al., 2015). The eggs require approximately 60 days of incubation.

Once the hatchlings emerge from the nest and leave the natal beach, very little is known about the juvenile life stage. While other species of sea turtle remain in pelagic waters and *Sargassum*, there are no records to indicate this is consistent with leatherbacks. So little is known about the early life history of leatherbacks that the period from hatching to approximately 10 years later, when females return to the nesting beach, is referred to as the "lost years" (Carr, 1986). Although some studies have used stable isotopes to help determine approximate distributions of other sea turtle species during this lifestage (Reich et al., 2007), the data are still short term and would require advanced technologies to better track hatchling turtles. Given that information on the "lost years" of hatchling to 10-year-old leatherbacks would inform better management decisions, research has been continuing to gain a better understanding of this lifestage. BOEM has determined that the incomplete or unavailable information is not essential to a reasoned choice among alternatives; the best available science has been used to evaluate the potential impacts of a proposed action and its alternatives.

Adult leatherbacks forage in temperate and subpolar regions from 71° N. to 47° S. latitude in all oceans and undergo extensive migrations between 90° N. and 20° S. latitude to and from the tropical nesting beaches (USDOC, NMFS and USDOI, FWS 2013a). The leatherback forages widely throughout the water column from the surface to great depths throughout tropical and temperate oceans of the world. The distribution of leatherbacks appears to be dependent upon the distribution of their prey (Leary, 1957), consisting mostly of jellyfish and other pelagic gelatinous organisms, such as tunicates. Adults have been tracked foraging in the GOM on the cannonball jellies, *Stomolophus* sp. and moon jellies, *Aurelia* sp. (Evans, 2006; Lohoefener et al., 1988). Adult leatherbacks are deep divers, with estimated dives to depths in excess of 3,281 ft (1,000 m) (Eckert et al., 1989), but they may come into shallow waters if there is an abundance of jellyfish nearshore.

Ongoing threats to leatherbacks include ingestion of marine debris (Shoop and Kenney, 1992; Bugoni et al., 2001; Mrosovsky et al., 2009), poaching of eggs and animals (Boulon, 2000), entanglement in longline fishing gear (USDOC, NMFS, 2001), coastal trawl, and net and longline fisheries (Marcano and Alio-M., 2000; USDOC, NMFS, 2007b). Leatherback sea turtles seem to be the most susceptible to entanglement. This susceptibility may be the result of attraction to gelatinous organisms and algae that collect on buoys and buoy lines at or near the surface, and perhaps to the lightsticks used to attract target species in the longline fishery. According to observer records, an estimated 6,363 leatherback sea turtles were caught by the U.S. Atlantic tuna and swordfish longline fisheries between 1992 and 1999, of which 88 were discarded dead (USDOC, NMFS, 2001). Since then, U.S. pelagic longline fisheries in the Atlantic have incorporated mandatory bycatch reduction measures (USDOC, NMFS and USDOI, FWS, 2013a). However, Atlantic (including the Mediterranean, which has much higher fishing effort) longline sea turtle bycatch rates are higher than Pacific bycatch (Lewison et al., 2004). Reports of incidental takes of leatherback turtles are incomplete for many nations, including and in particular, the GOM (USDOC, NMFS, 2001).

Loggerhead Sea Turtle (*Caretta caretta*)

The loggerhead sea turtle was listed as threatened on July 28, 1978 (*Federal Register*, 1978a). It is still considered threatened under the reclassification as the Northwest Atlantic Ocean DPS in the GOM (*Federal Register*, 2011b).

In the GOM, loggerhead turtles have been primarily sighted in waters above the continental shelf, although many surface sightings of this species have also been made above the outer slope beyond the 1,000-m (3,281-ft) isobath. Additionally, Van Houtan and Halley (2011) modeled oceanographic processes in relation to loggerhead regional population dynamics and found that they are strongly correlated; therefore, they should be considered in baseline conditions. Sightings of loggerheads in waters above the continental slope suggest that they may be in transit through these waters to distant foraging sites or seeking warmer waters during the winter. Although loggerheads are widely distributed during both summer and winter, their presence in surface waters above the slope was greater during winter than in summer (Mullin and Hoggard, 2000). Adult loggerheads are known to make extensive migrations between foraging areas and nesting beaches. During non-nesting years, adult females from U.S. beaches are distributed in waters off the eastern U.S. and throughout the Gulf of Mexico, Bahamas, Greater Antilles, and Yucatán (Conant et al., 2009).

Loggerheads mate in late March through early June in the southeastern U.S. The mean clutch size for loggerheads is 100-126 eggs per nest, with an average of 4.1 nests/nesting individual per nesting season (USDOC, NMFS, 2013; Murphy and Hopkins, 1984). The nesting migration for an individual female loggerhead is usually on an interval of 2-3 years but it can vary from 1 to 7 years (Dodd, 1988). In the western Atlantic, most loggerhead sea turtles concentrate their nesting in the north and south temperate zones and subtropics, and they generally do not nest in the geographic area ranging from North Carolina to the Florida Panhandle tropical areas (Magnuson et al., 1990; USDOC, NMFS and USDOI, FWS, 2007b). Major nesting areas include the coastal islands of Georgia, South Carolina, North Carolina, and Florida's Atlantic Coasts. In the GOM, major nesting areas include some coastal beaches in Mississippi, Alabama, and Florida (**Figure 4-25**). Reproductive adult females return to their original hatching site to nest. Nesting data trends are declining in this species (*Federal Register*, 2011b; Witherington et al., 2009; Lamont et al., 2012). Five recovery units have been identified; three that are relevant are Peninsular Florida, Dry Tortugas, and the northern GOM. According to Ehrhart et al. (2003), the peninsular Florida Recovery Unit represents approximately 87 percent of all nesting effort in the Northwest Atlantic Ocean DPS.

Developmental habitat for juveniles is in the open ocean. Offshore, they reside for months in the oceanic zone in *Sargassum* floats, generally along the Loop Current and the west coast of Florida. Refer to **Chapter 4.5** (*Sargassum* and Associated Communities) for additional information on pelagic waters. Somewhere between 7 and 12 years old, oceanic juveniles migrate to nearshore coastal areas to mature into adults. These nearshore waters become important foraging and migratory habitat for juveniles and adults. Juveniles may also spend time in bays, sounds, and estuaries (Epperly et al., 2007). Benthic immature loggerheads have been found from Cape Cod, Massachusetts, to southern Texas (USDOC, NMFS and USDOI, FWS, 2007d). Large benthic immature loggerheads (28-36 in; 70-91 cm) represent a larger proportion of the strandings and in-water captures along the south and western coasts of Florida as compared with the rest of the coast. Benthic immature loggerheads foraging in northeastern U.S. waters are known to migrate southward in the fall as water temperatures cool (Epperly et al., 1995; Morreale and Standora, 1999) and migrate northward in spring. Juveniles are omnivorous and forage on crabs, mollusks, jellyfish, and vegetation at or near the surface (Dodd, 1988). Subadult and adult loggerheads are primarily coastal and typically prey on benthic invertebrates such as mollusks and decapod crustaceans in hard bottom habitats. McClellan and Read (2007) found that the shift from oceanic to neritic (i.e., coastal) waters is complex and reversible; some move into coastal waters and then return to open ocean.

Loggerhead sea turtles originating from the western Atlantic nesting aggregations are believed to lead a pelagic existence in the North Atlantic gyre for as long as 7-12 years, but there is some variation in habitat use by individuals at all life stages. Stranding records indicate that, when pelagic immature loggerheads reach a 16- to 24-in (40- to 60-cm) straight-line carapace length, they begin to recruit to coastal inshore and nearshore waters of the continental shelf throughout the U.S. Atlantic and GOM. Bjorndal et al. (2013) combined datasets over a large spatial scale (range of 9-33° N. latitude) to examine northwest Atlantic loggerhead growth rates and found that there was a decline with increasing body size. Their study indicated that latitude may be a major factor for smaller turtles (<2.6 ft; 80 cm) and that loggerheads may grow more rapidly in waters south of the U.S., noting that more data are needed for those waters to determine growth rates (Bjorndal et al., 2013).

Several recent reports are available concerning GOM loggerheads' nesting habitats and movements (Hart et al., 2013b), post-nesting behavior (Foley et al., 2013), foraging sites (Foley et al., 2014; Tucker et al., 2014), and body size effects on growth rates (Bjorndal et al., 2013). These reports confirm the importance of GOM beaches, specifically for loggerheads. Lamont et al. (2015) also published a report on the importance of the GOM for different life stages of the Northwest Atlantic Ocean DPS. Lamont et al. (2015) suggested that the loss of any life stage habitat could have long-term consequences to population recovery by affecting several life stages. Additional relevant information can be found in **Chapter 4.3.2** (Coastal Barrier Beaches and Associated Dunes).

Ongoing threats to the western Atlantic loggerhead populations include incidental takes from dredging, commercial trawling (Epperly et al., 2002), longline fisheries (Lewison et al., 2004), and gillnet fisheries; loss or degradation of nesting habitat from storms (Brost et al., 2015) or coastal development and beach armoring; disorientation of hatchlings by beachfront lighting; nest predation by native and nonnative predators (Brost et al., 2015); degradation of foraging habitat; marine pollution and debris; watercraft strikes; and disease (USDOC, NMFS and USDOI, FWS, 2007b).

Critical Habitat

Of all five GOM sea turtles species, the loggerhead is the only sea turtle that has critical habitat established in the GOM (**Figure 4-25**). As described above, NMFS and FWS are jointly responsible for managing sea turtles. The NMFS designated marine critical habitats in its Final Rule in July 2014, and FWS' designated terrestrial critical habitat in its Final Rule in August 2014 (*Federal Register*, 2014a and 2014c). The offshore marine critical habitat is *Sargassum* and the terrestrial critical habitat is the nesting beaches (**Figure 4-25**).

Four of the five species of sea turtles found in the GOM are associated with floating *Sargassum* (Carr, 1987b; Coston-Clements et al., 1991; Schwartz, 1988; Witherington et al., 2012). The hatchlings of loggerhead, Kemp's ridley, green, and hawksbill sea turtles are thought to find the *Sargassum* rafts when actively seeking frontal zones and then utilizing the habitat as foraging grounds and protection during their pelagic "lost years" (juvenile years in which turtle sightings are scarce) (Carr, 1987b; Coston-Clements et al., 1991). Schwartz (1988) reported numerous loggerhead hatchlings during commercial trawling for *Sargassum* in the Atlantic. This provided the largest documented count of hatchlings to date. Witherington et al. (2012) conducted a study on juvenile turtle use of *Sargassum* habitats and further supported that these drifting communities are important areas for young sea turtles (84% of 1,884 turtles were observed within 1 m [3 ft] of floating *Sargassum*). Sea turtle digestive system samples contained mainly marine animals and plants, plastics, wood, and flying insects. Tarballs, oiled plastics, and liquid oil were observed in *Sargassum* drift lines during the surveys (Witherington et al., 2012). Putman and Mansfield (2015) reported that passive-drifting sea turtle juveniles (*Sargassum*-associated stage) were actually active swimmers. Their research used synchronized surface drifter and tagged turtle releases to support that sea turtles in the GOM are able to move independently from and are not dispersed solely by currents (Putnam and Mansfield, 2015). Details about *Sargassum* can be found in **Chapter 4.5** (*Sargassum* and Associated Communities).

4.9.2.2 Environmental Consequences

This chapter provides detailed information regarding the impact-producing factors from routine activities, accidental events, and cumulative impacts from activities described in **Chapter 3** and their potential impacts on sea turtles that would potentially result from a single lease sale or the alternatives. This analysis applies to all considered alternatives. While a proposed WPA lease sale (Alternative C) would be in a smaller area with less projected activity than a proposed regionwide (Alternative A) or proposed CPA/EPA lease sale (Alternative B) as described in **Chapter 3**, sea turtles are distributed throughout the planning areas. As such, activities isolated to specific planning areas pose similar potential impacts to populations as do activities occurring in all planning areas. Therefore, because of the free swimming ability and wide distribution of species across the Area of Interest, the level of impacts would be the same for Alternatives A, B, C, and D. However, Alternative E, No Action, would avoid impacts from a proposed lease sale and the related postlease activities as the lease sale would not be held; only impacts from past lease sales and associated postlease activities or other G&G permits would continue. Following this environmental consequences chapter, there is a summary of the potential impacts as they relate to the other action alternatives.

4.9.2.2.1 Routine Activities

Routine activities (described in **Chapter 3.1**) resulting from a proposed action have the potential to harm sea turtles, although this potential is unlikely to rise to a level of significance to the population due to the activity already present in the GOM and mitigations that have been historically applied and discussed below. The routine activities that could have impact-producing factors associated with a proposed action that may affect GOM sea turtles include geological and geophysical activities (**Chapter 3.1.2.1**), transportation (**Chapter 3.1.4**), discharges and wastes (**Chapter 3.1.5**), decommissioning (**Chapter 3.1.6**), and noise (**Chapter 3.1.9**). Scenario numbers presented in this chapter are for Alternative A, which represents a regionwide lease sale with expected lease stipulations for this and other alternative scenario numbers (refer to **Table 3-2**).

Geological and Geophysical Activities

Seismic operations have the potential to harm sea turtles in close proximity to active airgun arrays. The Protected Species Stipulation and NTL 2016-BOEM-G02, "Implementation of Seismic Survey Mitigation Measures and Protected Species Observer Program," minimize the potential of harm from seismic operations to sea turtles that could be within the exclusion zone. These mitigations for sea turtles and marine mammals include, but are not limited to, onboard observers, ramp-up procedures, and the use of a minimum sound source. Noise impacts on turtles from seismic surveys are described in the "Noise" section below.

Further detailed information on seismic surveys and other G&G survey types may be found in **Chapter 3.1.2.1**. More information on sea turtle hearing and sensitivity to acoustic impacts can be found in Appendix I of BOEM's *Atlantic OCS Proposed Geological and Geophysical Activities: Mid-Atlantic and South Atlantic Planning Areas, Final Programmatic Environmental Impact Statement*, (USDOI, BOEM, 2014a) and Appendix H of the *Geological and Geophysical Exploration for Mineral Resources on the Gulf of Mexico Outer Continental Shelf: Final Programmatic Environmental Assessment*, (USDOI, MMS, 2004b). As of this Multisale EIS, BOEM, with BSEE and NMFS as cooperating agencies, prepared the Gulf of Mexico G&G Programmatic EIS to evaluate the potential environmental impacts of multiple G&G activities within Federal waters of the Gulf of Mexico's OCS and adjacent State waters, and is currently in the process of evaluating public comments. This Gulf of Mexico G&G Programmatic EIS evaluates all G&G activities in the GOM (for oil and gas, marine minerals, and renewable activities) over a 10-year period, including a small subset of reasonably foreseeable postlease G&G activities that may occur as a result of a proposed lease sale being evaluated in this Multisale EIS.

Noise associated with G&G activities may cause behavioral effects (changes in direction or swimming speed) or auditory masking in sea turtles. Based on current information on sea turtle hearing capabilities, it is not clear whether or not sea turtles rely on sound or would be affected by auditory masking (Popper et al., 2014). For more on noise impacts, refer to the "Noise" section below. In addition, NMFS, BOEM, and BSEE collaborated to publish National Standards for a Protected Species Observer Program to reduce impacts to protected species from G&G activities by standardizing the variation in and improving the management of the program (Baker et al., 2013).

The only other impact-producing factor to sea turtles that is associated with G&G activities is the potential for gear interaction. Sea turtles can become entangled in some types of lines associated with G&G activities, which has occurred in the past with ocean bottom cable/ocean bottom node surveys and other activities where rope tethers were used (e.g., anchors, buoys). The deployment of nodes and cables is conducted by a remotely operated vehicle by dropping nodes on a tether, or by laying cables off the back of a layout boat. The G&G permit applications are reviewed by BOEM and NMFS to set conditions of approval with each activity that minimizes impacts caused by gear interactions, which are expected to be rare. With the implementation of mitigations, impacts from G&G activities would be expected to be **negligible** to **moderate**. Moderate impacts may occur if a sea turtle has a negative interaction with gear, leading to injury that is irreversible and does not impact the species at a population level.

Transportation

An estimated 29,000-270,000 (highest range under Alternative A) service-vessel roundtrips are expected to occur annually as a result of a proposed action. Transportation corridors would be through areas where sea turtles have been sighted. Helicopter operation round trips are expected to be 87,000-1,928,000 as a result of a proposed action. Noise from service-vessel traffic and helicopter overflights may elicit a startle response from sea turtles, and there is the possibility of short-term disruption of activity patterns. For noise impacts related to OCS vessel and air traffic activities, refer to the "Noise" section below. Other impacts related to transportation are described in this section.

Vessel strikes are impact-producing factors associated with transportation associated with a proposed action that could affect sea turtles. Sea turtles spend at least 3-6 percent of their time at the surface for respiration and perhaps as much as 26 percent of their time at the surface for basking, feeding, orientation, and mating (Lutcavage et al., 1997). Data show that collisions with all types of commercial and recreational vessels cause sea turtle mortality in the GOM (Lutcavage et al., 1997). Stranding data for the U.S. Gulf and Atlantic Coasts, Puerto Rico, and the U.S. Virgin Islands show that, between 1986 and 1993, about 9 percent of living and dead stranded sea turtles had boat strike injuries (Lutcavage et al., 1997).

Sea turtles located in shallower waters have shorter surface intervals, whereas turtles occurring in deeper waters 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 vessel traffic would increase the probability of collisions between vessels and turtles, potentially resulting in injury or death to some animals.

There have been no documented sea turtle strikes with drilling and service vessels in the GOM; however, collisions with small or submerged sea turtles may go undetected. Based on sea turtle density estimates in the GOM, the encounter rates between sea turtles and vessels would be expected to be greater in water depths <200 m (656 ft) (USDOC, NMFS, 2007a). To further minimize the potential for vessel strikes, NTL 2016-BOEM-G01 was issued; this NTL provides NMFS' guidelines for monitoring procedures related to vessel strike avoidance measures for sea turtles and other protected species. Historically, compliance with this NTL and other protective measures has been mandatory as a result of the Protected Species Stipulation, which has been applied at the lease sale stage. With the implementation of these measures and the avoidance of potential strikes from OCS vessels, the risk of collisions between oil- and gas-related vessels (including those for G&G, drilling, production, decommissioning, and transport) and sea turtles is appreciably reduced, but strikes may still occur. BOEM and BSEE monitor for any takes that have occurred as a result of vessel strikes and require that any operator immediately report the striking of any animal (NTL 2016-BOEM-G01). Given the scope and timing of a proposed action, the transitory nature of sea turtles, as well as the established mitigation described above, the impacts to sea turtles from vessel collisions are expected to be **negligible**; however, if by chance collisions occur that are not reasonably forseeable, impacts could be moderate, causing impacts that are irreversible and that do not affect the species at a population level.

Discharges and Wastes

Contaminants in waste discharges and drilling muds might indirectly affect sea turtles through food-chain biomagnification, but there is uncertainty concerning the possible impacts. Most operational discharges are diluted and dispersed when released in offshore areas and are considered to have sublethal effects (Kennicutt, 1995; Kennicutt et al., 1996). Any potential impacts from drilling fluids or other operational discharges and wastes would be indirect as a result of ingestion via the food chain (Neff et al., 1989). Impacts from water degradation are expected to be **negligible** due to rapid dilution of the discharges, which are also regulated by NPDES permits, and due to the wide-ranging movements of sea turtle species in the GOM. Refer to **Chapter 3.1.5** for more information on operational wastes and discharges generated by OCS oil- and gas-related facilities and **Chapter 4.2** for a discussion of potential water quality impacts as a result of these activities.

Decommissioning

Offshore structures serve as artificial reefs and are sometimes used by sea turtles for foraging and resting (Gitschlag and Herczeg, 1994). Explosive severance of these structures can affect turtles located in the vicinity of the structure during the severance activity. The estimated number of platforms to be decommissioned as a result of a selected alternative is reported in **Chapter 3.1.6**. With the highest range under Alternative A, an estimated 9-193 projects of explosive severance of structure removals are projected to occur over 50 years (**Table 3-2**).

Decommissioning activities, which are approved by BSEE, are described in detail in *Structure-Removal Operations on the Gulf of Mexico Outer Continental Shelf: Programmatic*

Environmental Assessment (USDOI, MMS, 2005), and they are summarized in **Chapter 3**. The NTL, "Decommissioning Guidance for Wells and Platforms" (NTL 2010-G05) provides guidelines for offshore operators that specify and reference NMFS's biological opinion mitigation requirements currently in place for protected species, including sea turtles. In addition, terms and conditions, and reasonable and prudent measures identified during ESA consultation for decommissioning would be required conditions of approval in any decommissioning authorizations. The regulations at 30 CFR part 550 outline the environmental, monitoring, and mitigation information that operators must submit with plans for exploration, development, and production. This regulation requires OCS energy-related activities to be conducted in a manner that is consistent with the provisions of the ESA. Additionally, NMFS has implemented a protected species observer program for structure decommissioning. Actual sea turtle impacts from explosive removals in recent years have been small. Though mitigations that are in place would minimize the risk of impacts to sea turtles, there is a possibility of sea turtles going undetected within the zone of explosive impacts; therefore, explosive severance could **moderately** impact sea turtles. However, the updated pre- and post-detonation mitigations should ensure that injuries remain extremely rare. With implementation of specified decommissioning mitigations, impacts to sea turtles from explosive severance are expected to be **negligible**.

Noise

Noise-induced stress has not been well-studied in sea turtles. 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 response has been observed for captive loggerhead and green sea turtles (O'Hara and Wilcox, 1990; Moein et al., 1993; Lenhardt, 1994). Loggerhead hearing frequency range is between 50 and 1100 Hz, depending on the size of the turtle (Lavender et al., 2014). Some loggerheads exposed to low-frequency sound responded by swimming towards the surface at the onset of the sound, presumably to lessen the effects of the transmissions (Lenhardt, 1994). The potential direct and indirect impacts of sound on sea turtles include physical auditory impacts (temporary threshold shift), behavioral disruption, long-term impacts, masking, and adverse impacts on the food chain. Low-frequency sound transmissions could potentially cause increased surfacing and avoidance from the area near the sound source (Lenhardt et al., 1983; O'Hara and Wilcox, 1990; McCauley et al., 2000). Leatherback hatchlings were shown to detect sounds between 50 and 1,200 Hz underwater and 50 and 1,600 Hz in air with maximum sensitivity between 100 and 400 Hz in water and 50 and 400 Hz in air (Dow Piniak et al., 2012).

For seismic sources, sea turtles have the potential for mortality or injury at or above 210 dB cumulative sound exposure level and above 207 dB peak pressure level (Popper et al., 2014). Sea turtles have been observed noticeably increasing their swimming in response to an operating seismic source at 166 dB in water (McCauley et al., 2000). There is a high potential for recoverable injury, temporary threshold shift (recoverable hearing loss), and behavioral modifications only when the turtle is in close proximity to the source. Mortality and injury caused by shipping and continuous noise are expected to have low levels of relative risk even if a sea turtle is near the source. The risk for temporary threshold shift near the source is moderate, while the risk for masking may be high both at near and intermediate distances from the source, and the risk for behavioral modifications near the source are high and moderate at intermediate distances from the source (Popper et al., 2014). Impacts from any sound source are relative to the source type, distance to the source, frequency, intensity and duration of the source, and distance to the animal. Refer to **Chapter 3.1.2.1** for more information on noise related to G&G activities.

Reactions to aircraft or vessel noise, such as avoidance behavior, may disrupt normal activities, including feeding. Important habitat areas (e.g., feeding, mating, and nesting) may be avoided because of noise generated in the vicinity. There is no information regarding the long-term consequences that these disturbances may have on sea turtles. There are no systematic studies published of the reactions of sea turtles to aircraft overflights; however, anecdotal reports indicate that sea turtles often react to the sound and/or the shadow of an aircraft by diving. It is projected that 70,000-3,750,000 OCS oil- and gas-related helicopter operations (take-offs and landings) would occur in the support of OCS oil- and gas-related activities over the 50-year analysis period (**Table 3-2**). The Federal Aviation Administration's Advisory Circular 91-36D (September 17, 2004) encourages pilots to maintain higher than minimum altitudes over noise-sensitive areas. Vessel noise is an impact-producing factor associated with a proposed action that could affect sea turtles. The dominant source of noise from vessels is propeller operation (i.e., cavitation), and the intensity of this noise is largely related to ship size and speed. 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. Vessel noise from activities resulting from a proposed action would produce low levels of noise, generally in the 150- to 170-dB re 1 µPa-m and at frequencies below 1,000 Hz. Vessel noise is transitory and generally does not propagate at great distances from the vessel. If sound affects any prey species, impacts to sea turtles would depend on the extent that prey availability might be altered.

Drilling and production facilities 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). 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; Bartol et al., 1999). 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). Oil and gas exploration and extraction occur in sea turtle foraging habitats and generates high-intensity, low-frequency, impulsive sounds within the leatherback hearing range (Dow Piniak et al., 2012).

Chronic sublethal effects (e.g., stress), resulting in persistent physiological or behavioral changes and/or avoidance of impacted areas from noise disturbance such as seismic activities, could cause declines in survival or fecundity and could result in population declines; however, such declines are not expected because of implementation of the Protected Species Stipulation and NTL 2012-JOINT-G02 minimizing potential harm. Overall noise impacts on sea turtles from a proposed action are expected to be **negligible** to **minor** depending on the location of the animal(s) relative to the sound source and the frequency, intensity, and duration of the source. A minor impact would be a behavioral change in response to noise. Refer to **Chapter 3.1.9** for more information on potential noise impact-producing factors associated with a proposed action.

4.9.2.2.2 Accidental Events

Reasonably foreseeable accidental events as a result of a proposed action have the potential to harm sea turtles. The major impact-producing factors resulting from the accidental events associated with a proposed action that may affect sea turtles include oil spills and spill-response activities. These have the potential to impact small to large numbers of sea turtles in the GOM, depending on the magnitude and frequency of low-probability accidents, the ability to respond to accidents, the location and date of accidents, various meteorological and hydrological factors, and life history stages of animals exposed to the hydrocarbons (NRC, 2003; USDOC, NMFS, 2015h).

Oil Spills

Improperly balanced well pressures that result in sudden, uncontrolled releases of fluids from a wellhead or wellbore can occur during any phase of development (i.e., exploratory drilling, development drilling, production, completion, or workover operations [refer to **Chapter 3.2.1** for description of development activities]). Though oil and gas exploration overlaps sea turtles habitats, it is the particular biology and behavior of sea turtles that place them at risk, including a lack of avoidance behavior, indiscriminate feeding in convergence zones, and large pre-dive inhalations (Shigenaka et al., 2010). Oil spills, however, are not the foremost danger to sea turtles, as described above. Impacts would occur as a result of actual contact with the spilled oil, regardless of the source.

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 prey. 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). Significant changes in blood chemistry following contact with hydrocarbons have been reported ranging from changes to blood's oxygen transport system to elevation in white blood cells, indicating stress (Lutcavage et al., 1995). Although disturbances may be temporary, long-term impacts remain unknown, and chronically ingested oil may accumulate in organs. Oil can adhere to the body surface of sea turtles. Oil has been observed to cling to the nares, eyes, and upper esophagus (Overton et al., 1983; Van Vleet and Pauly, 1987; Gramentz, 1988; Lutcavage et al., 1995). Witham (1983) found tar sealed the mouth and nostrils of small turtles. Periocular tissues and other mucous membranes would presumably be most sensitive to contact with hydrocarbons. Turtles may become entrapped by tar and oil slicks and rendered immobile (Witham, 1978; Plotkin and Amos, 1988; Gramentz, 1988). All structural and biochemical changes in the epidermis of sea turtles have been shown to be minor and reversible. 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).

Contact with hydrocarbons may not cause direct or immediate death but cumulative sublethal impacts, such as salt gland disruption or liver impairment, could impair a sea turtle's ability to function effectively in the marine environment (Vargo et al., 1986; Lutz and Lutcavage, 1989; Camacho et al., 2012). 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). Camacho et al. (2013) conducted blood plasma testing on stranded sea turtles to determine PAH concentrations. Burning fossil fuels and urban runoff, as well as oil spills, were considered as being potential environmental sources of PAHs detected in turtle blood plasma (Camacho et al., 2013). A similar study was conducted by Camacho et al. (2014) on live juvenile turtles and it was determined that the turtles had 34 of 52 organic contaminants. Contrary to previous data (Geraci and St. Aubin, 1983), PAH biomagnification does not occur in sea turtles, suggesting that sea turtles may be able to efficiently metabolize PAHs (Camacho et al., 2014).

Eggs, hatchlings, and small juveniles are particularly vulnerable if contacted (Fritts and McGehee, 1982; Lutz and Lutcavage, 1989; Bjorndal et al., 1994). Sea turtle hatchling exposure to, fouling by, or consumption of tarballs would likely be fatal. Sea turtle eggs are likely to be lethally impacted by contact with spilled oil (USDOI, NPS, 2011a). During nesting, a female turtle might crawl through tar prior to laying her eggs or might push oil mixed with sand into the nest and contaminate the eggs (Chan and Liew, 1988). Assuming a sea turtle's sense of smell is critical, oil fouling of a nesting area might disturb imprinting of hatchling turtles or confuse the turtles on their return migration (Geraci and St. Aubin, 1985; Chan and Liew, 1988). Potential toxic impacts to embryos would depend on the type of oil and degree of weathering, type of beach substrate, and especially upon the developmental stage of the embryo. Embryonic development in an egg may be altered or arrested by contact with oil (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 impacts. Fritts and McGehee (1982) concluded that oil contamination of nesting beaches would have its greatest impact on nests that were already constructed; nests made on fouled beaches are less likely to be affected, if at all. Residue oil may adhere to sand grains where eggs are deposited, later impeding hatchlings from successfully evacuating nests and ultimately leading to their death. Reproductive success could ultimately be impacted.

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*. Oil slicks, slickets, or tarballs moving through offshore waters may foul *Sargassum* mats that hatchling and juvenile sea turtles inhabit, which would conceivably result in the loss of sea turtle habitat and/or incidental takes as defined under the ESA. High rates of oil contact in young turtles suggest that bioaccumulation may occur over their potentially long lifespan. The result of adult sea turtles feeding selectively in surface convergence lines could be prolonged contact with viscous weathered oil (Witham, 1978; Hall et al., 1983). Balazs (1985) and Gramentz (1988) found tar to be the most prevalent marine pollution ingested by sea turtles. Bjorndal et al. (1994) examined digestive tracts from 51 juvenile sea turtles in Florida and found only 1 (<2%) to have tar in the gut. Similarly, Bugoni et al. (2001) found that only 1 turtle out of 50 (approximately 2%) stranded turtles that were analyzed had ingested oil. Some captive sea 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 firm evidence that free-ranging turtles can detect and avoid oil (Odell and MacMurray, 1986). Therefore, oil might have a more indirect impact on the behavior of sea turtles.

OSRA Modeling

The OSRA modeling results, which show the probabilities of a large spill (≥1,000 bbl) occurring in Federal offshore waters making contact with State offshore waters, are provided in **Figure E-20**. In general terms, coastal waters of the area may be contacted by many, frequent, small spills (≤1 bbl); few, infrequent, moderately-sized spills (>1 and <1,000 bbl); and a single large spill (≥1,000 bbl) as a result of a proposed action. Pipelines pose the greatest risk of a large spill occurring in coastal waters compared with platforms and tankers. Spill estimates over a 50-year time period are indicated in **Table 3-17**. According to **Table 3-17**, the majority of estimated spills would be small (<10 bbl). The actual number of spills that may occur in the future could vary from the estimated number. A spill size group for ≥10,000 bbl is not reasonably foreseeable; however, the impacts from such a spill are analyzed in the *Catastrophic Spill Event Analysis* white paper (USDOI, BOEM, 2016d). For more information on OSRA, refer to **Chapter 3.2.1.4** (Analysis of Offshore Spills ≥1,000 bbl).

Depending on the time and location of a spill's occurrence in coastal waters, its impact and resulting cleanup activities may interrupt sea turtle migration, feeding, mating, and/ or nesting activity for extended periods (i.e., days, weeks, or months). Spills originating in or dispersing through coastal waters of Texas or Louisiana may impact any of the five sea turtle species of the GOM. Aside from the acute impacts noted if sea turtles encounter an oil slick, the displacement of sea turtles to less suitable habitats from habitual feeding areas impacted by oil spills may increase vulnerability to predators, disease, or mortality from anthropogenic causes. A high incidence of juvenile sea turtle foraging occurs along certain coastal regions of the Gulf Coast. The interruption of mating and nesting activities for extended periods could influence the recovery of sea turtle populations.

Given the distribution of available leases and pipelines associated with a proposed action and the distribution of sea turtles in the northern GOM, the fate of an oil spill must be considered relative to the region and period of exposure. **Chapter 3.2.1** details the persistence, spreading, and weathering process for offshore spills.

Sea turtles are vulnerable to oil and dispersants at all life stages (i.e., eggs, post-hatchlings, juveniles, sub-adults, and adults), and there is no demonstrated avoidance behavior (Shigenaka et al., 2010). Impacts to sea turtles from OCS oil- and gas-related accidental oil spills are expected to range from **negligible** to **moderate** depending on the timing, size, and location of the spill, and the use of technologies to reduce the probability of an accidental event occurring. An example of a moderate impact would be a spill contacting an individual and causing injury that may be irreversible but that does not affect the continued viability of the population of that species.

Spill-Response Activities

In addition to the impacts from contact with hydrocarbons, spill-response activities could adversely affect sea turtle habitat and cause displacement from suitable habitat. Impact-producing factors might include artificial lighting from night operations, booms, machine and human activity, increased vessel traffic (refer to the "Transportation" section under "Routine Activities" above), equipment on beaches and in intertidal areas, sand removal and cleaning, and changed beach landscape and composition. Some of the resulting impacts from cleanup could include interrupted or deterred nesting behavior, crushed nests, entanglement in booms, and increased mortality of hatchlings because of predation during the increased time required to reach the water (Lutcavage et al., 1997). Increased human presence could influence turtle behavior and/or distribution, thereby stressing animals and making them more vulnerable to predators, the toxicological effects of oil, or other anthropogenic sources of mortality. The strategy for cleanup operations vary, depending on the season, recognizing that disturbance to the nest may be more detrimental than the oil (Fritts and McGehee, 1982). After passage of the Oil Pollution Act of 1990, 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.

Little is known about the effects of dispersants on sea turtles and, in the absence of direct testing, impacts are difficult to predict. Dispersant components absorbed through the lungs or gut may affect multiple organ systems and interfere with digestion, excretion, respiration, and/or salt-gland function. Inhalation of dispersant can interfere with function through the surfactant (detergent) effect. These impacts are likely similar to the empirically demonstrated effects of oil alone (Hoff and Shigenaka, 2003). The impacts to sea turtles from chemical dispersants could include nonlethal injury (e.g., tissue irritation, chemical burns, and inhalation), long-term exposure through bioaccumulation, infection, and potential shifts in distribution from some habitats (USDOC, NOAA, 2015k; Shigenaka et al., 2010). For more information on dispersants, refer to **Chapter 3.2.8.2.2** (Offshore Response, Containment, and Cleanup Technology).

Due to spill response and cleanup efforts, much of an oil spill may be recovered before it reaches the coast. However, cleanup efforts in offshore waters may result in additional harm or mortality of sea turtles, particularly to neonates and juveniles. Spill-response activities are expected to have minimal adverse effects on sea turtles based on the short exposure duration of the activities and are more likely to have a positive effect on sea turtles over time given the removal of spilled oil, turtle and nest relocation, and contact prevention efforts. Due to the nature of the response activities, minor impacts could occur by a behavioral change of sea turtles in the immediate area. Therefore, impacts from spill-response activities are expected to be **negligible** to **minor**. There are also mitigations and plans in place (e.g., from USCG, BSEE, States, NMFS, FWS, and NPS) to decrease impacts to sea turtles during response activities, which increase surveillance and the detection of animals, thus reducing potential impacts through avoidance measures.

Marine Trash and Debris

A wide variety of trash and debris is commonly observed in the GOM. Marine debris remains a continuous threat to sea turtles (Schuyler et al., 2014). Marine trash and debris comes from a variety of land-based and ocean sources (Cottingham, 1988). Some material is accidentally lost during drilling and production operations. Turtles may become entangled in drifting debris and ingest fragments of synthetic materials (Carr, 1987b; USDOC, NOAA, 1988; Mrosovsky et al., 2009; Santos et al., 2015). Once entangled, turtles may drown, incur impairment to forage or avoid predators, sustain wounds and infections from the abrasive or cutting action of attached debris, or exhibit altered behavior that threaten their survival (Laist, 1997). 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.

The marked tendency of leatherbacks to ingest plastic has been attributed to the misidentification of the translucent films as jellyfish. Lutz (1990) concluded that turtles would 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, 1997). Weakened animals are then more susceptible to predation and disease; they are also less able to swim, breed, or nest successfully. Microplastics are becoming an increasing concern for ingestion by all species of sea turtle, and they can also decrease maximum temperatures in beach sediments, which leads to sex bias in sea turtles due to temperature-dependant sex determination of the offspring (Bergmann et al., 2015).

Witherington (1994) studied post-hatchling loggerheads in drift lines 8-35 nmi (9-15 mi; 15-24 km) east of Cape Canaveral and Sebastian Inlet, Florida. Out of 103 turtles captured, 17 percent of the animals contained plastic or other synthetic fibers in their stomachs or mouths. Without mitigation, marine debris impacts would be **negligible** to **moderate**. Operators must comply with the guidelines provided in NTL 2015-BSEE-G03, “Marine Trash and Debris Awareness and Elimination.” BOEM would expect the NTLs to become mandatory under the Protected Species Stipulation which is typically applied at the lease sale stage. The BSEE prohibits the disposal of equipment, containers, and other materials into offshore waters by lessees (30 CFR § 250.300). Therefore, expected marine trash debris impacts to sea turtles from a proposed action should be **negligible**.

4.9.2.2.3 Cumulative Impacts

This cumulative analysis considers the effects of impact-producing factors related to a proposed action along with impacts of other commercial, military, recreational, offshore, and coastal activities that may occur and adversely affect populations of sea turtles in the same general area of a proposed action.

OCS Oil- and Gas-Related Impacts

The major impact-producing factors resulting from cumulative OCS energy-related activities associated with a proposed action that may affect GOM sea turtles and their habitats include those already described under "Routine Activities" and "Accidental Events" sections above, i.e., geological and geophysical activities, transportation, discharges, marine debris, decommissioning, noise, and accidental oil spills and spill response. Chapters providing supporting material for the sea turtle analysis include **Chapters 4.1** (Air Quality), **4.2** (Water Quality), **4.3** (Coastal Habitats), **4.4** (Deepwater Habitats), **4.5** (*Sargassum* and Associated Communities), **3.1** (Offshore Impact-Producing Factors and Scenario), **3.1.4** (Transport), **3.1.6** (Decommissioning), and **5.7** (Endangered Species Act). The cumulative impact of these ongoing OCS energy-related activities on sea turtles is expected to result in a number of chronic and sporadic sublethal effects (i.e., behavioral effects and nonfatal exposure to or intake of OCS oil- and gas-related contaminants or discarded debris) because these activities may stress and/or weaken individuals of a local group or population and may predispose them to infection from natural or anthropogenic sources.

Non-OCS Oil- and Gas-Related Impacts

Non-OCS oil- and gas-related impact-producing factors that may affect sea turtle populations include: accidental oil spills and response (State oil and gas), vessel traffic, commercial fishing (i.e., bycatch and entanglement), dredging and construction, habitat loss, historic overexploitation (that led to the initial listing of the species), marine trash and debris, military operations, natural phenomena including disasters and climate change, noise (i.e., from commercial fishing, recreational vessels, military activities, commercial shipping, tourism, construction), pathogens/disease, scientific research, and transportation and related noise (e.g., commercial shipping and research vessels). With the exception of some of the dredging activities being regulated by BOEM's Marine Minerals Program, BOEM does not regulate any of the aforementioned non-OCS oil- and gas-related activities, though some may be mitigated/regulated by other agencies. The factors that may have the largest impacts to sea turtles are outlined below.

The Gulf Coast is a well-populated and growing area, and development of previously unusable land for residential and commercial purposes is common. Increased human activity along the coast and offshore results in increased runoff and dumping. Many areas around the GOM already suffer from high contaminant levels due to river and coastal runoff and discharges. Contaminants may accumulate in species or in prey species. Sea turtles frequent coastal habitats to seek food (such as sponges, jellyfish, crabs, or seagrass) and shelter (Bjorndal, 1997). Coastal areas are also used by juvenile and adult Kemp's ridleys in Louisiana (Ogren, 1989; Shaver et al., 2013). Submerged areas of vegetation may be lost or damaged by activities (e.g., dredging) that alter salinity, turbidity, or natural tidal and sediment exchange.

Accidental oil spills and spill response by State oil and gas activities may occur with impacts similar to those described above for OCS oil- and gas-related activities. Impacts would be mainly dependent on the size and location of the spill, although State oil and gas activities are located in shallow waters closer to the coast, so there may be an increased potential for oil contacting the coastline. Naturally occurring seeps are also a source of oil that occurs in the water and potentially contacting the coast.

Numerous commercial and recreational fishing vessels use areas in the northern GOM. Tanker imports and exports of crude and petroleum products into the GOM are projected to increase. Crude oil would continue to be transported to the Gulf for refining from other areas of the United States (i.e., Alaska, California, and the Atlantic). Recreational pursuits can have an adverse effect on sea turtles through propeller and boat strike damage. Areas closer to shore where sea turtles regularly migrate, mate, nest, and forage (Shaver et al., 2013; Hart et al., 2010 and 2012) may have an elevated likelihood of vessel strikes or avoidance to aircraft, due to increased transportation in those areas.

Sea turtle bycatch in the GOM is high, specifically for the longline fishery, and can be driven by turtle density, fishing intensity or both (Lewison et al., 2014). For example, the chief areas used by Kemp's ridleys (coastal waters <59 ft [18 m] in depth) overlap with the shrimp fishery (Renaud, 1995; Shaver et al., 2013). A major source of mortality for loggerhead and Kemp's ridleys is capture and drowning in shrimp trawls (Caillouet et al., 1996; Epperly and Teas, 2002; Shaver et al., 2013; USDOC, NMFS and USDOI, FWS, 2015), which accounts for most (up to 98%) of the sea turtle bycatch in the U.S. (Finkbeiner et al., 2011). Crowder et al. (1995) reported that 70-80 percent of turtle strandings were related to interactions with this fishery. Caillouet et al. (1996) found a significant positive correlation between turtle stranding rates and shrimp fishing intensity in the northwestern GOM. The Kemp's ridley population, because of its distribution and small numbers, is at greatest risk. To reduce fishery impacts to turtles, NMFS has required the use of turtle excluder devices in southeast U.S. shrimp trawls since 1989 and has increased efforts over the years for adequate protection to decrease the number of strandings. The use of turtle excluder devices was believed to reduce hard-shelled sea turtle captures by 97 percent; however, evidence has shown that a large proportion of turtles are too big to fit through the openings (Epperly and Teas, 2002). Since implementing the required use of turtle excluder devices throughout the shrimp fishing industry, gear improvements continue to be introduced nearly annually. Turtles may be accidentally caught and killed in finfish trawls, seines, gill nets, weirs, traps, longlines, and driftnets (Witzell, 1992; Brady and Boreman, 1994; Epperly and Teas, 2002; USDOC, NMFS and USDOI, FWS, 2013a and 2013b). Florida and Texas have banned all but very small nets in State waters. Louisiana, Mississippi, and Alabama have also placed restrictions on gillnet fisheries within State waters, such that very little commercial gillnetting takes place in southeast waters. The State fishery for menhaden in the State waters of Louisiana and Texas is managed by the Gulf States Marine

Fisheries Council and is not federally regulated for sea turtle take. Fishery interactions with sea turtles remain a major source of mortality.

Dredge-and-fill activities occur in many of the coastal areas inhabited by sea turtles and can create impacts, but agencies permitting these activities must consult under the ESA and protective measures would be required to prevent adverse impacts. Operations range in scope from propeller dredging (scarring) by recreational boats to large-scale navigation dredging and fill for land reclamation. Dredging operations affect turtles through incidental take (entrainment) and habitat degradation (Michel et al., 2013b). The construction and maintenance of Federal navigation channels, as well as dredging offshore sand resource areas (i.e., borrow areas) to support coastal restoration and beach nourishment projects, have been identified as sources of sea turtle mortality. Hopper dredges can entrain and kill individuals, presumably either by catching sea turtles resting/foraging on the bottom or as the drag arm of the moving dredge overtakes a slower-moving animal. Hopper dredging has caused turtle mortality in coastal areas (Slay and Richardson, 1988). Nearly all sea turtles entrained by hopper dredges are dead or dying when found (NRC, 1990). However, there continues to be engineering of modified turtle excluding devices for hopper dredges to reduce entrainment (Henriksen et al., 2015). In addition to direct take, channelization of the inshore and nearshore areas can degrade foraging and migratory habitats via spoil dumping, degraded water quality/clarity, and altered current flow.

Construction, beach front development, beach vehicle traffic, beach erosion, nest predation, and artificial lighting are activities that disturb sea turtles or their nesting beaches (Garber, 1985; Conant et al., 2009). Vehicles and beach cleaning activities may crush nests, reducing hatching success (Coston-Clements and Hoss, 1983). Physical obstacles, such as deep tire tracks and expanded sand piles, may obstruct hatchling turtles from entering the sea or increase their stress and susceptibility to predation (Witham, 1995). Obstructions to the high watermark prevent nesting, and breakwalls are the most common and severe type of obstruction. Erosion can result in the loss of habitat, and artificial lighting affects nesting beaches. Human interference has hastened erosion in many places. Artificial lighting from buildings, street lights, and beachfront properties may disorient hatchlings, as well as adults (Witherington and Martin, 1996). Females tend to avoid areas where beachfront lighting is most intense; turtles also abort nesting attempts more often in lighted areas. Hatchlings are attracted to lights and may become disoriented, increasing their vulnerability to terrestrial predators. As part of NRDA's early restoration efforts, there is a project focused on restoring the night sky or identifying and reducing artificial lighting on shorelines. Details on the project can be found on NOAA's Habitat Conservation website (USDOC, NOAA, 2016b). Condominiums sometimes block sunlight on nesting beaches, which could presumably affect sex ratios of hatchlings (the sex of a turtle is dependent on egg temperature) by increasing the number of males produced (Mrosovsky et al., 1995). Increased human activities, such as organized turtle watches, on nesting beaches may adversely affect nesting activity (Fangman and Rittmaster, 1994; Johnson et al., 1996). Species that prey on sea turtle nests include fire ants, raccoons, armadillos, and opossums. Sea turtles entering coastal or inshore areas have been affected by entrainment in the cooling water systems of electrical generating plants (NRC, 1990). Deaths can result from injuries sustained in transit through the intake pipe, from drowning in capture nets, and perhaps from other causes before entrainment (Bressette et al., 1998). Thermal effluents from power plants may cause hatchlings to become disoriented and reduce their swimming speed (O'Hara, 1980). These effluents may also degrade important foraging seagrass and reef habitats (Coston-Clements and Hoss, 1983). It has been suggested that power plants could also provide positive impacts by providing warm-water refuge in some areas (McDonald et al., 1994; Turner-Tomaszewicz and Seminoff, 2012).

Sand mining, beach nourishment, and oil-spill cleanup operations may remove sand from the littoral zone and temporarily disturb onshore sand transport, potentially disturbing nesting activities. BOEM has evaluated the use of sand resources for levee, beach, and barrier island restoration projects. For more than 20 years, BOEM has provided over 113 million yd^3 (85 million m^3) of OCS sand for 40 coastal projects, restoring over 279 mi (433 km) of national coastline. As the demand for sand for shoreline protection and restoration increases, OCS sand and gravel has become an increasingly important resource. Use of these resources would require coordination with BOEM for appropriate authorization. Sea turtles are included in the potential impacts identified for sand dredging projects. Mitigating measures include requiring stipulations to protect sea turtles when it is determined that there is a likelihood of sea turtle presence within the area during the dredging operation, and a trailing suction hopper dredge is used. As part of NRDA's early restoration efforts, there are at least three artificial reef projects totaling $7.7 million in the GOM that would provide more shelter and feeding habitat for turtles. Details on these projects can be found on NOAA's website (USDOC, NOAA, 2016c).

Explosive discharges, such as those used for COE structure removals or coastal construction, can cause injury to sea turtles (Duronslet et al., 1986), but they are subject to ESA consultation with NMFS. Although sea turtles far from the site may suffer only disorientation, those near detonation sites could sustain fatal injuries. Injury to the lungs, intestines, and/or auditory system could occur. Other potential impacts include physical or acoustic harassment. Resuspension of bottom sediments, increased water turbidity, and mobilization of bottom sediments due to explosive detonation are considered to be temporary effects.

Historically, sea turtles were overexploited by the poaching of eggs and individuals, and with the added pressures of other historic non-OCS oil- and gas-related impact-producing factors described in this section (e.g., commercial fishing), NMFS determined there was a need to list them under the ESA. Human consumption of turtle eggs, meat, or byproducts still occurs worldwide and depletes turtle populations (Conant et al., 2009; USDOC, NMFS and USDOI, FWS, 2007b and 2013b). Commercial harvests are no longer permitted within continental U.S. waters, and Mexico has banned such activity (Aridjis, 1990).

Chronic pollution, including industrial and agricultural wastes and urban runoff, threatens sea turtles worldwide (Frazier, 1980; Hutchinson and Simmonds, 1991). Some turtle species have lifespans exceeding 50 years (Congdon, 1989; Frazer et al., 1989) and are secondary or tertiary consumers in marine environments, creating the potential for bioaccumulation of heavy metals, pesticides, and other contaminants (Davenport et al., 1990; Lutz and Lutcavage, 1989) in their tissues. Organochlorine pollutants (pesticides) have been documented in eggs, juveniles, and adult turtles (Rybitski et al., 1995). The DDE from DDT is the pesticide present in the greatest concentrations in sea turtles (Camacho et al., 2013). Contaminants could stress the immune system of sea turtles or act as carcinogens indirectly by disrupting neuroendocrine functions (Colborn et al., 1993; Camacho et al., 2012).

Numerous sources of aircraft fly over the coastal and offshore areas and create noise that may cause behavioral responses in sea turtles as described in the "Noise" section above. The air space over the GOM is used extensively by DOD for conducting various air-to-air and air-to-surface operations. Eleven military warning areas and five water test areas are located within the GOM, as stated in NTL 2014-BOEM-G04, "Military Warning and Water Test Areas" (**Figure 2-7**). Additional activities, including vessel operations, discharges associated with military activities, and ordnance detonation, also may affect sea turtles. Subject to the Federal Aviation Administration's guidelines, private and commercial air traffic further traverse these areas and have the potential to cause impacts to sea turtles.

Natural catastrophes, including storms, floods, droughts, and hurricanes, can also substantially damage nesting beaches and coastal areas used by sea turtles (Agardy, 1990; Fish et al., 2015). Abnormally high tides and waves generated by storms may exact heavy mortality on sea turtle nests by washing them from the beach, inundating them with sea water, or altering the depth of sand covering them. Furthermore, excessive rainfall associated with tropical storms may reduce the viability of eggs. Turtles could be harmed in rough seas by floating debris (Milton et al., 1994). In addition, the hurricane season for the Caribbean and Western Atlantic (June 1 through November 1) overlaps the sea turtle nesting season (March through November) (NRC, 1990). Nests are vulnerable to hurricanes during the incubation period as well as when hatchlings evacuate the nest. Hurricanes can cause mortality at turtle nests through immediate drowning from ocean surges, nest burial, or exhumation before hatching, and after hatching as a result of radically altered beach topography. Natural phenomena could result in numerous impacts to sea turtles as well. Rising sea levels could further diminish available nesting beach habitat. Changing ocean temperatures may alter distribution patterns for sea turtle prey (i.e., jellyfish for leatherbacks). This could impact adult survivability as well as nesting success. Warming temperatures may change the sex ratios of hatchlings as sex is determined by nest temperature. Larger, more frequent storms can physically impact nesting beaches (Intergovernmental Panel on Climate Change, 2016).

Noise from non-OCS oil- and gas-related activities may impact sea turtles and is described in **Chapter 3.3.2.7**. Areas closer to shore normally have higher noise levels (more human-use), and levels typically drop off moving into deeper water. Non-OCS noise sources include, but are not limited to, commercial fishing vessels, recreational vessels, scientific vessels, tourism vessels and watercraft, military operations, lightning, aircraft, State oil and gas activities, etc. Sea turtles have a high potential for recoverable injury from temporary hearing loss (i.e., temporary threshold shift) and behavioral modifications only when they are close in proximity to the source. Mortality and injury caused by shipping and continuous noise are expected to have low levels of relative risk even if a sea turtle is relatively near the source. The risk for temporary threshold shift near the source is moderate, while the risk for masking may be high both at near and intermediate distances from the source, and the risk for behavioral modifications near the source are high and moderate at intermediate distances from the source. Effects from sound are relative to the source type, distance to the source, frequency, intensity and duration of the source, and distance to the animal.

Sea turtles are affected by pathogens and disease, which may be secondary infections following other stressors, such as an entanglement injury or nutritional deficiencies. Some of these diseases are described in the affected environment and include fibropapillomatosis (believed to be caused by a herpes virus); viral, bacterial, and mycotic (fungal) infections; parasites (internal or external); and other environmental health problems (e.g., hypothermic stunning). Van Houtan et al. (2014) found fibropapillomatosis could be linked, at least in part, to eutrophication.

Scientific research may impact sea turtles. Many studies require the attachment of equipment to turtle shells that could reduce fitness, and often turtles must be caught and/or held captive for a period of time before being released back into their natural environment. This could cause stress to a turtle; however, research is typically seen as an overall positive impact due to learning more about life histories of turtles and, therefore, allowing for improved species management.

Due to the overall non-OCS oil- and gas-related activities affecting habitat, prey, and general health of sea turtles, the impacts could be **negligible** to **major**; however, the ESA process, including 5-year status reviews, general consultations with FWS and NMFS, and implementation of conservation measures, would protect sea turtle populations.

The incremental contribution to cumulative impacts on sea turtles as a result of a proposed action, even when taking into consideration the potential impacts of the *Deepwater Horizon* explosion, oil spill, and response, non-OCS oil- and gas-related factors and the minimization of OCS oil- and gas-related impacts through lease stipulations and regulations, would be expected to be **negligible**.

4.9.2.2.4 Incomplete or Unavailable Information

Unavailable information provides challenges in understanding the baseline conditions and changes within sea turtle populations. The impacts associated with the *Deepwater Horizon* explosion, oil spill, and response makes an understanding of the cumulative impacts less defined but overall changes the baseline as in less numbers of individual species. Not all of the information collected during the NRDA process and used as a basis for their determinations is publicly available. BOEM used existing information and reasonably accepted scientific methodologies to extrapolate from publicly available information on sea turtles in completing the relevant analysis of sea turtle populations. There are existing leases in the GOM with ongoing or the potential for exploration, drilling, and production activities. In addition, non-OCS oil- and gas-related activities would continue to occur in the GOM irrespective of a proposed action (e.g., fishing, military activities, and scientific research). Also, little is known about the early life history of leatherbacks regarding the “lost years”

(Carr, 1986). BOEM used available research and presented what is known in **Chapter 4.9.2.1**. Therefore, BOEM concludes that the unavailable information from these events may be relevant to foreseeable significant adverse impacts to sea turtles because the full extent of impacts on sea turtles is not known, but BOEM has determined that the information is not essential to a reasoned choice among alternatives for this Multisale EIS (including the No Action and Action Alternatives).

4.9.2.2.5 Alternatives A, B, C, and D

With respect to sea turtles, the effects associated with selection of any of the action alternatives would be equivalent because of the diversity and distribution of sea turtles throughout the potential Area of Interest. The preceding analyses assumed a wide distribution of species and considered impacts to sea turtles occurring in a wide range of habitats across all planning areas. While a proposed WPA lease sale (Alternative C) would be in a smaller area with much less projected activity than a proposed regionwide (Alternative A) or proposed CPA/EPA lease sale (Alternative B) as described in **Chapter 3**, sea turtles are distributed throughout the planning areas. As such, activities isolated to specific planning areas pose similar potential impacts to populations as do activities occurring in all planning areas. Therefore, a similar mix of species would be exposed to the analyzed impact-producing factors, regardless of the specific action alternative selected. The activities proposed under Alternatives A, B, C, and D would directly impact sea turtles within the GOM and would contribute incrementally to the cumulative effects on these species.

Sea turtles of all five species are present throughout the northern GOM; however, only Kemp's ridley and loggerheads nest on beaches in the GOM. Individual animals make migrations into nearshore waters as well as other areas of the Gulf of Mexico, Atlantic Ocean, and Caribbean Sea. Historically, intense harvesting of eggs, loss of suitable nesting beaches, and fishery-related mortality led to rapid declines of sea turtle populations.

Anthropogenic impacts, as discussed in the cumulative impact chapter above, continue to pose the greatest threat to sea turtles. Sea turtle critical habitat and nesting sea turtles are threatened with climate change, natural disasters, beach erosion, armoring, nourishment, artificial lighting, beach driving and cleaning, increased human presence, human response to disasters, coastal development, recreational beach use including equipment and furniture, exotic dune and beach vegetation, natural habitat obstructions, military testing and training activities, poaching, and nest predation.

Although there would always be some level of incomplete information relevant to the impacts from activities under a proposed action on GOM sea turtles, BOEM does not believe it is essential to a reasoned choice among alternatives. To date, there is no peer-reviewed scientific information available supporting that any impacts expected from a proposed action would be expected to rise to the level of reasonably foreseeable population-level impacts. BOEM acknowledges that impacts from routine activities or accidental events could be greater on individuals or populations already affected by other OCS oil- and gas-related or non-OCS oil- and gas-related impact-producing factors. Nevertheless, routine activities are ongoing in a proposed action area as a result of active leases and related activities. Further, activities that could result in an accidental spill in the GOM would be ongoing whether or not a proposed action occurred.

In order to minimize potential interactions and impacts to sea turtles, operators are required to follow all applicable lease stipulations and regulations, as clarified by NTLs. The operator's compliance with NTL 2016-BOEM-G01 ("Vessel-Strike Avoidance and Injured/Dead Protected Species Reporting") and NTL 2015-BSEE-G03 ("Marine Trash and Debris Awareness Elimination") and the transient nature of sea turtles, as well as the limited scope, timing, and geographic location of a proposed action, would result in a minimized impact from a proposed action on sea turtles. In addition, NTL 2016-BOEM-G02, "Implementation of Seismic Survey Mitigation Measures and Protected Species Observer Program," minimizes the potential of harm from seismic operations to sea turtles and marine mammals; these mitigations include onboard observers, airgun shut-downs for whales in the exclusion zone, ramp-up procedures, and the use of a minimum sound source.

Because of the mitigations (e.g., BOEM and BSEE's proposed compliance with NTLs) described above, routine activities and accidental events related to a proposed action are not expected to have long-term adverse effects on the size and productivity of any sea turtle species or populations in the northern GOM. Lethal impacts could occur from chance collisions with OCS service vessels or ingestion of accidentally released plastic materials from OCS vessels and facilities, which would be considered **moderate** impacts.

While the impact-producing factors associated with a proposed action could potentially impact sea turtles if unmitigated, the incremental contribution to cumulative impacts on sea turtles, even when taking into consideration the potential impacts of the *Deepwater Horizon* explosion, oil spill, and response, non-OCS oil- and gas-related factors and the minimization of OCS oil- and gas-related impacts through lease stipulations and regulations, would be expected to be **negligible** as a result of a proposed action. Within the GOM, there is a long-standing and well-developed OCS Program (more than 50 years), and population-level impacts to sea turtles are not anticipated.

4.9.2.2.6 Alternative E—No Action

Under Alternative E, there would be no lease sale held and therefore no postlease activities related to such a lease sale to impact sea turtles. However, there would be continuing impacts to sea turtles related to previous OCS oil- and gas-related development and non-OCS oil- and gas-related activities. Sea turtles move in the GOM over great spatial scales and they would be expected to move in and out of the previously leased blocks. In addition, many of these blocks already have existing OCS oil- and gas-related development, and sea turtles would continue to be impacted by routine activities and accidental events from this pre-existing OCS development.

4.9.3 Beach Mice (Alabama, Choctawhatchee, Perdido Key, and St. Andrew)

The following four subspecies of beach mouse (*Peromyscus polionotus*) occupy restricted habitats in the mature coastal dunes of Florida and Alabama and are federally listed as endangered: Alabama (*P.p. ammobates*), Perdido Key (*P.p. trisyllepsis*), and Choctawhatchee (*P.p. allophrys*) (listed June 6, 1985) (*Federal Register*, 2006b) and St. Andrew (*P.p. peninsularis*) (listed December 18, 1998) (*Federal Register*, 1998). Current critical habitat is included in the critical habitat map (**Figure 4-25**). Populations of the listed subspecies have fallen to levels approaching extinction. These four subspecies of beach mice are similar in appearance but can be identified by pelage color and location (Bowen, 1968). The approach of this analysis is to focus on the potential impact-producing factors from OCS oil- and gas-related routine activities (i.e., exploration, development, and production), as well as accidental events and cumulative impacts, and to define impact-level measures for each impact-producing factor (refer to **Table 4-18** in **Chapter 4.9**).

4.9.3.1 Description of the Affected Environment

Beach mice are restricted to the coastal barrier sand dunes along coastal Alabama and the Florida panhandle, and are nocturnal herbivores that forage on sea oats and beachgrass, occasionally consuming invertebrates (Ehrhart, 1978; Moyers, 1996). For a detailed description of dunes, refer to **Chapter 4.3.2.1** (Coastal Barrier Beaches and Associated Dunes, "Description of the Affected Environment"). Optimal overall beach mouse habitat is currently thought to be comprised of a heterogeneous mix of interconnected habitats including frontal dunes, scrub (tertiary) dunes farther inland, and interdunal areas between these dune habitats. Beach mice dig burrows mainly in the frontal dunes and interior scrub dunes where the vegetation provides suitable cover for avoiding predators, storing food, and providing cover during the day and during inclement weather conditions.

Critical habitat for the four subspecies of beach mouse extend from Baldwin County, Alabama, to Gulf County, Florida. The beach and dunal areas that are associated with beach mouse habitat include the coastal regions associated with the CPA and EPA. Complete descriptions of current critical habitat can be found in USDOI, FWS (2010a) and **Figure 4-25**. Due to the dynamic nature of mouse populations that fluctuate with environmental conditions, abundance estimates are unreliable. Trends in populations are determined using percent area occupied, with ongoing monitoring efforts for each of the beach mouse subspecies.

4.9.3.2 Environmental Consequences

This chapter provides detailed information regarding the impact-producing factors from routine activities, accidental events, and cumulative impacts from the activities described in **Chapter 3** that are associated with non-OCS and OCS oil- and gas-relate activities. This analysis applies to all considered alternatives. Because of the diversity and distribution of species in the Area of Interest, the level of impacts would be the same generally for Alternatives A, B, and D. Alternative C would have no impacts since no beach mice habitat is near the WPA proposed lease sale area. However, Alternative E, No Action, would only have impacts associated with ongoing activities from past lease sales and non-OCS oil- and gas-related activities. Following the environmental consequences chapter, there is a summary of the potential impacts as they relate to the action alternatives.

4.9.3.2.1 Routine Activities

There are no impact-producing factor associated with routine activities that may affect beach mice or their critical habiat. All routine activity is expected to be far enough from beach mouse habitat that no impacts are expected to occur.

4.9.3.2.2 Accidental Events

The major impact-producing factors resulting from accidental events reasonably expected to be associated with the OCS oil- and gas-related activities that may affect beach mice include coastal and offshore oil spills, spill-response activities, and marine trash and debris (**Chapter 3.2.7**) that would reach their habitat.

Oil spills may directly impact beach mice since direct contact with spilled oil can cause skin irritation and/or cause the fur to mat, resulting in the loss of its insulative properties for thermoregulation. Other direct toxic impacts may result from oil ingestion, absorption, or respiratory effects from the inhalation of fumes. Indirect impacts may include contamination and depletion of food supply, destruction of habitat, and fouling of burrows. There is no definitive information on the persistence of oil in the event that a spill was to contact beach mouse habitat. In Prince William Sound, Alaska, after the *Exxon Valdez* spill in 1989, buried oil has been measured in the intertidal zone of beaches, but no effort has been made to search for residual buried oil above high tide. Similarly, NRC (2003) makes no mention of studies of oil left above high tide after a spill. Regardless of the potential for persistence of oil in beach mouse habitat, a slick cannot wash over the foredunes unless carried by a heavy storm swell. The oiling of beach mouse populations could result in local extinction, but this is unlikely given that the chance of a spill occurring and contacting the habitat is between <0.5 and 1 percent after 10 or 30 days of a spill, and the area of viable habitat is broad relative to the area potentially contacted by a large spill according to the OSRA model (refer to **Chapter 3.2.1.4**). A reasonably foreseeable noncatastrophic oil spill is not likely to occur near beach mouse habitat; therefore, it would have **negligible** impacts to beach mice.

Impacts can also occur from spill-response activities. Vehicle traffic and other activities associated with oil-spill cleanup can degrade preferred habitat and crush burrows, resulting in displacement of mice from these areas. These impacts could be reduced if personnel are properly trained to identify and avoid sensitive habitat (which may be on short notice if under emergency conditions). Impacts from an accidental oil spill and cleanup efforts would be **negligible** because a reasonably foreseeable noncatastrophic oil spill is not likely to occur near beach mouse habitat. For more information on habitat impacts from accidental events, refer to **Chapter 4.3.2.3** (Coastal Barrier Beaches and Associated Dunes).

Impacts to beach mice may occur directly to the animal or its habitat. Marine trash and debris could affect beach mice due to the potential to ingest and/or become entangled. The BSEE has taken measures to reduce marine debris issue by imposing marine debris awareness and prevention measures on the oil and gas industry through NTL 2015-BSEE-G03, which provides guidance to industry operators to reduce trash and debris elimination into the marine environment and informs operators of regulations set by other regulatory agencies (i.e., USEPA and USCG). This mitigation is a binding part of leases through the Protected Species Stipulation. The OCS oil- and gas-related proposed activities may contribute minimal marine debris or disruption to beach mouse areas, but the impacts would be **negligible**. Due to the proximity of the beach mouse habitat to any OCS oil- and gas-related activity, any accidental loss of debris as a result of OCS oil- and gas-related activities would be minimal.

4.9.3.2.3 Cumulative Impacts

This cumulative analysis considers factors that affect beach mice, including oil spills, alteration and reduction of habitat, predation (especially from feral or free-roaming domestic cats) and competition, ingestion and entanglement of beach trash and debris, beach development, coastal spills, and natural catastrophes (i.e., hurricanes and tropical storms).

OCS Oil- and Gas-Related Activities

Oil spills that are related to the importing and transporting of oil resulting from prior and future lease sales are not expected to contact beach mice or their habitats because the species lives above the intertidal zone where contact is less likely. For more information on impacts to the dune habitat, refer to **Chapter 4.3.2** (Coastal Barrier Beaches and Associated Dunes). Therefore, the expected incremental contribution of OCS oil- and gas-related activities to the cumulative impacts is **negligible**, given the proximity of beach mouse habitat and the relatively small likelihood that a reasonably foreseeable spill would reach their habitat.

Non-OCS Oil- and Gas-Related Activities

The greatest impacts to beach mice are based on impacts to their habitat. Non-OCS oil- and gas-related activities may also incur negative impacts to the habitat or directly by interactions with other species. Cumulative impacts from coastal development, State oil and gas activities, predation, recreational beach use, trash and debris, disease, hurricanes, and the effects of sea-level rise may affect the protected subspecies of beach mice. For a full list of cumulative impacts to beach habitat, refer to **Chapter 4.3.2** (Coastal Barrier Beaches and Associated Dunes).

Habitat Alteration and Reduction

Coastal development is the greatest threat to beach mouse survival. Habitat reduction and fragmentation have affected the ability of beach mice to quickly recover following tropical storms. Habitat fragmentation also reduces genetic diversity by limiting gene flow within contiguous habitat. Critical habitat provides an area of protected refugia for these subspecies of beach mouse and is important to sustain each population.

Predation and Competition

Non-native predators such as red fox and domestic cats pose a threat to beach mice. Feral cats may pose one of the greatest threats to beach mice (Bowen, 1968; Humphrey and Barbour, 1981; Moyers, 1996). Gore and Schaeffer (1993) showed a significant correlation between the presence of cat tracks and beach mouse tracks on Santa Rosa Island. Predation by cats in conjunction with other threats may result in significant adverse impacts to beach mice (*Federal Register*, 1998). The recovery plans for these four subspecies of beach mice include a component of managing feral and free-ranging cats near beach mouse habitat by educating the public and control measures to eliminate feral cat populations near dune habitats. Predation and competition are serious concerns for beach mice regarding impacts to populations.

Hurricanes

Population viability analysis is essentially a demographic modeling exercise to predict the likelihood that a population would continue to persist over time (Groom and Pascual, 1998). The objective of a population viability analysis for beach mice is to determine how large and what configuration of habitat is necessary to reasonably assure that the species would survive to recover. The most recently revised model, which includes data from hurricanes, projects a risk of extinction of 26.8 ± 1.0 percent over the next 100 years. Falcy (2011) used modeling to show recovery of Alabama beach mouse populations during the 4 years after Hurricane Ivan (2004) and Hurricane Katrina (2005). Further modeling showed that increasing the rate of population growth in a refuge, like interior dunes after a hurricane, would have a much larger impact on population persistence than increasing the rate of recovery of damaged habitat, like foredunes after a hurricane. Yuro (2011) studied Hurricanes Ivan and Katrina and showed that the Alabama beach mouse has the ability to survive hurricanes if they are not successive. Therefore, the expected cumulative impacts of strong hurricanes is negligible.

When considering the cumulative impacts from both OCS oil- and gas-related and non-OCS oil- and gas-related sources, the impacts to beach mice would be **negligible** to **major**; however, the incremental contribution of a proposed action would be **negligible**.

4.9.3.2.4 Incomplete or Unavailable Information

BOEM has determined that there is no incomplete or unavailable information regarding the listed beach mice relevant to the potential impacts from a proposed action or alternatives, and no such information was essential to a reasoned choice among alternatives. BOEM used existing information and reasonably accepted scientific methodologies to extrapolate from available information on beach mice in completing the relevant analysis of impacts.

4.9.3.2.5 Alternative A—Regionwide OCS Proposed Lease Sale (The Preferred Alternative)

An impact from the OCS oil- and gas-related routine activities associated with a proposed action (i.e., proposed regionwide lease sale) on the Alabama, Choctawhatchee, St. Andrew, and Perdido Key beach mice is possible but unlikely.

The oiling of beach mouse populations caused by one or more of the reasonably foreseeable accidental events as a result of a proposed action could result in local extinctions. Oil-spill response and cleanup activities could also have a substantial impact to beach mice and their habitat if all cleanup personnel are not adequately trained to avoid areas where beach mouse burrows are present. However, potential spills that could result from OCS oil- and gas-related activities are not expected to contact beach mice or their habitats. Impacts may result from ingestion or entanglement in beach trash and debris that could be accidentally lost, despite mitigations typically applied through the lease and NTLs. Because OCS oil- and gas-related routine activities would deposit only a small portion of the total debris that would reach the habitat, the impacts related to a proposed lease sale under Alternative A would be **negligible**. A review of the available information shows that reasonably foreseeable impacts on beach mice from accidental impacts associated with OCS oil- and gas-related activities would be **negligible**.

Cumulative activities have the potential to harm or reduce the numbers of the four listed subspecies of beach mouse. Those activities include oil spills, alteration and loss of habitat, predation and competition, ingestion and entanglement in beach trash and debris, and natural catastrophes (hurricanes and tropical storms). Most spills that may occur as a result of the proposed activities are not expected to contact beach mice or their habitats because they use areas above the intertidal zone where contact is less likely. Within the last 30-40 years, the combination of habitat loss due to beachfront development, the isolation of remaining beach mouse habitat areas and populations, and the destruction of remaining habitat by tropical storms and hurricanes have increased the threat of extinction of several subspecies of beach mice. Given these other cumulative factors and their relative impacts on the beach mouse and their habitat, the expected incremental contribution of OCS oil- and gas-related activities from a proposed lease sale under Alternative A to the cumulative impacts is **negligible**.

4.9.3.2.6 Alternative B—Regionwide OCS Proposed Lease Sale Excluding Available Unleased Blocks in the WPA Portion of the Proposed Lease Sale Area

The impacts of this alternative would be the same as those identified in Alternative A, as portions of the proposed lease sale area under both alternatives (i.e., the CPA/EPA) are near beach mouse habitat. Reasonably foreseeable impacts are expected to be **negligible** for the reasons provided under Alternative A. The beach mouse subspecies included in the analysis are distributed across coastal Alabama and the Florida panhandle, and are adjacent to the EPA and CPA.

4.9.3.2.7 Alternative C—Regionwide OCS Proposed Lease Sale Excluding Available Unleased Blocks in the CPA/EPA Portions of the Proposed Lease Sale Area

The impacts of Alternative C would yield **negligible** impacts to beach mice as a result of any new leases in the WPA and related Gulfwide postlease activities since the subspecies distributions are limited to coastal Alabama and the Florida panhandle as described in Alternative A.

4.9.3.2.8 Alternative D—Alternative A, B, or C, with the Option to Exclude Available Unleased Blocks Subject to the Topographic Features, Live Bottom (Pinnacle Trend), and/or Blocks South of Baldwin County, Alabama, Stipulations

The impacts of this alternative would be the same as those identified in either Alternative A, B, or C because the Topographic Features, Live Bottom (Pinnacle Trend), and Blocks South of Baldwin County, Alabama, Stipulations do not directly affect the beach mouse or its habitat and because of the small number of blocks subject to these stipulations and their distance from beach mice habitat. Reasonably foreseeable impacts would be **negligible**.

4.9.3.2.9 Alternative E—No Action

If a proposed lease sale does not occur, then there would be no additional impacts to beach mice as there would be no lease sale held, thus leading to no new impacts from OCS oil- and gas-related activities resulting from a lease sale. There would be no incremental contribution to cumulative impacts on the species or habitat; however, other past lease sales, postlease activities related to previous lease sales, or other authorized OCS oil- and gas-related activities may continue and have an incremental increase on the impacts on these subspecies of beach mouse. The cumulative impacts from both OCS oil- and gas-related and non-OCS oil- and gas-related sources would remain the same.

4.9.4 Protected Birds

The analyses of the potential impacts of routine activities and accidental events associated with a GOM proposed action and a proposed action's incremental contribution to the cumulative impacts to ESA-listed birds are presented in this chapter. The approach of the analysis is to focus on the potential impact-producing factors from OCS oil- and gas-related routine activities (i.e., exploration, development, and production), as well as accidental events and cumulative impacts, and to define impact-level measures for each impact-producing factor (refer to **Table 4-18** in **Chapter 4.9**).

4.9.4.1 Description of the Affected Environment

The protected birds analyzed in this Multisale EIS include those species that use the OCS or coastal counties/parishes along the Gulf of Mexico during any part of their lifecycle and are listed under the Endangered Species Act as threatened or endangered. Other species that met these criteria were excluded if their habitats were more upland or away from the coast (**Appendix F**). All of the following protected bird species are also protected under the Migratory Bird Treaty Act. The impact-producing factors that could affect protected birds are outlined in **Table 4-18** in **Chapter 4.9**. A review of a description of associated impact-producing factors for these species is discussed in detail and can be referenced from **Chapter 4.8** (Birds). However, similar impact-producing factors that may affect protected species may have greater impacts to protected species and their associated critical habitat due to their small population size and ESA-listing status. Those impacts are considered in the following analysis.

The habitats of the protected bird species described in this Multisale EIS vary from upland habitat, freshwater wetlands, estuarine, coastal beaches, and tidal flats to offshore migration and foraging; impacts to the physical aspects of the coastal habitats are identified in **Chapter 4.3** (Coastal Habitats). Critical habitat status is presented at the beginning of each species description below and geographically in **Figure 4-25**.

Collectively, the bird species included in this analysis are distributed across the GOM region from southern Florida to eastern Texas as year-round residents or migratory with a strong seasonal component. Many of the migratory bird species are less abundant along the GOM during the season when they are on their breeding grounds and have higher densities and/or wider distributions during migration and non-breeding season.

Cape Sable Seaside Sparrow

Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*) is a small, resident species that was originally federally listed as endangered on March 11, 1967. A South Florida Multi-Species Recovery Plan was completed on May 18, 1999. A Five-Year Status Review was completed on August 18, 2010, indicating continued declines and no change to its status. A final rule for critical habitat designations was issued in 2007 (*Federal Register*, 2007). The average estimated population size for all six subpopulations from 2005 to 2009 was 3,021 individuals (USDOI, FWS 2010b). In 2014, a range-wide survey indicated that the population had declined to 2,720 individuals (Beerens et al., 2016).

It is associated with marl prairie and ephemeral wetlands, and is distributed in six small isolated populations in southern Florida, including Collier, Miami-Dade, and Monroe Counties along the Gulf Coast within Everglades National Park and Big Cypress National Preserve. These populations are located in areas where OCS oil- and gas-related activities would rarely occur, if at all. Habitat loss and fragmentation through hydrologic alteration from wetland drainage, tilling, diking, controlled burns, agriculture activities, and commercial and private development in its preferred habitat are likely the primary causes for its original listing. The species appears to have highly variable nest success and survival (Boulton et al., 2009), which is problematic for a species with such low population numbers. Overall, this population appears to be limited by available nesting habitat and the “normal” onset of summer rains that result in decreased productivity later in the nesting season (Nott et al., 1998; Elderd and Nott, 2008) rather than restricted dispersal due to fragmented habitat (Van Houtan et al., 2010).

Piping Plover

Two populations of piping plover (*Charadrius melodus*) winter along the Gulf Coast and are recognized under the ESA: the Great Lakes (endangered) and the Great Plains (threatened) populations (*Federal Register*, 1985). The Great Plains population breeds primarily along the Missouri River system and its tributaries, as well as alkali wetlands and lakes in the Dakotas, Montana, and in prairie Canada; this population winters primarily along the GOM (Haig et al., 2005; Roche et al., 2010). The Great Lakes population breeds primarily along the shores and cobble beaches and associated islands with similar substrate in the Great Lake States and Canadian provinces (Stucker et al., 2010); the population winters primarily along the south Atlantic Coast with the greatest densities between St. Catherine's Island, Georgia, and Jacksonville, Florida, but it can be found as far west as the Laguna Madre, Texas (Stucker and Cuthbert, 2006; Gratto-Trevor et al., 2009). As much as 75 percent of all breeding piping plovers may winter along the GOM, spending up to 8 months on the wintering grounds (February-October).

The latest Five-Year Review was published on September 29, 2009, with recommendations that their statuses remain unchanged. Habitat loss and degradation due to commercial, residential, and recreational developments on both breeding and wintering areas is the likely cause for declines. The piping plover is considered a State Species of Conservation Concern in all Gulf Coast States. The piping plover population estimates indicate declines for at least two of three populations at their breeding grounds (Great Lakes and Atlantic) (Haig et al., 2005; Roche et al., 2010).

In order to protect migratory birds, it is important to consider all seasonal habitats in the area of potential impacts that are used during the life cycle of the species. The habitats used by wintering birds along the GOM include beaches, mud flats, sand flats, algal flats, and washover passes (areas where breaks in the sand dunes result in an inlet). Wintering plovers are dependent on a mosaic of habitat patches and move among these patches depending on local weather and tidal conditions. It has been hypothesized that, because of habitat attributes (i.e., foraging and roosting opportunities), specific wintering habitat may attract the largest concentrations of piping plovers because of a preferred prey base and/or because the substrate color provides protection from aerial predators due to cryptic and camouflage color (Nicholls and Baldassarre, 1990).

Rufa Red Knot

The rufa red knot (*Calidris canutus rufa*) subspecies is a small, migratory shorebird listed as threatened in January 2015 (*Federal Register*, 2014d). There is currently no established critical habitat or recovery plan for rufa red knot.

Three of the six subspecies of red knot occur in North America, all three of which breed in the Arctic; the rufa subspecies occurs along the coast of the Gulf of Mexico. The rufa red knot is a long distance migrant that traverses the North and South America continents via the Atlantic Coast or a mid-continental route, roughly 9,300 mi (15,000 km). During spring and fall migration, it uses coastal beaches, bays, tidal flats, salt marshes, and lagoons primarily along the Atlantic and Gulf Coasts, which may serve as the final wintering destination for some birds.

Habitats used by red knots in migration and wintering are similar in character. For wintering, they generally use coastal marine and estuarine habitats with large areas of exposed intertidal sediments. In North America, red knots are commonly found along sandy, gravel, or cobble beaches, tidal mudflats, salt marshes, shallow coastal impoundments and lagoons, and peat banks. The supra-tidal (above the high tide) sandy habitats of inlets provide important areas for roosting, especially at higher tides when intertidal habitats are inundated. In wintering and migration habitats, red knots commonly forage on bivalves, gastropods, and crustaceans.

Within the GOM region, wintering birds are found primarily in Florida and Texas, but the species has also been observed in Louisiana, Alabama, and Florida. The red knot uses salt marsh, brackish lagoons, tidal mudflats, mangrove areas, and beach habitats. In Lee County, on Florida's Gulf Coast, during fall migration, the red knot used intertidal substrates on ocean beaches at inlets. Along the Texas coast, red knots forage on beaches, oyster reefs, and exposed bay bottoms, and they roost on high sandflats, reefs, and other sites protected from high tides.

Based on the best available information, there is currently no precise population estimate for this subspecies; however, since 2000, declines of 70-75 percent have been recorded in Tierra del Fuego for the wintering birds and in Delaware Bay during the spring migration. Harvesting of horseshoe crabs in Delaware Bay has reduced their availability as a major food source near Delaware Bay, resulting in negative effects to the population. This is an important source of nutrition for the migrating birds that stop to refuel during their transition between wintering and breeding grounds. Declines have also been observed in the population that departs the central Canadian Arctic in August.

Roseate Tern

The North American subspecies of roseate tern (*Sterna dougallii dougallii*) is separated into two distinct population segments according to the location of the breeding areas: the Northeastern population (along the Atlantic Coast from Nova Scotia to North Carolina and Bermuda) fluctuating around 3,500 breeding pairs, which is listed as endangered; and the Southeast U.S./Caribbean population (including Florida, Puerto Rico, and the Virgin Islands) with between 4,000 and 5,000 breeding pairs, which is listed as threatened (Gochfeld et al., 1998). Both populations were listed on November 11, 1987, due to habitat loss as well as increased competition and predation (*Federal Register*; 1987). Recovery plans for the Northeast and Caribbean populations were completed on September 24, 1993, and November 5, 1998, respectively.

The Northeastern population breeds in the northeastern United States and eastern Canada (Kirkham and Nettleship, 1987) with migratory routes over the open ocean to the West Indies and South America. Migratory information for the Caribbean population is less understood, but information for the Florida breeders indicates peak arrival in mid-April to mid-May and peak departure in mid-August to mid-September. By the 1990's, there were two remaining nesting sites in Florida: Pelican Shoal and the rooftop of the Marathon Government Building in Monroe County, Florida (Zambrano et al., 2000). These sites are in the Florida Keys and far from potential interactions from proposed OCS oil- and gas-related activities. In Florida, approximately 350 breeding pairs are estimated, with 15-225 pairs in the Dry Tortugas (USDOI, FWS, 2010c). Terns are seabirds that forage by plunge diving for small fish in coastal and pelagic waters. The roseate tern is considered a State Species of Conservation Concern in Florida and is protected by the Migratory Bird Treaty Act.

Mississippi Sandhill Crane

The population of Mississippi sandhill crane (*Grus canadensis pulla*) has a nonmigratory, resident population with an extremely limited distribution (Jackson County, Mississippi). This subspecies was listed as endangered on June 4, 1973 (*Federal Register*, 1973b), due to a small population size, restricted distribution, habitat loss, and habitat fragmentation (consisting of wet pine savanna). This species is presently reproductively isolated and persists primarily due to augmentation from a captive-breeding program. In February 2016, there were 129 cranes in the wild population; annual reports are provided for updates on FWS' website (USDOI, FWS, 2016). At present, much of its habitat is protected in the Mississippi Sandhill Crane National Wildlife Refuge. Three separate critical habitat designations were completed in the 1970's (*Federal Register*, 1975, 1977a, and 1977b). The I-10 corridor jeopardized the existence of this population, but a settlement agreement resulted in the Mississippi Department of Transportation purchasing 1,960 ac (793 ha) to be set aside as habitat, and an interchange was built (USDOI, FWS, 1991). The Mississippi Sandhill Crane National Wildlife Refuge in Jackson County, Mississippi, represents 74 percent of the total acres of critical habitat (USDOI, FWS, 1991).

The sandhill crane feeds primarily on land or in shallow emergent wetlands. In fall and winter, Mississippi sandhill cranes roost mainly in the Pascagoula Marsh (Tacha et al., 1992), thus making them vulnerable to coastal or offshore oil spills if a spill reached their roosting habitat within estuarine marshes.

Whooping Crane

The whooping crane (*Grus americana*) was federally listed as endangered on March 11, 1967, primarily due to overhunting and habitat loss (*Federal Register*, 1967). In 1941, only 15 whooping cranes remained. Critical habitat (established in 1978) along the Gulf Coast is within the Aransas National Wildlife Refuge in Texas (*Federal Register*, 1978b).

The whooping crane currently exists in the wild as one self-sustaining wild population (i.e., the Aransas-Wood Buffalo National Park Population) and the released, experimental, nonessential populations including Florida, Louisiana, Wisconsin, Colorado, Idaho, Wyoming, New Mexico, and Utah (*Federal Register*, 2011c). There are 12 captive sites that contribute to the captive breeding and release program (USDOI, FWS, 2012). The self-sustaining Aransas-Wood Buffalo population spans across Kansas, Montana, Nebraska, North Dakota, Oklahoma, South Dakota, and Texas during migration. This includes the only self-sustaining population, i.e., the Aransas-Wood Buffalo population, which is estimated at 308 birds from FWS' 2014-2015 annual survey of their wintering grounds in Texas (USDOI, FWS, 2015i). This population nests in Wood Buffalo National Park and adjacent areas in Canada, and it winters in coastal marshes in Texas. The majority of the Aransas-Wood Buffalo National Park population migrates down through the Dakotas, Nebraska, Kansas, and Oklahoma before arriving on the wintering grounds in the coastal marshes and estuarine habitats in the Aransas National Wildlife Refuge in Texas where they typically arrive by late October to mid-November and depart in late March to mid-April. As of February 2015, there were 603 whooping cranes in the total North America wild and captive populations.

Whooping cranes have a strong tendency to show site fidelity to previously used locations for breeding, migrating, and roosting sites. Preferred roosting habitat includes open areas with sand and gravel bars or shallow water in rivers and lakes (*Federal Register*, 1978b). Coastal Texas, where the population winters, has a low probability of impact from proposed OCS oil- and gas-related activities.

Wood Stork

The wood stork (*Mycteria americana*) is the largest breeding wading bird and the only stork native to the U.S. The U.S. breeding population of the wood stork was listed as endangered on February 28, 1984 (*Federal Register*, 1984). The species was formally downlisted to threatened on July 30, 2014, as a result of a population increase and expansion of the breeding range (*Federal Register*, 2014e). It was originally listed as a result of three potentially interacting factors: loss of preferred wetland habitats and associated available nesting sites; lack of protection at nest sites; and loss of preferred foraging habitats and/or prey (Brooks and Dean, 2008). The wood stork population in the southeastern U.S. appears to be stable or increasing (Borkhataria et al., 2008; Brooks and Dean, 2008). The wood stork is considered a State species of Conservation Concern in all Gulf Coast States except Louisiana. No critical habitat rules have been published for this species.

Its distribution is restricted to freshwater and estuarine wetlands in the southeastern U.S., including North and South Carolina, Georgia, Florida, Alabama, Mississippi, and Louisiana, although it is no longer considered to breed in the latter three states (Coulter et al., 1999). For more information regarding coastal habitats and proposed OCS oil- and gas-related activities, refer to **Chapter 4.3** (Coastal Habitats). Breeding locations often change annually due to variation in wetland conditions and because of the ability of breeding pairs to track resource availability (i.e., wetland conditions and food); not all colonies are occupied every year (Kushlan and Frohring, 1986; Bryan et al., 2008). Birds located at the northern edge of the breeding range tend to migrate south to winter in southern Georgia and Florida (USDOI, FWS, 2007). Though storks breed throughout Florida, it appears the center of the traditional breeding range has shifted northward primarily into north and central Florida, Georgia, and South Carolina (Kushlan and Frohring, 1986; Ogden et al., 1987; Rodgers et al., 2008). There is evidence of relatively major post-breeding dispersal with large numbers of birds frequently observed in the Mississippi River Valley; some mixing of U.S. and Mexican populations may occur (Bryan et al., 2008).

4.9.4.2 Environmental Consequences

This chapter provides detailed information regarding the impact-producing factors from routine activities, accidental events, and cumulative impacts from activities described in **Chapter 3** and their potential effects that would potentially result from a single lease sale or the alternatives. This analysis applies to all considered alternatives. Because of the distribution of the different protected bird species in the Area of Interest, the level of impacts would vary for Alternatives A, B, C, and D. However, Alternative E, No Action, would only have impacts associated with continuing effects from past lease sales and non-OCS oil- and gas-related activities. This chapter will include a summary of the potential impacts as they relate to the action alternatives and the protected bird species. The analyses of applicable impact-producing factors are the same as those for birds in general (refer to **Chapter 4.8.2,** Birds); however, the resulting level of impact would differ, as defined under the protected species impact criteria.

4.9.4.2.1 Routine Activities

The major impact-producing factors associated with routine activities include those that may affect birds found in coastal areas, including beaches, wetlands and mudflats, or offshore. For more details on impacts to birds in general, refer to **Chapter 4.8** (Birds). Also, since many of these birds are found in coastal areas, refer to **Chapter 4.3.2** (Coastal Barrier Beaches and Associated Dunes) for information on impacts from the proposed activities on coastal habitats. The Red Knot, Piping Plover, and Roseate Tern are the only protected bird species that may be found offshore during migration or foraging. The Mississippi sandhill crane, whooping crane, and wood stork use wetland areas that are associated with coastal marshes. The Cape Sable seaside sparrow and roseate tern are only in extreme south Florida. The piping plover and rufa red knot use beach and mudflat areas across the Gulf of Mexico at suitable wintering and stop-over locations.

Routine impacts include discharges and wastes, air and water quality (**Chapters 4.1 and 4.2**), structure presence, lighting, noise, and marine debris.

Waste discharges to air or water produced as a result of routine activities are regulated by the USEPA and BOEM and result in reduced potential impacts. Due to these regulations and the associated environmental monitoring, and the fact that the protected birds are spending more time in coastal areas away from many of the discharge and waste associated with a proposed action, the impacts to protected birds would be **negligible**.

Structure presence and lighting could impact bird species from collision and behavioral changes that may lead to energy expense or mortality. In the Gulf of Mexico, a study reported that many species of songbirds, shorebirds, wading birds, and raptors were involved in collisions or circulating events (Russell, 2005). The red knot, piping plover, and roseate tern would be the only protected bird species to use the offshore environment since they either migrate across the GOM or forage offshore; however, only the knot was detected offshore during Russell's study. The impacts of offshore structures to protected birds would be **negligible** to **moderate** since most of the protected bird activity is associated with coastal habitats and is not near the offshore structures. Moderate impacts would occur if a protected bird species changes its normal migratory behavior due to artificial lighting or if there is a collision with a platform.

Operational noise from OCS oil- and gas-related helicopters and vessel traffic (including G&G activities) may cause temporary disturbance to any bird that is near the flight path or landing areas. Due to the short-term nature of the impact and that many of these birds would not be in the area of known flight paths, the impact would be **negligible**.

4.9.4.2.2 Accidental Events

The major impact-producing factors resulting from accidental events associated with proposed OCS oil- and gas-related activities that may affect protected birds include accidental oil spills and response efforts. All species of protected birds in the potentially affected area could be impacted by an accidental oil spill and response activities. In the case of an accidental oil spill, impacts would be **negligible** to **moderate** depending on the magnitude of the oil spilled and spatiotemporal proximity of such an event to the particular species of protected birds. These impact levels would also be related to the response activities associated with oil-spill cleanup efforts. The impacts would depend on the seasonal timing related to migration or breeding seasons where birds may be absent or present in higher densities. Impacts from oil spill on birds are discussed in **Chapter 4.8.2** (Birds, Environmental Consequences), but oil spills may have a greater impact on protected species due to their ESA listing criteria.

During the *Deepwater Horizon* explosion, oil spill, and response, there were at least 100 species of birds directly affected by oil or associated with oil-affected habitats. Due to the timing and location of the catastrophic spill, piping plover was the only ESA-listed species reported that incurred direct mortality and loss of productivity (Deepwater Horizon Natural Resource Damage Assessment Trustees, 2016).

Marine debris produced by OCS oil- and gas-related activities as a result of accidental disposal into the water may affect protected birds by entanglement or ingestion. Due to regulations prohibiting intentional disposal of items, impacts from accidental release would be **negligible** to **moderate**. Impacts would be negligible through beach-cleaning efforts to remove debris from certain locations and the use of marine debris awareness and prevention measures on the oil and gas industry through NTL 2015-BSEE-G03 (formerly NTL 2012-BSEE-G01), which provides guidance to industry operators regarding the reduction of trash and debris elimination into the marine environment and which informs operators of regulations set by other regulatory agencies (i.e., the USEPA and USCG). Implementation of BSEE’s Marine Trash and Debris NTL is required through ESA consultation with FWS and is expected to be applied by the oil and gas industry for any associated OCS oil- and gas-related activity. **Moderate** impacts would occur if one of the protected bird species has a negative interaction with trash or debris, leading to mortality.

4.9.4.2.3 Cumulative Impacts

The cumulative impacts of the OCS oil and gas program that could affect protected birds are impacts to air and water quality, noise, G&G activities, platform presence and lighting, and construction. Mortality associated with collision with offshore structures has been reported in the Gulf of Mexico (Russell, 2005). Behavioral changes have also been observed with lighting associated with offshore structures. Migratory birds may become disoriented with the lights, expending energy in excessive circular flight. This can lead to exhaustion and mortality for individuals that are already metabolically compromised due to the energy expense of migratory flight. Accidental events include oil spills and related cleanup, impacts of which are discussed in detail in **Chapter 4.8.2** (Birds, Environmental Consequences).

As for non-OCS oil- and gas-related events, State oil- and gas-related activities would have the same general impact-producing factors as the OCS oil- and gas-related activities discussed above; however, the activities would be in closer proximity to protected bird species' coastal habitat. The Mississippi River watershed contributes nutrients, causing a seasonal population explosion of phytoplankton, which creates a hypoxic or anoxic area. This can decrease fauna in the upper water column and decrease chances of successful forging for birds, leading to changes in behavior and decreased health condition; therefore, impacts are expected to be negligible to moderate. Wetland and beach loss would continue in the foreseeable future and would have a major impact to protected birds. Most of the coastal habitats used by protected birds are regulated and mitigated by different Federal and State agencies; however, continued coastal erosion and wetland loss is expected along the Gulf of Mexico. As noted earlier, piping plover population estimates indicate declines for at least two of three populations at their breeding grounds (Haig et al., 2005; Roche et al., 2010). Emerging infectious diseases such as the West Nile virus, Avian influenza, and Newcastle disease may impact protected birds, and impacts would be expected to be major if protected species populations were affected by such pathogens. Non-OCS impacts overall are expected to be **negligible** to **major** depending on the degree of impact

When considering the cumulative impacts to the protected bird species, the incremental contribution to impacts would be **negligible** from a proposed action. A proposed action would yield a much smaller impact proportionately when compared with the impacts from multiple sources as noted above.

4.9.4.2.4 Incomplete or Unavailable Information

Incomplete or unavailable information regarding birds (including protected birds) can be found in **Chapter 4.8.2** (Birds).

4.9.4.2.5 Alternative A—Regionwide OCS Proposed Lease Sale (The Preferred Alternative)

The impact-producing factors associated with the Alternative A would include all those listed above. The impacts from a proposed action could range from **negligible** to **moderate** because of current and ongoing mitigations (such as the NTL 2012-BSEE-G01, "Marine Trash and Debris Awareness and Elimination") that are in place and applied during postlease activity reviews. Moderate impacts are not expected but may occur if a protected bird species suffers mortality as a result of encountering marine debris or an accidental oil spill and cleanup activities.

4.9.4.2.6 Alternative B—Regionwide OCS Proposed Lease Sale Excluding Available Unleased Blocks in the WPA Portion of the Proposed Lease Sale Area

The impacts of Alternative B would be the same as Alternative A for all previously specified protected bird species, with the exception of the whooping crane with the listed population in Texas and outside of the CPA or EPA. Wintering whooping crane critical habitat is near Port Aransas, Texas, along a coastal area of the WPA. The expected impacts to the whooping crane would be **negligible**, but the impacts may be **moderate** in the unlikely event (which is seasonally dependent according to the timing of the incident and the presence of the species at the time) of an oil spill in the CPA/EPA, if it resulted in the death of at least one bird.

4.9.4.2.7 Alternative C—Regionwide OCS Proposed Lease Sale Excluding Available Unleased Blocks in the CPA/EPA Portions of the Proposed Lease Sale Area

The impacts of this alternative would be the same as Alternative A for the species that occur in the WPA. The Cape Sable seaside sparrow, roseate tern, and the Mississippi sandhill crane are not found off Texas; therefore, they would not be impacted by a proposed lease sale in the WPA. Existing lease activity in the CPA and EPA and new activity in the WPA could yield **negligible** to **moderate** impacts. Moderate impacts may occur if a protected bird species is affected by an accidental oil spill and/or response.

4.9.4.2.8 Alternative D—Alternative A, B, or C, with the Option to Exclude Available Unleased Blocks Subject to the Topographic Features, Live Bottom (Pinnacle Trend), and/or Blocks South of Baldwin County, Alabama, Stipulations

The impacts of this alternative would be the same as Alternative A, B, or C because these stipulations are specific to areas that do not have any impact on ESA-protected bird species or their habitats.

4.9.4.2.9 Alternative E—No Action

The impacts of Alternative E would yield no additional impacts to protected birds. There would be no additional incremental contribution to the cumulative impacts to ESA-protected bird species or their habitats.

4.9.5 Protected Corals

This chapter provides detailed information regarding the protected coral species. However, the types of impact-producing factors affecting these species are the same as those described in **Chapter 4.6.1** (Topographic Features); therefore, they are only briefly summarized here in the context of protected coral species. A wider impact analysis for live bottom habitats (which protected corals may inhabit) can be found in **Chapter 4.6** (Live Bottom Habitats). However, the level of impact from OCS oil- and gas-related and non-OCS oil- and gas-related activities differs from those seen in **Chapter 4.6.1**because the protected coral species have smaller population sizes; therefore, the impact levels for protected coral species are described in **Table 4-18** in **Chapter 4.9**.

> *Though the listed coral species are protected, they would experience the same types of potential impacts from a proposed action as other coral species.*

4.9.5.1 Description of the Affected Environment

Corals in the GOM that are protected under the ESA include those listed in **Table 4-17**. Distribution of the listed species within U.S. Exclusive Economic Zone ranges from the State of

Florida, Flower Garden Banks National Marine Sanctuary, and the U.S. territories of Puerto Rico, U.S. Virgin Islands, and Navassa Island. Critical habitat was designated for the elkhorn (*Acropora palmata*) and staghorn (*Acropora cervicornis*) coral species by NMFS in 2008 and includes four counties in the State of Florida (Palm Beach, Broward, Miami-Dade, and Monroe Counties), as well as the U.S. territories of the U.S. Virgin Islands (St. John/St. Thomas and St. Croix) and Puerto Rico (*Federal Register*, 2008c). However, this designated critical habitat is located outside of the GOM planning area and is not expected to be affected by a proposed action, as seen in **Figure 4-25** in **Chapter 4.9**. Furthermore, the OCS lease blocks in the EPA near these critical habitat areas are not being offered in a proposed lease sale due to the current leasing moratorium and are therefore too distant to be reasonably affected by routine activities or accidental events. Though the listed species are protected, they would experience the same types of potential impacts from a proposed action as other coral species. For a detailed description and impact analysis of coral habitats in the GOM, refer to **Chapter 4.6**.

Elkhorn coral and staghorn coral were listed as threatened under the ESA in 2006 (*Federal Register*, 2006c). Both corals naturally occur on spur and groove, bank reef, patch reef, and transitional reef habitats, as well as on limestone ridges, terraces, and hard bottom habitats (Goldberg, 1973; Gilmore and Hall, 1976; Cairns, 1982; Davis, 1982; Jaap, 1984; Wheaton and Jaap, 1988; Miller et al., 2008). During the 1970's and 1980's, both elkhorn and staghorn corals underwent swift declines in abundance throughout their ranges. Although data suggest that white-band disease, a disease that affects acroporid corals and is distinguishable by the white band of dead coral tissue that it forms, was the primary cause of initial decline in Atlantic/Caribbean elkhorn and staghorn coral abundances, other threats, such as elevated seawater temperatures, ocean acidification, and physical damage from hurricanes, are credible and potentially significant impediments to recovery of these species (USDOC, NMFS, 2015i). Additionally, anthropogenic physical damage (e.g., vessel groundings, anchors, divers, and snorkelers), coastal development, competition, and predation were deemed by NMFS to be moderate threats to both corals in the recent recovery plan (USDOC, NMFS, 2015i).

Although the majority of elkhorn coral distributions are outside of the proposed lease sale area, a single colony was discovered on the West Flower Garden Bank in 2001 and was still present in 2004 (Aronson et al., 2005). This colonization event could potentially represent the early stages of a range expansion of Atlantic acroporids related to global warming (Precht and Aronson, 2004), but there are currently no long-term data that analyze and test a definitive range expansion. Because this colony of elkhorn coral is located in the Flower Garden Banks National Marine Sanctuary, this species is considered for the following impact analysis. Staghorn coral was scoped out for this analysis because known distributions of staghorn coral do not occupy any areas that are being offered in a proposed lease sale and are too distant to be reasonably affected by routine activities or accidental events occurring in leased areas. (Refer to **Appendix I** for list of species not considered further because they are unlikely to be affected by the proposed activities.)

On September 10, 2014, the *Federal Register* published a final rule listing the boulder star coral (*Orbicella franksi*), lobed star coral (*Orbicella annularis*), and mountainous star coral (*Orbicella* *faveolata*) as threatened under the ESA (*Federal Register*, 2014b). This Orbicella species complex occurs in the western Atlantic and greater Caribbean, including the Flower Garden Banks. It has historically been a dominant component on Caribbean coral reefs, characterizing the so-called “buttress zone” and “annularis zone” in the classical descriptions of Caribbean reefs. The species complex has also become the major reef-builder in the greater Caribbean since the die-off of Acropora spp. (USDOC, NMFS, 2015i).

The species complex has high susceptibility to negative impacts from ocean warming, acidification, disease, sedimentation, and nutrients; some susceptibility to trophic effects of fishing and sea-level rise; and low susceptibility to predation (USDOC, NMFS, 2015i).

Between 1999 and 2009, overall cover of the *Orbicella* species complex in the Florida Keys declined, but it differed by habitat type (Ruzicka et al., 2013). Percent cover declined on the deep and shallow fore-reefs but remained stable on patch reefs (Ruzicka et al., 2013). In 2010, a cold-water bleaching event occurred in the Florida Keys where water temperatures dropped into the upper 40’s and lower 50’s, which is about 20 ºF (-7 ºC) lower than the typical temperatures in the upper 60’s (USDOC, NMFS, 2015i). This event reduced cover of the *Orbicella* species complex from 4.4 percent to 0.6 percent on four patch reefs in the upper and middle Florida Keys. However, the areas in the Florida Keys where the cold-water bleaching event occurred are not being offered in a proposed lease sale and are too distant to be reasonably affected by routine activities or accidental events occurring in leased areas.

Random surveys in the Flower Garden Banks between 2002 and 2006 found that the *Orbicella* species complex (predominantly *O. franksi*) was the dominant coral, comprising between 27 and 40 percent benthic cover (Hickerson et al., 2008). Coral reef systems in the Flower Garden Banks are relatively well studied due to the long-term coral reef monitoring program that was established in 1989. A more recent study that analyzed mean coral cover at the East Flower Garden Bank and West Flower Garden Bank from 1989 through 2014 found similar results to Hickerson et al. (2008), with the *Orbicella* species complex being the dominant coral with the greatest mean percent cover (31.8%) (Johnston et al., 2016).

4.9.5.2 Environmental Consequences

Some activities as a result of a proposed lease sale have the potential to impact protected coral habitat within the GOM. Because of the similarity and overlap of the effects of many activities that occur in the OCS, the relevant impact-producing factors considered for protected corals can result from bottom-disturbing activities (i.e., routine activities and accidental events) and the potential accidental release of drilling muds and contaminants. **Chapter 4.6.1** (Topographic Features and Associated Communities) provides further detail on the other impact-producing factors that were considered but eliminated from further analysis and why.

4.9.5.2.1 Routine Activities

Potential routine impact-producing factors on protected corals are the same as those analyzed and described in **Chapter 4.6.1** (Topographic Features and Associated Communities). Impacts resulting from both routine activities and accidental events are mitigated through the Topographic Features Stipulation. Protective measures are detailed in NTL 2009-G39. The site-specific survey information and distancing requirements required during postlease reviews would allow BOEM to identify and protect live bottom features (which protected corals may inhabit) from potential harm by proposed OCS oil- and gas-related activities. Further, it is believed that most, if not all, of the protected corals either occur in the Flower Garden Banks National Marine Sanctuary, an area currently excluded from future leasing, or else occur far from the area of proposed activities in shallow waters under the jurisdiction of the State of Florida or the U.S. territories named above. Moreover, the OCS portions of the EPA that are adjacent to Florida State waters are currently excluded from any leasing by a Congressional moratorium in effect through at least 2022. Assuming adherence to all expected lease stipulations and other postlease, protective restrictions and mitigations, along with site-specific reviews of proposed activities, the routine activities related to a proposed action are expected to have **negligible** impacts.

4.9.5.2.2 Accidental Events

While accidental events have the potential to cause severe damage to specific coral communities, the number of such events is expected to be small. Impacts resulting from bottom-disturbing activities, as described under "Routine Activities" in **Chapter 4.6.1** (Topographic Features and Associated Communities), are largely the same for accidental events. If a small spill occurs close to a protected coral community, those communities may become smothered by the particles and exposed to hydrocarbons, which have the potential to severely impact protected corals via mortality, loss of habitat, change in community structure, and failed reproductive success. Beyond the area of spilled oil, impacts are expected to be less severe as particles are biodegraded and become more widely dispersed. Many of the protected corals either occur in the Flower Garden Banks National Marine Sanctuary, which is currently excluded from future leasing, or are far from the area of proposed activities. Therefore, impacts from reasonably foreseeable accidental events, when considering the proximity of the Flower Garden Banks National Marine Sanctuary to leased areas, are expected to be **negligible** short in duration, and limited to the area where the accident occurs. A **negligible** impact would be largely undetectable and may cause slight, localized changes to a protected coral species community where recovery from the impact is expected.

4.9.5.2.3 Cumulative Impacts

Proposed OCS oil- and gas-related activities would contribute incrementally to the overall OCS and non-OCS cumulative impacts experienced by corals. A variety of non-OCS oil- and gas-related activities, including fishing and anchoring, along with shifting natural conditions such as invasive species and climate change, may have a considerable impact on these corals in the future. These alternatives would also do little to increase the cumulative impacts since many blocks near the features are already leased and non-OCS oil- and gas-related activities are not expected to decrease. BOEM recognizes these impacts and has determined that a proposed action would not increase the cumulative effects on protected corals beyond what they are currently experiencing. Overall, impacts from individual OCS oil- and gas-related events are usually temporary, highly localized, and expected to impact only small numbers of organisms and substrates at a time, particularly since protected corals are distributed in the Flower Garden Banks National Marine Sanctuary, which is currently excluded from future leasing, or are far from the area of proposed activities. Also, adherence to the expected Topographic Features Stipulation, as well as site-specific plan reviews/mitigations, would distance many of these activities, greatly diminishing potential effects. Therefore, the incremental contribution of these proposed OCS oil- and gas-related activities is expected to have **negligible** impacts. Impacts of non-OCS oil- and gas-related activities are expected to range between negligible to major depending on the effects of natural stressors such as disease and climate change to a protected coral community. which could cause changes in community structure and ecological functioning. As such, the incremental contribution of OCS oil- and gas-related activities to the overall cumulative impacts of a proposed action, combined with non-OCS oil- and gas-related activities, is expected to be **negligible**.

4.9.5.2.4 Alternatives A, B, and C

Under Alternatives A, B and C, the proposed activities would have the same impact levels to coral habitats whether they occur in the WPA, CPA, or EPA. While the WPA is a smaller area with less projected activity than is proposed for the CPA/EPA (refer to **Chapter 3**), many of the protected corals either occur in the Flower Garden Banks National Marine Sanctuary, which has no leasing, or are far from the area of proposed activities. Additional protection is provided through current and ongoing mitigations that are restated during postlease activity reviews (**Appendix B**). Because protected corals occur far from the area of proposed activities and are further protected through current and ongoing mitigations, impacts from reasonably foreseeable routine activities and accidental events are both expected to be **negligible**. A **negligible** impact would be largely undetectable and may cause slight, localized changes to a protected coral species community where recovery from the impact is expected. No mortality or injury to an individual or group would be expected to occur. Under Alternative B, a proposed lease sale, which includes the Flower Garden Banks National Marine Sanctuary, would not occur in the WPA; therefore, impacts to protected corals as a result of a proposed lease sale would not be reasonably foreseeable to occur. There would, however, be ongoing cumulative impacts to the resources associated with ongoing OCS oil- and gas-related activities resulting from previous lease sales and from non-OCS oil- and gas-related activities. Development of oil and gas would, in all likelihood, be postponed to a future lease sale decision; in that case, the overall level of OCS oil- and gas-related activity would be delayed, not reduced, at least in the short term. It would take several cancelled lease sales before there would likely be a noticeable decrease in postlease activities from previous oil and gas lease sales.

4.9.5.2.5 Alternative D—Alternative A, B, or C, with the Option to Exclude Available Unleased Blocks Subject to the Topographic Features, Live Bottom (Pinnacle Trend), and/or Blocks South of Baldwin County, Alabama, Stipulations

Under Alternative D, should the blocks subject to the Topographic Features and Live Bottom (Pinnacle Trend) Stipulations be excluded, protected corals would be further protected by distancing OCS oil- and gas-related activities farther from these habitats, thereby reducing the probability of potential impacts from routine activities or accidental events. Blocks subject to the Topographic Features Stipulation include any available unleased block in which a No Activity Zone or Shunting Zone may be applied. A total of 207 blocks within the CPA and 160 blocks in the WPA are affected by the Topographic Features Stipulation. The exclusion of any of the other blocks subject to the Blocks South of Baldwin County, Alabama, Stipulation is not expected to change the impacts to protected corals because of the small number of blocks and their distance from these corals. For additional information related to the specific blocks that would be excluded, refer to **Appendix D**. Because protected corals occur far from the area of proposed activities and are further protected through current and ongoing mitigations, impacts from reasonably foreseeable routine activities and accidental events are both expected to be **negligible** because it would be very unlikely that protected corals would encounter any impact-producing factor from OCS oil- and gas-related activities if the blocks subject to the Topographic Features and/or the Live Bottom (Pinnacle Trend) Stipulations are excluded.

4.9.5.2.6 Alternative E—No Action

Under Alternative E, a proposed lease sale would not occur; therefore, no impacts to protected corals as a result of a proposed lease sale would occur. There would, however, be ongoing cumulative impacts to the resources associated with ongoing OCS oil- and gas-related activities resulting from previous lease sales and from non-OCS oil- and gas-related activities. Development of oil and gas would, in all likelihood, be postponed to a future lease sale decision; in that case, the overall level of OCS oil- and gas-related activity would be delayed, not reduced, at least in the short term. It would take several cancelled lease sales before there would likely be a noticeable decrease in postlease activities from previous oil and gas lease sales.

4.10 COMMERCIAL FISHERIES

The analyses of the potential impacts of routine activities and accidental events associated with a proposed action and a proposed action's incremental contribution to the cumulative impacts to commercial fisheries are presented in this chapter. The approach of the analysis is to focus on the potential impact-producing factors from OCS oil- and gas-related routine activities (i.e., exploration, development, and production), as well as accidental events and cumulative impacts, and to define the impact-level measures for each impact-producing factor (**Table 4-20**). The potential magnitude of impact for each of these impact-producing factors is provided in **Table 4-20** to help the reader quickly identify the level of potential impacts for commercial fisheries. The impact-level definitions and the analyses supporting these conclusions are then discussed in detail in this chapter. The analysis in this chapter relies on the analysis and conclusions reached in **Chapter 4.7** (Fish and

Invertebrate Resources). Therefore, in general, the impact-producing factors identified in **Chapter 4.7** would have the potential to impact commercial fisheries as well.

Impact-Level Definitions

In this chapter, the impact levels are defined in terms of the duration, intensity, and geographical extent of the impacts to the human uses of commercial fisheries along the Gulf Coast. Long-term impacts are those lasting more than 1 year. Extensive impacts are those for which it is difficult to find substitute fishing sources nearby, while severe impacts mostly or completely prevent commercial fishing in an area. In particular, the impacts of each impact-producing factor are summarized in **Table 4-20**, using the impact-level definitions below.

- **Beneficial** – Impacts would be positive. The level of benefical impacts are specified in the analysis, which could be low, medium, or high.
- **Negligible** – Little or no detectable adverse impact.
- **Minor** – Adverse impacts are detectable but less than severe.
- **Moderate** – Adverse impacts are severe but are short term and/or not extensive.
- **Major** – Adverse impacts are long term, extensive, and severe.

Table 4-20. Commercial Fisheries Impact-Producing Factors That Are Reasonably Foreseeable.

Commercial Fisheries	Magnitude of Potential Impact[1]				
Impact-Producing Factors	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
Routine Activities					
Fish Population	Negligible to Minor	Negligible to Minor	Negligible to Minor	Negligible to Minor	Negligible
Space-Use Conflicts	Negligible to Minor	Negligible to Minor	Negligible to Minor	Negligible to Minor	Negligible
Production Structure Emplacement and Removal	Beneficial to Minor	Beneficial to Minor	Beneficial to Minor	Beneficial to Minor	Negligible
Accidental Events					
Oil Spills	Negligible to Minor	Negligible to Minor	Negligible to Minor	Negligible to Minor	Negligible

<table>
<tr><th colspan="6">Cumulative Impacts</th></tr>
<tr><td>Incremental Contribution[2]</td><td>Beneficial to
Minor</td><td>Beneficial to
Minor</td><td>Beneficial to
Minor</td><td>Beneficial to
Minor</td><td>Negligible</td></tr>
<tr><td>OCS Oil and Gas[3]</td><td colspan="5">Beneficial to
Moderate</td></tr>
<tr><td>Non-OCS Oil and Gas[4]</td><td colspan="5">Beneficial to
Major</td></tr>
</table>

[1] The analysis supporting these conclusions is discussed in detail in the "Environmental Consequences" chapter below.
[2] This includes all activities (i.e., routine activities projected to occur and accidental events that could occur) as a result of a single proposed lease sale in the 2017-2022 Five-Year Program.
[3] This includes all activities (i.e., routine activities projected to occur and accidental events that could occur) from past, proposed, and future lease sales.
[4] This includes other past, present, and reasonably foreseeable future activities occurring within the same geographic range and within the same timeframes as a proposed action, but they are not related to the OCS Oil and Gas Program.

4.10.1 Description of the Affected Environment

The Gulf of Mexico is home to a large and complex commercial fishing industry. There were $1.027 billion in finfish and shellfish landings in the Gulf of Mexico in 2014, which comprised 19 percent of total U.S. landings (USDOC, NMFS, 2016c). Some of the most economically important commercial fisheries in the Gulf of Mexico are white shrimp (*Litopenaeus setiferus*), brown shrimp (*Farfantepenaeus aztecus*), eastern oysters (*Crassostrea virginica*), Gulf menhaden (*Brevoortia patronus*), blue crab (*Callinectes sapidus*), red grouper (*Epinephelus morio*), red snapper (*Lutjanus campechanus*), and tunas (*Thunnus* spp.). Fisheries are managed by NOAA Fisheries (NMFS), as advised by the regional fisheries management councils. Commercial fisheries are regulated by various mechanisms, including permitting, closures, quotas, and gear restrictions; details regarding these mechanisms are described by the Gulf of Mexico Fishery Management Council (2015). This source also describes the allowable gear types for each fishery. Some of the most common gear types are trawls (for shrimp), purse seines (for menhaden), dredges (for oysters), traps (for blue crab), and longlines (for various finfish). The biological aspects of the affected environment for the targeted species are discussed in **Chapter 4.7.1** (Fish and Invertebrate Resources).

Landings Revenues

Panel A of **Table 4-21** presents the total landings revenues for key GOM fisheries, while Panels B through F present the landings revenues for the key fisheries in each Gulf Coast State from 2011 through 2014. There were $1.027 billion in landings revenues in 2014, compared with $812 million in 2011, $746 million in 2012, and $944 million in 2013. Fisheries landed offshore of Louisiana accounted for the most fisheries revenue in 2014, followed (in descending order) by Texas, West Florida, Alabama, and Mississippi. Shrimp species (particularly white shrimp and brown shrimp) account for the most landings revenues ($587,986,000 in 2014) in the Gulf of Mexico. Shrimp are caught offshore of all states, particularly Texas and Louisiana, in Federal and State waters. Menhaden accounts for the most pounds (769,943,000 pounds in 2014) landed in the Gulf of Mexico (USDOC, NMFS, 2016c). However, because the average price per pound of menhaden is much lower than for other species, menhaden landings accounted for the fourth most landings revenue ($70,917,000) in 2014. Menhaden is primarily caught in State and Federal waters offshore of Louisiana and Mississippi. Oysters ($86,751,000) and blue crab ($73,426,000) accounted for the second and third highest landings revenues in 2014. These species are caught in State waters of all Gulf Coast States. Red snapper and tunas are primarily caught in Federal waters offshore various states. Stone crab (*Menippe mercenaria*) and Caribbean spiny lobster (*Panulirus argus*) are primarily caught offshore Florida.

Table 4-21. Landings Revenues: Landings Revenue by Species and State.

Panel A: Gulfwide					Panel B: Louisiana				
Species	2011	2012	2013	2014	Species	2011	2012	2013	2014
Shrimp	441,384	390,464	510,486	587,986	Shrimp	133,670	125,587	182,144	227,318
Oysters	65,273	71,688	76,413	86,751	Menhaden	82,881	60,934	84,951	63,364
Blue crab	48,794	47,984	61,802	73,426	Oysters	41,652	37,832	44,835	61,365
Menhaden	92,855	83,450	95,331	70,917	Blue crab	36,784	38,196	51,566	61,082
Groupers	19,679	23,415	23,396	28,830	Crawfish	9,914	4,998	16,490	13,430
Stone crab	24,521	24,039	24,763	27,135	Red snapper	2,261	2,434	4,824	6,400
Red snapper	11,413	13,565	20,621	23,088	Tunas	3,369	7,752	4,595	4,276
Tunas	5,516	10,516	7,308	6,330	King mackerel	1,594	1,475	1,517	2,299
Total Revenue	811,905	745,822	943,640	1,027,885	Total Revenue	324,123	291,721	403,650	451,371
Panel C: Texas					Panel D: West Florida				
Species	2011	2012	2013	2014	Species	2011	2012	2013	2014
Shrimp	216,382	180,562	228,768	242,299	Lobsters	35,616	21,136	46,749	50,537
Oysters	12,789	21,302	23,465	19,221	Shrimp	28,456	21,463	28,498	40,714
Red snapper	3,254	4,448	7,324	7,617	Stone crab	24,430	23,934	24,710	27,132
Blue crab	2,845	2,878	2,331	3,050	Red grouper	15,087	16,737	16,219	20,944
Black drum	1,448	1,491	1,699	1,981	Mullets	8,630	5,050	11,081	8,072
Groupers	549	723	1,121	1,128	Red snapper	5,417	6,141	8,073	8,067
Atlantic croaker	622	743	819	681	Blue crab	7,719	5,142	6,454	6,977
Vermillion snapper	1,274	1,434	659	604	Oysters	8,582	9,706	5,783	4,038
Total Revenue	240,566	215,083	267,998	278,353	Total Revenue	166,015	143,188	181,507	203,372
Panel E: Mississippi					Panel F: Alabama				
Species	2011	2012	2013	2014	Species	2011	2012	2013	2014
Shrimp	18,514	23,844	22,055	15,210	Shrimp	44,361	39,009	49,021	62,445
Menhaden	9,871	22,394	10,230	7,358	Blue crab	1,128	1,044	1,036	1,319
Oysters	928	1,596	1,544	1,685	Mullets	687	1,206	1,178	1,046
Blue crab	318	724	416	997	Spanish mackerel	582	1,149	940	472
Red snapper	168	226	NA	307	Oysters	1,322	1,253	786	441
Total Revenue	30,291	49,335	34,953	25,995	Total Revenue	50,910	46,495	55,532	68,793

[1]Landings are presented in thousands of dollars.
Source: USDOC, NMFS, 2016c.

Fisheries Supply Chain

The fisheries landings discussed above are brought to shore at various ports along the Gulf Coast. Some of the leading commercial fishing ports, along with the fisheries revenues received in 2014 at these ports, are Empire-Venice, Louisiana ($127.3 million); Brownsville-Port Isabel, Texas ($76.3 million); Galveston, Texas ($69 million); Dulac-Chauvin, Louisiana ($69 million); Bayou La Batre, Alabama ($58.1million); Intracoastal City, Louisiana ($43.3 million); and Port Arthur, Texas ($40.6 million) (USDOC, NMFS, 2016d). Fish landings then proceed through supply chains that include dealers, processors, distributors, markets, and restaurants. The NMFS used economic modeling techniques to estimate the supply chain impacts of fisheries landings (USDOC, NMFS, 2016c). The NMFS' estimates of the number of jobs and the amount of value-added supported by fisheries landings in each Gulf Coast State are listed below. The large impacts in Florida are due to its high numbers of seafood importers, wholesalers, distributors, and retailers.

- Texas (33,880 jobs; $ 1,238,477,000)
- Louisiana (44,066 jobs; $1,115,858,000)
- Mississippi (4,714 jobs; $102,731,000)
- Alabama (15,069 jobs; $333,185,000)
- Florida (92,858 jobs; $6,135,060,000)

4.10.2 Environmental Consequences

The impacts from routine activities and accidental events, and the cumulative impacts to commercial fisheries that would arise from projected activities from a proposed action are analyzed in this chapter. While there are some differences in the amount of activities associated with the alternatives, many of the impacts associated with the alternatives are similar. Therefore, this chapter will describe the impacts that are expected to apply to all alternatives, while any deviations from these impact conclusions will be discussed in **Chapters 4.10.2.5-4.10.2.9**.

4.10.2.1 Routine Activities

Routine operations (such as seismic surveys [**Chapter 3.1.2.1**], drilling activities [**Chapters 3.1.2.2 and 3.1.3.1**], service-vessel traffic [**Chapter 3.1.4.3**], and production structure emplacement [**Chapter 3.1.3.3**], and decommissioning [**Chapter 3.1.6**]) can impact commercial fisheries by impacting the fish populations that support commercial fishing or by impacting fishermen's access to those fish populations. The impacts to fish populations that support commercial fishing are described in **Chapter 4.7**, which describes the impacts of anthropogenic sound, bottom-disturbing activities, and habitat modification on fish populations. The impacts to commercial fishing from routine activities would depend on the types and scales of commercial fishing activities in an impacted area, which are discussed in **Chapter 4.10.1**. Shrimp, menhaden, red snapper, tunas, and groupers are the species most often sought by commercial fishermen in Federal waters and would therefore be most directly impacted by a proposed action. Disturbances to those populations would have proportionate impacts on the seafood supply chain. However, since the impacts to fish populations from routine OCS oil- and gas-related activities would be **negligible** or **minor** (determined in **Chapter 4.7**), the corresponding impacts to commercial fisheries would also be **negligible** or **minor**. This is because disruptions to fish and invertebrate populations would proportionately reduce commercial fishing revenues, as well as the impacts on the seafood supply chain.

Space-use conflicts with commercial fishing can arise from routine operations such as service-vessel traffic, seismic surveys, pipeline emplacement, drilling, and production structure emplacement and removals. The nature of space-use conflicts from these activities depend on the durations of the activities, as well as the locations and species affected. For example, structure emplacement prevents trawling in the associated area and, thus, could impact the shrimp fishery. However, the amount of area closed to trawling would be minimal relative to the vast areas where shrimp trawling occur (refer to **Chapter 3.1.3.4.2**). On the other hand, production platforms can facilitate fishing for reef fish such as red snapper and groupers. Scott-Denton et al. (2011) present observational data regarding the geographic distribution of various reef fish in the Gulf of Mexico, where production structure emplacement can enhance commercial fishing. The eventual decommissioning of a platform would reverse the effects of structure emplacement unless the structure were reefed in place or moved to an artificial reef site. Due to the small scale of a proposed action (**Chapter 3**), the impacts of space-use conflicts and structure emplacement and eventual decommissioning are expected to range from **beneficial (low)** to **minor** adverse effects. The exact impacts would depend on the locations of activities, the species affected, the intensity of commercial fishing activity in the affected area, and the substitutability of any lost fishing access.

4.10.2.2 Accidental Events

Accidental events, such as oil spills (**Chapter 3.2.1**), can impact commercial fisheries by impacting the fish populations that support commercial fishing activities, by impacting fishermen's access to those fish populations, or by impacting the seafood supply chain. The impacts of oil spills on fish populations that support commercial fishing are described in **Chapter 4.7**. For example, **Chapter 4.7** describes the impacts of potential sediment displacement due to a spill, as well as the potential lethal and sublethal impacts to fish and shellfish species. The corresponding impacts to commercial fishing would depend on the size of the oil spill, as well as on the types and scales of commercial fishing activities in an impacted area, which are discussed in **Chapter 4.10.1**. Oil spills in Federal waters would be most likely to affect fisheries for coastal or oceanic species (such as shrimp, menhaden, reef fish, tunas, and groupers), and accidental spills in State waters would be most likely to affect coastal and inshore fisheries (e.g., shrimp, menhaden, oysters, and blue crab). Most commercially valuable species in the Gulf of Mexico have planktonic eggs and/or larvae. These early life stages are generally more vulnerable to impacts resulting from exposure to oil and could be affected if a spill coincides with a spawning event or impacts nursery habitat (e.g., Coastal Habitats [**Chapter 4.3**] or *Sargassum* and Associated Communities [**Chapter 4.5**]).

The area surrounding a spill could be closed to commercial fishing for some period of time. However, fishing closures would likely be limited in size and duration. Commercial fishermen would likely have numerous alternate fishing sites for the duration of a closure. Oil spills can have other impacts to the supply or demand of seafood. Greater New Orleans, Inc. (2011) provides information regarding how the various impacts to commercial fisheries evolved subsequent to the *Deepwater Horizon* oil spill, which provides insights regarding the potential impacts of future spills. For example, an oil spill could cause seafood safety concerns, which would reduce the demand for the affected species. An oil spill could also cause certain fishermen to stop fishing to participate in the cleanup operations or for economic reasons. Carroll et al. (2016) provides additional information regarding the short-term impacts of the *Deepwater Horizon* explosion, oil spill, and response on the seafood industry. For example, this report analyzes, both quantitatively and qualitatively, how the reductions in fisheries landings due to the *Deepwater Horizon* explosion, oil spill, and response affected the supply chain for each fishery. A large oil spill could have some longer-term impacts on commercial fisheries. While long-term impacts to fish populations as a result of past oil spills in the GOM have not been described, impacts could be masked by natural variations in populations or may not be evident for several years. However, the oil spills that could arise from a proposed action are forecast to be small. Therefore, an oil spill would likely have limited impacts on fish populations, as well as limited impacts on the supply and demand for seafood. Therefore, the impacts of oil spills arising from a proposed action would be **negligible** to **minor**. The exact impacts would depend on the locations of oil spills, the species affected, the intensity of commercial fishing activity in the affected area, and the substitutability of any lost fishing access.

4.10.2.3 Cumulative Impacts

This chapter analyzes the OCS oil- and gas-related and non-OCS-oil-and-gas-related cumulative impacts to commercial fisheries. The geographic bounds of the analysis increase from site-specific impacts to Gulfwide impacts. The temporal bounds of the analysis correspond to the life cycle of activities forecasted to arise from leasing activities (refer to **Chapter 3**). The cumulative impacts to commercial fisheries would be determined by the cumulative impacts to fish and invertebrate populations, which are discussed in **Chapter 4.7**. The impacts to fish and invertebrate populations would impact commercial fishing in proportion to the intensity of commercial fishing for a particular species in a particular location. The cumulative impacts to commercial fisheries would also be determined by other factors that could affect access to fishing sites or that could affect the supply and demand for seafood.

OCS Oil- and Gas-Related Impacts

A proposed action would contribute to the impacts from the routine activities and accidental events of the overall OCS Program. **Chapter 4.7** discusses the cumulative impacts to fish and invertebrate populations from OCS oil- and gas-related sound, bottom-disturbing activities (**Chapter 3.3.1.5**), and habitat modification. These impact-producing factors could cause displacement, physical harm, or fatalities. The associated cumulative impacts to commercial fisheries would be determined by the intensity of commercial fishing for each species in an affected area (described in **Chapter 4.10.1**). In particular, impacts to fish populations could lead to decreased fishing landings and revenues, which would impact jobs and incomes throughout the seafood supply chain. A proposed action would also contribute to the space-use conflicts (**Chapter 3.3.1.6**) and the potential for accidental events (which are discussed above) arising from the OCS Program. The installation of production structures could enhance reef fish habitat and thus enhance commercial fishing opportunities, although the ultimate decommissioning of production structures could negatively impact commercial fishing. Finally, the *Deepwater Horizon* oil spill may still have some lingering impacts on commercial fisheries. Long-term impacts to fish populations as a result of past oil spills in the GOM have not been described, but impacts could be masked by natural variations in populations or may not be evident for several years. **Chapter 4.10.1** describes that landings revenues for most species have generally recovered since the spill.

Overall OCS oil- and gas-related impacts will range from **beneficial (medium)** to **moderate**. Negative impacts arising from impacts to fish populations, space-use conflicts, and accidental events will be greater than for an individual lease sale. The overall number of production structures also serves more of a beneficial role for reef fish, although the corresponding decommissioning of these structures negatively impact commercial fishing for reef species. The exact impacts would depend on the locations of activities, the species affected, the intensity of commercial fishing activity in the affected area, and the substitutability of any lost fishing access.

Non-OCS Oil- and Gas-Related Impacts

The non-OCS oil- and gas-related impacts that could have an effect on commercial fisheries including anthropogenic sound (**Chapter 3.3.2.7**), habitat modifications, state oil and gas activities (**Chapter 3.3.2.1**), space-use conflicts, severe weather, commercial fishing regulations, and various economic forces.

Chapter 4.7 discusses the impacts of anthropogenic sound and habitat modifications on fish resources. These effects would impact commercial fishing to the extent that landings of certain species were impacted, which would likely occur in proportion to the scale of commercial fishing in an area (**Chapter 4.10.1**).

State oil and gas activities also have impacts on commercial fisheries. For example, State oil and gas activities could lead to space-use conflicts with commercial fisheries and could lead to accidental events. State oil and gas platforms could also support reef fish populations important to commercial fishermen. The nature of these impacts would be similar to those of a proposed action, although the affected species may be different. Accidental spills in State waters would most likely affect coastal and inshore fisheries due to proximity to the shorelines (e.g., shrimp, menhaden, oysters, and blue crab). The early life stages of these targets are generally more vulnerable to oil exposure and could be affected if a spill coincides with a spawning event or if a spill impacts nursery habitat. For example, oysters and blue crab are primarily located in State waters and thus could be impacted by the associated State oil and gas routine and accidental impacts.

Commercial fishermen also encounter space-use conflicts with recreational, commercial, and military vessels that temporarily restrict access to fishing areas. Marinevesseltraffic.com (2015) provides maps of current and historical vessel traffic in the Gulf of Mexico. There is a large amount of vessel traffic in the Gulf of Mexico, particularly near major ports.

Although tropical storms and hurricanes are parts of the natural environment and not considered to adversely impact fish populations, severe events could affect various types of infrastructure (e.g., vessels, fish houses, and suppliers) that support commercial fishing. Storms could also temporarily prevent fishermen from fishing in certain areas.

A proposed action should also be viewed in light of various economic forces affecting commercial fisheries. Participants in the GOM seafood industry compete with participants in various other domestic and international markets. The USDOC, NMFS (2015j) presents various statistics regarding these markets. For example, GOM shrimp competes with a large import market. In 2013, there were $5.3 billion of shrimp imports into the U.S., $4 billion of which came from Asian countries. Demand for GOM seafood is also positively correlated with the overall state of the economy; information regarding the expected progression of the economy is presented in **Chapter 4.14.2**.

The cumulative impacts to commercial fisheries would also be influenced by the management strategies employed by NMFS, the Gulf of Mexico Fishery Management Council, and various State agencies. For example, NOAA and the Texas Parks and Wildlife Department annually close Federal and State waters to shrimp fishing for 45-90 days in late spring to ensure a healthy shrimp population (USDOC, NFMS, 2015k). Fisheries managers also develop strategies for species, such as red snapper, that are important to recreational and commercial fishing (USDOC, NFMS, 2015l). Finally, the NMFS has published the final rule for mechanisms to manage aquaculture in the Federal Gulf of Mexico (*Federal Register*, 2016g). The NFMS has published a programmatic EIS for its Gulf of Mexico aquaculture management plan (USDOC, NMFS, 2009). **Chapter 3.3.2.6.5** provides more information regarding aquaculture in the Gulf of Mexico.

Overall non-OCS oil- and gas-related impacts to commercial fisheries would range from **beneficial (high)** to **major**. This wide range reflects the myriad of non-OCS oil- and gas-related impacts that could occur over the timeframe of this cumulative analysis. For example, changes in economic conditions could noticeably impact the supply or demand for a certain segment of the commercial fishing industry. Similarly, major events (such as a hurricane) or major regulatory changes could cause major impacts to commercial fisheries. However, regulatory actions and economic adjustments would likely eventually stabilize any major shocks to commercial fishing activities.

A proposed action would be relatively small when compared with the OCS oil- and gas-related and non-OCS oil- and gas-related factors discussed above (refer to **Chapter 3**). Therefore, the incremental cumulative impacts of a proposed action relative to these factors would range from **beneficial (low)** to **minor** adverse impacts. The exact impacts would depend on the locations of activities, the species affected, the intensity of commercial fishing activity in the affected area, and the substitutability of any lost fishing access.

4.10.2.4 Incomplete or Unavailable Information

BOEM has determined that there is incomplete or unavailable information related to commercial fisheries. Some of this incomplete or unavailable information relates to fish populations that support commercial fishing, which is discussed in **Chapter 4.7**. For example, there is incomplete or unavailable information regarding the long-term impacts of acute and chronic exposure to oil on fish and invertebrates that support commercial fishing. This information is unavailable because these impacts would only become evident through time. In lieu of the incomplete or unavailable information, BOEM used various data sources and studies to estimate the affected environment and impacts of OCS oil- and gas-related and non-OCS oil- and gas-related activities for commercial fishing. For example, BOEM used the most recent NMFS landings data, as well as the information in Carroll et al. (2016). BOEM has determined that the incomplete or unavailable information is not essential to a reasoned choice among alternatives because existing data sources are sufficient for BOEM to reasonably estimate impacts.

4.10.2.5 Alternative A—Regionwide OCS Lease Sale (The Preferred Alternative)

The impacts of Alternative A would correspond to the impacts discussed in **Chapter 4.10.2**. Alternative A could affect commercial fisheries by affecting fish populations or by affecting the socioeconomic aspects of commercial fishing. The impacts of a proposed action on fish populations are presented in **Chapter 4.7**. Routine activities such as seismic surveys, drilling activities, and service-vessel traffic can cause space-use conflicts with fishermen. Structure emplacement could have positive or negative impacts, depending on the location and species. Accidental events, such as oil spills, could cause fishing closures and have other impacts on the supply and demand for seafood. However, accidental events that could arise from a proposed action would likely be small. Alternative A should also be viewed in light of the overall OCS Program, State oil and gas activities, overall vessel traffic, hurricanes, economic factors, and Federal and State fisheries management strategies. The incremental impacts of Alternative A on commercial fisheries are expected to range from **beneficial (low)** to **minor** due to the limited scale of a proposed action. The exact impacts would depend on the locations of activities, the species affected, the intensity of commercial fishing activity in the affected area, and the substitutability of any lost fishing access.

4.10.2.6 Alternative B—Regionwide OCS Proposed Lease Sale Excluding Available Unleased Blocks in the WPA Portion of the Proposed Lease Sale Area

Alternative B entails leasing a subset of the area considered in Alternative A. Therefore, the analysis of Alternative A covers the potential impacts of Alternative B. There are some differences (described in **Chapter 4.10.1**) in the scales of commercial fishing in the CPA/EPA compared with the WPA. For example, menhaden and blue crab comprise larger percentages of landings revenues in the CPA/EPA (particularly in Louisiana) compared with the WPA. However, the impact conclusions for Alternatives A and B are the same because the types of activities that occur in the WPA and the CPA are similar and because most offshore oil- and gas-related activities will occur in the CPA.

4.10.2.7 Alternative C—Regionwide OCS Proposed Lease Sale Excluding Available Unleased Blocks in the CPA/EPA Portions of the Proposed Lease Sale Area

Alternative C entails leasing a subset of the area considered in Alternative A. Therefore, the analysis of Alternative A covers the potential impacts of Alternative C. There are some differences (described in Chapter 4.10.1) in the scales of commercial fishing in the CPA/EPA compared with the WPA. For example, menhaden and blue crab comprise larger percentages of landings revenues in the CPA/EPA (particularly in Louisiana) compared with the WPA. Alternative C would also entail significantly less overall activity than Alternative A. However, these differences are not large enough to change the range of impact conclusions (discussed above) for Alternatives A and C. However, due to the lower levels of OCS oil- and gas-related activities associated with Alternative C than Alternative A, the probability that an impact to commercial fishing would be **negligible** (rather than **minor**) would be higher for Alternative C.

4.10.2.8 Alternative D—Alternative A, B, or C, with the Option to Exclude Available Unleased Blocks Subject to the Topographic Features, Live Bottom (Pinnacle Trend), and/or Blocks South of Baldwin County, Alabama, Stipulations

Alternative D entails leasing a subset of the area considered in Alternatives A, B, or C by making blocks that would normally be subject to the Topographic Features, Live Bottom (Pinnacle Trend), and/or Blocks South of Baldwin County, Alabama, Stipulations unavailable for lease. Therefore, the analyses for those alternatives (described above) cover the potential impacts of Alternative D. In addition, Alternative D would not exclude large areas to commercial fishing. This is particularly true since fishermen would probably not use certain gear types, such as bottom trawls, near topographic features for fear of entangling and damage to gear. Therefore, the impact conclusions (which are discussed above) remain the same, though there may be a slight offsetting effect to commercial fishing in the excluded blocks, as it would reduce any potential conflict with OCS oil- and gas-related activities but would similarly prevent the potential for beneficial effects from new platforms or other fish attractions in the blocks.

4.10.2.9 Alternative E—No Action

Alternative E would prevent the impacts discussed in **Chapter 4.10.2** from occurring. Since there is an expansive existing oil and gas industry, Alternative E would cause some economic adjustments (refer to **Chapter 4.14.2**), which could cause **negligible** impacts to commercial fishing activities. For example, Alternative E would cause workers in the oil and gas industry supply chain to lose income, which could slightly affect their demand for seafood. Commercial fisheries would still be subject to the impacts from the OCS Oil and Gas Program, as well as the impacts from the non-OCS oil- and gas-related sources discussed above.

4.11 RECREATIONAL FISHING

The analyses of the potential impacts of routine activities and accidental events associated with a proposed lease sale and a proposed lease sale's incremental contribution to the cumulative impacts to recreational fishing are presented in this chapter. The approach of the analysis is to focus on the potential impact-producing factors from OCS oil- and gas-related routine activities (i.e., exploration, development, and production), as well as the accidental events and cumulative impacts, and to define the impact-level measures for each impact-producing factor. The analysis in this chapter relies on the analysis and conclusions reached in **Chapter 4.7** (Fish and Invertebrate Resources). Therefore, in general, the impact-producing factors identified in **Chapter 4.7** would have the potential to impact recreational fishing as well.

Impact-Level Definitions

In this chapter (and in the analyses of the alternatives), the impact measures are defined in terms of the intensity, duration, and geographical extent of the impacts to the human uses of recreational fisheries along the Gulf Coast. Long-term impacts are those lasting more than 1 year. Extensive impacts are those for which it is difficult to find substitute fishing sources nearby, while severe impacts mostly or completely prevent recreational fishing in an area. The impacts of each impact-producing factor are summarized in **Table 4-22** using the impact-level measures below to help the reader quickly identify the level of potential impacts for recreational fishing. The analyses supporting these conclusions are then discussed in detail in this chapter.

- **Beneficial** – Impacts would be positive. The level of benefical impacts are specified in the analysis, which could be low, medium, or high.
- **Negligible** – Little or no detectable adverse impact.
- **Minor** – Adverse impacts are detectable but less than severe.
- **Moderate** – Adverse impacts are severe but are short term and/or not extensive.
- **Major** – Adverse impacts are long term, extensive, and severe.

Table 4-22. Recreational Fishing Impact Producing Factors That Are Reasonably Foreseeable.

Recreational Fishing	Magnitude of Potential Impact[1]				
Impact-Producing Factors	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
Routine Activities					
Anthropogenic Sound	Negligible to Minor	Negligible to Minor	Negligible to Minor	Negligible to Minor	Negligible
Bottom-Disturbing Activities	Negligible	Negligible	Negligible	Negligible	Negligible
Space-Use Conflicts	Negligible to Minor	Negligible to Minor	Negligible to Minor	Negligible to Minor	Negligible

Recreational Fishing	Magnitude of Potential Impact[1]				
Impact-Producing Factors	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
Production Structure Emplacement and Removal	Beneficial to Minor	Beneficial to Minor	Beneficial to Minor	Beneficial to Minor	Negligible
Accidental Events					
Oil Spills	Negligible to Minor	Negligible to Minor	Negligible to Minor	Negligible to Minor	Negligible
Cumulative Impacts					
Incremental Contribution[2]	Beneficial to Minor	Beneficial to Minor	Beneficial to Minor	Beneficial to Minor	Negligible
OCS Oil and Gas[3]	Beneficial to Moderate				
Non OCS Oil and Gas[4]	Beneficial to Major				

[1] The analysis supporting these conclusions is discussed in detail in the "Environmental Consequences" chapter below.
[2] This includes all activities (i.e., routine activities projected to occur and accidental events that could occur) as a result of a single proposed lease sale in the 2017-2022 Five-Year Program.
[3] This includes all activities (i.e., routine activities projected to occur and accidental events that could occur) from past, proposed, and future lease sales.
[4] This includes other past, present, and reasonably foreseeable future activities occurring within the same geographic range and within the same timeframes as a proposed action, but they are not related to the OCS Oil and Gas Program.

4.11.1 Description of the Affected Environment

Recreational fishing is a popular pastime in many parts of the Gulf of Mexico. The GOM's extensive estuarine habitats (**Chapter 4.3.1**), live bottom habitats (**Chapter 4.6**), and artificial substrates (including artificial reefs, shipwrecks, and oil and gas platforms) support several valuable recreational fisheries. Fisheries are managed by NOAA Fisheries (NMFS), as advised by the regional fisheries management councils. Details regarding the most recent regulatory mechanisms relevant to recreational fishing are described by the Gulf of Mexico Fishery Management Council (2015). Recreational landings and effort data for Louisiana, Mississippi, Alabama, and Florida are provided by NMFS; recreational fishing data for Texas is provided by the Texas Parks and Wildlife Department. Although a proposed lease sale is a regionwide lease sale, the data from these two sources are presented separately to allow for methodological differences between them. These data, along with data on the economic impacts of recreational fishing, are presented in subsequent sections. The biological aspects of the affected environment are discussed in **Chapter 4.7** (Fishes and Invertebrate Resources).

CPA/EPA Catch and Effort Data

The NMFS collects and provides public access to data on recreationally targeted species, landings, and angler effort (USDOC, NMFS, 2014). The NMFS provides recreational fishing data for

Louisiana through 2013; therefore, this chapter will present NMFS data through 2013 to allow for consistent comparisons among states. The NMFS also publishes annual reports summarizing these data and the economic impacts to the Gulf Coast States (USDOC, NMFS, 2016c). **Table 4-23** presents data on the number of angler trips taken in Louisiana, Mississippi, Alabama, and West Florida from 2008 to 2013. The total number of angler trips in these four states declined from 2008 through 2010, but then gradually increased from 21 million trips in 2010 to 25.3 million trips in 2013. In 2013, there were 15.9 million angler trips in West Florida, 4.7 million angler trips in Louisiana, 2.9 million angler trips in Alabama, and 1.8 million angler trips in Mississippi. **Table 4-23** also breaks down these trips by location and mode. The three geographic locations for each state are inland, (inshore saltwater and brackish waterbodies), State ocean waters, and Federal ocean waters. The three modes of fishing are shore fishing, charter fishing, and private/rental fishing. The last column in **Table 4-23** present the percentage of recreational fishing in 2013 broken down by location and mode. The least amount of recreational fishing occurs in Federal waters, where most OCS oil- and gas-related activities occur. In the four states combined in 2013, 59.7 percent of recreational fishing occurred in inland waters, 32.7 percent occurred in State ocean waters, and 7.6 percent occurred in Federal ocean waters. In 2013, 53.5 percent of recreational fishing occurred on private or rental boats, 42.9 percent occurred from shore, and 3.6 percent occurred on charter boats.

Table 4-23. CPA and EPA Effort Data: Angler Trips in the Gulf of Mexico.

Area	2008	2009	2010	2011	2012	2013	% of State Total in 2013
Alabama							
Shore Ocean (< 3 nmi)	249,893	322,126	447,041	603,546	750,159	1,250,811	43.70%
Shore Inland	452,192	449,470	365,234	598,700	461,221	515,982	18.03%
Charter Ocean (<3 nmi)	9,967	9,166	8,860	19,874	15,785	20,615	0.72%
Charter Ocean (>3 nmi)	38,046	36,259	17,424	48,616	28,340	56,145	1.96%
Charter Inland	7,700	10,656	7,221	6,351	14,536	12,976	0.45%
Private/Rental Ocean (<3 nmi)	247,876	131,997	114,816	191,563	137,321	118,801	4.15%
Private/Rental Ocean (>3 nmi)	74,074	134,411	69,335	188,994	131,897	278,821	9.74%
Private/Rental Inland	624,197	618,502	656,226	825,821	766,027	608,280	21.25%
Total	1,703,945	1,712,587	1,686,157	2,483,465	2,305,286	2,862,431	
West Florida							
Shore Ocean (< 9 nmi)	3,076,591	2,688,011	1,610,807	1,982,194	2,199,810	3,745,909	23.49%
Shore Inland	3,704,990	3,793,756	4,034,208	3,862,665	4,016,544	3,191,414	20.01%
Charter Ocean (<9 nmi)	187,810	196,753	159,317	179,880	242,666	199,908	1.25%
Charter Ocean (>9 nmi)	255,300	262,005	203,201	236,088	307,121	322,185	2.02%
Charter Inland	127,801	113,842	98,440	119,826	149,315	161,479	1.01%

Area	2008	2009	2010	2011	2012	2013	% of State Total in 2013
Private/Rental Ocean (<9 nmi)	3,624,073	2,605,196	2,257,349	1,901,217	2,087,991	2,572,325	16.13%
Private/Rental Ocean (>9 nmi)	1,242,935	751,869	681,551	500,067	755,470	1,136,161	7.12%
Private/Rental Inland	5,277,665	5,265,888	5,221,323	5,118,740	5,021,267	4,619,920	28.97%
Total	17,497,165	15,677,320	14,266,196	13,900,677	14,780,184	15,949,301	
Louisiana							
Shore Ocean (< 3 nmi)	62,712	38,930	11,664	48,893	152,094	247,502	5.31%
Shore Inland	870,042	730,053	717,006	1,073,035	978,657	1,101,517	23.63%
Charter Ocean (<3 nmi)	10,468	3,931	2,762	6,937	3,646	5,058	0.11%
Charter Ocean (>3 nmi)	32,805	21,173	8,106	15,742	19,827	15,373	0.33%
Charter Inland	135,915	157,692	68,018	90,057	91,192	101,935	2.19%
Private/Rental Ocean (<3 nmi)	97,797	81,008	59,347	77,986	116,854	82,512	1.77%
Private/Rental Ocean (>3 nmi)	89,859	99,352	11,568	80,952	88,503	65,730	1.41%
Private/Rental Inland	3,320,459	2,995,875	2,984,016	3,182,645	2,685,791	3,041,527	65.25%
Total	4,620,057	4,128,014	3,862,487	4,576,247	4,136,564	4,661,154	
Mississippi							
Shore Ocean (< 3 nmi)	0	143	0	0	811	0	0.00%
Shore Inland	359,438	309,612	596,544	760,788	947,075	763,983	43.39%
Charter Ocean (<3 nmi)	4,286	2,803	904	3,123	1,628	2,190	0.12%
Charter Ocean (>3 nmi)	718	330	949	221	125	153	0.01%
Charter Inland	8,229	7,656	4,989	7,891	9,738	8,911	0.51%
Private/Rental Ocean (<3 nmi)	12,056	16,962	12,419	18,682	4,116	6,124	0.35%
Private/Rental Ocean (>3 nmi)	28,007	26,316	4,626	12,974	41,137	53,886	3.06%
Private/Rental Inland	555,951	715,505	612,162	811,711	945,819	925,512	52.56%
Total	968,685	1,079,327	1,232,593	1,615,390	1,950,449	1,760,759	
Gulf of Mexico Total CPA and EPA Effort Data							
Shore Ocean (< 3 nmi)	3,389,196	3,049,210	2,069,512	2,634,633	3,102,874	5,244,222	20.78%
Shore Inland	5,386,662	5,282,891	5,712,992	6,295,188	6,403,497	5,572,896	22.09%
Charter Ocean (<3 nmi)	212,531	212,653	171,843	209,814	263,725	227,771	0.90%
Charter Ocean (>3 nmi)	326,869	319,767	229,680	300,667	355,413	393,856	1.56%
Charter Inland	279,645	289,846	178,668	224,125	264,781	285,301	1.13%
Private/Rental Ocean (<3 nmi)	3,981,802	2,835,163	2,443,931	2,189,448	2,346,282	2,779,762	11.02%

Area	2008	2009	2010	2011	2012	2013	% of State Total in 2013
Private/Rental Ocean (>3 nmi)	1,434,875	1,011,948	767,080	782,987	1,017,007	1,534,598	6.08%
Private/Rental Inland	9,778,272	9,595,770	9,473,727	9,938,917	9,418,904	9,195,239	36.44%
Total	24,789,852	22,597,248	21,047,433	22,575,779	23,172,483	25,233,645	

Source: USDOC, NMFS, 2016c.

Table 4-24 presents data on the most commonly landed species by recreational fishermen in Louisiana, Mississippi, and Alabama combined from 2008 to 2013. Landings data for these states are presented separate from data for West Florida since most OCS oil- and gas-related activities will occur offshore of Louisiana, Mississippi, and Alabama. Some of the most popular recreational species in these states are spotted seatrout (*Cynoscion nebulosus*), red drum (*Sciaenops ocellatus*), Atlantic croaker (*Micropogonias undulatus*), sand seatrout (*Cynoscion arenarius*), Spanish mackerel (*Scomberomorus maculatus*), and black drum (*Pogonias cromis*). In 2013, landings of most species were similar to landings observed in prior years. However, there were noticeable increases in landings of red drum, black drum, red snapper, and Spanish mackerel; sand seatrout landings were lower in 2013 than had been observed in prior years. Dolphin landings decreased from 96,899 in 2008 to much lower levels from 2009 through 2012, and then increased to 31,524 in 2013.

Table 4-24. CPA and EPA Catch Data: Number of Fish Species Caught by Recreational Anglers from 2008 through 2013 in Louisiana, Mississippi, and Alabama Combined.

Species/Year	2008	2009	2010	2011	2012	2013
Atlantic Croaker	4,648,460	4,696,500	4,907,698	7,461,690	4,757,605	4,562,458
Black Drum	1,819,040	1,645,416	1,544,695	1,768,605	1,629,633	2,472,942
Blackfin Tuna	57,274	59,046	1,793	33,008	64,007	35,705
Cobia	31,484	21,575	3,519	50,263	25,105	40,448
Dolphins	96,899	7,200	2,174	911	9,418	31,524
Gag	45,383	42,835	10,274	13,523	12,939	20,573
Gray Snapper	233,841	255,943	33,479	142,062	451,724	375,596
Great Amberjack	29,728	28,422	16,982	56,163	15,962	30,410
King Mackerel	35,373	82,508	38,069	70,898	124,839	124,211
Little Tuny	18,529	9,520	14,175	28,660	40,005	17,172
Pinfishes	474,606	454,356	521,732	1,460,956	1,101,630	1,227,257
Red Drum	7,292,431	6,467,215	7,486,800	6,809,940	6,305,267	9,009,223
Red Grouper	12	774	2,296	0	168	2,326
Red Snapper	905,870	894,732	368,901	851,662	607,516	1,743,402
Sand Seatrout	4,052,323	5,294,998	5,715,702	7,115,540	5,194,418	3,768,286
Sheepshead	1,643,546	1,422,352	1,183,531	1,966,957	1,163,684	1,334,601
Southern Flounder	557,809	825,776	982,237	964,675	1,016,969	1,320,715
Southern Kingfish	1,350,161	1,190,382	1,045,644	1,075,935	760,688	1,180,114
Spanish Mackerel	196,011	200,662	397,247	541,435	844,101	2,525,453

Species/Year	2008	2009	2010	2011	2012	2013
Spotted Seatrout	24,013,172	21,657,958	15,118,683	19,843,879	20,452,196	22,327,595
Striped Mullet	322,245	293,375	866,308	1,412,632	1,163,763	1,623,070
White Grunt	0	1,084	0	0	0	0

Source: USDOC, NMFS, 2016c.

Table 4-25 presents data on the species most commonly landed by recreational fishermen in West Florida from 2008 to 2013. These species include pinfish (*Lagodon rhomboides*), spotted seatrout, gray snapper (*Lutjanus griseus*), Spanish mackerel, white grunt (*Haemulon plumieri*), and red grouper (*Epinephelus morio*). In 2013, landings of most species were similar to landings observed from 2008 through 2012. However, there were noticeable increases in landings of dolphins, gray snapper, and Spanish mackerel; there were noticeable decreases in landings of sand seatrout and spotted seatrout.

Table 4-25. CPA and EPA Catch Data: Fish Species Caught by Recreational Anglers from 2008 through 2013 in West Florida.

Species/Year	2008	2009	2010	2011	2012	2013
Atlantic Croaker	372,271	333,201	429,614	488,456	468,451	437,425
Black Drum	156,391	125,064	218,938	115,842	112,817	219,579
Blackfin Tuna	80,613	25,933	30,354	20,821	44,190	56,765
Cobia	128,670	64,532	58,880	59,124	69,045	71,391
Dolphins	543,588	394,692	267,944	455,918	359,146	1,922,167
Gag	4,511,351	2,926,723	2,250,467	1,255,515	1,112,826	1,382,809
Gray Snapper	7,082,879	4,190,312	2,418,388	2,658,705	4,073,840	6,618,012
Great Amberjack	219,182	183,807	365,690	194,791	151,623	327,080
King Mackerel	338,965	591,022	252,995	173,914	242,302	291,727
Little Tuny	185,031	158,836	126,299	173,102	296,492	157,557
Pinfishes	15,637,922	9,422,451	9,893,857	7,390,804	12,258,510	9,675,256
Red Drum	3,017,880	1,665,659	2,231,738	3,182,220	2,713,322	2,560,823
Red Grouper	3,105,147	3,171,464	2,240,450	2,009,532	2,009,920	3,166,786
Red Snapper	1,883,804	2,046,716	1,400,636	1,189,850	1,408,331	2,322,435
Sand Seatrout	1,282,681	1,337,450	613,338	1,152,573	2,157,703	899,277
Sheepshead	1,412,235	1,489,548	1,700,583	1,882,258	1,805,203	1,608,128
Southern Flounder	37,117	11,332	9,522	23,120	33,346	28,887
Southern Kingfish	240,040	227,140	404,764	87,367	74,894	93,384
Spanish Mackerel	3,742,003	2,938,091	3,643,511	2,934,531	2,434,336	4,986,910
Spotted Seatrout	11,127,967	9,042,259	9,584,787	12,856,960	12,545,581	9,165,609
Striped Mullet	1,083,471	674,022	925,554	801,743	1,395,641	1,555,565
White Grunt	3,721,050	2,283,923	2,494,075	2,852,807	3,405,536	4,701,436

Source: USDOC, NMFS, 2016c.

WPA Catch and Effort Data

Table 4-26 provides data on the number of recreational fishing trips in Texas bays, State waters, and the Exclusive Economic Zone during each season of 2011-2015 (Fisher, official communication, 2016). There were 1,043,098 angler trips in 2015, slightly lower than in prior years. The least amount of recreational fishing occurs in Federal waters, where most OCS oil- and gas-related activities occur. In 2015, 95.3 percent of fishing occurred in bays, 3.2 percent occurred in State ocean waters (Texas Territorial Sea), and 1.5 percent occurred in Federal offshore waters. Texas divides its data into two fishing seasons: Season A (November 21-May 14) and Season B (May 15-November 20). In 2015, 71 percent of angler trips occurred in Season B, and 14 percent of trips occurred by charter boats. In recent years, fishing during Season A has been gradually declining, while fishing during Season B has been relatively stable.

Table 4-27 provides data regarding the individual species caught by anglers in Texas during 2011-2015. Panel A presents overall catch data in Texas, while Panels B, C, and D present catch data for Texas bays, State waters, and the Exclusive Economic Zone. Consistent with the effort data, most recreational fishing catch occurs in bays. The most popular species in bays include spotted seatrout, red drum, black drum, and Atlantic croaker. Red snapper (*Lutjanus campechanus*) and king mackerel (*Scomberomorus cavalla*) are the most popular species in Federal waters. The 2015 landings of most species were in the ranges observed in prior years. However, landings of sand seatrout continued on a downward trend. Landings of Atlantic croaker.were steady from 2011 through 2013, but then decreased noticeably in 2014, then increased in 2015 to a higher level than observed in any of the prior years.

Table 4-26. Texas Effort Data: Number of Angler Trips from 2011 through 2015.

2011											
	Season A				Season B				Annual Total		
Area	Private	Charter	Total		Private	Charter	Total		Private	Charter	Total
Bay	330,461	29,842	360,303		576,735	122,855	699,590		907,196	152,697	1,059,893
TTS	14,830	4,779	19,609		24,372	2,988	27,360		39,202	7,767	46,969
EEZ	1,424	850	2,274		15,138	1,126	16,264		16,562	1,976	18,538
Total	346,715	35,471	382,186		616,245	126,969	743,214		962,960	162,440	1,125,400
2012											
	Season A				Season B				Annual Total		
Area	Private	Charter	Total		Private	Charter	Total		Private	Charter	Total
Bay	331,889	87,696	419,585		563,656	134,502	698,158		895,545	222,198	1,117,743
TTS	7,563	1,172	8,735		15,375	1,622	16,997		22,938	2,794	25,732
EEZ	1,270	0	1,270		12,668	1,774	14,442		13,938	1,774	15,712
Total	340,722	88,868	429,590		591,699	137,898	729,597		932,421	226,766	1,159,187
2013											
	Season A				Season B				Annual Total		
Area	Private	Charter	Total		Private	Charter	Total		Private	Charter	Total
Bay	350,918	39,054	389,972		613,508	101,135	714,643		964,426	140,189	1,104,615
TTS	5,193	111	5,304		18,559	2,269	20,828		23,752	2,380	26,132

2011											
	Season A				Season B				Annual Total		
EEZ	989	575	1,564		15,695	1,592	17,286		16,684	2,166	18,850
Total	357,100	39,740	396,840		647,761	104,996	752,757		1,004,861	144,735	1,149,597
2014											
	Season A				Season B				Annual Total		
Area	Private	Charter	Total		Private	Charter	Total		Private	Charter	Total
Bay	292,988	30,722	323,710		605,314	101,802	707,116		898,302	132,524	1,030,826
TTS	3,550	127	3,677		18,886	2,664	21,550		22,436	2,791	25,227
EEZ	510	0	510		10,403	2,159	12,562		10,913	2,159	13,072
Total	297,048	30,849	327,897		634,603	106,625	741,228		931,651	137,474	1,069,125
2015											
	Season A				Season B				Annual Total		
Area	Private	Charter	Total		Private	Charter	Total		Private	Charter	Total
Bay	262,952	36,570	299,522		590,080	104,155	694,235		853,032	140,725	993,757
TTS	4,888	546	5,434		25,294	3,105	28,399		30,182	3,651	33,833
EEZ	62	0	62		12,926	2,520	15,446		12,988	2,520	15,508
Total	267,902	37,116	305,018		628,300	109,780	738,080		896,202	146,896	1,043,098

EEZ = Exclusive Economic Zone; TTS = Texas Territorial Sea

(1) Season A is November 21 - May 14 and Season B is May 15 - November 20.

(2) These data are presented in terms of person-trips. This means that if multiple people go fishing at the same time on the same boat that is counted as multiple trips.

Source: Fisher, official communication, 2016.

Table 4-27. Texas Catch Data: Top Species Landed by Recreational Fishermen.

Panel A: Total Landings							Panel B: Landings in Bays					
Species	2011	2012	2013	2014	2015		Species	2011	2012	2013	2014	2015
Atlantic Croaker	156	157	152	117	213		Atlantic Croaker	154	156	151	117	213
Black Drum	129	256	150	139	127		Black Drum	127	256	150	139	127
King Mackerel	9	9	10	13	8		King Mackerel	–	–	–	–	--
Red Drum	347	323	269	246	241		Red Drum	344	321	266	245	240
Red Snapper	36	34	47	40	50		Red Snapper	–	–	–	–	--
Sand Seatrout	226	177	151	146	109		Sand Seatrout	220	169	150	145	108
Sheepshead	57	143	84	39	51		Sheepshead	57	143	84	39	51
Southern Flounder	92	96	92	71	85		Southern Flounder	92	96	92	71	85
Spotted Seatrout	1,137	810	795	590	824		Spotted Seatrout	1,119	798	789	585	809
Panel C: Landings in State Waters							Panel D: Landings in the Exclusive Economic Zone					
Atlantic Croaker	2	1	–	–	--		Atlantic Croaker	–	–	1	–	--
Black Drum	2	–	–	–	--		Black Drum	–	–	–	–	--
King Mackerel	5	4	4	6	4		King Mackerel	4	5	6	7	4
Red Drum	3	2	2	1	1		Red Drum	–	–	1	–	--
Red Snapper	22	21	30	33	34		Red Snapper	14	13	17	7	16

Sand Seatrout	5	8	1	1	1		Sand Seatrout	1	–	–	–	--
Sheepshead	–	–	–	–	--		Sheepshead	–	–	–	–	--
Southern Flounder	–	–	–	–	--		Southern Flounder	–	–	–	–	--
Spotted Seatrout	18	11	6	5	14		Spotted Seatrout	–	1	–	–	1

(1) Fish landings are presented in thousands of fish.
(2) The TPWD presents data in terms of two seasons: Season A is November 21 - May 14 and Season B is May 15 - November 20. Therefore, the annual data reflects combined catch for Seasons A and B. For example, the catch data for 2013 reflects catch from November 21, 2012 to November 20, 2013.

Source: Fisher, official communication, 2016.

Economic Impacts of Recreational Fishing

Recreational fishing can affect regional economies in various ways. Most directly, anglers affect the economy through spending on fishing-related goods and services. This direct spending includes trip expenditures and expenditures on durable equipment. Direct angler spending supports firms in related industries along an economy's supply chain. In addition, spending by fishermen serves as income to other actors in an economy, which supports overall spending patterns. The NMFS conducted an analysis that quantified this dependence of regional economies on recreational fishing activity (USDOC, NMFS, 2016c); this analysis utilized the techniques of an earlier study by Gentner and Steinback (2008). These studies utilized input-output economic models, which create multipliers that predict the sales, value-added, and jobs that result from direct angler spending. The levels of value-added and employment supported by recreational fishing in each Gulf Coast State in 2014 are listed below.

- West Florida ($4,868,743; 70,109 jobs)
- Louisiana ($1,029,281; 15,241 jobs)
- Texas ($1,205,146; 16,496 jobs)
- Alabama ($827,849; 14,124 jobs)
- Mississippi ($247,281; 4,174 jobs)

4.11.2 Environmental Consequences

The impacts from routine activities and accidental events, and the cumulative impacts to recreational fishing that would arise from projected activities from a proposed lease sale are analyzed in this chapter. While there are some differences in the amount of activities associated with the alternatives, many of the impacts associated with the alternatives are similar. Therefore, this chapter will describe the impacts that are expected to apply to all alternatives, while any deviations from these impact conclusions will be discussed in **Chapters 4.11.2.5-4.11.2.9**.

4.11.2.1 Routine Activities

Routine OCS oil and gas operations (such as anthropogenic sound, bottom disturbances, service-vessel traffic, and production structure emplacement) can affect recreational fisheries by impacting populations of recreationally targeted species. The impacts of anthropogenic sound and short-term bottom disturbances on fish populations are discussed in **Chapter 4.7** (Fish and Invertebrate Resources). The corresponding impacts of anthropogenic sound on recreational fishing would be **negligible** to **minor** because disruptions to fish populations could reduce landings in proportion to the amount of recreational fishing activities in an area (refer to **Chapter 4.11.1**). The exact impacts would depend on the locations of activities, the species affected, the intensity of recreational fishing activity in the affected area, and the substitutability of any lost fishing access.

The OCS oil- and gas-related vessel traffic could also cause space-use conflicts with recreational fishermen. The OCS vessel traffic would occur between ports that service the offshore industry and drilling and production facilities in Federal waters. However, there is limited spatial overlap between recreational fishing and oil and gas ports. In addition, most recreational fishing activities in the Gulf of Mexico occur inland or in State waters. Finally, recreational vessels can often easily avoid temporary OCS vessel traffic. Therefore, the impacts of OCS oil- and gas-related vessel traffic on recreational fishing are expected to be **negligible** to **minor**. The exact impacts would depend on the locations of activities, the species affected, the intensity of recreational fishing activity in the affected area, and the substitutability of any lost fishing access.

The impacts of short-term bottom disturbances on recreational fishing are expected to be **negligible** because the impacts to fish populations would similarly be **negligible** and because most recreational fishing does not target bottom-dwelling species that are more likely to be impacted by these disturbances. The installation of production platforms can enhance recreational fishing opportunities because platforms often attract recreationally important species. Hiett and Milon (2002) estimate that 20.2 percent of private boat fishing, 32.2 percent of charter boat fishing, and 50.9 percent of party boat fishing in Texas, Louisiana, Mississippi, and Alabama combined occur within 300 ft (91 m) of an oil or gas structure in State or Federal waters. However, the removal of a platform would preclude its use for recreational fishing unless it is redeployed as artificial reef substrate as part of an artificial reef program (**Chapter 3.3.2.1.2**). The BSEE presents more information regarding the status of Rigs-to-Reefs activities in the Gulf of Mexico (USDOI, BSEE, 2015f). Ajemian et al. (2015) analyze the fish community structures at operational platforms, decommissioned platforms that were reefed using a variety of methods, and Liberty Ships (World War II era ships that now serve as artificial reefs) offshore Texas. This study found that recreationally important species such as red snapper were prevalent among all types of platform structures, suggesting that the reefing of a platform could maintain some of the properties desired by recreational fishermen. The structures installed due to a proposed lease sale would likely have **beneficial (low)** to **minor** impacts on recreational fishing because of the limited amount of activity that occurs in Federal waters (**Chapter 4.11.1**) and because the positive and negative effects of routine OCS oil- and gas-related activities that modify habitat (i.e., infrastructure emplacement and decommissioning) would partially offset each other.

4.11.2.2 Accidental Events

Oil spills can arise from accidents with respect to vessels, pipelines, drilling operations, or production operations. The potential impacts of oil spills on fish populations that support recreational fishing are described in **Chapter 4.7** (Fish and Invertebrate Resources). Oil spills can also lead to localized fishing closures that could directly impact fishermen's access to fish resources. The corresponding impacts to recreational fishing would depend on the types and scales of recreational fishing activities in an impacted area, which are discussed in **Chapter 4.11.1**. For example, red snapper is a popular recreational species that is prevalent near oil and gas platforms. Therefore, an oil spill that occurred near a platform could impact recreational fishing for red snapper and other reef fish, at least in the short term. An oil spill could also dissuade anglers if it affected the aesthetics of fishing in an area. For example, anglers could be dissuaded by perceived oil in water, tainted fish populations, or response activities. Reductions in recreational fishing could also impact the various firms that supply goods and services to anglers. Gentner Consulting Group (2010) presents a methodology for estimating the economic impacts of an oil spill in the Gulf of Mexico that entails estimating State-level recreational fishing levels and then scaling these levels by the size and duration of a closure area. However, these economic impacts would likely be **negligible** to **minor** because an oil spill arising from a proposed lease sale would likely be small and localized, leaving recreational fishermen numerous alternative fishing sites. The exact impacts would depend on the locations of oil spills, the species affected, the intensity of recreational fishing activity in the affected area, and the substitutability of any lost fishing access. In addition, as shown in the effort and landings data above, recreational fishing activity recovered fairly quickly in the aftermath of the *Deepwater Horizon* explosion, oil spill, and response, which was much larger than any reasonably foreseeable spill from a proposed lease sale.

4.11.2.3 Cumulative Impacts

A proposed lease sale would contribute to the impacts of the overall OCS Program, as well as the impacts of various non-OCS sources. The cumulative analysis will describe these various impacts, and will then reach impact conclusions regarding the incremental impacts of a proposed lease sale relative to these OCS and non-OCS sources. The geographic bounds of the analysis increase from site-specific impacts to regionwide impacts. The temporal bounds of the analysis correspond to the life cycle of activities forecasted to arise from leasing activities (refer to **Chapter 3**).

OCS Oil- and Gas-Related Impacts

A proposed lease sale would add to the impacts to fish populations from sound and short-term bottom disturbances arising from the overall oil- and gas-related activities of past and future lease sales (refer to **Chapter 4.7**, Fish and Invertebrate Resources). As discussed above, these would have impacts to recreational fishing to the extent that angler effort and species' landings are impacted. A proposed lease sale would also add to the space-use conflicts with recreational fishermen that arise from the OCS Oil and Gas Program. A proposed lease sale would also add to the impacts to recreational fishing resulting from accidental events, such as oil spills, arising from the

OCS oil- and gas-related activities from past and future lease sales. The scales of these impacts are similar as to those discussed above, but they would be proportionally higher to the larger scale of the OCS Oil and Gas Program compared with a proposed lease sale.

As discussed above, oil and gas platforms generally enhance opportunities for recreational fishing. Conversely, structure removals prevent the use of those structures for recreational fishing. The number of platforms in the Federal Gulf of Mexico fell from a peak of 4,049 in 2001 (USDOI, BSEE, 2015g) to 2,225 in 2016 (USDOI, BOEM, 2016f), which has reduced opportunities for recreational fishing in certain areas. However, anglers still have numerous places to fish, including artificial reefs (some of which have been created out of decommissioned platforms) and natural habitat features. A proposed lease sale would initially have positive incremental impacts on recreational fishing because more structures would be installed than if the lease sale did not occur. The eventual removals would offset those impacts unless some structures were maintained through Rigs-to-Reefs programs (discussed above and in **Chapter 3.3.2.1.2**).

Overall OCS oil- and gas-related impacts to recreational fishing will range from **beneficial (medium)** to **moderate**. Negative impacts arising from impacts to fish populations, space-use conflicts, and accidental events will be greater than for an individual lease sale. The overall number of production structures also serves more of a beneficial role for reef fishing, although the corresponding decommissioning of these structures negatively impacts recreational fishing. However, as discussed above, most recreational fishing in the Gulf of Mexico occurs close to shore. The exact impacts would depend on the locations of activities, species affected, intensity of recreational fishing activity in the affected area, and substitutability of any lost fishing access.

Non-OCS Oil- and Gas-Related Impacts

A proposed lease sale would contribute to the impacts of oil and gas activities in State waters, which are described in **Chapter 3.3.2.1**. The nature of these impacts would be similar to activities in Federal waters, although the impacts on recreational fishing depend on the intensity and species sought in a particular area. As discussed in **Chapter 4.11.1**, 1.5 percent of recreational fishing in Texas occurs in Federal waters, while 7.6 percent of angler effort in the four other Gulf Coast States combined occurs in Federal waters.

Recreational fishing in the Gulf of Mexico also encounters space-use conflicts with recreational, commercial, and military vessels. Marinevesseltraffic.com (2015) provides maps of current and historical vessel traffic in the Gulf of Mexico. There is a large amount of vessel traffic in the Gulf of Mexico, particularly near major ports. This vessel traffic causes various localized conflicts with recreational fishermen.

Tropical storms and hurricanes can impact boats and other infrastructure that support recreational fishing. Recreational fishing would also be negatively affected by wetlands loss or other ecosystem degradation. Recreational fishing would also be affected by any impact-producing factor, such as a non-OCS oil- and gas-related accidental event, that affects the aesthetics of a particular fishing site. Recreational fishing would also be positively correlated with general trends in tourism (discussed in **Chapter 4.12**, Recreational Resources) and the overall economy (discussed in **Chapter 4.14.2**, Economic Factors). Finally, recreational fishing activity is heavily influenced by regulations and artificial reef development (discussed in **Chapter 4.11.1**).

Overall non-OCS oil- and gas-related impacts to recreational fishing will range from **beneficial (high)** to **major**. This wide range reflects the myriad of non-OCS oil- and gas-related impacts that could occur over the timeframe of this cumulative analysis. For example, hurricanes, wetlands loss, or economic developments could cause major impacts to recreational fisheries. Similarly, economic developments, artificial reef development, or regulatory changes could significantly benefit recreational fishing. However, the most likely case is that regulatory actions and economic adjustments will serve to stabilize any major shocks to recreational fishing activities and that recreational fishing will occur within the ranges observed in prior years.

Incremental Impacts

Relative to all OCS- oil- and gas-related and non-OCS oil- and gas-related activities, a proposed lease sale would have **beneficial (low)** (due to fish attraction at platforms and the potential use of decommissioned platforms as rigs-to-reefs) to **minor** adverse incremental impacts (due to impacts to fish populations, space-use conflicts, and oil spills) on recreational fishing activities because of the limited amount of activity and because the positive and negative impacts would partially offset each other.

4.11.2.4 Incomplete or Unavailable Information

BOEM has identified incomplete or unavailable information regarding the extent to which recreational fishing is dependent upon OCS platforms, as well as on the site-specific determinants of this dependency. In lieu of this incomplete or unavailable information, BOEM used existing information and reasonably accepted scientific methodologies. For example, BOEM used data on recreational fishing activity provided by the Texas Parks and Wildlife Department and NMFS to examine trends in recreational fishing in various areas. BOEM has also used information from Heitt and Milon (2002) and Ajemian et al. (2015), which provide some information on the scale and location of platform-dependent recreational fishing. BOEM does not expect the incomplete or unavailable information to significantly change its estimates of the impacts of the OCS Program on recreational fishing activity because BOEM still has enough baseline data to reasonably estimate impacts. Therefore, BOEM has determined that the incomplete or unavailable information is not essential to a reasoned choice among alternatives.

4.11.2.5 Alternative A—Regionwide OCS Lease Sale (The Preferred Alternative)

The impacts of Alternative A would correspond to the impacts discussed in **Chapter 4.11.2**. Namely, a proposed lease sale could affect recreational fishing by affecting fish populations or by affecting the socioeconomic aspects of recreational fishing. The impacts of Alternative A on fish populations are presented in **Chapter 4.7** (Fish and Invertebrate Resources) and include impacts due to anthropogenic sound, short-term bottom disturbances, and habitat modifications. Vessel traffic arising from Alternative A could cause space-use conflicts with anglers. Structure emplacement generally enhances recreational fishing, although this **beneficial (low)** impact would be offset during decommissioning unless a structure was maintained as an artificial reef. Accidental events, such as oil spills, could cause fishing closures and affect the aesthetics of fishing in an area. However, these impacts would be **negligible** to **minor** because the oil spills forecast to arise from a proposed action would be small and localized. Alternative A should also be viewed in light of overall trends in OCS platform decommissioning, State oil and gas activities, overall vessel traffic, severe weather, economic factors, and Federal and State fisheries management strategies. The incremental impacts of Alternative A on recreational fisheries are expected to be **beneficial (low)** to **minor** because of the relatively small scale of a proposed lease sale and because the positive and negative effects would partially offset each other. The exact impacts would depend on the locations of activities, the species affected, the intensity of recreational fishing activity in the affected area, and the substitutability of any lost fishing access.

4.11.2.6 Alternative B—Regionwide OCS Proposed Lease Sale Excluding Available Unleased Blocks in the WPA Portion of the Proposed Lease Sale Area

Alternative B entails leasing only in the CPA/EPA, which is a subset of the area considered in Alternative A. Therefore, the analysis of Alternative A covers the potential impacts of Alternative B. There are some differences (described in **Chapter 4.11.1**) in the types and scales of recreational fishing in the WPA compared with the CPA/EPA. For example, 1.5 percent of recreational fishing in Texas occurs in Federal waters, while 7.6 percent of recreational fishing in the other Gulf Coast States combined occurs in Federal waters. However, these differences are not large enough to change the impact conclusions (discussed above) for Alternatives A and B. This is because Alternative B entails conducting most of the OCS oil- and gas-related activities proposed under Alternative A.

4.11.2.7 Alternative C—Regionwide OCS Proposed Lease Sale Excluding Available Unleased Blocks in the CPA/EPA Portions of the Proposed Lease Sale Area

Alternative C entails leasing only in the WPA, which is a subset of the area considered in Alternative A. Therefore, the analysis of Alternative A covers the potential impacts of Alternative C. There are some differences (described in **Chapter 4.11.1**) in the types and scales of recreational fishing in the WPA compared with the CPA/EPA. For example, 1.5 percent of recreational fishing in Texas occurs in Federal waters, while 7.6 percent of recreational fishing in the other Gulf Coast States combined occurs in Federal waters. In addition, a proposed WPA lease sale would likely lead to much fewer oil and gas activities than a proposed regionwide lease sale. However, these differences are not large enough to change the range of impact conclusions (discussed above) for Alternatives A and C. However, due to the lower levels of OCS oil- and gas- related activities associated with Alternative C than Alternative A, the probability that an impact would be **negligible** (rather than minor) would be higher for Alternative C.

4.11.2.8 Alternative D—Alternative A, B, or C, with the Option to Exclude Available Unleased Blocks Subject to the Topographic Features, Live Bottom (Pinnacle Trend), and/or Blocks South of Baldwin County, Alabama, Stipulations

Alternative D entails leasing a subset of the area considered in Alternatives A, B, or C by making blocks that would normally be subject to the Topographic Features, Live Bottom (Pinnacle Trend), and/or Blocks South of Baldwin County, Alabama, Stipulations unavailable for lease. Alternative D would not exclude large areas to recreational fishing (refer to **Chapter 4.12.1**). Alternative D would reduce any potential conflict with OCS oil- and gas-related activities, but it would prevent the potential for beneficial effects from new platforms or other fish attractions in the blocks. Due to the size of the Alternative D blocks relative to the areas in which recreational fishing occurs, the range of impact conclusions (which are discussed above) for Alternatives A and D are the same.

4.11.2.9 Alternative E—No Action

Alternative E would prevent the beneficial (low) to minor impacts associated with a proposed lease sale, as discussed above. Beneficial impacts of fish attraction to new platforms or decommissioned platforms turned into reefs would be negated. Negligible to minor adverse impacts, such as space-use conflicts, oil spills, or direct harm to fish populations, would be avoided. Since there is an expansive existing oil and gas industry, Alternative E would cause some economic adjustments (refer to **Chapter 4.14.2**), which could cause **negligible** impacts to recreational fishing activities. For example, Alternative E would cause workers in the oil and gas industry's supply chain to lose income, which could slightly lessen their propensity to go recreational fishing. However, recreational fisheries would still be subject to the impacts from other ongoing activities related to previous lease sales under the OCS Oil and Gas Program, as well as the impacts from the non-OCS oil- and gas-related sources discussed above.

4.12 RECREATIONAL RESOURCES

Recreational resources are natural or manmade things that are used as part of activities that are primarily for human enjoyment.

This chapter analyzes the potential impacts of routine activities and accidental events associated with a proposed action on recreational resources, as well as a proposed action's incremental contribution to the cumulative impacts to recreational resources. The approach of the analysis is to focus on the potential impact-producing factors from OCS oil- and gas-related routine activities (i.e., exploration, development, and production), accidental events and cumulative impacts, and to define the impact-level measures for each impact-producing factor.

Impact-Level Definitions

In this chapter (and in the analyses of the alternatives) the impact measures are defined in terms of the intensity, duration, and geographical extent of the impacts to the human uses of recreational resources along the Gulf Coast. Long-term impacts are those lasting more than 1 year. Extensive impacts are those for which it is difficult to find substitute recreational activities nearby, while severe impacts mostly or completely diminish the recreational value of a resource. In particular, the impacts of each impact-producing factor are summarized in **Table 4-28** using the impact-level measures below to help the reader quickly understand the potential impacts of a lease sale on recreational resources. The analyses supporting these conclusions are then discussed in detail.

- **Beneficial** – Impacts would be positive. The level of benefical impacts are specified in the analysis, which could be low, medium, or high.
- **Negligible** – Little or no detectable adverse impact.
- **Minor** – Adverse impacts are detectable but less than severe.
- **Moderate** – Adverse impacts are severe but are short term and/or not extensive.
- **Major** – Adverse impacts are long term, extensive, and severe.

Table 4-28. Recreational Resources Impact-Producing Factors That Are Reasonably Foreseeable.

Recreational Resources	Magnitude of Potential Impact[1]				
Impact-Producing Factors	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
Routine Activities					
Space-Use Conflicts	Negligible to Minor	Negligible to Minor	Negligible to Minor	Negligible to Minor	Negligible
Structure Emplacement and Removal	Beneficial to Minor	Beneficial to Minor	Beneficial to Minor	Beneficial to Minor	Negligible
Visual Impacts	Negligible to Minor	Negligible to Minor	Negligible	Negligible to Minor	Negligible
Indirect Econoic Impacts	Beneficial to Minor	Beneficial to Minor	Beneficial to Minor	Beneficial to Minor	Negligible
Accidental Events					
Oil Spills	Negligible to Minor	Negligible to Minor	Negligible to Minor	Negligible to Minor	Negligible
Marine Debris	Negligible to Minor	Negligible to Minor	Negligible to Minor	Negligible to Minor	Negligible
Cumulative Impacts					
Incremental Contribution[2]	Beneficial to Minor	Beneficial to Minor	Beneficial to Minor	Beneficial to Minor	Negligible
OCS Oil and Gas[3]	Beneficial to Moderate				
Non-OCS Oil and Gas[4]	Beneficial to Major				

[1] The analysis supporting these conclusions is discussed in detail in the “Environmental Consequences” chapter below.

[2] This includes all activities (i.e., routine activities projected to occur and accidental events that could occur) as a result of a single proposed lease sale in the 2017-2022 Five-Year Program.
[3] This includes all activities (i.e., routine activities projected to occur and accidental events that could occur) from past, proposed, and future lease sales.
[4] This includes other past, present, and reasonably foreseeable future activities occurring within the same geographic range and within the same timeframes as a proposed action, but they are not related to the OCS Oil and Gas Program.

4.12.1 Description of the Affected Environment

The GOM is home to various resources that support recreational activities. These include ocean-based resources as well as resources in counties and parishes along the Gulf of Mexico. The overall scales of recreation and tourism are discussed in the following section. The resources that support recreational activities are presented in subsequent sections and are organized according to the type of recreational resource.

Scales of Recreation and Tourism

Eastern Research Group (2014a) developed methodologies for estimating the amount of employment supported by recreation and tourism activities in a particular area. This entailed defining which industries comprise recreation and tourism, as well as estimating the percent of each industry that supports tourism. For example, the hotel industry is primarily supported by tourists, while the restaurant industry is supported by both tourists and local residents. BOEM has identified 23 Economic Impact Areas (EIAs), which are critical to understanding how a proposed action would affect human resources across the Gulf of Mexico (illustrated in **Figure 4-29** in **Chapter 4.14**). **Table 4-29** presents data on recreational employment, recreational value-added, tourism employment, and tourism value-added in the EIAs. **Table 4-29** was derived by applying data from IMPLAN Group, LLC. (2015) to the methodologies developed in Eastern Research Group (2014a). As can be seen, the recreation and tourism industries are sizable in many areas along the Gulf Coast. The areas with the largest recreation and tourism industries are TX-3 (which includes Houston and Galveston), LA-6 (which includes New Orleans), and various EIAs along the Florida coast. Parts of coastal Mississippi and Alabama also have sizeable recreational economies, which are supported by parks, beaches, and casinos.

Table 4-29. Recreational and Tourism Employment and Value-Added in BOEM's Economic Impact Areas in 2013.

EIA	Recreational Employment	Recreational Value-Added	Tourism Employment	Tourism Value-Added
TX-1	68,769	2,596,402,975	19,081	1,203,931,388
TX-2	48,362	1,868,401,512	15,225	739,484,187
TX-3	366,048	15,331,216,510	123,709	8,466,549,982
TX-4	5,033	188,869,415	1,227	100,190,697
TX-5	18,829	709,291,174	4,763	395,566,972
TX-6	1,417	53,257,782	387	23,864,658

LA-1	14,399	683,645,908	6,149	293,572,508
LA-2	2,799	105,494,355	775	46,049,357
LA-3	32,869	1,315,185,525	9,639	566,173,408
LA-4	17,725	788,255,437	6,269	274,186,740
LA-5	50,188	2,028,801,718	14,122	975,127,188
LA-6	89,036	4,458,755,918	34,493	1,976,234,240
LA-7	23,637	948,326,917	6,577	379,903,898
MS-1	33,103	1,560,781,492	14,167	545,645,437
MS-2	1,475	54,100,278	391	19,098,912
AL-1	37,649	1,274,887,170	10,477	681,999,085
AL-2	3,483	120,034,728	873	73,873,691
FL-1	72,212	2,756,594,208	24,852	1,233,121,800
FL-2	31,357	1,173,072,208	10,300	445,046,333
FL-3	7,954	278,409,013	2,438	114,397,442
FL-4	67,758	2,497,491,474	18,301	1,153,527,693
FL-5	254,735	11,239,013,764	80,319	4,948,465,196
FL-6	115,642	5,472,107,011	45,683	2,263,684,576
State Totals				
Texas EIAs	508,457	20,747,439,369	164,393	10,929,587,884
Louisiana EIAs	230,653	10,328,465,778	78,023	4,511,247,338
Mississippi EIAs	34,578	1,614,881,770	14,558	564,744,348
Alabama EIAs	41,132	1,394,921,898	11,349	755,872,776
Florida EIAs	549,658	23,416,687,679	181,891	10,158,243,038
All EIAs	1,364,478	57,502,396,493	450,215	26,919,695,385

EIA = Economic Impact Area.

Sources: Eastern Research Group, Inc.(2014a) and IMPLAN Group, LLC (2015).

Beaches

Beach visitation is one of the most popular activities along the Gulf Coast. The USEPA's "National List of Beaches" (USEPA, 2015e) is an online tool that lists and provides information regarding the beaches in any county or parish along the Gulf Coast. Texas and West Florida have the most beaches, although there are various beach areas in Louisiana, Mississippi, and Alabama. The National Survey on Recreation and the Environment estimates the following number of Americans age 16 and older that visited the beaches in each Gulf Coast State annually from 2005 through 2009: Florida (21,989,300); Texas (4,929,700); Alabama (1,527,900); Mississippi (956,700); and Louisiana (578,500) (Betz, official communication, 2010).

Wildlife Viewing

A variety of information regarding the scales of wildlife tourism in various Gulf Coast areas is presented in Lowe and Stokes (2013). For example, this report finds that over 1,100 wildlife guide businesses support over 11,000 dining and lodging businesses. This report estimated that wildlife tourism along the Gulf Coast supports over $19 billion in spending and generates over $5 billion in Federal, State, and local tax revenues. The three primary forms of wildlife tourism are fishing (which supports $8 billion in spending), wildlife watching (which supports $6.5 billion in spending), and hunting (which supports $5 billion in spending). Wildlife tourism supports the most spending in Florida ($8 billion) and Texas ($5 billion); wildlife tourism supports approximately $2 billion in spending each in Louisiana, Mississippi, and Alabama.

Artificial Reefs

Activities such as recreational fishing and diving are supported by various artificial reef structures in the Gulf of Mexico. Oil and gas platforms are particularly supportive of recreational fishing and diving activities; more information regarding the affected environment for recreational fishing is presented in **Chapter 4.11** (Recreational Fishing). The locations of oil and gas platforms in the GOM can be accessed on the, Energy Information Administration's online tool that lists all energy infrastructure in the GOM (USDOE, Energy Information Administration, 2015e). The Gulf Coast States also have programs to develop artificial reef structures (including decommissioned oil and gas structures) to support biological diversity and recreational activities. Details regarding these programs, including the locations of reef sites, are described in Fikes (2013). Additional information regarding BSEE's Rigs-to Reefs program can be found on BSEE's website (USDOI, BSEE, 2015f) and in **Appendix A**.

Marine Protected Areas

The GOM is home to many marine protected areas that support recreational activities such as wildlife viewing, nature experiences, and beach visitation. The marine protected areas in the GOM include various Federal and State entities, such as parks, wildlife refuges, national marine sanctuaries, and national seashores. A map of all of the marine protected areas in the Gulf of Mexico can be found on NOAA's website (USDOC, NOAA, 2015l). Estimates of the number of visitors, amount of spending, number of jobs, and amount of income in 2014 supported by each national park along the Gulf Coast are provided in Cullinane-Thomas et al. (2015). The number of visitors and the amount of visitor spending supported by parks along the Gulf Coast are listed below.

- Padre Island National Seashore (Texas) (578,814 visitors; $23,892,700)
- Jean Lafitte National Historical Park and Preserve (Louisiana) (445,524 visitors; $24,986,300)
- Gulf Islands National Seashore (Mississippi and Florida) (4,455,240 visitors; $185,611,000) (About 25 percent of these impacts occur in the Mississippi District.)
- De Soto National Memorial (Florida) (342,039 visitors; $19,182,600)
- Big Cypress National Preserve (Florida) (1,192,856 visitors; $91,111,200)

- Everglades National Park (Florida) (1,110,900 visitors; $104,476,500)
- Dry Tortugas National Park (Florida) (64,865 visitors; $3,783,600)

National seashores are expanses of sea coast maintained for the study of wildlife and for public recreational use. Additional details regarding the two national seashores in the Gulf of Mexico are presented below.

Gulf Islands National Seashore

The Gulf Islands National Seashore consists of two mainland portions and four barrier island portions in the northwest Florida panhandle, and a mainland section and six barrier islands in Mississippi (**Figure 4-26**). The Gulf Islands National Seashore was established by Congress in 1971 to preserve the outstanding natural and recreational values of these areas. In particular, these areas are used for diverse recreational activities such as swimming, camping, wildlife-watching, and wilderness experiencing. In 1978, Horn and Petit Bois Island were designated as having wilderness status. This status reflects the pristine and undeveloped nature of these islands. The Final General Management Plan of the Gulf Islands National Seashore provides detailed information regarding the recreational opportunities in various locations (USDOI, NPS, 2014a).

Padre Island National Seashore

The Padre Island National Seashore consists of a portion of Padre Island along the southern Gulf Coast of Texas. The Padre Island National Seashore was established in 1962 to protect the largest stretch of undeveloped barrier island in the world. The Padre Island National Seashore offers excellent opportunities for beach visitation, swimming, fishing, birdwatching, and windsurfing. More information regarding the recreational opportunities at the Padre Island National Seashore is provided in *Beach Vehicle Environmental Assessment for Padre Island* (USDOI, NPS, 2011b).

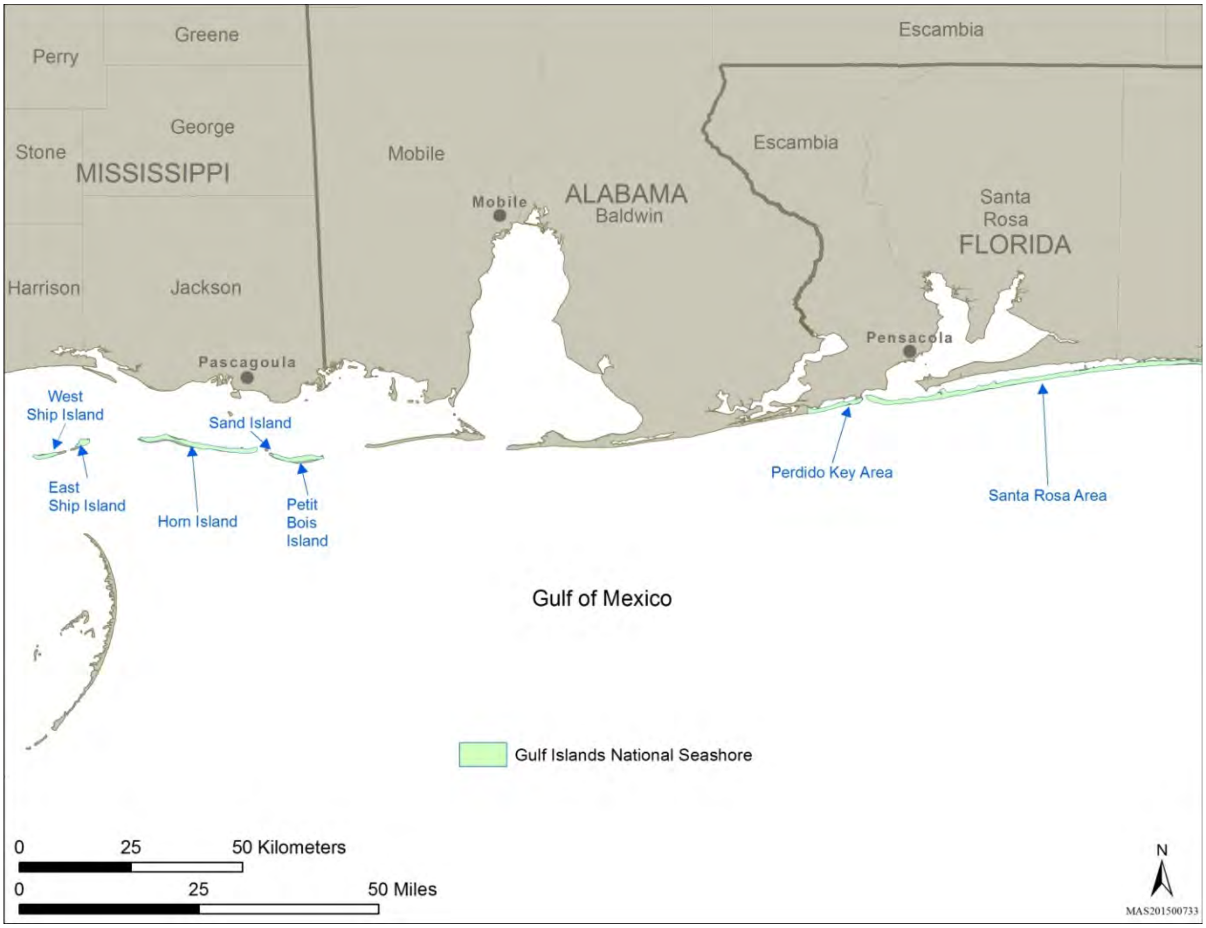

Figure 4-26. Gulf Islands National Seashore.

4.12.2 Environmental Consequences

The impacts from routine activities and accidental events, and the cumulative impacts to recreational resources that would arise from projected activities from a proposed action are analyzed in this chapter. While there are some differences in the amount of activities associated with the alternatives, many of the impacts associated with the alternatives are similar. Therefore, this chapter describes the impacts that are expected to apply to all alternatives, while any deviations from these impact conclusions are discussed in **Chapters 4.12.2.5-4.12.2.9**.

4.12.2.1 Routine Activities

The following routine OCS oil-and gas-related activities associated with a proposed action would potentially affect recreational resources: vessel traffic (**Chapter 3.1.4.3**); platforms serving as artificial reefs (**Chapter 3.1.6.2**); visibility of OCS platforms (**Chapter 3.1.3.4.3**); and economic factors.

The OCS vessel traffic can affect the aesthetics of recreational experiences in certain areas. The OCS vessel traffic can also cause space-use conflicts with recreational vessels. However, OCS vessels move between onshore support bases (which are typically not near recreational areas) and production areas far offshore, meaning any potential impact would likely be temporary. In addition, a proposed action would add only a small amount of vessel traffic. **Chapter 3.1.4.3** provides more information regarding OCS vessel traffic. Therefore, impacts from vessel activity would likely be **negligible** to **minor.**

The OCS platforms serve as artificial reefs and, thus, often have beneficial impacts on recreational fishing and diving (Hiett and Milon, 2002). The extent to which a particular platform supports recreational activities would depend on numerous factors, such as its distance from shore, the fish populations it supports, and the aesthetics of an area (Ditton et al., 2002). The positive effects of platforms would be reversed at decommissioning unless a platform is maintained as an artificial reef through a Rigs-to-Reefs program (**Appendix A**). Additional details regarding Rigs-to-Reefs and other artificial reef programs, including the locations of reef sites, can be found in Fikes (2013). Overall, there would be **beneficial (low)** to **minor** adverse impacts on recreational resources due to structure installations and removals.

The visibility of OCS platforms can affect the aesthetics of certain recreational areas. These impacts depend on the type of recreational area and on the extent to which platforms are visible. For example, OCS platforms could detract from the nature experiences in certain Gulf Coast parks. The size and location of an offshore structure depends on the reservoir being tapped, characteristics of the well-stream fluid, and the type of processing needed to treat the hydrocarbons. The extent to which a platform is visible depends on various factors, such its distance, elevation, size, weather conditions, air pollution, and lighting (Bounds, 2012). Federal OCS waters are 9 nmi (10.36 mi; 16.67 km) from the Texas shore, and only under good weather conditions would a platform be visible to a person standing at the shoreline or to a person in a multi-story building. Federal OCS waters are 3 nmi (3.5 mi; 5.6 km) from Louisiana, Mississippi, and Alabama. In a study conducted by the Geological Survey of Alabama (1998), several facets of the visibility of offshore structures were analyzed. This study found that visibility is dictated not only by the sizes and locations of the structures but also by the curvature of the Earth, atmospheric conditions, and the viewer's expectations and perceptions.

During scoping for recent EISs, NPS raised questions regarding the potential visual impacts from OCS platforms to Horn and Petit Bois Islands. Horn and Petit Bois Islands are federally designated wilderness areas and are sensitive to disruptions to nature experiences. Cole (2012) is a literature review of various types of wilderness experiences. For example, NPS is concerned regarding the impacts from OCS platforms on the sky-viewing experiences on these islands, particularly at night. The NPS provided BOEM with baseline data regarding the overall scales of natural and anthropogenic light at Horn and Petit Bois Islands (USDOI, NPS, 2014a). This data found that the anthropogenic light ratio is 537 percent higher than baseline conditions at Horn Island and 510 percent higher than baseline conditions at Petit Bois Island. However, these data do not distinguish between OCS oil and gas and non-OCS light sources. The U.S. Dept. of Homeland Security, Coast Guard (2008) provides more information regarding the lighting requirements for OCS structures, such as the number and orientation of lights, to ensure maritime safety.

Historical experiences offer some insights into the potential visual impacts of platforms near Horn and Petit Bois Islands. Bounds (2012) offers evidence that oil and gas development near Dauphin Island (Alabama) caused negative impacts to tourism. The visibility of oil and gas structures near Texas and Louisiana appear to have more limited (and in some cases positive) impacts (USDOI, NPS, 2001; Nassaur and Benner, 1984), although the visual impacts of platforms arising from a proposed action would be subjective depending on the location and people in question. For example, platform lighting can detract from some nature experiences but it can also improve visibility and add contrast to the landscape. However, the most relevant historical analogy is that of offshore development near Mississippi. **Figure 4-26** presents information regarding the current and historical locations of structures in the vicinity of Horn and Petit Bois Islands. The OCS structures have existed close to Petit Bois Island. Most of these have been removed; only a few structures remain within 15 mi (11-16 km) of Horn and Petit Bois Islands. No studies have analyzed the impacts of the historical OCS structures on visitor experiences. **Figure 4-27** is a photograph of the remaining OCS structures taken from Petit Bois Island. **Figure 4-27** also shows a ship passing through the major shipping fairway near Petit Bois Island; the location of this shipping fairway is shown in **Figure 2-7**. This shipping fairway would continue to be used regardless of a proposed action. In **Figure 4-27**, the platforms are barely visible and have less of an impact on the viewshed than the passing ship.

Figure 4-27. Photograph of Remaining OCS Structures taken from Petit Bois Island Looking South (modified and reprinted with permission from Bob Marsh, [official communication, 2016]). (Petit Bois Island is within the Gulf Islands National Seashore and is a National Park Service-designated wilderness area.)

An analysis of the visual impacts of a proposed action depends importantly on the locations of the structures likely to arise. BOEM provides data on the estimated remaining oil and gas reserves for each lease block (USDOI, BOEM, 2016e). This source does not show any known remaining oil or gas reserves in nonleased blocks within 10 mi (16 km) of the GUIS. This makes it unlikely that a production platform would arise near Horn and Petit Bois Islands in the foreseeable future, particularly given the low current energy prices. Even if there were a lease near Horn or Petit Bois Island, it would probably be developed using minimal structures that tie back to existing platforms due to cost considerations. In addition, BOEM developed the Information to Lessees and Operators (ITL) that provides for NPS consultation on a lessee's plans (excerpt from past ITL below), as appropriate, and began adding the ITL to the Notices of Sale for proposed CPA lease sales beginning with CPA Lease Sale 231. The lease blocks that have previously been included the Gulf Islands National Seashore ITL are illustrated in **Figure 2-6**. BOEM would expect this ITL to be applied to any future GOM lease sales encompassing all or a portion of the CPA. For these reasons, potential impacts to these islands would likely be **negligible** to **minor**. The overall visual impacts of a proposed action would also be **negligible** to **minor** because of the distances that OCS structures will be from other recreational resources.

> (q) <u>Gulf Islands National Seashore</u>. Potential bidders are hereby notified that postlease plans submitted by lessees of whole and partial lease blocks located within the first 12 miles of Federal waters near the Gulf Islands National Seashore (State of Mississippi Barrier Island Chain Map, enclosed with ITL) may be subject to additional review in order to minimize visual impacts from development operations on these blocks. BOEM will review and make decisions on a lessee's plans for these blocks in accordance with applicable Federal law and regulations, and BOEM policies, to determine if visual impacts are expected to cause serious harm and if any additional mitigative action is required. Mitigations may include, but are not limited to, requested changes in location, modifications to design or direction of proposed structures, pursuing joint use of existing structures on neighboring blocks, changes in color design, or other plan modifications. BOEM may consult with the State of Mississippi and/or the State of Alabama and with the National Park Service, Southeast Regional Office, during such reviews as appropriate.
>
> The following whole and partial blocks, are specifically identified for this ITL: Chandeleur Area – 1; Mobile – 765-767, 778, 779, 809-823, 853-867, 897-910, 942-954, 987-997; and Viosca Knoll – 24-27.

The OCS oil- and gas-related activities can also affect recreational resources indirectly due to economic factors (which are described in **Chapter 4.14.2.2**). First, increased coastal infrastructure necessary to support offshore activities can create space-use conflicts. However, even if a space-use conflict was to arise in a particular instance, it is likely that a number of substitute recreational sites would be available. The OCS oil- and gas-related activities also have the potential to increase or decrease the demand for recreational resources in certain communities. Increased demand for recreational resources has the potential to attract new recreational firms to a community; however, increased demand also has the potential to lessen the enjoyment of a particular resource by some community members. The OCS structures could also affect property values in nearby areas. However, as discussed in **Chapter 3.1.7**, the existing oil and gas infrastructure would likely be sufficient to handle the amount of activity associated with a proposed action. Thus, there would likely be no noticeable increase in such impacts. In addition, there is sufficient land in the analysis area to handle any new development. Therefore, these indirect economic impacts would likely be **beneficial (low)** to **minor**.

4.12.2.2 Accidental Events

Accidental events, such as oil spills and the subsequent response activity and marine trash and debris, could affect various recreational resources. The impacts of drilling fluid spills and chemical spills on recreational resources are expected to be negligible because of their small sizes and far distances from recreational resources and are thus not discussed in detail. An oil spill that remained offshore could cause closures that may affect recreational fishing, diving, and boating. An offshore oil spill could also impact nearby coastal areas through media coverage or through misperceptions and uncertainty regarding the extent of the spill. An oil spill would have more direct impacts if it were to reach coastal areas. Environmental Sensitivity Indexes (ESIs) provide overall measures of the sensitivity of a particular coastline to a potential oil spill. The ESIs rank coastlines from 1 (least sensitive) to 10 (most sensitive). Marshes and swamps are examples of resources that have ESIs of 10 due to the difficulty of removing oil from these areas. The ESIs for beach areas generally range from 3 to 6, depending on the type of sand and the extent to which gravel is mixed into the beach area. The ESI maps for any coastline along the Gulf of Mexico can be viewed using the National Oceanic and Atmospheric Administration's ERMA mapping system (USDOC, NOAA, 2015m). The ESI maps also provide point indicators for recreational resources.

The effects of an oil spill on a region would depend on the size of the spill, as well as the success of the containment and cleanup operations following an oil spill. Both manual and machine-based techniques can be used to clean oil; the cleaning technique chosen for a particular beach would depend on the nature of the oiling of a particular beach area. The nature of cleanup operations would also depend on whether a particular beach serves as a habitat to particular animal species because removing oil deep below a beach surface can sometimes do more ecological harm than good. As a result, ecological beaches are often only cleaned to a shallow depth, while nonecological ("amenity") beaches are often cleaned more extensively. The cleanup plan for any particular beach is determined by a Shoreline Treatment Recommendation, which is prepared by the relevant State and Federal agencies for a particular spill. An example of a Shoreline Treatment Recommendation following the *Deepwater Horizon* explosion and oil spill for Grande Isle, Louisiana, can be found at RestoreTheGulf.gov (2010).

Recreational resources such as beaches serve as important bases for certain local economies. Therefore, oiled beach regions can cause economic losses to both individuals and firms in the area of an oiled or closed beach. An economic analysis of the costs of hypothetical beach closures along the Texas Gulf Coast was performed by Parsons and Kang (2007). They estimate that the economic costs of beach closures along the Padre Island National Seashore would range from $26,000 to $172,000 per day, depending on the time of year at which the closures would occur.

The New Orleans oil spill of 2008 demonstrates that a spill can affect different types of recreational activities. Namely, this spill impacted some of the boating and restaurant businesses in its vicinity; it also caused some aesthetic impacts to the experiences of tourists in the region (Tuler et al., 2010).

Eastern Research Group (2014b) analyzed the impacts of the *Deepwater Horizon* oil spill on tourism activities in the Gulf region. Eastern Research Group analyzed *Deepwater Horizon* claims data, reviewed newspaper accounts of the spill, analyzed county-level employment data, and conducted interviews with people involved in the tourism industry. These various methodologies paint a rich picture of the impacts of the *Deepwater Horizon* explosion, oil spill, and response, and revealed some broad conclusions. First, the *Deepwater Horizon* explosion, oil spill, and response had a broad geographic reach, partially due to public perceptions of the nature and scope of the spill. In addition, restaurants and hotels were particularly impacted by the *Deepwater Horizon* explosion, oil spill, and response, which led areas with more diversified tourism economies to hold up better in the spill's aftermath. Also, tourism generally rebounded strongly after the initial decline. Indeed, employment held up well in most counties and parishes following the *Deepwater Horizon* explosion, oil spill, and response, which supported the recovery. Finally, the impacts of the spill on tourism were shaped by the damage payment system, cleanup processes, and lessons learned from prior disasters. The Trustees estimated that the *Deepwater Horizon* oil spill led to 16.9 million lost user days of boating, fishing, and beach-going experiences (Deepwater Horizon Natural Resource Damage Assessment Trustees, 2016). However, an oil spill along the lines of the *Deepwater Horizon* oil spill is not reasonably foreseeable and is not considered as part of a proposed action. The impacts of a catastrophic oil spill are analyzed in the *Catastrophic Spill Events Analysis* white paper (USDOI, BOEM, 2017).

Any oil spills arising from a proposed action are likely to be small and localized, and thus, the corresponding impacts would be less than those experienced after the *Deepwater Horizon* explosion, oil spill, and response. In addition, there would likely be response and mitigation efforts subsequent to an oil spill. Finally, there would likely be numerous alternative recreational sites during the duration of an oil spill of the same type and size of those potentially impacted by accidental spills resulting from a proposed lease sale. Therefore, the impacts of an oil spill on recreational resources are expected to be **negligible** to **minor**.

Accidental discharges of marine debris from OCS oil- and gas-related vessels and facilities could reach beaches and other coastal resources, which could affect the aesthetics of these areas. The discharge of marine debris is subject to a number of laws and treaties. These include the Marine Debris Research, Prevention, and Reduction Act; the Marine Plastic Pollution Research and Control Act; and the MARPOL-Annex V Treaty. Regulation and enforcement of these laws is conducted by a number of agencies such as the U.S. Environmental Protection Agency, NOAA, and the U.S. Coast Guard. The BSEE provides information on marine debris and awareness and requires training of all OCS personnel through the "Marine Trash and Debris Awareness and Elimination" NTL (NTL 2015-BSEE-G03). This NTL instructs OCS operators to post informational placards on production facilities and drilling rigs that outline the legal consequences and potential ecological harms of discharging marine debris. This NTL also states that OCS workers should complete annual marine debris prevention training; operators are also instructed to develop a certification process for the completion of this training by their workers. Compliance with this NTL would become mandatory if the Protected Species Stipulation were applied. These various laws, regulations, and NTL would likely lead the potential damage to recreational resources from the discharge of marine debris from OCS operations to be **negligible** to **minor**.

4.12.2.3 Cumulative Impacts

The cumulative analysis considers the incremental impacts of a proposed action relative to past, present, and future OCS lease sales. The following cumulative OCS oil-and gas-related activities would potentially affect recreational resources: marine trash and debris, visibility of OCS platforms, space use conflicts, OCS related spills, and infrastructure emplacement and removal. This analysis also considers the incremental impacts of a proposed action relative to non-OCS oil- and gas-related sources such as aesthetic impacts, beach/wetland erosion, beach disruptions, space-use conflicts, and economic factors.

OCS Oil- and Gas-Related Impacts

Aesthetic Impacts

A proposed action would contribute to aesthetic impacts of the existing and future OCS Programs. For example, OCS oil- and gas-related activities contribute to the marine debris problems along the Gulf Coast. The BSEE provides information on marine debris and awareness and requires training of all OCS personnel through the “Marine Trash and Debris Awareness and Elimination” NTL (NTL 2015-BSEE-G03); this NTL is discussed above. Compliance with this NTL, particularly if the Protected Species Stipulation is applied, and other regulations as outlined in the “Routine Activities” section above would likely reduce the potential damage to recreational resources from the discharge of marine debris from OCS oil- and gas-related activities.

A proposed lease sale would also add to the visual impacts from the OCS Oil and Gas Program. These impacts would depend on the type of recreational area and on the extent to which platforms are visible. For example, OCS platforms could detract from the nature experiences in certain Gulf Coast parks. As discussed above, during scoping for recent EISs, the National Park Service raised questions regarding the potential visual impacts from OCS platforms to Horn and Petit Bois Islands. **Figure 4-26** presents information regarding the current and historical locations of structures in the vicinity of Horn and Petit Bois Islands. The OCS structures have existed close to Petit Bois Island for approximately 30 years. Most of these have been removed; a few structures remain 7-10 mi (11-16 km) away. **Figure 4-27** is a photograph of the remaining OCS structures taken from Petit Bois Island, in which these structures are minimally visible. The impacts of any new structure would likely be limited unless it was closer to Petit Bois Island than the existing structures. However, as discussed previously, it is highly unlikely that such a structure would arise from a proposed action because of the locations of oil and gas reserves, economic considerations, and the Bureau of Ocean Energy Management’s ITL regarding this issue.

Space-Use Conflicts

A proposed action would also contribute to space-use conflicts between recreational activities and the broader OCS Program. Bernhardt et al. (2006) present an analysis of space-use conflicts for oil and gas activities off the coast of Texas, although the issues they raise are generally applicable to OCS oil- and gas-related activities. They use a GIS-based framework to identify specific locations where conflicts between oil activities and other concerns (including recreational use) are most acute; they find that recreational use conflicts tend to be concentrated around some of the major wildlife viewing and beach areas near the larger population areas in Texas. There would also be the potential for space-use conflicts, e.g., near ports, along coastal Louisiana due to the high concentration of the OCS oil and gas industry in this area. The vessel traffic near these facilities could cause space-use conflicts with boating and recreational fishing activities. However, even if a space-use conflict was to arise in a particular instance, it is likely that a number of substitute recreational sites would be available. In addition, given the entrenched nature of the OCS oil and gas industry along the WPA and CPA, it is unlikely that any particular OCS oil- and gas-related activity would significantly add to space-use conflicts. As any of the alternatives would propose leasing only a very small portion of the EPA, such space-use conflicts are even less likely in the EPA.

Oil Spills

A proposed action would contribute incrementally to the likelihood of an oil spill caused by the broader OCS oil- and gas-related activities. Accidental spills most likely would be small, of short duration, and not likely to impact Gulf Coast recreational resources. In particular, as shown in **Table 3-17**, most spills would range from 0 to 500 bbl. Should an oil spill occur and contact a beach area or other recreational resource, it would cause some disruption during the impact and cleanup phases of the spill. However, any oil spill arising from a proposed action is expected to be small.

Infrastructure Emplacement and Removal

The overall OCS Oil and Gas Program can contribute to coastal erosion through activities such as channel dredging and pipeline emplacements. A more detailed discussion of the cumulative impacts of OCS oil- and gas-related activities on coastal beaches and dunes is presented in **Chapter 4.3.2**. Further information on the cumulative impacts of OCS oil- and gas-related activities on estuarine ecosystems can be found in **Chapter 4.3.1**. Platform emplacements can encourage some recreational activities, such as fishing and diving. However, decommissioning of these structures can have negative impacts on recreational diving if a particular platform were a popular diving site. Hiett and Milon (2002) provide survey data that suggest that the majority of recreational diving in the Gulf of Mexico occurs near oil and gas structures. More information regarding the impacts of infrastructure emplacement and removal is presented above and can be found in **Chapter 4.11**.

The impacts from aesthetics changes, space-use conflicts, oil spills, and infrastructure emplacement and removals from the overall OCS Program would be **beneficial (medium)** to

moderate. This is because of the broader scale of the overall OCS Program compared with a single proposed lease sale. The exact impacts would depend on the nature of the oil- and gas-related activities and recreational activities in a given area.

Non-OCS Oil- and Gas-Related Impacts

Aesthetic Impacts

Marine debris can detract from the aesthetic values of coastal areas, particularly beaches. Non-OCS oil- and gas-related marine debris can originate from State oil and gas activities, sewage treatment plants, recreational and commercial fishing, industrial manufacturing, cruise ships, and various forms of vessel traffic. Various government agencies participate in a coordinated effort to combat marine debris; a broad summary of the issues involved and the policy structure with respect to marine debris can be found in the Interagency Marine Debris Coordinating Committee's report (USDOC, NOAA, 2008b). Ocean Conservancy (2007) describes the structure of the National Marine Debris Monitoring Program; Ocean Conservancy (2014) is the most recent marine debris monitoring report. The incremental impacts of a proposed action are expected to be **negligible** to **minor** because the amount of marine debris that would arise from OCS oil- and gas-related activities would be small relative to the amount of marine debris arising from the sources mentioned above.

Aesthetic impacts can also arise from State oil and gas activities. For example, State oil and gas activities occur closer to shore and, thus, would cause more noise and visual impacts than OCS oil- and gas-related activities. In 2014, Mississippi's plans to hold an offshore oil and gas lease sale in State waters were suspended when a judge ruled against Mississippi's determination that such leases were purely administrative actions (NOLA.com, 2014). It is unclear how this issue would evolve. The visual impacts to Horn and Petit Bois Islands would also be influenced by the major shipping fairway between the islands. This shipping artery (which is shown in **Figure 4-26**) leads to the Port of Pascagoula, which is the 21st most active port in the United States (U.S. Dept. of the Army, COE, 2015c). A proposed action should also be viewed in light of the overall levels of noise on Horn and Petit Bois Islands. White (2014) provides data on baseline noise levels at Horn and Petit Bois Islands relative to Fort Pickens (which is a nonwilderness, higher human use area) in the Florida District of the Gulf Islands National Seashore. This study found that Horn and Petit Bois Islands have lower overall levels of extrinsic noise than Fort Pickens. Horn and Petit Bois Islands have higher measures of watercraft noise and lower levels of aircraft noise than Fort Pickens.

Beach/Wetland Erosion

The OCS Program occurs in an environment in which beach and wetland resources are undergoing depletion due to human development, hurricanes, and natural processes. The ongoing risk of hurricanes is a particular coastal erosion threat in the Gulf of Mexico; coastal erosion also lessens protection against future hurricanes. Non-OCS-related oil spills also have the potential to contribute to beach erosion, both due to contaminated sediment and the potential sediment losses during the cleanup process. More information regarding these issues can be found in **Chapter 3.3.2.8**. Coastal erosion trends would have impacts on recreational resources to the extent that parts of these areas are used for recreational activities, such as beach visitation, recreational fishing, and boating.

Beach Disruptions

The recreational value of beaches can be affected by beach disruptions. For example, red tides, which are caused by growth of microscopic algae, can negatively impact the aesthetic value of beaches. Red tides can also cause respiratory problems and skin irritation for beachgoers (State of Texas, Dept. of State Health Services, 2015). As discussed in **Chapter 4.3.2** (Coastal Barrier Beaches and Associated Dunes), beaches can also be affected by changes in water and sediment flow. The recreational value of beaches can also be negatively impacted by degradations of air quality and water quality (**Chapters 4.1 and 4.2**).

Space-Use Conflicts

Space-use conflicts with recreational activities may arise from commercial and military traffic. **Chapter 3.3.2.6.1** describes the military activities in the vicinity of a proposed action. For example, **Chapter 3.3.2.6.1** discusses the military warning areas and Eglin water test areas, as well as the Military Areas Stipulation that applies to GOM leases. **Chapter 4.14.1.2** describes the cumulative impacts of vessel traffic, including the ports that support the highest vessel traffic. These activities could disrupt recreational fishing, diving, and boating.

Economic Factors

The recreational resources along the Gulf Coast would be subject to various impacts arising from economic development. For example, there may be pressures to develop other industries into existing parks and natural resources. However, development may also encourage the expansion of other recreational resources, such as hotels and restaurants, to accommodate increased tourism and/or local recreation. The projected path of the economies along the Gulf Coast would be influenced by national economic trends. Recreational and tourism activity is positively correlated to the state of the overall national economy because higher levels of disposable income encourage consumers to dedicate more money to travel and leisure activities. More information regarding economic factors can be found in **Chapter 4.14.2**.

Overall non-OCS oil- and gas-related impacts would range from **beneficial (high)** to **major**. This wide range reflects the myriad of non-OCS oil- and gas-related impacts that could occur over the time-frame of this cumulative analysis. For example, beach and wetland erosion could have major impacts to recreational activities in certain areas. In addition, economic developments could have important beneficial or adverse impacts to recreational resources. However, the various recreational resources in the Gulf of Mexico, as well as economic and social adjustments to impacts, should generally support high levels of recreational activities in the future.

Incremental Impacts

A single proposed lease sale would be relatively small when compared with all past, present, and future lease sales (refer to **Table 3-23**). A proposed action would also be relatively small when compared with the non-OCS oil- and gas-related factors discussed above (refer to **Chapter 3**). For example, marine debris or visual disruptions would be more likely to arise from non-OCS oil- and gas-related activities such as shipping traffic. In addition, a proposed action would have small impacts relative to the space-use conflicts, beach/wetlands erosion, and economic factors that will impact recreational resources. Therefore, the incremental cumulative impacts of a proposed action relative to these OCS- and non-OCS oil- and gas-related factors would range from **beneficial (low)** to **minor**.

4.12.2.4 Incomplete or Unavailable Information

There is some incomplete or unavailable information regarding the visual impacts from a proposed action. In particular, the attitudes of people towards the visibility of structures that could arise in certain areas are not fully known. BOEM has determined that such information is not essential to a reasoned choice among alternatives because much of this uncertainty relates to the inherent uncertainty regarding where (and what types) of structures would arise from a proposed action. In addition, existing information allows for sufficient estimates of the overall dependence of visual impacts to factors such as distance, height, brightness, and general location. BOEM used generally accepted scientific principles to estimate the visual impacts of a proposed action, including literature sources, data sources, and photographic evidence. This evidence suggests that the incremental visual impacts of a proposed action would be **negligible** to **minor**. In addition, BOEM has issued an ITL to ensure that visual impacts near the Gulf Islands National Seashore are considered at BOEM's site-specific review stage.

4.12.2.5 Alternative A—Regionwide OCS Lease Sale (The Preferred Alternative)

The impacts of a proposed action would correspond to the impacts described in **Chapter 4.12.2**. In particular, a proposed action would contribute to the negative aesthetic impacts and the space-use conflicts that arise due to the broader OCS Oil and Gas Program. Structure emplacements can have positive impacts on recreational fishing and diving because platforms often act as artificial reefs, although decommissioning would offset these impacts. Oil spills can negatively impact beaches and other coastal recreational resources. The impacts resulting from the routine activities and accidental events would range from **beneficial (low)** to **minor**. A proposed action should also be viewed in light of economic trends, as well as various non-OCS oil- and gas-related factors than can cause space-use conflicts and aesthetic impacts, such as commercial and military activities. The incremental cumulative impacts of Alternative A relative to the impacts of all other OCS oil- and gas-related and non-OCS oil- and gas-related factors would be **beneficial (low)** to **minor**.

4.12.2.6 Alternative B—Regionwide OCS Proposed Lease Sale Excluding Available Unleased Blocks in the WPA Portion of the Proposed Lease Sale Area

Alternative B entails leasing a subset of the area considered in Alternative A. Therefore, the analysis of Alternative A covers the potential impacts of Alternative B. There would be some differences in impacts between Alternatives A and B due to the scales of OCS oil- and gas-related activities (described in **Chapter 4.12.1**) and to the geographic distributions of activities. Namely, Alternative B would prevent most impacts to recreational resources near drilling and production activities in Federal waters off Texas. However, since CPA/EPA activities may still be serviced by vessels departing from Texas ports, there could still be some space-use conflicts or impacts from oil spills near Texas. However, the differences between Alternatives A and B are not large enough to change the broad impact measures. In particular, Alternative B would contribute to the negative aesthetic impacts and the space-use conflicts that arise due to the broader OCS Oil and Gas Program. Structure emplacements can have positive impacts on recreational fishing and diving because platforms often act as artificial reefs, although decommissioning would offset these impacts. Oil spills can negatively impact beaches and other coastal recreational resources. Alternative B should also be viewed in light of economic trends, as well as various non-OCS oil- and gas-related factors than can cause space-use conflicts and aesthetic impacts such as commercial and military activities. The incremental cumulative impacts of Alternative B relative to the impacts of all other OCS oil- and gas-related and non-OCS oil- and gas-related factors would be **beneficial (low)** to **minor**.

4.12.2.7 Alternative C—Regionwide OCS Proposed Lease Sale Excluding Available Unleased Blocks in the CPA/EPA Portions of the Proposed Lease Sale Area

Alternative C entails leasing a subset of the area considered in Alternative A. Therefore, the analysis of Alternative A covers the potential impacts of Alternative C. There would be some differences in impacts between Alternatives A and C due to the scales of OCS oil- and gas-related activities (described in **Chapter 4.12.1**) and to the geographic distributions of activities. Namely, Alternative C would prevent most impacts to recreational resources near drilling and production activities in CPA/EPA Federal waters. However, since activities in the WPA may still be serviced by vessels departing from ports adjacent to the CPA/EPA, there could still be some space-use conflicts or impacts from oil spills near all Gulf Coast States. However, the differences between Alternatives A and C are not large enough to change most of the broad impact measures. The only difference is that the visual impacts due to structure emplacements should be **negligible** because all structures would be at least 9 nmi (10.36 mi; 16.67 km) from shore and because there would be fewer structure installations in the WPA than in the CPA. In addition, Alternative C would prevent visual impacts to the GUIS from structure installations. Alternative C would contribute to the negative aesthetic impacts and the space-use conflicts that arise due to the broader OCS Program. Structure emplacements can have positive impacts on recreational fishing and diving because platforms often act as artificial reefs, although decommissioning would offset these impacts. Oil spills can negatively impact beaches and other coastal recreational resources. Alternative C should also be viewed in light of economic trends, as well as various non-OCS oil- and gas-related factors than can cause space-use conflicts and aesthetic impacts such as commercial and military activities. The incremental cumulative impacts of Alternative C relative to the impacts of all other OCS oil- and gas-related and non-OCS oil- and gas-related factors would be **beneficial (low)** to **minor**.

4.12.2.8 Alternative D—Alternative A, B, or C, with the Option to Exclude Available Unleased Blocks Subject to the Topographic Features, Live Bottom (Pinnacle Trend), and/or Blocks South of Baldwin County, Alabama, Stipulations

Alternative D entails leasing a subset of the area considered in Alternative A, B, or C. Therefore, the analysis of Alternative A, B, or C covers the potential impacts of Alternative D. The areas that would be restricted from leasing under Alternative D would generally be far from shore and comprise a small portion of recreational activities along the Gulf Coast. In addition, there would be some offsetting adverse impacts (due to aesthetics, space-use conflicts, and oil spills) and some beneficial impacts (due to structure emplacements). The exclusion of blocks south of Baldwin County would prevent some potential negative impacts to tourism arising from the visibility of OCS oil- and gas-related infrastructure; it would also prevent the space-use conflicts, aesthetic impacts, and impacts from accidental events described above. However, the exclusion of these blocks would not prevent similar impacts in other GOM areas. Therefore, the overall impact conclusions for Alternative D are the same as those concluded under Alternative A, B, or C, as appropriate.

4.12.2.9 Alternative E—No Action

Under Alternative E, the impacts discussed above would not occur as a result of a proposed lease sale. There could be **negligible** impacts to recreational resources due to the small economic adjustments that would occur in light of Alternative E. For example, Alternative E would lower the income of employees in the offshore oil and gas supply chain, which could slightly lessen the demand for recreational activities. However, recreational resources would still be subject to the impacts from the broader OCS Oil and Gas Program, as well as the impacts from the non-OCS oil- and gas-related sources discussed above. In the short term, there would be a reduction of exploration and drilling activities, and there would be fewer impacts from the space-use conflicts, oil spills, and aesthetics of such activities. If lease sales were not held for a lengthy period of time, there may be a long-term reduction in impacts arising from production activities (such as the role of platforms as artificial reefs) as mature leases reach the end of their production period and are decommissioned. Tthe Five-Year Program EIS presents more information regarding the impacts of a long-term cessasion of leasing activities.

4.13 ARCHAEOLOGICAL RESOURCES

The magnitude of impact to an archaeological site expresses the maximum severity of potential impacts, should they occur, in spite of or in the absence of an assigned mitigation. BOEM does not differentiate between archaeological site types when conducting an impact analysis at the programmatic level.

Archaeological resources are any material remains of human life or activities that are at least 50 years of age and that are capable of providing scientific or humanistic understanding of past human behavior, cultural adaptation, and related topics through the application of scientific or scholarly techniques, such as controlled observation, contextual measurement, controlled collection, analysis, interpretation, and explanation (30 CFR § 550.105). The full analyses of the potential impacts of routine activities and accidental events associated with a proposed action and a proposed action's incremental contribution to the cumulative impacts are presented in the following sections. The approach of the analysis is to focus on the potential impact-producing factors from routine OCS oil- and gas-related activities (i.e., exploration, development, and production), as well as accidental events and cumulative impacts (**Table 4-31**). A brief summary of potential impacts follows. Archaeological resources are primarily impacted by any activity that directly disturbs or has the potential to disturb the seafloor. For the OCS Program, this includes the placement of drilling rigs and production systems on the seafloor; pile driving associated with platform emplacement; pipeline placement and installation; the use of seismic receiver nodes and cables; the dredging of new channels, as well as maintenance dredging of existing channels; anchoring activities; post-decommissioning activities including trawling clearance; and the masking of archaeological resources from industry-related infrastructure and debris. Visual impacts to coastal archaeological and historic sites are not considered, as offshore oil and gas infrastructure has existed on the Gulf of Mexico OCS since the 1940s and constitutes a seaward historic viewshed in its own right. Additionally, offshore oil and gas infrastructure predates the NHPA, and therefore, any coastal historic property currently on the National Register of Historic Places would not derive its eligibility from an unobstructed view of the GOM.

Impact-Level Definitions

The definition of impact thresholds used in this analysis are listed below.

- **Negligible** – The lowest level of detection that would have neither adverse nor beneficial impacts.
- **Minor** – Disturbance of archaeological resources would result in little, if any, loss of site integrity.
- **Moderate** – Site disturbance would result in a loss of integrity and a partial loss of the character-defining features and information potential that form the basis of the site's National Register of Historic Places' eligibility. Mitigation is accomplished by a combination of archeological data recovery and in-place preservation.
- **Major** – The disturbances result in a loss of site integrity to the extent that the resource is no longer eligible for listing in the National Register of Historic Places. The site's character-defining features and information potential are lost to the extent that archeological data recovery is the primary form of mitigation.
- **Beneficial** – An archeological site is stabilized in its current condition to maintain its existing level of integrity or an archeological site is preserved in accordance with the Secretary of the Interior's Standards for the Treatment of Historic Properties.

Duration: Short-term impacts last for the duration of construction-related activities while long-term impacts last beyond the proposed construction activities and are permanent. Generally, impacts to archeological sites are considered long-term impacts.

The impact of coastal and marine environmental degradation from OCS oil- and gas-related activities is expected to minimally affect cultural resources in comparison to other sources of coastal erosion and subsidence. Impacts of routine discharges are localized in time and space, are regulated by USEPA permits, and would have minimal impact. Accidental events that could impact archaeological resources include blowouts and oil or chemical spills and the associated cleanup response activities, and also the loss of debris from an MODU, platform, lay barge, etc. during offshore operations. A noncatastrophic oil spill (even one reasonably foreseeable as a result of a proposed lease sale) occurring and contacting a submerged archaeological resource is unlikely, given that oil released tends to rise quickly to the surface and that the most common size of a spill is <1 bbl (refer to **Chapter 3.2.1.5.3**).

Archaeological surveys, where required prior to an operator beginning OCS oil- and gas-related activities, are expected to be effective at identifying possible archaeological sites. Offshore oil and gas activities resulting from a proposed action could adversely impact an archaeological resource because of incomplete knowledge on the location of these sites in the GOM. The risk of contact to archaeological resources is greater in instances where archaeological survey data are unavailable. Such an event could result in the disturbance or destruction of important archaeological information. Archaeological surveys provide the necessary information to develop avoidance strategies that would reduce the potential for adverse impacts on archaeological resources. As part of the environmental reviews conducted for postlease activities, available information would be evaluated regarding the potential presence of archaeological resources within the proposed action area to determine if additional archaeological resource surveys and mitigation is warranted.

4.13.1 Description of the Affected Environment

4.13.1.1 Prehistoric

Available evidence suggests that sea level in the northern GOM was at least 90 m (295 ft), and possibly as much as 130 m (427 ft), lower than present sea level 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. (Pearson et al., 1986). During periods that the continental shelf was exposed above sea level, the area was open to habitation by prehistoric peoples.

Until the late 20th century, it was generally accepted by archaeologists that the earliest humans in North America were the so-called Clovis peoples, named for a lanceolate-shaped, fluted projectile point first found near Clovis, New Mexico. The Clovis culture was thought to have entered the continent by way of Beringia, a landmass connecting Asia to North America exposed during the Last Glacial Maximum, and along an ice-free corridor opened between the Cordilleran and Laurentide ice sheets around 13,500 years B.P. Today, however, a growing body of evidence has dispelled the "Clovis First" model with discovery of several sites with indisputable pre-Clovis dates in the eastern United States (Goodyear, 2005), Chile (Dillehay, 1989; Meltzer et al., 1997) and central Texas (Waters et al., 2011). The Buttermilk Creek Complex identified by Waters et al. (2011) at the Debra L. Friedkin Site (41BL1239) is the nearest to the Gulf of Mexico region and is dated from ~13,200 to 15,000 years B.P.

Establishing a reliable date for the entrance of Native Americans into the coastal regions of the GOM is complicated by the fact that archaeological deposits pre-dating 5500 B.P. lie buried under as much as 40 m (131 ft) of sediment or are underwater on the OCS (Rees, 2010). Conclusive evidence for prehistoric sites on the OCS is sparse. The McFaddin Beach Site (41JF50) in Jefferson County, Texas, has produced hundreds of artifacts 8,000 years old or older that have been redeposited from sites eroding from the now-submerged Pleistocene shoreline. Forty-three percent of the total sample includes artifacts diagnostic of the Middle and Late Paleoindian periods and include Clovis, Dalton, Scottsbluff, and San Patrice projectile points (Stright et al., 1999).

Recent archaeological research in Florida has confirmed that Pre-Clovis peoples inhabited the southeastern region of North America more than 14,500 years ago (Halligan et al., 2016). The sea-level curve for the northern GOM proposed by Coastal Environments, Inc. (CEI) suggests that sea level at 12,000 years B.P. would have been approximately 45-60 m (148-197 ft) below the present-day sea level (CEI, 1977 and 1982). On this basis, the continental shelf shoreward of the 45- to 60-m (148- to 197-ft) bathymetric contours has potential for prehistoric sites dating after 12,000 years B.P. Because of inherent uncertainties in both the depth of sea level and the entry date of prehistoric man into North America, BOEM adopted the 60-m (197-ft) water depth as the seaward extent for prehistoric archaeological site potential in GOM region.

Based on their 1977 baseline study, CEI (1977) proposed that sites analogous to the types of sites frequented by Paleoindians can be identified on the now-submerged shelf. Geomorphic features that have a high potential for associated prehistoric sites include barrier islands and back-barrier embayments, river channels and associated floodplains and terraces, and salt-dome features. Investigations in Louisiana and Florida indicate the mound-building activity by prehistoric inhabitants may have occurred as early as 6,200 years B.P. (cf. Haag, 1992; Saunders et al., 2005; Russo, 1992). Therefore, manmade features, such as mounds, may also exist in the shallow inundated portions of the OCS.

Regional geological mapping studies by BOEM allow interpretations of specific geomorphic features and assessments of archaeological potential in terms of age, type of system the geomorphic features belong to, and geologic processes that formed and modified them. In general, sites protected by sediment overburden have a high potential for preservation from the destructive effects of marine transgression. The same holds true for sites submerged in areas subjected to low wave energy and for sites on relatively steep shelves, which were inundated during periods of rapid rise in sea level. Although many specific areas in the GOM having potential for prehistoric site preservation have been identified through archaeological surveys, industry generally has chosen to avoid these areas rather than conduct further investigations.

Holocene sediments form a thin veneer or are absent over the majority of the continental shelf off western Louisiana and eastern Texas (USDOI, MMS, 1984). Many large, late Pleistocene, fluvial systems (e.g., the Sabine-Calcasieu River Valley) are within a few meters of the seafloor in this area. Farther to the south and west, a blanket of Holocene sediments overlies the Pleistocene horizon. Along the coast, prehistoric sites representing the Paleoindian culture period through European contact have been reported. The McFaddin Beach site, east of Galveston in the McFaddin National Wildlife Refuge, has produced late Pleistocene megafauna remains and lithics from all archaeological periods, including a large percentage of Paleoindian artifacts (Stright et al., 1999). A study funded by the Minerals Management Service (MMS) (BOEM's predecessor) to locate prehistoric archaeological sites in association with the buried Sabine-Calcasieu River Valley was completed in 1986 (CEI, 1986). Five types of relict landforms were identified and evaluated for archaeological potential. Coring of selected features was performed, and sedimentary analyses suggested the presence of at least two archaeological sites.

High-resolution geophysical surveys have produced evidence of floodplains, terracing, and point-bar deposits in association with relict late Pleistocene fluvial systems. Prehistoric sites associated with these features would have a high potential for preservation. Salt diapirs with bathymetric expression have also been recorded during lease-block surveys in this area. Solution features at the crest of these domes would have a high potential for preservation of associated prehistoric sites. The Salt Mine Valley site on Avery Island is a Paleoindian site associated with a salt-dome solution feature (CEI, 1977). The proximity of most of these relict landforms to the seafloor facilitates further investigation and data recovery.

4.13.1.2 Historic

Historic archaeological resources on the OCS consist of historic shipwrecks and a single historic lighthouse, the Ship Shoal Light. A historic shipwreck is defined as a submerged or buried vessel or its associated components, at least 50 years old, that has foundered, stranded, or wrecked, and that is currently lying on or embedded in the seafloor. Europeans are known to have traversed the waters of the western Gulf of Mexico as early as Captain Alonso Alvarez de Piñeda's expedition in 1519. Alvar Nuñez Cabeza de Vaca is likely to have the dubious distinction of being the first European to be shipwrecked along the Texas coast as early as 1528 (Francaviglia, 1998).

The NPS and MMS (BOEM's predecessor) contracted three studies (CEI, 1977; Garrison et al., 1989; Pearson et al., 2003) aimed at modeling areas in the GOM where historic shipwrecks are most likely to exist, though numerous shipwreck discoveries since the publication of those studies have empirically shown their models to be flawed due to reporting biases in the historic record. The 1977 study concluded that two-thirds of the total number of shipwrecks in the northern GOM lie within 1 mi (1.6 km) of shore and most of the remainder lies between 1 and 6 mi (1.6 and 10 km) of shore (CEI, 1977). Changes in the late 19th- and early 20th-century sailing routes increased the frequency of shipwrecks in the open sea in the eastern GOM to nearly double that of the central and western GOM (Garrison et al., 1989). The Garrison et al. study also found 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. Based on the results of this study, MMS identified which OCS lease blocks would require the operator to submit an archaeological report with their EP, DOCD, DPP, or other permit application.

Pearson et al. (2003) benefited from the experience of almost 15 years of high-resolution, shallow hazard surveys in lease blocks (a typical lease block is 9 mi^2 [5,760 ac]) and along pipeline routes. Some of these surveys (almost exclusively for pipeline routes) were conducted in deep water. Taking the new data into account, the 2003 study recommended including some deepwater areas, primarily on the approach to the Mississippi River, among those lease areas requiring archaeological investigation. With this in mind, MMS (BOEM's predecessor) revised its guidelines for conducting archaeological surveys and added about 1,200 lease blocks in the CPA to the list of blocks requiring an archaeological survey and assessment. These requirements are posted on BOEM's website under NTL 2005-G07 and NTL 2011-JOINT-G01. Based on additional shallow hazard survey data and shipwreck discoveries since 2008, an archaeological survey may be required as a result of site-specific NEPA analysis conducted for new bottom-disturbing activity associated with plans (USDOI, BOEMRE, 2011), pipelines, and structure-removal activities. **Table** 4-30 illustrates the results of the surveys and archaeological reviews in the last 6 years.

Table 4-30. Archaeological Surveys and Resources Identified, 2009-2014.

Year	Blocks Surveyed	Identified Shipwreck Sites	Potential Archaeological Sites Mitigated by Avoidance (identified through requisite industry surveys)
2009	118	11	479 magnetic anomalies and 103 sonar targets
2010	74	8	274 magnetic anomalies and 100 sonar targets
2011	120	15	577 magnetic anomalies and 171 sonar targets
2012	115	15	341 magnetic anomalies and 112 sonar targets
2013	166	6	374 magnetic anomalies and 163 sonar targets
2014	144	13	417 magnetic anomalies and 146 sonar targets

Many of the above-listed shipwrecks were not previously known to exist in these areas from the historic record. Recent research on historic shipping routes, moreover, suggests that the ultra-deepwater area of the Gulf of Mexico, between 25º and 27.5º N. latitude, was located along the historic Spanish trade route, which therefore increases the probability that a historic shipwreck could be located in this area (Lugo-Fernandez et al., 2007). This route runs through the proposed action area. A study to conduct archival research on these historic shipping routes was completed in 2010 (Krivor et al., 2011) and concluded that both Spanish and French vessels were lost in the 16th, 17th, and 18th centuries while transiting the route between Vera Cruz, New Orleans, and Havana.

A proprietary database of shipwrecks maintained by BOEM currently lists over 1,300 named shipwrecks in the GOM. Many of these reported shipwrecks may be considered historic and could be eligible for nomination to the National Register of Historic Places. Most of these wrecks are known only through the historical record and, to date, have not been located on the ocean floor. This list should not be considered exhaustive; 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.

Submerged shipwrecks off the coasts of Texas, Louisiana, Mississippi, and Alabama are likely to be moderately well-preserved because of the high sediment load in the water column from upland drainage and wind and water erosion. Wrecks occurring within or close to the mouth of bays likely would have been quickly buried by transported sediment and therefore somewhat protected from the destructive effects of wood-eating shipworms (*Teredo navalis*) or storms, as has been observed at the site of *La Belle* in Matagorda Bay, Texas (Bruseth and Turner, 2005). Wrecks occurring in deeper water also have a moderate to high preservation potential. In the deep water, temperature at the seafloor is extremely cold (~4 ºC; 39 ºF), which slows the oxidation of ferrous metals. While the cold water at depth would eliminate the wood-eating shipworm *Teredo navalis*, it is clear from recent studies that other marine organisms, including chemosynthetic species, consume wooden shipwrecks, and that microbial organism are at work breaking down steel and iron hulls (Atauz et al., 2006; Church et al., 2007; Church and Warren, 2008; Ford et al., 2008). Due to the high levels of preservation and the decrease in impacts from anthropogenic (e.g., diving, looting, and fishing trawling) and meteorological (e.g., tropical storms and hurricanes) events, the potential is higher in deep water to discover undisturbed sites.

Hurricane activity in the Gulf of Mexico has the ability to directly impact archaeological resources in water depths exceeding 200 ft (61 m) (Gearhart et al., 2011; Lukens and Selberg, 2004). Wrecks occurring as a result of an extremely violent storm are more likely to be scattered over a broad area. The wreckage of the 19th-century steamer *New York*, which was destroyed in a hurricane, lies in 65 ft (20 m) of water and has been documented by MMS/BOEM (Irion and Anuskiewicz, 1999; Gearhart et al., 2011) as scattered over the ocean floor in a swath over 1,500 ft (457 m) long. 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 on the OCS.

It is almost certain that any shipwrecks in shallow water within the path of Hurricanes Katrina or Rita were impacted to some extent by these storms. In September 2005, the NPS conducted a study of sites along the Gulf Coast that were impacted by Hurricane Katrina (USDOI, NPS, 2005). This assessment identified three types of damage that can occur to archaeological sites: tree throws; storm surge, scouring, and erosion; and seabed shifting. On the OCS, the two primary types of damage would be associated with storm surge and seabed shifting. In early 2007, MMS awarded a study to investigate the impacts that recent storm activity may have had on historic shipwrecks in the Gulf of Mexico. Analysis of the remote-sensing surveys and diver investigations indicates that at least 3 of the 10 shipwrecks examined were affected by recent storm activity and that older wooden wrecks that had achieved some level of equilibrium in their environment were less affected than more recent steel-hulled wrecks (Gearhart et al., 2011).

4.13.2 Environmental Consequences

Impacts to archeological sites occur when proposed activities result in complete or partial destruction of the resource and are equivalent to a loss of integrity as defined in the National Historic Preservation Act (NHPA) (54 U.S.C. §§ 300101 *et seq.*). In determining the appropriate impact threshold, both the extent to which the proposed activity results in a loss of integrity and the degree to which losses can be compensated by mitigating activities, including preservation or data recovery, are considered. For the purposes of this analysis, all alternatives may be assumed to have effectively similar potential impacts to archaeological resources. Only those resources determined eligible or potentially eligible for listing in the National Register of Historic Places are considered under the NHPA. Resources are eligible for listing in the National Register of Historic Places if they meet one or more eligibility criteria (for archeological sites, generally Criterion D, having the potential to provide information important to history or prehistory) and if they possess integrity. For purposes of archaeological mitigation, BOEM/BSEE considers all uninspected shipwrecks, sonar targets, and magnetic anomalies to be potentially eligible for the National Register of Historic Places.

For the analysis of impacts to archeological resources, the determination of the intensity of an impact is based on the foreseeable loss of integrity to known or potential resources. The analysis considers only the direct impacts of seafloor disturbance associated with the below-listed impact-producing factors as there should be no additional impacts upon archeological resources under any of the alternatives under consideration upon completion of said activities. As each archaeological resource is unique and exists at a specific location on the seafloor, there is a high level of variability in how a site may be impacted by any potential impact-producing factor. Therefore, it is impossible to evaluate the potential impact to an archaeological site from a proposed action at the programmatic level. During postlease activities, each permitted action would be assessed for site-specific potential impacts during the permit application process, and avoidance buffers would be placed around identified resources in order to mitigate potential impacts.

4.13.2.1 Routine Activities

Routine impact-producing factors associated with a proposed action that could affect archaeological resources include (1) geotechnical testing/geophysical surveys; (2) well development (drilling), structure installation, and maintenance; (3) pipeline installation and maintenance; (4) vessel or structure anchoring; and (5) idle structure removal.

Geotechnical Testing/Geophysical Surveys

Geotechnical testing includes, but is not limited to, soil boring, seafloor coring, and sediment grabs. The area of effect for a typical geotechnical test is approximately 1 m^2 (11 ft^2); however, several tests are usually conducted as part of a project. The likelihood that an individual test would negatively impact an archaeological site in an unsurveyed area is minimal; however, the effect to an impacted site would be significant were it to occur. Large area geophysical surveys to resolve deep geological structures use either ocean bottom cables or ocean bottom nodes as acoustic receivers. The ocean bottom cables are deployed from a surface vessel onto the seafloor. While the cable itself is light and flexible, the acoustic node assembly and sound dampeners can weigh up to approximately 400 lb (181 kg). The "blind" method of laying down and peeling up the cable from the seafloor could cause the cable to snag on an unknown shipwreck, causing major adverse impacts. The ocean bottom nodes are either dropped from a surface vessel, with a large area of potential bottom contact, or they are placed by ROVs. An archaeological survey is not required in advance of a geophysical survey; however, identified and potential archaeological resources are noted for avoidance. The deployment of ocean bottom cables and ocean bottom nodes dropped from the surface have the potential to significantly negatively impact unidentified archaeological resources. The ocean bottom nodes placed by ROV have minimal potential to impact archaeological resources as the seafloor is visually inspected before placement and recovery. Impacts to archaeological resources from the geotechnical testing/geophysical survey range from **negligible** to **major** if no survey is performed, no mitigation is imposed, a mitigation is not followed, or a site is unidentified prior to the activity.

Well Development (Drilling), Structure Installation, and Maintenance

In total, approximately 6,700 platforms have been installed in the GOM. For fixed-legged structures, depending on water depth, seafloor characteristics, and vessel availability, an anchored barge, moored barge, or liftboat may be used in platform installation. Wells are typically drilled in a new location prior to structure installation. Depending primarily on water depth and vessel availability, a jack-up rig or anchored or dynamically positioned MODU may be used. Several directional wells may be drilled from a single top-hole location. Estimates of wells to be drilled and platforms to be installed, by water depth, are presented in **Table 3-2**. Impacts to archaeological resources from well development, structure installation, and maintenance activities range from **negligible** to **major** if no survey is performed, no mitigation is imposed, a mitigation is not followed, or a site is unidentified prior to the activity.

Pipeline Installation and Maintenance

Pipelines in the Gulf of Mexico OCS are installed as either a part of lease-block infrastructure or as a right-of-way across others' leases or unleased areas. Pipeline permits allow an operator to install a pipeline within a planned 200-ft (61-m) corridor. Pipelines are laid with either an anchored or a dynamically positioned lay barge. Pipelines installed in water depths <200 ft (61 m) and those deemed a hazard to navigation must be buried at least 3-16 ft (1-5 m) depending on local uses (e.g., fairways, anchorages, etc.), typically using a water jet. Long segments have been observed to flex and move across the seafloor, usually due to storm activity. A survey for all proposed pipeline installation, regardless of location, has only been required since 2005. An example of an adverse impact to an archaeological site from a pipeline installation is the 2001 installation of an oil and gas pipeline that bisected and damaged what is known as the Mica Shipwreck (Atauz et al., 2006). Impacts to archaeological resources from pipeline installation and maintenance activities range from **negligible** to **major** if no survey is performed, no mitigation is imposed, a mitigation is not followed, or a site is unidentified prior to the activity.

Vessel or Structure Anchoring

Anchoring associated with exploration drilling, platform and pipeline emplacement, and decommissioning may also physically impact archaeological resources. It is assumed that, during anchor emplacement, an array of 20,000-lb (9,072-kg) anchors is repositioned within the area of potential effect. The anchor's chain has the potential to lie along and sweep across the seafloor. Impacts to archaeological resources from anchoring activities range from **negligible** to **major** if no survey is performed, no mitigation is imposed, a mitigation is not followed, or a site is unidentified prior to the activity.

Idle Structure Removal

As per NTL 2010-G05 ("Decommissioning Guidance for Wells and Platforms") (idle iron initiative), idle and toppled oil and gas industry-related structures embedded in the seafloor, including single-leg caissons, multi-legged jacketed fixed platforms, floating platforms secured by suction pilings, and subsea well-head and manifold systems, must be decommissioned and removed. Depending on water depth, seafloor characteristics, and vessel availability, an anchored barge, moored barge, or liftboat may be used. Additionally, the site must be cleared of debris to a radius of 600 or 1,320 ft (183 or 402 m) depending on the structure type and use. Clearance may be carried out by trawling or by sonar and diving operations. As of 2013, BOEM may require, as a condition of approval for a decommissioning permit, an archaeological survey in advance of structure-removal activities when no preexisting survey of the area of potential effect exists. Impacts to archaeological resources from structure-removal activities range from **negligible** to **major** if no survey is performed, no mitigation is imposed, a mitigation is not followed, or a site is unidentified prior to the activity.

To mitigate potential adverse impacts to archaeological resources, BOEM requires archaeological reconnaissance survey of all areas impacted by bottom-disturbing activities and avoidance or other actions, up to and including full Phase III excavation, of all potential archaeological resources within the identified area of potential effect of the undertaking. Archaeological surveys are expected to be effective at identifying possible archaeological sites. The technical requirements of the archaeological resource reports are detailed in NTL 2005-G07, "Archaeological Resource Surveys and Reports." Under 30 CFR § 550.194(c) lessees are required to immediately notify BOEM's Regional Director of the discovery of any potential archaeological resources. Under 30 CFR § 250.194(c) and 30 CFR § 250.1010(c), lessees are also required to immediately notify BOEM's and BSEE's Regional Directors of the discovery of any potential archaeological resources.

4.13.2.2 Accidental Events

Accidental impact-producing factors associated with a proposed action that could affect archaeological resources include accidental oil spills and loss of debris from a vessel or structure.

Accidental Oil Spills

Impacts on archaeological resources could occur as a result of an accidental oil spill. A major impact from an oil spill would be visual and chemical contamination of a historic coastal site, such as a prehistoric shell midden, historic fort, or lighthouse. Although such impacts may be temporary and reversible, cleaning oil from historic structures is by no means a simple or inexpensive process (e.g., Chin and Church, 2010). The major impacts to coastal archaeological sites from the *Exxon Valdez* spill in Alaska in 1989 were related to cleanup activities, such as the construction of helipads, roads, and parking lots, and to looting by cleanup crews rather than from the oil itself (Bittner, 1996). As a result, cultural resources were recognized as significant early in the response to the *Deepwater Horizon* oil spill, and archaeologists were embedded in Shoreline Cleanup and Assessment Technique (SCAT) teams and consulted with cleanup crews.

An oil spill occurring and contacting a submerged archaeological resource is unlikely, given that oil released tends to rise quickly to the surface and that the average size of any spill would be small. However, if it occurred, an oil spill contacting a coastal archaeological resource is possible. As noted in **Chapter 3.2.8.2.2**, the use of dispersants is reasonably foreseeable. However, if dispersants are used, the impacts to archeological sites have not been quantified. Refer to the *Catastrophic Spill Event Analysis* white paper (USDOI, BOEM, 2017) for an analysis of the potential impacts of a catastrophic oil spill on coastal and submerged archaeological resources.

The impacts to archaeological sites from oil spills and associated activities **have not been quantified** because of incomplete or unavailable information, which are discussed later in this resource chapter.

Loss of Debris from a Vessel or Structure

Another impact that could result from an accidental event is from the loss of debris from an MODU, platform, lay barge, etc. during offshore operations. Debris such as structural components (i.e., grating, wire, tubing, etc.), boxes, pallets, and other loose items can become dislodged during heavy seas or storm events and fall to the seabed. Similarly, thousands of joints of drill pipe are used during drilling operations, requiring regular transport out to the MODU via workboats. There is the potential to lose pieces of drill pipe during transfer operations or when “tripping pipe” in and out of the wellbore. Similar to the impacts noted under “Routine Activities” (e.g., pipeline movement and anchor damage), if lost drill pipe or debris were to fall onto an unknown archaeological resource, the resulting disturbance could destroy fragile materials, such as the hull remains and artifacts, and could disturb the site’s context and associated artifact assemblage. Additionally, lost material could result in the masking of actual archaeological resources or the introduction of false targets that could be mistaken in the remote-sensing geophysical record as historic resources. Impacts to archaeological resources from the loss of debris from a vessel or structure range from **negligible** to **major**.

4.13.2.3 Cumulative Impacts

In addition to the cumulative impacts of the OCS Program whose impacts are the same as described above, the cumulative scenario activities that could potentially impact archaeological resources include (1) oil spill and response, (2) State oil and gas programs, (3) sand extraction, (4) artificial reef development, (5) fairway and anchorage use and maintenance, (6) commercial bottom trawling (fishing), (7) treasure hunting/looting, (8) sport diving, (9) research and monitoring, and (10) hurricanes. The chance that a localized cumulative scenario activity could impact any particular archaeological resource on the OCS is negligible (archaeological resources cannot be considered as a population); therefore, if a cumulative scenario activity were to impact an archaeological resource, it would constitute the primary impact to that resource. Consequently, this analysis identifies the range of potential impact levels to a particular archaeological site from specific cumulative scenario activities if the impact were to occur.

OCS Oil- and Gas-Related Impacts

Oil Spill and Response

Oil spills in the GOM range from sub-seafloor contained production casing leaks to environmentally damaging well blowouts to shipping accidents. There have been seven significant oil spills in the GOM, including accidents in State and Mexican waters: *Ixtoc* (1979); Burmah Agate (1979); *Alvenus* (1984); *Megaborg* (1990); *Ocean 255* (1993); the aggregation of the effects of Hurricane Katrina (2005) (USDOC, NOAA, n.d.); and *Deepwater Horizon*/*Macondo* (2010). Activities associated with oil spills that may affect archaeological resources include anchoring of response vessels, drilling relief wells, the application of chemical dispersant, and the distribution of oil. Due to the emergency nature of oil spills, an archaeological survey is not feasible before related activities take place. The impacts to archaeological sites from oil spills and associated activities **have not been quantified**.

Non-OCS Oil- and Gas-Related Impacts

State Oil and Gas Programs

State oil and gas program wells, structures, and pipelines in State waters are not under the jurisdiction of BOEM with respect to the archaeological resource protection requirements of the NHPA. Under the NHPA, other Federal agencies (such as the COE) that issue permits associated with pipelines in State waters are responsible for taking into consideration the effects of agency-permitted actions on archaeological resources. Therefore, the impacts that might occur to archaeological resources by pipeline construction originating from OCS oil- and gas-related activity within State waters should be mitigated under the requirements of the NHPA, and the same archaeological surveys for planned pipelines that lead into a landfall or a tie-in to a pipeline in State waters are required. Impacts to archaeological resources from State oil and gas program activities range from **negligible** to **major** if no survey is performed, no mitigation is imposed, a mitigation is not followed, or a site is unidentified prior to the activity.

Sand Extraction

Impacts to archaeological resources as a result of sand extraction activities include direct contact of a resource by the dredge head or anchors, redepositing of artifacts into the dredge disposal area, sediment transport and/or seabed destabilization around wrecks adjacent to the dredge pit, and direct contact of terrestrial or submerged resources in the dredge disposal area. The OCS sand resources have been identified off the coasts of Mississippi, Louisiana, and Texas in the following OCS areas: High Island; West Cameron; Vermilion; South Marsh Island; Eugene Island; Ship Shoal; South Pelto; West Delta; Chandeleur; and Main Pass. An archaeological review is required in advance of sand extraction activities. A current/ongoing BOEM study is quantifying the impacts to archaeological resources from sand extraction to incorporate into future sand extraction permit application review. Impacts to archaeological resources from sand extraction activities range from **negligible** to **major** if no survey is performed, no mitigation is imposed, a mitigation is not followed, or a site is unidentified prior to the activity.

Artificial Reef Development

Artificial reef areas are designated by the COE for the disposal of decommissioned vessels, platform jackets, and other materials in order to promote and enhance biological systems. Potential impacts to archaeological resources include direct contact of the resource by the reefed material. Reefing areas are typically developed in <600 ft (183 m) of water; however, two fixed platform jackets have been reefed in place offshore Louisiana in water depths 620 and 650 ft (189 and 198 m). Nine additional fixed platforms that range in water depths of 650-1,350 ft (198-411 m) are currently being considered for reefing in place by State-managed artificial reef programs (Texas, Louisiana, and Alabama). In addition to the State-managed programs, there are old artificial reefs and disposal areas that are not included in a State-managed program; these areas have not been quantified. The COE does not consistently require archaeological survey in advance of reef permitting. Most sonar and multibeam surveys by the State artificial reef programs are conducted after artificial reef deployments to verify placement. The area of potential effect of reefing activities also includes the anchor radius of tow and placement barges, which often extends outside of the reefing area. Impacts to archaeological resources from artificial reef development activities range from **negligible** to **major** if no survey is performed, no mitigation is imposed, a mitigation is not followed, or a site is unidentified prior to the activity.

Fairway and Anchorage Area Use and Maintenance

Fairways and anchorage areas are established to provide safe approaches to major ports in the GOM. Fairways and anchorage areas regulate allowable oil and gas industry and other activities within them, such as installation spacing, anchor and cable depth, pipeline burial, etc. Proper aids to navigation must be affixed to the seafloor. Fairways may be dredged to maintain safe water depths for navigation. An archaeological survey may not have been required in advance of fairway and anchorage area designation. Impacts to archaeological resources from fairway and anchorage area use and maintenance range from **negligible** to **major** if no survey is performed, no mitigation is imposed, a mitigation is not followed, or a site is unidentified prior to the activity..

Commercial Bottom Trawling (Fishing)

Commercial bottom trawling may make use of nets, rakes, or dredges to harvest commercially important benthic organisms (e.g., shrimp, oysters, etc.). An archaeological survey and review has never been required in advance of the development of a commercial bottom trawling fishery in the GOM. Geophysical and diver inspection surveys have shown that trawling apparatuses have negligible to fully destructive impacts to submerged archaeological resources depending on the resources composition and integrity (Steinmetz, 2010). For example, a shrimp net may snag and remain attached to the hull of a 20th-century steel vessel, while a shellfish rake or dredge may obliterate a 19th-century wooden sailing vessel leaving little to no trace of it on the seafloor. Impacts to archaeological resources from commercial bottom trawling range from **negligible** to **major**. There is no archaeological mitigation applied to commercial fishing.

Treasure Hunting/Looting

Treasure hunting involves the intentional, nonscientific, usually commercial exploitation of archaeological resources for profit. Often, specific shipwrecks are targeted for salvage. It is unknown how many archaeological sites have been salvaged by treasure hunters in the GOM. Two recent examples of commercial treasure hunting in the Gulf of Mexico OCS are the salvage of the *New York* (Gearhart et al., 2011; Irion and Ball, 2001; Bowers, 2008) and *El Cazador* (www.elcazador.com). Looting involves the planned or opportunistic removal of artifacts or features from an archaeological site. It may range from the collection of mobile surface artifacts to the complete destruction and/or removal of the vessel. An example of the looting of an archaeological site was the attempted collection and destruction of artifacts on the shipwreck known as the Mardi Gras wreck during an remotely operated vehicle pipeline inspection (Ford et al., 2008). Impacts to archaeological resources from commercial treasure hunting/looting range from **moderate** to **major**. There is no archaeological mitigation applied to treasure hunting/looting.

Sport Diving

Sport diving includes private or commercial recreational diving on archaeological sites for pleasure and education. Negative impacts to archaeological sites from sport diving may result from boat anchor and mooring damage, disturbance to and removal (looting/souvenir hunting) of artifacts, intentional and unintentional physical contact (body or equipment), and the interaction of exhaled air bubbles with the site (Edney, 2006). Sport divers may, however, have a beneficial impact to archaeological sites by monitoring sites, encouraging fellow divers to protect sites, and by reporting any observed adverse impacts to the appropriate State or Federal agency. Impacts to archaeological resources from sport diving range from **beneficial** to **major**. There is no archaeological mitigation applied to sport diving.

Research and Monitoring

Research and monitoring activities in the GOM are not quantified; however, it is possible to discuss a potential range of impacts to archaeological sites from them. Negative impacts to archaeological sites may result from seafloor disturbance such as specimen collection by bottom trawling or geotechnical core sampling. Beneficial impacts may result from the visual identification and/or inspection of sites during ancillary scientific activities or the collection of environmental data that may be used to evaluate the condition of archaeological sites. Impacts to archaeological resources from research and monitoring range from **beneficial** to **major**. Archaeological mitigation may be recommended for research and monitoring if BOEM is (1) aware of the project and (2) is provided the opportunity to comment on the research design.

Hurricanes

Hurricanes and tropical storms are normal occurrences in the GOM and along the Gulf Coast. Shipwrecks in shallow waters are exposed to storm-induced wave action and a greatly intensified, longshore current during tropical storms (Clausen and Arnold, 1975). Under such conditions, there is a potential for hull components and artifacts (e.g., ceramics and glass) to be dispersed. Overall, a significant loss of data from sites has probably occurred, and would continue to occur, in the northern Gulf from the impacts of tropical storms. Impacts to archaeological resources from hurricanes range from **negligible** to **major**. BOEM does not apply any archaeological mitigation in advance of potential hurricane activity.

4.13.2.4 Incomplete or Unavailable Information

There is incomplete or unavailable information regarding the long-term impacts of oil, dispersed oil, and/or dispersant contamination on, and the location of, archaeological resources in the GOM. As discussed above, there are currently no published studies on the long-term impacts to archaeological resources exposed to oil, dispersed oil, or dispersant contamination. However, considering the low probability of an accidental oil spill contacting an archaeological site as a result of a proposed action, BOEM has determined that the information is not essential to a reasoned choice among alternatives.

Additionally, the locations of all archaeological resources in the GOM cannot be determined because the overall costs of obtaining that information through survey of the entire GOM are exorbitant. This incomplete information may be relevant to adverse impacts because the locations and integrity of many archaeological resources remain unknown. Nevertheless, this incomplete information is not likely to be available within the timeline contemplated in the NEPA analysis of this Multisale EIS. It would take many years before data confirming the presence (or lack thereof) of archaeological resources, and the status of each, could be investigated, analyzed, and compiled. Archaeological sites within the GOM have the potential to be buried, embedded in, or laying on the seafloor. The seafloor is comprised of highly variable bathymetric and geophysical regimes, which differentially affect the ease and ability to identify, ground truth, and evaluate archaeological sites. This fact, combined with the scope of the acreage within the GOM, results in the aforementioned exorbitant costs and time factors.

BOEM used existing information and reasonably accepted scientific theories on archaeological site potential in the Gulf of Mexico to extrapolate from available information in completing the relevant analysis. In addition, future site-specific, remote-sensing surveys of the seafloor, where required, establish the presence of potential resources (NTL 2005-G07, "Archaeological Resource Surveys and Reports"). The results of these surveys are reviewed in tandem with credible scientific evidence from previously identified sites, regional sedimentology, and physical oceanography that is relevant to evaluating the adverse impacts on resources that are a part of the human environment. The survey data are analyzed by industry and BOEM's archaeologists prior to the authorization of any new or significant bottom-disturbing impacts and, if necessary, avoidance of potential archaeological resources is prescribed. Archaeological surveys are expected to be effective in identifying resources to allow for mitigation application and protection of the resource during OCS oil- and gas-related activities. A proposed action is not expected to have a reasonably foreseeable significant impact because BOEM's evaluation of such impacts is based upon pre-disturbance and site-specific surveys, the results of which BOEM uses to require substantial avoidance of any potential resource that could be affected by the proposed activity. Therefore, BOEM has determined that the gaps in information on the presence of or status of archaeological resources is not essential to a reasoned choice among alternatives at the lease sale stage.

4.13.2.5 Alternatives A, B, C, and D

Regardless of which planning area a proposed lease sale is held, the greatest potential impact to an archaeological resource as a result of a proposed action under any of the action alternatives is site specific and would result from direct contact between an offshore activity (i.e., platform installation, drilling rig emplacement, decommissioning, or dredging or pipeline project) and a site. During postlease activities, each permitted action would be assessed for site-specific potential impacts during the permit application process. Archaeological surveys, where required prior to an operator beginning OCS oil- and gas-related activities on a lease, are expected to be effective at identifying possible archaeological sites. The technical requirements of the archaeological resource reports are detailed in NTL 2005-G07, "Archaeological Resource Surveys and Reports." Under 30 CFR § 250.194(c) and 30 CFR § 250.1010(c), lessees are required to immediately notify BOEM's and BSEE's Regional Directors of the discovery of any potential archaeological resources.

Offshore oil- and gas-related activities resulting from a proposed action could impact an archaeological resource because of incomplete knowledge on the location of these sites in the Gulf of Mexico. The risk of contact to archaeological resources is greater in instances where archaeological survey data are unavailable. Such an event could result in the disturbance or destruction of important archaeological information. Archaeological surveys would provide the necessary information to develop mitigation strategies that would reduce the potential for impacts on archaeological resources.

Accidental events producing oil spills may threaten archaeological resources along the Gulf Coast. Should a spill contact an archaeological site, damage might include direct impact from oil-spill cleanup equipment, contamination of materials, and/or looting. A major effect from an oil-spill impact would be contamination of a historic coastal site, such as a historic fort or lighthouse. It is expected that any spill cleanup operations would be considered a Federal action for the purposes of Section 106 of the NHPA and would be conducted in such a way as to minimize to the extent possible impacts to archaeological resources. Recent research suggests the impact of direct contact of oil on historic properties may be long term and not easily reversible without risking damage to fragile historic materials (Chin and Church, 2010).

The potential for spills is low, the impacts of most noncatastrophic spills would generally be localized, and the cleanup efforts would be regulated. A proposed action, therefore, is not expected to result in impacts to archaeological sites; however, should such impacts occur, unique or substantial archaeological information could be lost and this impact could be irreversible.

There is also the potential for debris from vessels and offshore structures to be lost on the OCS. Debris resulting from accidental events could lead to impacts similar to those expected from routine impacts such as damage through contact with historic archaeological sites and/or the masking of archaeological resources during geophysical surveys.

There is no acceptable threshold of negative cumulative impacts to archaeological sites. A proposed action, including the drilling of wells and installation of platforms, installation of pipelines, anchoring, removal of platforms and other structures installed on the seafloor, and site clearance activities without archaeological review and mitigation may result in **major** impacts to archaeological sites. Identification, evaluation, and avoidance or mitigation of archaeological resources is expected to result in **negligible** long-term cumulative impacts to archeological resources as described in the previous section; however, if an archaeological site were to be impacted, impacts may range from **negligible** to **major**.

4.13.2.6 Alternative E—No Action

If selected, Alternative E, the No Action Alternative, would result in BOEM not undertaking a proposed lease sale. Therefore, the impact-producing factors mentioned above would not take place, and any impact that these actions could cause would not occur. As a result, whatever archaeological resources may be present would not be affected in any way if the No Action Alternative is selected.

4.14 Human Resources and Land Use

4.14.1 Land Use and Coastal Infrastructure

For land use and coastal infrastructure, a proposed action would involve all of the Gulf Coast States: Texas; Louisiana; Mississippi; Alabama; and Florida. Particular emphasis is placed on the 133 counties and parishes that constitute the 23 BOEM-identified Economic Impact Areas (EIAs) and are located in the coastal areas of all five Gulf Coast States. This geographic area is broadly diverse in types of land use and distribution of coastal infrastructure related to OCS oil- and gas-related activities. Some counties and parishes are more closely connected to the offshore oil and gas industry than others, such as Harris County, Texas, and Lafourche Parish, Louisiana. **Figures 3-9, 3-11, and 3-12** illustrate the analysis area's key infrastructure.

Impacts to land use and coastal infrastructure may be positive as well as negative. For example, increased economic demand for services provided by infrastructure facilities would lead to more hiring, and this additional employment would further the positive economic trend as new workers spend their wages in the community. The impacts of each impact-producing factor for Alternatives A-D are summarized in **Table 4-31** to help the reader quickly identify the level of potential impacts for each impact-producing factor using the impact-level definitions below. The affected environment and analyses supporting these conclusions are then discussed in detail in this chapter. BOEM has concluded that the selection of Alternative E would result in negligible impacts. Cumulative impacts of current and past activities, however, would continue to occur under Alternative E.

Impact-Level Definitions

- **Beneficial** – Positive impacts in the form of maintaining current employment levels, creating new employment, indirect and induced positive impacts through increased spending, and stimulating local and regional economies.
- **Negligible** – Little or no measureable adverse impact.
- **Minor** – Small-scale measurable adverse impact, temporary in duration and geographically small area (less than county/parish level).
- **Moderate** – Medium-scale measurable adverse impact and may last from a few weeks to 1 year and geographically may affect multiple counties/parishes.
- **Major** – Large-scale measurable or potentially unmeasurable adverse impact, long-lasting (1 year to many years), and may occur over a geographically large regional area.

A current snapshot of land use and coastal infrastructure in the GOM reveals a diverse social and economic landscape, with the oil and gas industry playing a substantially larger role in some states (i.e., Texas and Louisiana) than in the rest of the GOM. The oil and gas industry has developed across the region over many decades and is intimately intertwined with its socioeconomic structure. This complex structure involves offshore (i.e., on the Federal OCS and in State waters) and onshore (i.e., on private land and State and Federal onshore lands) exploration, development, and production activities, complicating the environmental impact analysis because it is very difficult, if not impossible, to separate the impacts of Federal OCS oil- and gas-related activities from those of oil and gas activities in State waters and onshore, or foreign imports.

Oil and gas exploration, production, and development activities on the OCS are supported by an expansive onshore network of coastal infrastructure that includes large and small companies providing a wealth of services from construction facilities, service bases, and waste disposal facilities to crew, supply, and product transportation, as well as processing facilities. **Chapter 3.1.7** discusses coastal infrastructure scenario projections, and **Chapter 3.1.5.3** discusses onshore waste disposal. A description of the affected environment covers land use in the area and different infrastructure categories that support thousands of jobs. These jobs represent direct, indirect, and induced economic impacts that ripple through the Gulf Coast economy. As a long-standing part of the regional economy that developed over the past several decades, the coastal infrastructure network is quite mature in the Gulf of Mexico region. The affected environment is described in the following chapter and a discussion of the impacts of routine activities, accidental events, and cumulative impacts as they relate to land use and coastal infrastructure follows.

Table 4-31. Land Use and Coastal Infrastructure Impact-Producing Factors That Are Reasonably Foreseeable.

Land Use and Coastal Infrastructure	Magnitude of Potential Impact[1]				
Impact-Producing Factors	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
Routine Activities					
Changes in the Level of OCS Exploration, Development, and Production Activities	Negligible to Moderate	Negligible to Moderate	Negligible to Moderate	Negligible to Moderate	Negligible
Expansions of Existing Infrastructure	Minor to Moderate	Minor to Moderate	Minor to Moderate	Minor to Moderate	Negligible
New Infrastructure Facility Construction	Minor to Moderate	Minor to Moderate	Minor to Moderate	Minor to Moderate	Negligible
Onshore Waste Disposal	Negligible to Minor	Negligible to Minor	Negligible to Minor	Negligible to Minor	Negligible
Navigation Channel Maintenance Dredging	Negligible to Minor	Negligible to Minor	Negligible to Minor	Negligible to Minor	Negligible
Accidental Events					
Oil Spills (coastal and offshore)	Negligible to Moderate	Negligible to Moderate	Negligible to Moderate	Negligible to Moderate	Negligible
Chemical/Drilling-Fluid Spills	Negligible to Moderate	Negligible to Moderate	Negligible to Moderate	Negligible to Moderate	Negligible
Spill Response	Negligible to Moderate	Negligible to Moderate	Negligible to Moderate	Negligible to Moderate	Negligible
Vessel Collisions	Negligible to Moderate	Negligible to Moderate	Negligible to Moderate	Negligible to Moderate	Negligible
Cumulative Impacts					
Incremental Contribution[2]	Minor				Negligible
OCS Oil and Gas[3]	Beneficial to Moderate				
Non-OCS Oil and Gas[4]	Beneficial to Major				

[1] The analysis supporting these conclusions is discussed in detail in the “Environmental Consequences” chapter below.
[2] This includes all activities (i.e., routine activities projected to occur and accidental events that could occur) as a result of a single proposed lease sale in the 2017-2022 Five-Year Program.
[3] This includes all activities (i.e., routine activities projected to occur and accidental events that could occur) from past, proposed, and future lease sales.
[4] This includes other past, present, and reasonably foreseeable future activities occurring within the same geographic range and within the same timeframes as a proposed action, but they are not related to the OCS Oil and Gas Program.

4.14.1.1 Description of the Affected Environment

Along the Gulf Coast, from the southern tip of Cameron County, Texas, to the Florida Keys, 23 BOEM-defined EIAs are identified for the Gulf of Mexico region. The counties and parishes that form the EIAs are listed and the EIAs are visually illustrated on **Figure 4-28**. The EIAs geographically link together not only counties and parishes immediately adjacent to the GOM but also those tied to coastal counties and parishes as parts of functional economic areas. An analysis that encompasses where people live as well as where they work permits a more meaningful assessment of the impact of offshore oil and gas activities. The OCS oil- and gas-related activities draw on existing infrastructural, economic, and labor capacity from across the GOM region. BOEM’s analysis considers the potential impacts in all 23 EIAs regardless of where a proposed action may take place.

4.14.1.1.1 Land Use

The coastal zone of the GOM is not a physically, culturally, or economically homogenous unit (Gramling, 1984). The counties and parishes along the Gulf Coast represent some of the most valuable coastline in the U.S. and cover approximately 1,631 mi (2,625 km). Not only does it include miles of recreational beaches and an extended system of barrier islands, but it also has deepwater ports, oil and gas support industries, manufacturing, farming, ranching, and hundreds of thousands of acres of wetlands and protected habitat. These counties and parishes vary in their histories and in the composition and economic activities of their respective local governments.

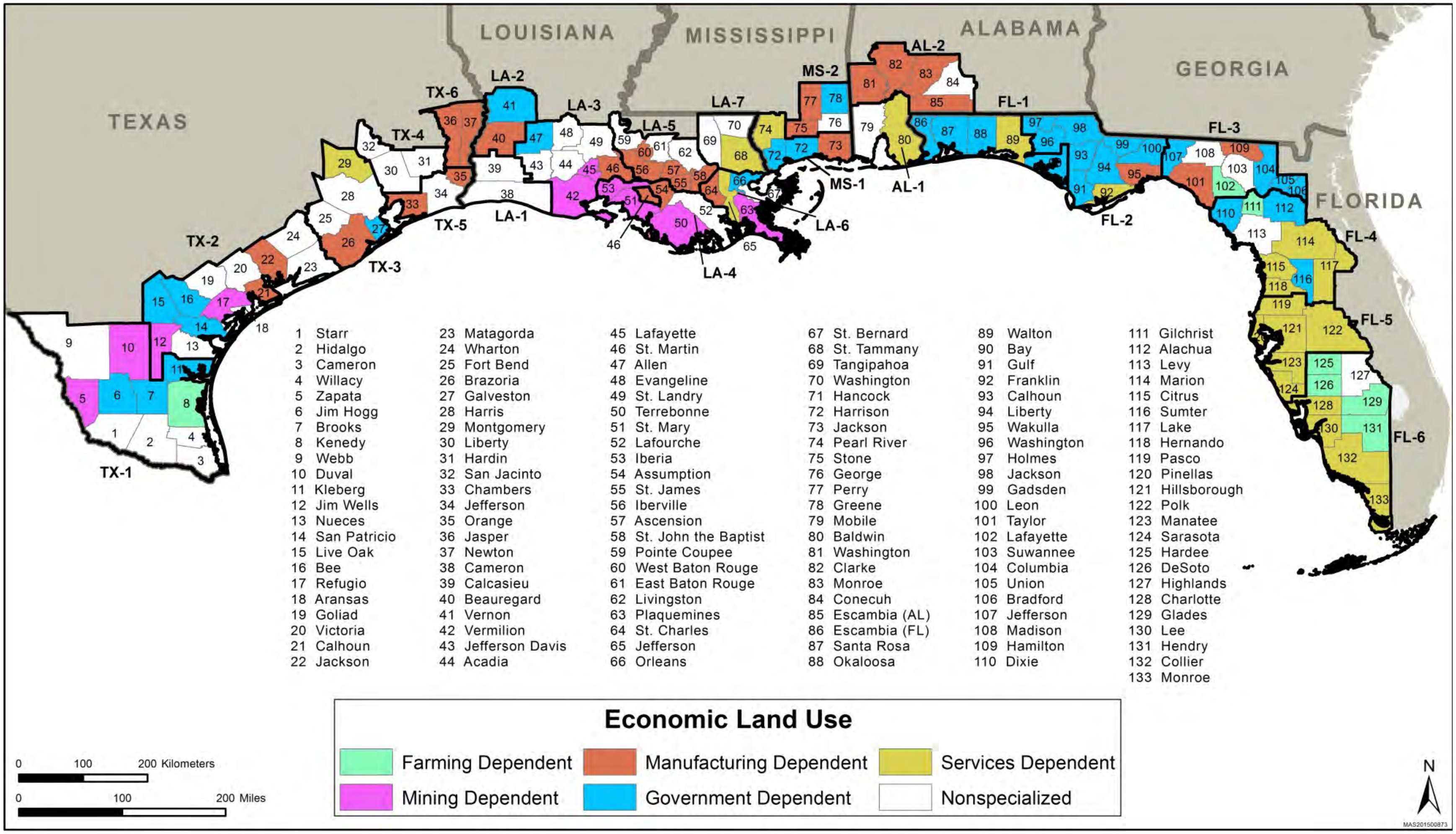

Figure 4-28. Economic Land Use Patterns.

The Gulf coastal plain of Texas makes up most of eastern and southern Texas and constitutes more than one-third of the State. Near the coast, this region is mostly flat and low-lying. It rises gradually to 1,000 ft (300 m) farther inland, where the land becomes more rolling. Belts of low hills occur across the Gulf coastal plain in many areas. In the higher areas, the stream valleys are deeper and sharper than those along the coast. Texas' coastline along the GOM is 367 mi (591 km). However, long narrow islands called barrier islands extend along the coast; if the shoreline of all the islands and bays is taken into account, the coastline is 3,359 mi (5,406 km) long. The region is made up of farmland (i.e., cotton, rice, and citrus fruit), forests, cattle ranches, major cities of commerce (e.g., Houston) and education, tourist locales (e.g., South Padre Island), Federal installations (e.g., Lyndon B. Johnson Space Center), and major ports. The oil and gas industry has also been part of the local economies since the early 1900's. Today, the majority of oil and gas corporations have headquarters in Houston while numerous industries associated with oil and gas (i.e., petrochemicals and the manufacture of equipment) are located in the area. In addition to oil and gas, the area has aggressively pursued technology companies such as computers and aerospace. The military has had a significant presence in general, particularly in the Corpus Christi Bay area and in San Patricio County on the eastern shore of the bay (Petterson et al., 2008).

The Louisiana coastal area includes broad expanses of coastal marshes and swamps interspersed with ridges of higher well-drained land along the courses of modern and extinct river systems. Most of the urban centers in coastal Louisiana are located along major navigable rivers and along the landward edge of the coastal zone (i.e., Lafayette and Lake Charles). Southwestern Louisiana is Acadian country. The area's natural features vary from marshland, waterways, and bayous in the coastal areas to flat agricultural lands in the northern part of the same parishes. While the area's traditionally strong ties to agriculture, fishing, and trapping are still evident, they are no longer the mainstay of the economy. Southeastern Louisiana, from Jefferson Parish east to St. Tammany Parish and the State border with Mississippi, is a thriving metropolitan area with shipping, navigation, U.S. Navy facilities, and oil and chemical refineries, all vying with local residents for land (Petterson et al., 2008). Historically, Terrebonne, Plaquemines, and Lafourche Parishes have been the primary staging and support area for offshore oil and gas exploration and development. The Port of Fourchon, at the mouth of Bayou Lafourche on the GOM, is a major onshore staging area for OCS oil- and gas-related activities in the GOM, and it is the headquarters of the Louisiana Offshore Oil Port (LOOP), which offloads 10 percent of U.S. foreign oil imports and transports that oil to half of the Nation's refining capacity and services over 90 percent of deepwater GOM production (The Greater Lafourche Port Commission, 2015). The LOOP has received and transferred over 11 billion barrels of crude oil since its inception (LOOP LLC, 2015).

Coastal Mississippi is characterized by bays, deltas, marshland, and waterways and is comprised of Hancock, Harrison, and Jackson Counties. Two-thirds of this 44-mi (71-km) coastline is devoted to State-chartered gambling and heavy tourism along the beachfront. The remaining one-third (Jackson County) is industrial—oil refining and shipbuilding. Upland portions of the three coastal counties are timberlands (Petterson et al., 2008). Offshore barrier islands form part of the Gulf Islands National Seashore, providing tourists with beaches to enjoy, trails to hike, and many fishing opportunities. Jackson County has a strong industrial base and designated industrial parks.

Pascagoula, in Jackson County, is home to Ingalls Shipbuilding, an 800-ac (324-ha) shipyard that employs 11,000 people, and the Chevron Pascagoula Refinery located in the Bayou Casotte Industrial Park (Ingalls Shipbuilding, 2015; Chevron, 2015). The Port of Pascagoula is one of the top 20 ports in the U.S. by foreign cargo volume, handling forest products, chemicals, crude oil, phosphate rock, and aggregate. The port includes the Pascagoula River Harbor and the Bayou Casotte Harbor (Port of Pascagoula, 2015). Now in a state of expansion after recovering from Hurricane Katrina damages, the Port of Gulfport houses some major OCS oil- and gas-related companies (i.e., shipbuilding, shipyards, pipelaying, and offshore support services) in addition to food importers, casino operations, university research activities, and renewable energy interests (Port of Gulfport, 2016).

Southwestern Alabama's coastline is comprised of Mobile and Baldwin Counties, which oppose each other across Mobile Bay. The coastal plain of Alabama is characterized by beaches, wetlands, bayous, coastal bays, rivers, and estuaries. The only barrier island in Alabama, Dauphin Island, is populated with residences, businesses, and hotels. Coastal resource-dependent industries in this area include navigation, tourism, marine recreation, commercial fishing, and offshore natural gas development and production. Large quantities of natural gas were discovered in Alabama's offshore waters in 1979. Baldwin County has a strong tourism economy and a large retiree population. The important commercial fishing industry in the area is located in southeastern Mobile County. The Port of Mobile, the largest seaport in Alabama, is also in Mobile County. The military has had a long presence in the area. The buildup and downsizing of military installations has handed the area some special challenges. The area's second port, Mobile Middle Bay Port, is a former Naval Station. Major manufacturers in Mobile include three paper mills, a German-owned chemical plant, and two large shipbuilding and repair yards (Petterson et al., 2008). Mobile County has a strong industrial base and designated industrial parks, especially at Theodore Industrial Park and Canal and the Alabama State Docks. In addition, Bayou La Batre in south Mobile County has many shipbuilding firms. Theodore, in Mobile County, has boat and helicopter facilities, and onshore supply bases to support drilling and production (Dismukes, 2011).

The GOM coastal area of Florida includes bays, beaches, estuaries, wetlands, an extensive barrier island system, and increasing concentrations of human settlement. This area ranges from heavily urbanized areas, such as Pensacola in Escambia County and Panama City in Bay County with shipping ports and Naval air bases, to scarcely populated areas along the coastal rim, such as the towns of Port St. Joe, Apalachicola, and Carrabelle in Gulf and Franklin Counties. The Florida Panhandle area has military, tourism, fishing, and ports as major components of the economy. The military has had a substantial presence in the Florida Panhandle since World War II. The four main military installations are Pensacola Naval Air Station, Eglin Air Force Base (Okaloosa County), Tyndall Air Force Base, and the Coastal Systems Station (Bay County). The three air bases use the northern GOM as a weapon-testing and training range. These bases were largely untouched by the downsizing of the military in the 1990's and remain an important part of the Florida Panhandle economy. Tourism and recreation are extremely important to the area, along with both commercial and recreational fishing activities. The development of the Florida Panhandle as a major tourist area began in the mid-1930's and grew rapidly after World War II, becoming what is now a key industry in the Florida Panhandle. "Sugar-white" beaches, fishing, other water-based activities, and natural habitats are key parts of the tourist attraction. In the Florida Panhandle, the commercial fishing industry employs several hundred people, who land millions of pounds of fish and shellfish annually (Petterson et al., 2008). Three major deepwater ports are Port of Pensacola, Port Panama City, and Port Tampa Bay. The Port of Pensacola is turning away from bulk container cargo and focusing on expanding operations to cater to the oil and gas industry, and new projects such as deep-sea pipe manufacturing have begun development (Offshore Inland, 2014; DeepFlex, 2014; *Pensacola News Journal*, 2014). Port Panama City served as an onshore support base for exploratory drilling in the GOM during the 1980's before drilling was banned in most of the EPA. Since that time the Port has continued diversifying and has initiated the development of the Port Panama City Intermodal Distribution Center to attract more businesses to the area. Most of the Port handles bulk container cargo, seafood products, and some petroleum products (Dehart, 2013; World Port Source, 2015).

The U.S. Dept. of Agriculture's Economic Research Service classifies counties (includes parishes) into economic types that indicate primary land-use patterns. According to the most recent statistics, most notably only 7 of the 133 counties in the analysis area are classified as farming dependent. Ten counties are defined as mining dependent, suggesting the importance of oil and gas development to these local economies. Manufacturing dependence is noted for another 26 counties. Local school districts and public facilities, such as hospitals and prisons, are often the largest employers in sparsely populated rural areas. Thus, it is not surprising that 19 non-metro counties and 13 metropolitan counties are classified as government employment centers. Another 21 counties have economies tied to service employment while 37 counties are considered nonspecialized. The Economic Research Service also classifies counties in terms of their status as a retirement destination, and of the 133 counties/parishes, 44 are considered major retirement destinations (U.S. Dept. of Agriculture, Economic Research Service, 2008). The varied land-use patterns are displayed in **Figure 4-28**.

4.14.1.1.2 Coastal Infrastructure

The onshore coastal infrastructure is extensive, covers a wide-ranging area, supports development, and consists of thousands of large and small companies. These companies cover every facet of coastal and offshore industry activity, but for analysis purposes, these infrastructure types are organized into the following categories: construction facilities; support facilities; transportation; and processing facilities. More extensive information on OCS oil- and gas-related coastal infrastructure can be found in **Chapter 3.1.7**.

Onshore coastal infrastructure discussed in this chapter supports both OCS and non-OCS oil- and gas-related activities, complicating impact analysis for this resource.

Construction Facilities

The major players among construction facilities in the coastal GOM include platform fabrication yards (**Chapter 3.1.7.1.1**), shipbuilding and shipyards (**Chapter 3.1.7.1.2**), and pipe-coating plants and yards (**Chapter 3.1.7.1.3**). These facilities' service involves both onshore and offshore (State and Federal OCS) oil and gas exploration, development, and production activities. Shipbuilding and shipyards may also be servicing the commercial and recreational fishing industry or the military. Impact analysis becomes more complex because of the difficulty inherent in trying to separate the impacts of OCS oil- and gas-related activities from non-OCS oil- and gas-related activities, given that they utilize the same critical coastal infrastructure.

Support Facilities

The major support facilities in the coastal GOM (**Chapter 3.1.7.2**) include service bases and ports, waste disposal facilities, and natural gas storage facilities. State and Federal (both onshore and offshore) oil and gas exploration, development, and production activities utilize the same critical coastal support infrastructure. Other types of support sectors to the oil and gas industry that may have coastal facilities can include drilling contractors, geological and geophysical contractors, underwater contractors (divers and remotely operated vehicle equipment). Ports and service bases are also used for international and domestic import and export activities, and service other industries including commercial and recreational fishing, cruise ship terminals, and research vessels. Maritime military operations generally have their own ports and bases along the coast, but they may use community waste disposal facilities.

Transportation

The major forms of crew, supply, and product transportation include the following: heliports; coastal pipelines/pipeline landfalls/pipeline shore facilities; and coastal barging/barge terminals. These transportation services can involve both onshore and offshore (State and Federal OCS) exploration, development, and production activities. This complicates impact analysis because of the difficulty inherent in trying to separate the impacts of OCS oil- and gas-related activities from non-OCS oil- and gas-related activities, given that they utilize the same coastal infrastructure. The OCS product that is piped to shore facilities and terminals may be moved by barge up rivers or through the Gulf Intracoastal Waterway and major shipping channels to service bases. Critical to the success of service bases and port facilities are the railways and major interstates that traverse the areas along the inner margin of the coastal zone. There are nine interstate highways that access the regional area; however, there are numerous other highways into and across the analysis area. The most critical is Louisiana Highway 1 (LA Hwy 1) that provides the only link between Port Fourchon, Louisiana, and the rest of the Nation. **Chapter 3.1.4** discusses transport and **Chapter 3.1.7** provides more detail on coastal infrastructure.

Processing Facilities

The major forms of processing facilities in the coastal GOM (**Chapter 3.1.7.3**) include gas processing plants, LNG terminals, refineries, and petrochemical plants. Basic chemical production from petrochemical plants is concentrated along the Gulf Coast, where petroleum and natural gas feedstock are available from refineries. Of the top 10 production complexes in the world, 5 are located in Texas and 1 is located in Louisiana. These facilities can process onshore and offshore (State and Federal OCS) production and foreign imported production. This complicates impact analysis because of the difficulty inherent in trying to separate the impacts of OCS oil- and gas-related activities from non-OCS oil- and gas-related activities, given that they utilize the same critical coastal infrastructure for downstream processing of their products.

4.14.1.2 Environmental Consequences

Analysis and discussion of impact-producing factors from routine activities, accidental events (non-catastrophic), and cumulative activities follow below. For a detailed analysis of a high-impact, low-probability catastrophic oil spill, which is not reasonably foreseeable as a result of a proposed action, refer to the *Catastrophic Spill Event Analysis* white paper (USDOI, BOEM, 2017).

4.14.1.2.1 Routine Activities

Routine activities of the oil and gas industry result in various impact-producing factors that could affect land use and coastal infrastructure, including the following: fluctuations in the level of OCS exploration, development, and production activities; expansions of existing facilities; construction of new facilities; onshore disposal of OCS waste; and maintenance dredging of existing navigation channels. These routine activities impact, to some extent, each of the infrastructure types discussed in the "Affected Environment" section above, including construction facilities, support services, transportation modes for people and products, and processing facilities Given that the oil- and gas-related coastal infrastructure is a mature and extensive system, resulting from long-term industry trends, it is not subject to rapid fluctuations. Routine activities related to a proposed action are expected to minimally affect the current land use of the analysis area because most subareas have strong industrial bases and designated industrial parks with existing infrastructure and facilities that have sufficient capacity to accommodate future growth. For this reason, land use conflicts from a single proposed lease sale are not likely to occur.

Fluctuations in OCS exploration, development, and production activity levels can impact land use and coastal infrastructure because higher activity levels increase demand for services, which can affect land use if a facility needs to acquire additional land for expansion to meet the demand, and it would affect infrastructure facilities by potentially increasing profits and the need to hire additional employees. This would be a positive impact and could cause localized expansion of economies (i.e., increased demand for services, consumer spending, and indirectly, new employment), resulting in localized land-use changes including commercial and residential development and growth. If activity levels decrease, then the opposite impact occurs. Decreases in demand for services could cause a negative ripple impact through the local (and possibly regional) economies. The OCS activity levels fluctuate based on changes in demand, commodity prices, and offshore service vessel day rates (for shipyards, shipbuilding, and transportation services). When activity levels increase, commuter and truck traffic increase, producing additional wear and tear on the transportation infrastructure. For example, in Louisiana, LA Hwy 1 is the only road providing critical access to Port Fourchon, the largest OCS oil- and gas-related service base, which supports 90 percent of all OCS deepwater activities (World Oil, 2016; LA1 Coalition, 2016). A multi-phase LA Hwy 1 improvement project has been ongoing for several years and was approved for a $12.5-million additional Phase 2 funding in 2015 (LA1 Coalition, 2015) The impacts described above range from **negligible** to **moderate** depending on the specific situation, type of infrastructure facility being considered, and its location. For example, a small-scale expansion of a facility located in a remote area would be a **negligible** impact. If the facility was located in a populated area, it may cause temporary disruption to traffic from construction activities and thus be a **minor** impact. If it was a larger-scale expansion and the facility was located in a more populated area, then the impact would be **moderate** because the scale of the project would make the disruption last anywhere from a few weeks to a year.

Land use and coastal infrastructure may also be affected by expansions of current facilities that result from oil and gas industry-generated service demand increases. Because of the environmental and regulatory difficulties inherent in permitting and building new facilities, most companies would opt to expand their existing facilities (i.e., fabrication yards, shipyards, pipe-coating facilities, service bases, refineries, gas processing plants, and waste disposal facilities). Expansions of existing facilities generate a positive momentum with increased capabilities leading to increased profitability. Whether positive or negative, the impacts described above range from facility expansions ranges from **minor** to **moderate** depending on the specific situation. For example, a small-scale expansion of a refinery would be a **minor** impact because of the small size of the project, the temporary disruptions caused by increased constructions traffic and the geographically small area affected. If the refinery was located in a more populated area and the project was larger in scale, causing disruptions because of construction activities that last up to one year, then the impact would be **moderate.** BOEM's scenario projections forecast most increases in demand to be met by expansions at currently existing facilities (Dismukes, official communication, 2015).

Much less common in the GOM, the construction of new facilities requires substantial capital investment and assurances of future service demand to make this option attractive to investors. BOEM's scenario projections call for possibly 0-1 new gas processing plant and 0-1 new pipeline landfall during the 50-year analysis period for a proposed lease sale (Dismukes, official communication, 2015). If either were to occur, it may negatively impact land use because of potential space-use conflicts, and some existing gas processing facilities also could be negatively impacted because it may become necessary to increase efforts to maintain competitiveness. In the rare instance of new facility construction, the impacts would range from **minor** to **moderate** depending on the nature and location of the project(s).

The OCS oil- and gas-related waste disposal to onshore facilities is an impact-producing factor that could affect onshore waste disposal facilities and land use if a new facility needs to be constructed to meet the level of offshore wastes coming to shore. **Chapter 3.1.5.3** discusses OCS oil- and gas-related waste disposal and outlines BOEM's scenario analysis, which concluded that no new solid-waste facilities would be built as a result of a single lease sale. Existing solid-waste disposal infrastructure is adequate to support both existing and projected offshore oil and gas drilling and production needs. The industry trend is toward innovative methods to handle wastes to reduce the potential for environmental impacts, e.g., hydrocarbon recovery/recycling programs, slurry fracture injection, treating wastes for reuse as road base or levee fill, and segregating waste streams to reduce treatment time and improve oil recovery. The volume of OCS waste generated is closely correlated with the level of offshore drilling and production activity (Dismukes et al., 2007, Dismukes, 2011, Dismukes, official communication, 2015). The impact of fluctuations in offshore waste disposal would range from **negligible** to **minor** and would not be expected to result in more extensive impacts because existing spare capacity of current facilities is sufficient to meet demand.

Maintenance dredging of existing navigation channels is essential for proper water depths to allow all shipping to move safely through the waterways to ports, services bases, and terminal facilities. Several million cubic yards of sand, gravel, and silt are dredged from waterways and harbors every year. **Chapter 3.1.3.3.4** discusses scenario projections for navigation channels along the Gulf Coast. Much of the traffic navigating these channels is unrelated to OCS oil- and gas-related activity, and the current system of navigation channels in the northern GOM is projected to be adequate for accommodating traffic generated by a proposed lease sale. Therefore, no new navigation channels are expected to be created as a result of a proposed lease sale (Dismukes, 2011; Dismukes, official communication, 2015). **Chapter 4.3.2** provides a discussion of wetlands and the impacts of navigation channel dredging. Impacts to land use and coastal infrastructure as a result of maintenance dredging are expected to range from **negligible** to **minor** depending on the location of dredging projects.

Routine activities are not expected to produce any major impacts to land use and coastal infrastructure because current supporting oil and gas infrastructure is mature and not subject to rapid changes. As OCS oil- and gas-related activity levels fluctuate, the demand for services provided by coastal infrastructure facilities would fluctuate. If necessary, increases in demand would be met with facility expansions. Regarding new construction, BOEM's scenario projections call for up to one new gas processing facility, up to one new pipeline landfall over the 50-year life of a proposed lease sale, and no new waste disposal facilities. The impacts on land use and coastal infrastructure would be limited, would occur on lands designated for such purposes, and would be **negligible** to **moderate** because expansions at current facilities could cause either little or no measurable adverse impact (negligible) or may cause small-scale, temporary adverse impacts affecting a small area (minor). Impacts could possibly reach a moderate level if a new gas processing facility is installed sometime during the 50-year life of the lease because it could cause medium-scale impacts lasting up to a year and possibly affecting more than one county or parish. However, the likelihood of a future gas processing facility is closer to zero than the possible one projected. Maintenance dredging of navigation channels as a result of a proposed lease sale is expected to produce **negligible** to **minor** impacts to land use and coastal infrastructure (Dismukes, official communication, 2015).

4.14.1.2.2 Accidental Events

Impact-producing factors associated with accidental events that may affect land use and coastal infrastructure include coastal and offshore oil spills, chemical/drilling fluid spills, spill-response activities, and vessel collisions. Accidental events associated with a proposed action would occur at differing levels of severity, based in part on the location and size of event. Coastal and offshore oil-spill events discussed in this section are noncatastrophic in nature, smaller in size, occur more frequently, and must be distinguished from low-probability catastrophic oil spills such as the *Deepwater Horizon* blowout, oil spill, and response. **Chapter 3.2.1** provides a detailed discussion of oil spills that have occurred and their frequency. A complete analysis of a high-impact, low-probability catastrophic oil spill is provided in the *Catastrophic Spill Event Analysis* white paper (USDOI, BOEM, 2017).

Coastal and offshore oil spills may be associated with OCS exploration, production, or transportation activities that result from a proposed lease sale. Detailed risk analysis of offshore oil spills ≥1,000 bbl, <1,000 bbl, and coastal spills associated with a proposed lease sale is provided in **Chapters 3.2.1.4, 3.2.1.5, and 3.2.1.6**. Because spills <1,000 bbl are not expected to persist as a slick on the surface of the water beyond a few days and because spills on the OCS would occur at least 3-10 nmi (3.5-11.5 mi; 5.6-18.5 km) from shore, it is unlikely that any spills would make landfall prior to breaking up. The combined probabilities for an offshore spill ≥1,000 bbl occurring and contacting coastal and offshore areas for each alternative can be found in the figures in **Appendix E**. For a proposed action, the probabilities of an oil spill ≥1,000 bbl occurring and contacting the shoreline within 10 days range from <0.5-1 percent to 2-8 percent, with the highest probability in Plaquemines Parish, Louisiana, at 1-6 percent (**Figure E-2)**. The probabilities of an oil spill ≥1,000 bbl occurring and contacting the shoreline within 30 days range from <0.5-1 percent to 2-8 percent, with the highest probability in Plaquemines Parish, Louisiana, at 2-8 percent (**Figure E-3)**. Oil spills in coastal and inland waters, such as spills resulting from the operations of offshore supply vessels, pipelines, barges, tanker ships, and ports, are more likely to affect land use and coastal infrastructure categories. For example, if waterways are closed to traffic, this may result in impacts to upstream and downstream business interests as it impedes the flow of commerce. Other potential impacts could include damages to private and public lands, personal injury, damages to collateral property (moveable property such as vehicles and boats), and economic damages from the disruption of business. The impacts to land use and coastal infrastructure from coastal and offshore oil spills could range from **negligible** to **moderate** depending on the size and location of the spill. For more information on the potential impacts of a low-probability catastrophic spill (which is not part of a proposed action and not reasonably foreseeable as a result of a proposed action), refer to BOEM's *Catastrophic Spill Event Analysis* technical report (USDOI, BOEM, 2017). More specifically, the intensity of the impact would be experienced inconsistently among businesses and residents, meaning it would be worse for some businesses/residents than others. For example, those who have alternative means of transporting their goods would not feel the impact as harshly as those who are most dependent on the waterway for transport. The mean number and sizes of spills estimated to occur in OCS offshore waters from an accident related to rig/platform and pipeline activities supporting a proposed action over a 50-year period are presented in **Table 3-18**.

Chemical/drilling-fluid spills may affect land use and coastal infrastructure and could be associated with exploration, production, or transportation activities that result from a proposed lease sale. **Chapter 3.2.6** provides a detailed discussion of chemical and drilling-fluid spills. Each year, between 5 and 15 chemical spills are expected to occur; most of these are ≤50 bbl in size. Large spills (≥1,000 bbl) are much less frequent but may be reasonably foreseeable and are therefore considered within this Multisale EIS; in contrast, a catastrophic event of a magnitude similar to the *Deepwater Horizon* explosion, oil spill, and response is not reasonably foreseeable and not part of a proposed action. Even though additional production chemicals are needed in deepwater operations where hydrate formation is a possibility, offshore spill volumes are expected to remain stable because of advances in subsea processing. Spills may also occur during transport in coastal waters. Overall, the impact of chemical and drilling-fluid spills is expected to be **negligible** to **moderate** depending on the location, size, and duration of the event. For example, potential impacts could include damages to private and public lands, personal injury, damages to collateral property (moveable property such as vehicles and boats), and economic damages from the disruption of business. If a spill is very small (not measurable) in size, located in a remote area, and dissipates quickly, its impact would be **negligible**. If a spill is measurable, occurs in a less remote area, and lasts a few days to a month, then its impact would be **minor**. If a spill occurs in a highly populated area (e.g., Houston Ship Channel), is larger in quantity, and the response and cleanup last over a month and up to a year with either waterborne commerce affected and/or land transportation affected, then the impact would be **moderate**.

While not an accidental event specifically, spill-response activity results from an accidental spill and therefore is included in this analysis. Spill-response activities may affect land use and coastal infrastructure because of the requisite needs for staging operations, equipment handling, and waste disposal. Depending on where an accidental event occurs, it is expected that the oil-spill response equipment needed to respond to an offshore spill as a result of a proposed lease could be called out from one or more of the following oil-spill equipment base locations: Aransas Pass, Baytown, Corpus Christi, Galveston, Houston, Ingleside, Pasadena, and Port Arthur, Texas; Baton Rouge, Belle Chasse, Fort Jackson, Franklin, Grand Isle, Harvey, Houma, Lake Charles, New Iberia, Port Fourchon, and Sulphur, Louisiana; Kiln and Pascagoula, Mississippi; Bayou La Batre and Mobile, Alabama; Key West, Miami, Panama City, Pensacola, and Tampa, Florida (Marine Spill Response Corporation, 2015b; National Response Corporation, 2015). The impact of spill-response activities on land use and coastal infrastructure would range from **negligible** to **moderate** depending on the spill's location, duration, and whether the event is a small-scale spill or a larger spill. For example, potential impacts could include space-use conflicts related to staging operations, potential mishandling of cleanup equipment (boom), and improper disposal of oily wastes. In addition, the additional use of waterways or roadways used for the vehicles servicing spill response may result in localized increased wear and tear.

Vessel collisions may be associated with exploration, production, or transportation activities that result from a proposed lease sale. **Chapter 3.2.5** provides a detailed discussion of vessel collisions. The majority of offshore vessel collisions involve service vessels colliding with platforms or pipeline risers, although sometimes vessels collide with each other. In coastal waters, vessel collisions are more likely to include other vessels or stationary structures like bridges and docks. Human error accounted for about half of all reported vessel collisions from 1996 through 2009. These collisions often result in spills of various substances and, while most occur on the OCS far from shore, spills in coastal waters can have impacts to land use and coastal infrastructure that can range from **negligible** to **moderate**, depending on the severity and location of a vessel collision, the size of the vessels involved, and whether the collision involves a bridge, pier, or other structure.

Land use may be affected if a bridge, pier, or other structure is involved because it could affect the transportation of goods, services, and people to and from work and schools.

The impact of reasonably foreseeable oil spills, chemical and drilling-fluid spills, and vessel collisions are not likely to last long enough to adversely impact overall land use or coastal infrastructure in the analysis area. Spill-response impacts would depend on the location and duration of a spill.

4.14.1.2.3 Cumulative Impacts

Land use and coastal infrastructure experience cumulative impacts that include all human activities and natural processes and events. The cumulative analysis considers impacts that comprise the incremental contribution of a proposed lease sale combined with all past, present, and reasonably foreseeable future Federal OCS oil- and gas-related lease sales, considered along with the natural baseline conditions before the first lease sale in 1954, as well as all past, present, and reasonably foreseeable future actions unrelated to the Federal OCS oil- and gas-related activities (**Chapter 3.3**).

The cumulative analysis geographically includes all 133 counties that comprise the 23 BOEM-identified EIAs, covering the coastal areas of all five Gulf Coast States from the southern tip of Texas to the Florida Keys. Temporally, the natural baseline conditions were those in existence before the first Federal OCS lease sale in 1954, several decades ago. At that time, population in the five Gulf Coast States was only 19.8 million, much less than half of the 60.3 million residents in 2015 (USDOC, Census Bureau, 2015a, 2015b, 2015c, 2015d, and 2015e) (**Table 4-32**).

Table 4-32. Comparison of the 1954 and 2015 Populations by State.

State	1954	2015	# Increase	% Difference
Alabama	3,014,000	4,858,979	1,844,979	37.97%
Florida	3,505,000	20,271,272	16,766,272	82.71%
Louisiana	2,883,000	4,670,724	1,787,724	38.28%
Mississippi	2,064,000	2,992,333	928,333	31.02%
Texas	8,382,000	27,469,114	19,087,114	69.49%
Total	19,848,000	60,262,422	40,414,422	67.06%

Sources: USDOC, Census Bureau, 2015a, 2015b, 2015c, 2015d, and 2015e.

The coastal areas experienced the greatest proportion of population growth over the years (USDOC, NOAA, 2011). Though coastal areas were less developed and more rural in 1954 than they are now, there was much cultural variation across the region, especially in Louisiana (White, 1998). The oil and gas industry had been thriving in Texas and Louisiana since 1901 with the Beaumont, Texas, Spindletop discovery and the first Louisiana oil well in Jennings (Austin et al., 2008; Texas Almanac, n.d.; State of Louisiana, Dept. of Natural Resources, n.d.). All manner of oil and gas infrastructure developed over the decades from 1901 to 1954. The onshore oil and gas industry developed and matured, bringing many jobs and economic opportunity to the area. The

1950's marked one of the most prosperous time periods for the United States, with more wealth being created from 1950 to 1965 than in any previous era (Arabe, 2003). When the Federal Government formalized its control over the OCS in 1953, the oil and gas industry was already booming onshore and in coastal waters along the Gulf Coast and had been for many decades.

The Submerged Lands Act and the OCSLA, both passed in 1953, laid the foundation for the creation of the Federal OCS Oil and Gas Leasing Program. The first lease sale of OCS lands in the Gulf of Mexico occurred on October 13, 1954. Since that time, in the Gulf of Mexico region, the Federal OCS Oil and Gas Program has held over 120 lease sales, leasing in excess of 143 million ac (58 million ha), with over $66 billion in total bonuses for leased blocks (USDOI, BOEM, 2016a). The past and present OCS Programs (with >120 lease sales) has occurred simultaneously with numerous non-OCS oil- and gas-related past and present activities that, when taken in their entirety, have resulted in the current make-up of the analysis area (refer to **Figure 4-27** and "Description of the Affected Environment" above). BOEM adds to this all reasonably forseeable future OCS oil- and gas-related and non-OCS oil- and gas-related activities to complete the cumulative analysis within the geographical bounds of the 23 BOEM-identified EIAs spanning across 133 counties and parishes.

Incremental Contribution

Within this divided analytical framework of OCS oil-and gas-related and non-OCS oil- and gas-related impacts, the largest quantity of impact-producing factors for land use and coastal infrastructure occur as non-OCS oil- and gas-related impacts because these resources are located onshore and exist for the benefit of both offshore and onshore oil- and gas-related activities, as well as other societal and business needs. Land use and coastal infrastructure reside within an extremely complex socioeconomic structure, and offshore OCS oil- and gas-related activities comprise a very small portion of this structure. Therefore, the incremental contribution to cumulative impacts of a proposed action, i.e., a single proposed lease sale, would be **minor** for land use and coastal infrastructure in the Gulf Coast region.

OCS Oil- and Gas-Related Impacts

Potential impacts related to OCS oil- and gas-related activities include the cumulative impact of all past, present, and future lease sales, and the resultant exploration, development, and production in Federal waters that contribute to the following possible impacts: fluctuations in OCS oil- and gas-related activity levels; increases in commuter and truck traffic; onshore infrastructure expansions; construction of new infrastructure facilities; increases in waste disposal volumes; coastal and offshore oil spills, chemical/drilling-fluid spills, spill-response activities, and vessel collisions, which are all discussed above under "Routine Activities" above. A proposed lease sale would make a **minor** incremental contribution to the cumulative impacts of all past, present, and future lease sales.

The OCS oil- and gas-related onshore coastal infrastructure is extensive, covers a wide-ranging area, supports OCS development, and consists of thousands of large and small companies. **Chapter 3.3.1.10** describes the cumulative coastal infrastructure scenario projections for the OCS Program. BOEM estimates no additional service bases, heliports, platform fabrication yards, shipyards, or pipe-coating yards. Lease sales would serve mostly to maintain ongoing activity levels associated with the current OCS Program. Industry would more or less maintain its current usage of infrastructure. Expectations for new gas processing facilities being built during the 70-year analysis period as a direct result of the OCS Program are dependent on long-term market trends that are not easily predicable over the next 70 years. Existing facilities would experience equipment switch-outs or upgrades during this time. BOEM projects that expansions at existing LNG facilities and the construction of new facilities would not occur as a direct result of the OCS Program. Cumulative impacts of OCS oil- and gas-related activities are dependent on fluctuations in OCS activity levels; increases in commuter and truck traffic; expansions at existing facilities; new construction of infrastructure; increases in waste disposal volumes; and accidental events such as coastal and offshore oil spills, chemical/drilling-fluid spills, spill-response activities, and vessel collisions. BOEM's scenario projections call for the new construction of 0-1 new gas processing facility and 0-1 new pipeline landfall to result from a proposed lease sale over the analysis period. Increases in demand for services at other facilities would be met by current excess capacity or expansions at current facilities. These activities, along with noncatastrophic accidental events, are reasonably foreseeable. Cumulative impacts resulting from all past, present, and reasonably foreseeable future OCS oil- and-gas related activities could range from **beneficial** to **moderate** depending on the specifics of each situation, whether the impacts are measurable, how long the impacts would last, and the size of the affected geographic area.

Non-OCS Oil- and Gas-Related Impacts

Non-OCS oil and gas-related cumulative impacts encompass all human activities and natural processes that may affect land use and coastal infrastructure. A discussion of every conceivable human activity and natural process from a global or universal perspective would consume volumes and would not be a reasonable or realistic undertaking (e.g., international commodity markets, geopolitical agendas [OPEC], Zika virus, or asteroid strikes). Therefore, BOEM limits this cumulative analysis to the following most relevant (past, present, and reasonably foreseeable future) impact-producing factors:

- State oil and gas activity;
- onshore oil and gas activities;
- demands on transportation systems and ports;
- maintenance and improvements to transportation systems;
- construction and maintenance of industrial facilities;
- agricultural uses;
- urbanization;
- demographic shifts (i.e., in-migration and out-migration);

- evolution of State and Federal regulations;
- city planning and zoning;
- development of residential areas and recreational facilities;
- modifications to public facilities such as water, sewer, educational, and health facilities;
- military activities;
- coastal land loss;
- coastal storms; and
- global, national, and regional economic trends.

All of the cumulative non-OCS oil- and gas-related impacts discussed in this section can range across the scale, i.e., from **beneficial** to **major** adverse impacts depending on the unique specifics of each situation, whether the impacts are measurable, how impacts are measured, how long they would last, the size of the affected area, and most importantly, the viewpoints of the various people that may be involved. For example, in the case of urbanization, land developers would say any negative impacts are minor or negligible because they would be out-weighed by the beneficial economic benefits to the area (e.g., jobs, increased tax revenues), but a conservationist would say the impacts are major, negative, and highly detrimental because of habitat loss and damages to air and water quality. Given that within each listed category above there can be a myriad of potential situations that arise across the very large (133 counties and parishes) Gulf Coast analysis area, the discussion below does not assign individual labels (i.e., beneficial, negligible, minor, moderate, or major) to every category of cumulative impacts described.

Non-OCS oil- and gas-related activities onshore and in State waters utilize many of the same coastal infrastructure facilities as offshore OCS oil- and gas-related activities (**Figure 3-9**) and would continue to contribute to the cumulative impacts on land use and coastal infrastructure throughout the 70-year analysis period. Over the past several years, there has been a substantial decrease in offshore natural gas production in shallow waters, partially as a result of increasing emphasis on onshore shale gas development, which is less expensive to produce and which provides larger per-well production opportunities and reserve growth. Onshore unconventional natural gas production has increased to the point that existing Gulf Coast LNG facilities are seeking, and some have started, to export natural gas to foreign consumers. For all coastal infrastructure types, especially processing facilities, it has proven impossible to parse out what percentage of demand is generated by OCS oil- and gas-related activities as opposed to non-OCS oil- and gas-related activities. This difficulty is an inherent problem in analyzing most cumulative impacts to coastal land use and infrastructure.

For example, demands on transportation systems and ports are not isolated to OCS oil- and gas-related activities. Transportation systems (e.g., rail, trucks, highways, barges, supply vessels, and tankers) and ports also serve oil and gas activities onshore and in State waters, as well as other industrial uses unrelated to oil and gas activities (e.g., agricultural and manufacturing transport, and commercial and recreational fishing). The maintenance and improvements necessary for transportation systems and ports also are likely to cause cumulative impacts to land use and coastal infrastructure, in varying degrees, depending on the magnitude of each project. Similarly, construction or expansion and maintenance of non-OCS-related industrial facilities, such as paper mills and aluminum plants, could contribute to cumulative impacts on land use and coastal infrastructure depending on proximity and scale of the work being done.

Agricultural uses may also contribute to cumulative impacts on land use and coastal infrastructure. Of the over 400,000 mi^2 (1,035,995 km^2) comprising these coastal states, 18 percent of the total land area is covered in cropland, which includes cropland harvested, crop failure, cultivated summer fallow, cropland used only for pasture, and idle cropland. Texas and Mississippi have the highest percentages of cropland, with 20 percent and 19 percent of each respective state's total land being used for cropland. Texas leads the Nation in cattle, cotton, hay, sheep, and wool. Texas also leads the Nation in the number of farms and ranches, with 247,500 farms and ranches covering 130.4 million ac (52.8 million ha). For all four coastal states, 42 percent of the total land area is used for grassland pasture and range, with Texas devoting 61 percent or close to 262,000 mi^2 (679,095 km^2) for grassland pasture and range. Agriculture places many demands on the environment and produces impacts that include, but are not limited to, habitat fragmentation, pesticide and nutrient runoff, competing urban and agricultural water needs, changes to watershed hydrology, and changes in soil quality. Both State and Federal entities regulate various farming and ranching practices through laws such as the Clean Water Act, which establishes pollutant standards for many of the inputs used in conventional farming methods (Lubowski et al., 2006).

Cumulative impacts of urbanization on land use and coastal infrastructure affect the Gulf of Mexico EIAs with the highest numbers of people. Demographic shifts as people move in and out of areas contribute to the cumulative impacts on land use and coastal infrastructure. Census urban areas include densely populated areas with at least 50,000 people ("urbanized areas") and densely populated areas with 2,500-50,000 people ("urban clusters"). Included in the Census urban area definition are residential areas and concentrations of nonresidential urban areas such as commercial, industrial, and institutional land; office areas; urban streets and roads; major airports; urban parks and recreational areas; and other land within urban defined areas. Development takes the place of natural ecosystems and fragments habitat. It also influences decisions people make about how to get around and determines how much people must travel to meet daily needs. These mobility and travel decisions have indirect impacts on human health and the natural environment by affecting air and water pollution levels. Impacts of urbanization include habitat fragmentation, reduced water and air qualities, and the urban heat island impact. On the other hand, residents of cities live in smaller homes and drive less because of the close proximity of amenities. Future trends in urban land use would be largely determined by economics, demographic shifts, local ordinances, and zoning (USEPA, 2013b).

Within the geo-political realm, non-OCS related cumulative impacts on land use and coastal infrastructure could also include evolving State and Federal regulations (especially environmental), city planning and zoning, residential development, recreational facilities, public facilities (i.e., water, sewer, health, and education), and military activities. Land- use patterns vary greatly by region, reflecting differences in soils, climate, topography, and patterns of population settlement. Land-use changes would largely depend upon local zoning and economic trends. Mississippi and Louisiana are located in what the U.S. Department of Agriculture's Economic Research Service calls the Delta farm production region, while Alabama is located in the Southeast farm production region, and Texas is located in the Southern Plain region (Lubowski et al., 2006). The Economic Research Service conducts land- use inventories based on available land- use data obtained from surveys conducted both by the Economic Research Service and predecessor agencies. **Figure 4-29** illustrates the dominant land-use patterns in the counties and parishes that comprise the BOEM-identified EIAs.

Coastal land loss resulting from erosion, subsidence, sea-level rise, and coastal storms is one of the more significant cumulative impacts for land use and coastal infrastructure. The Gulf Coast region has been experiencing land loss in varying degrees from state to state, especially in coastal Louisiana, which is sinking faster than any place in the world (Marshall, 2013). **Figure 4-29** shows the amount of land that coastal Louisiana has lost from 1932 to 2010. Produced for Louisiana's Coastal Master Plan (2012), **Figuree 4-30 and 4-31** illustrate scientists' projections for future land loss in Louisiana. The moderate projection (**Figure 4-30**) assumes more mitigating measures, and the less optimistic projection (**Figure 4-31**) shows the impact if extensive mitigating measures are not instituted. Overlaid on all three of these figures are the locations of existing OCS oil- and gas-related infrastructure. As evident from these visual depictions, coastal land loss is one of the greatest threats to the stability and future of OCS oil- and gas-related infrastructure, producing a **major** negative impact to those facilities located close to areas vulnerable to land loss. The severe threat to coastal infrastructure and communities becomes more evident each year, and the requests for action continue to increase (Traywick, 2016; Marshall, 2015).

Second only to coastal land loss as a **major** cumulative impact on land use and coastal infrastructure are the regular changes in economic trends on the regional, national, and global levels. Micro-economic and macro-economic shifts in demand, investment opportunities, and commodity prices all affect the course of business in the oil and gas industry and the regional economies and communities in ways that are not always in tandem. For example, the drop in the price of oil from the end of 2014 through 2015 kept the price of gas down, which is good for people and businesses that require cars and trucks to travel. However, the downturn has also led to increasing layoffs in the oil and gas industry (Larino, 2015; Stickney, 2015; Strauss, 2015; Thompson, 2016). Despite a rise in oil prices in early 2016, bankruptcies increased for oil companies (Eaton, 2016). By mid-2016, with the number layoffs totalling over 350,000, oil companies were predicted to be facing a shortage of skilled workers when oil prices rebound (Cunninham, 2016). An economic Gordian knot best explains the complex relationship between the industry, society at large, and the resources of land use and coastal infrastructure, which reside at the core of this intricate system of effects and counter-effects.

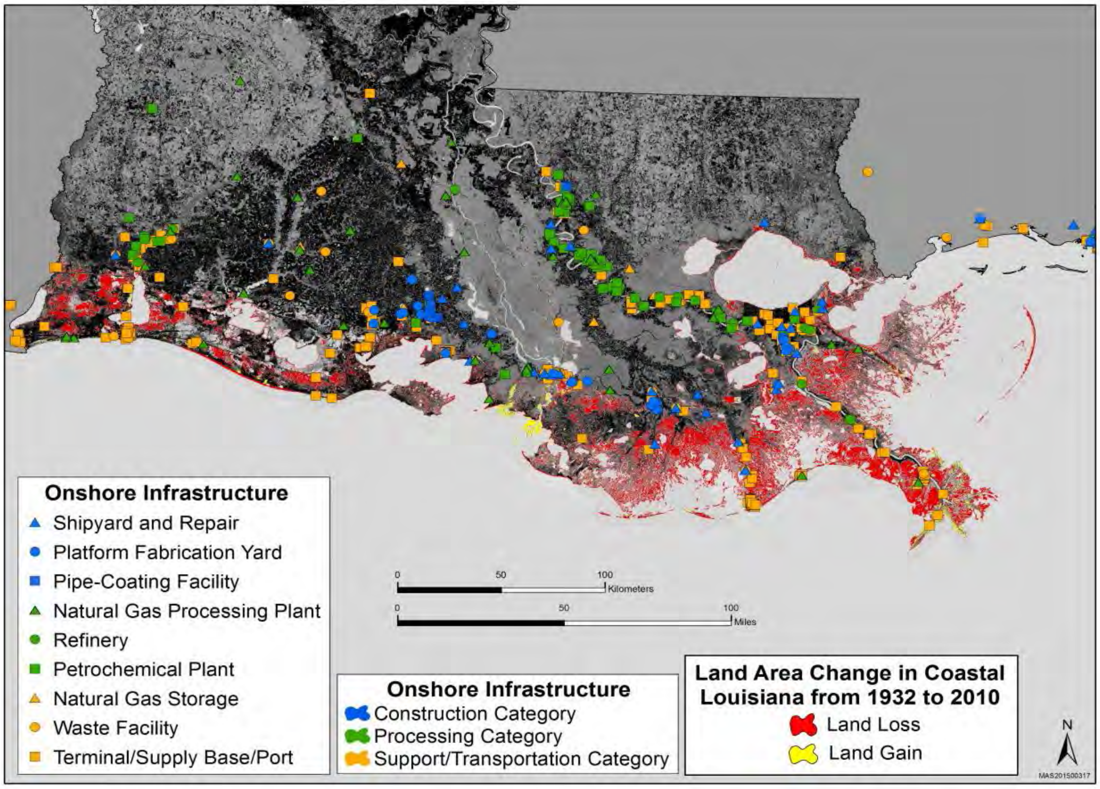

Figure 4-29. Historical Land Loss in Louisiana, 1932-2010.

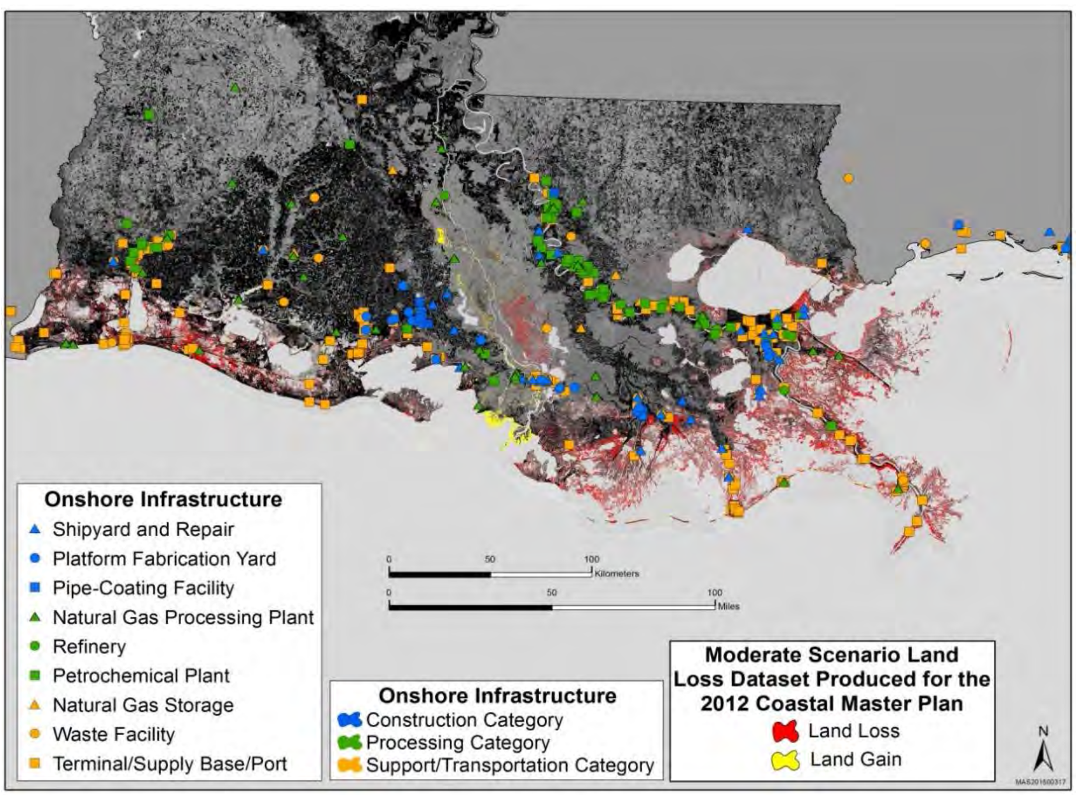

Figure 4-30. Moderate Scenario: Projected Land Loss in Louisiana.

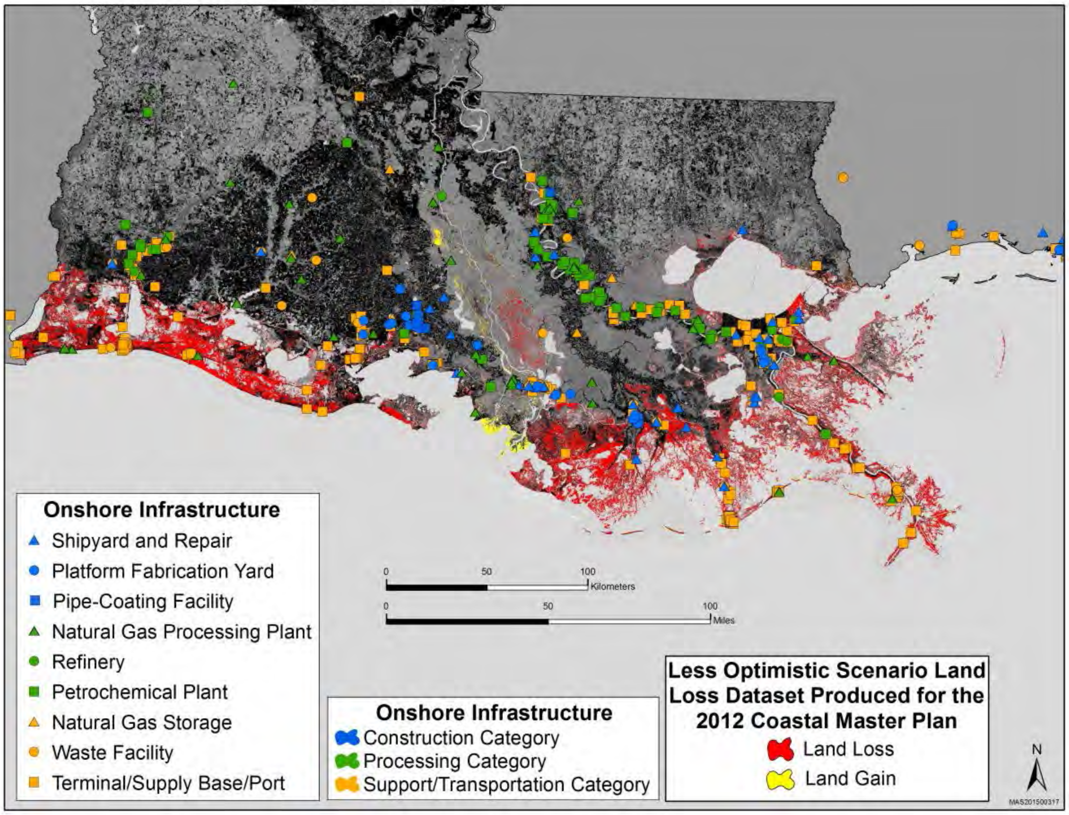

Figure 4-31. Less Optimistic Scenario: Projected Land Loss in Louisiana.

Cumulative impacts resulting from all past, present, and reasonably foreseeable future non-OCS oil- and-gas related activities could range from **beneficial** to **major** depending on the specifics of each situation, whether the impacts are measurable, how long the impacts would last, and the size of the affected geographic area.

4.14.1.2.4 Incomplete or Unavailable Information

BOEM has identified incomplete information regarding the potential impacts of coastal land loss on land use and coastal infrastructure. This incomplete information may be relevant to adverse impacts because it is not completely known how current subsidence and erosion is affecting industry or what plans industry is making to mitigate current or future impacts. Because there are hundreds of large and small property-owning businesses spread across the coastal zone, which directly and indirectly support the offshore petroleum industry, the identity of these properties and the possibilities of losses due to subsidence, sea-level rise and erosion cannot be quantified at this time. BOEM has employed reasonably accepted scientific methodologies to extrapolate from existing information on dredged material and other approaches used to mitigate for land loss in completing its analysis and formulating the conclusions presented here. For a more detailed discussion on deltaic land loss, refer to **Chapter 4.3.2** (Coastal Barrier Beaches and Associated Dunes). In the case of coastal ports, for example, dredged material from navigation slips are used to fill in property and mitigation habitat areas for wildlife and to act as a barrier to protect ports from storm surges (Volz, 2013). This example shows that, although BOEM does not possess a complete understanding of what industrial infrastructure improvements may occur, such as mitigation for land loss, industry would most likely mitigate as necessary to protect existing and growing infrastructure. With each passing year, the pressure increases to take action and protect critical oil and gas infrastructure (Traywick, 2016). Like any industrial infrastructure improvements, future adaptations would occur on an as-needed basis or as new technologies become available. While coastal infrastructure is subject to the impacts of coastal land loss and routine tropical storm activity, there is still considerable motivation to protect existing infrastructure. Therefore, BOEM has determined that the information is not essential to a reasoned choice among alternatives. BOEM continues to monitor industry and its infrastructure footprint over time to document short- and long-term impacts of continued land loss.

4.14.1.2.5 Alternative A—Regionwide OCS Lease Sale (The Preferred Alternative)

Oil and gas exploration, production, and development activities on the OCS are supported by an expansive onshore network of coastal infrastructure that includes hundreds of large and small companies. Land use in the Gulf Coast analysis region covers a broad spectrum from rural to metropolitan land uses, ranging across 133 counties and parishes from the southern tip of Texas north along the Texas coastal plain and looping around the Gulf Coast through Louisiana, Mississippi, Alabama, and Florida, all the way southward to Key West in Monroe County, Florida. For routine operations, impacts would vary across the range of measures from **negligible** to **moderate** because land use in the region has adjusted to the presence of the oil and gas industry over many decades, and oil- and gas-related coastal infrastructure is a mature and extensive system, resulting from long-term industry trends, and it is not subject to rapid fluctuations. For example, a small-scale expansion of a gas-processing plant would be a **negligible** impact because of the small size of the project, the temporary disruptions caused by increased construction traffic, and the geographically small area affected. If the expansion project was larger, lasting a few weeks and affecting a larger geographic area, then the impact would be **minor**. If the gas-processing plant project was larger in scale, causing disruptions because of construction activities that last up to 1 year, then the impact would be **moderate**. Activities related to a proposed action are expected to minimally affect the current land use of the analysis area because most subareas have strong industrial bases and designated industrial parks with existing infrastructure and facilities that have sufficient capacity to accommodate future growth. BOEM's scenario projections call for the new construction of 0-1 new gas processing facility and 0-1 new pipeline landfall to result from a proposed lease sale over the analysis period. Increases in demand for services at other facilities would be met by current excess capacity or expansions at current facilities (Dismukes, official communication, 2015). These activities, along with noncatastrophic accidental events, are reasonably foreseeable.

The impacts of reasonably foreseeable accidental events, such as oil spills, chemical and drilling fluid spills, vessel collisions, and spill-response activities are expected to be **negligible** to **moderate** depending on the location, size, and duration of the event. Potential impacts could include damages to private and public lands, personal injury, damages to collateral property (moveable property such as vehicles and boats), and economic damages from the disruption of business. For example, if an oil spill is very small (not measurable) in size, located in a small geographic and remote area, and dissipates quickly, its impact would be **negligible**. If a spill is measurable, covers a larger geographic area, and lasts a few days to a month, then its impact would be **minor**. If a spill occurs in a highly populated area, is larger in quantity, and the response and cleanup last over a month and up to a year with either waterborne commerce affected and/or land transportation affected, then the impact would be **moderate**.

Cumulative impacts resulting from all past, present, and reasonably foreseeable future OCS oil- and-gas related activities could range from **beneficial** to **moderate**, depending on the specifics of each situation, whether the impacts are measurable, how long the impacts would last, and the size of the affected geographic area. In general, activities relating to the OCS Oil and Gas Program and State oil and gas production are expected to minimally affect the current land use of the analysis area because most subareas have strong industrial bases and designated industrial parks to accommodate future growth. The incremental contribution of a proposed lease sale to the cumulative impacts on land use and coastal infrastructure are expected to be **minor** because the impacts of one lease sale are minimal when compared with the combination of all past, present, and future lease sales (USDOI BOEM, 2016a). The cumulative impacts of non-OCS oil- and gas-related factors on land use and coastal infrastructure could range from **beneficial** to **major** adverse impacts depending on the specific situation, whether the impacts are measurable, how impacts are measured, how long they would last, the size of the affected area, and the viewpoints of the various people that may be involved.

4.14.1.2.6 Alternative B—Regionwide OCS Proposed Lease Sale Excluding Available Unleased Blocks in the WPA Portion of the Proposed Lease Sale Area

Impacts for land use and coastal infrastructure are directly related to the level of OCS oil- and gas-related activities in the Gulf of Mexico. Alternative B would result in less OCS oil- and gas-related activities than Alternative A because the WPA (approximately 23 million ac) would not be available for leasing. Alternative A includes all three planning areas of the GOM (i.e., the WPA, CPA, and EPA). Alternative B includes the CPA and EPA, and excludes the WPA. Therefore, Alternative B would produce proportionately smaller OCS oil- and gas-related activities than Alternative A, and the impacts of Alternative B would be proportionately less than Alternative A and greater than Alternative C. Alternative B impacts could range from **neglible** to **moderately negative** for routine operations and accidental events, and **beneficial** to **major** adverse impacts for cumulative impacts depending on the specific situation, whether the impacts are measurable, how impacts are measured, how long they would last, the size of the affected area, and the viewpoints of the various people that may be involved.

4.14.1.2.7 Alternative C—Regionwide OCS Proposed Lease Sale Excluding Available Unleased Blocks in the CPA/EPA Portions of the Proposed Lease Sale Area

Impacts for land use and coastal infrastructure are directly related to the level of OCS oil- and gas-related activities in the Gulf of Mexico. Alternative C would result in less OCS oil- and gas-related activities than Alternative A or B because the CPA and EPA (approximately 48 million ac) would not be available leasing. Alternative A includes the WPA, CPA, and EPA, and Alternative B include the CPA and EPA. In contrast, Alternative C includes only the WPA. Therefore, Alternative C would produce proportionately smaller OCS oil- and gas-related activities than Alternative A and B. The impacts of Alternative C would be proportionately less than either Alternative A or B, but they would also range from **neglible** to **moderate** for routine operations and accidental events, and **beneficial** to **major** adverse impacts in the cumulative analysis depending on the specific situation, whether the impacts are measurable, how impacts are measured, how long they would last, the size of the affected area, and the viewpoints of the various people that may be involved.

4.14.1.2.8 Alternative D—Alternative A, B, or C, with the Option to Exclude Available Unleased Blocks Subject to the Topographic Features, Live Bottom (Pinnacle Trend), and/or Blocks South of Baldwin County, Alabama, Stipulations

Impacts for land use and coastal infrastructure are directly related to the level of OCS oil- and gas-related activities in the Gulf of Mexico. Alternative D would have minimal impact because there are so few available unleased blocks subject to the Topographic Features, Live Bottom (Pinnacle Trend), and Blocks South of Baldwin County, Alabama, Stipulations. The difference between Alternatives A, B, and C, with and without the exclusionary stipulations, is imperceptible for land use and coastal infrastructure. The impacts under Alternative D would not be much different and likely not even be measurable when compared with the other alternatives. To the extent that Alternative D may possibly generate less OCS oil- and gas-related activities due to the reduced number of blocks available for lease, the impacts of Alternative D may be slightly less than Alternative A, B or C, but this difference would likely be indiscernible because BOEM cannot speculate as to what blocks industry may have bid on if Alternative D was not chosen. Since the difference between Alternative D and Alternatives A, B, and C cannot be determined, the impacts would still range from **neglible** to **moderate** for routine operations and accidental events, and **beneficial** to **major** adverse impacts in the cumulative analysis depending on the specific situation, whether the impacts are measurable, how impacts are measured, how long they would last, the size of the affected area, and the viewpoints of the various people that may be involved.

4.14.1.2.9 Alternative E—No Action

Alternative E would result in no lease sale and, thus, no direct impacts as a result of a proposed lease sale and no incremental contribution of impacts to land use and coastal infrastructure beyond a temporary negative economic impact for the oil and gas industry and coastal states, such as Louisiana, that are more dependent on oil and gas revenues. **Chapter 4.14.2** describes specific economic impacts.

4.14.2 Economic Factors

This chapter discusses the affected environment, routine activities, accidental events, and cumulative impacts to economic factors that would arise from the alternatives. Many of the economic impacts of the alternatives would be beneficial, and these impacts are stated in terms of standard measures of economic activity. The negative impacts are measured in terms of the severity, duration, and geographical extent of impacts. Long-term impacts are those lasting more than 1 year. Extensive impacts are those that affect numerous economic impact areas. Severe impacts cause sizeable impacts to economic activity in levels or relative to the size of an economic impact area. The impact-level definitions are listed below.

Impact-Level Definitions

- **Beneficial** – Positive impacts stated in levels and percentages of employment (number of jobs), labor income (wages, benefits, and sole-proprietor income), and/or value-added (contribution to gross regional product).
- **Negligible** – Little or no detectable adverse impact.
- **Minor** – Adverse impacts are detectable but less than severe.
- **Moderate** – Adverse impacts are severe but are short-term and/or not extensive.
- **Major** – Adverse impacts are long-term (more than 1 year), extensive, and severe.

4.14.2.1 Description of the Affected Environment

Economic factors are factors that explain and quantify the human behaviors that determine the positive and negative impacts from the alternatives. The following sections discuss the overall economies that could be impacted by the alternatives and provide specific information regarding the offshore oil and gas industry.

Economic Impact Areas

Offshore oil and gas activities affect various onshore areas because of the various industries involved and because of the complex supply chains for these industries. Many of these impacts occur in counties and parishes along the Gulf of Mexico region. BOEM aggregates 133 GOM counties and parishes into 23 EIAs based on economic and demographic similarities among counties/parishes (Fannin and Varnado, official communication, 2015); **Figure 4-29** is a map of these EIAs. Much of the analysis below focuses on these EIAs since many of the positive and negative impacts of the alternatives would be concentrated in these EIAs. These EIAs also serve as consistent units for which to present economic and demographic data.

Economic and Demographic Data

Woods & Poole Economics, Inc. (2016) provides county-level economic and demographic data for prior years, as well as forecasts of these data through 2050. **Table 4-33** aggregates the Woods & Poole data for 2015 by EIA and presents each EIA's population, employment, gross regional product, labor income, median age, male percentage, and race composition. The largest EIAs (presented in descending order of gross regional product) are TX-3 (which includes Houston and Galveston), FL-5 (which includes Tampa), LA-6 (which includes New Orleans), FL-6, LA-5 (which includes Baton Rouge) and TX-1. The smallest EIAs (presented in ascending order of gross regional product) are MS-2, TX-6, AL-2, LA-2, and TX-4. The forecasts from Woods & Poole Economics, Inc. (2016) for future years are presented in the cumulative analysis (**Chapter 4.14.2.2**). Kaplan et al. (2011) presents additional economic and demographic data for certain GOM regions that are important to the offshore oil and gas industry.

Table 4-33. Economic and Demographic Information for BOEM's Economic Impact Areas in 2015.

	Economic Variables				Demographic Variables						
EIA	Population	Employment	Gross Regional Product[1]	Labor Income	Median Age	Male %	White	Black	Hispanic	Native American	Asian
Texas											
TX-1	1,708,427	751,524	47,016,273	26,381,857	32.0	48.9%	7.4%	0.5%	91.1%	0.1%	0.9%
TX-2	759,550	444,670	42,601,774	21,698,404	39.0	50.0%	37.7%	4.9%	55.5%	0.3%	1.7%
TX-3	6,410,474	3,951,656	452,267,859	275,676,978	35.8	49.7%	37.3%	17.2%	37.2%	0.3%	8.0%
TX-4	162,698	60,147	4,238,588	2,096,976	40.0	49.5%	75.6%	8.9%	14.3%	0.4%	0.7%
TX-5	375,116	208,555	19,231,977	11,061,067	36.7	50.8%	53.9%	25.8%	16.9%	0.4%	3.1%
TX-6	50,032	22,204	1,346,951	681,012	41.6	49.9%	74.8%	18.0%	5.9%	0.5%	0.7%
Louisiana											
LA-1	204,995	124,347	10,798,391	6,185,263	38.5	48.8%	69.9%	25.0%	3.1%	0.5%	1.4%
LA-2	88,820	40,311	3,652,318	1,938,194	34.0	52.2%	75.0%	14.5%	7.3%	1.3%	1.9%
LA-3	590,283	337,688	32,356,769	16,331,528	36.6	49.2%	68.4%	26.6%	3.3%	0.5%	1.3%
LA-4	363,427	218,383	22,856,912	12,097,141	37.5	49.3%	67.3%	23.3%	4.8%	3.0%	1.6%
LA-5	854,933	536,057	48,085,588	26,632,392	37.2	48.6%	56.6%	37.0%	4.0%	0.3%	2.2%
LA-6	941,496	618,008	56,199,457	32,026,768	36.4	48.4%	46.3%	39.8%	9.8%	0.4%	3.7%
LA-7	424,409	208,711	15,432,610	8,742,974	38.4	48.7%	73.9%	19.8%	4.7%	0.4%	1.2%
Mississippi											
MS-1	443,912	227,999	15,847,063	9,864,828	39.3	49.4%	71.2%	20.7%	5.0%	0.5%	2.5%
MS-2	68,307	22,231	1,138,488	676,391	38.3	52.0%	79.7%	18.0%	1.7%	0.4%	0.3%
Alabama											
AL-1	621,342	337,084	22,645,147	13,605,409	40.0	48.1%	66.7%	27.2%	3.4%	0.9%	1.8%
AL-2	114,322	51,063	3,434,323	1,993,558	42.3	49.0%	57.9%	37.4%	1.6%	2.8%	0.4%
Florida											
FL-1	921,108	500,868	34,429,364	20,965,492	39.2	50.4%	75.7%	14.1%	6.3%	0.8%	3.2%
FL-2	510,345	273,431	18,122,863	10,995,475	40.4	50.8%	61.8%	29.4%	6.0%	0.5%	2.3%
FL-3	234,152	88,771	5,348,686	3,245,975	41.3	54.3%	70.6%	21.8%	6.3%	0.5%	0.8%
FL-4	1,436,271	609,646	36,373,271	21,964,488	48.4	48.6%	75.5%	11.2%	10.4%	0.3%	2.6%
FL-5	4,173,838	2,261,114	164,280,085	100,732,515	45.4	48.5%	66.9%	11.9%	17.6%	0.3%	3.2%
FL-6	1,509,624	771,147	48,463,312	29,687,008	45.6	49.6%	68.3%	8.0%	21.8%	0.3%	1.6%

EIA = Economic Impact Area.

[1] Gross Regional Product and labor income are presented in thousands of dollars.

Source: Woods & Poole Economics, Inc., 2016.

Offshore Oil and Gas Industry

The offshore energy industry in the Gulf of Mexico extracts oil, natural gas, and natural gas liquids (NGLs), which are then processed and transported for use in various activities, including transportation, electricity generation, space heating, and chemical manufacturing. Extraction of oil, natural gas, and natural gas liquids entails spending on various processes, including G&G surveying, drilling, platform fabrication, shipbuilding, and various support services. Spending on these processes supports businesses further along supply chains and supports spending by workers. Quest Offshore Resources, Inc. (2011) provides an overview of the spending impacts of the offshore oil and gas industry in the Gulf of Mexico. This report estimates that $26.9 billion in capital and operating expenditures supported $29.1 billion in U.S. gross domestic product in 2009. Kaiser et al. (2013) provide background information on the drilling and rig construction markets; Eastern Research Group, Inc. (2011) provides background information on the oil services contract industry; and Priest and Lajaunie (2014) and Austin et al. (2014a) present background information on the shipbuilding and fabrication industries.

The offshore energy industry has been adapting to recent declines in energy prices. Lower energy prices have caused slowdowns in offshore drilling activities (Beaubouef, 2015) and rig construction (Odell, 2015). However, offshore oil and gas production is generally slower to respond to changes in energy prices since offshore developments take years to be designed, approved, and developed. Once a project is producing, it is often most profitable to maintain production as long as the revenues received are above the marginal costs of production. Indeed, GOM offshore oil production is forecast to increase from an average of 1.5 MMbbl/day in 2015 to 1.9 MMbbl/day in the fourth quarter of 2017 (USDOE, Energy Information Administration, 2016e). This production increase reflects the contributions of 14 Gulf of Mexico projects that are expected to come online in 2016 and 2017 (USDOE, Energy Information Administration, 2016f).

Office of Natural Resources Revenue Data

Government revenues are generated from offshore oil and gas activities through bonus bids, rental payments, and royalty payments. Bonus bids are received shortly after a lease sale, rental payments occur during the nonproducing phase of a lease, and royalties are paid as a percentage of oil and gas output from a lease. BOEM's "Fair Market Value" webpage describes the rental rates, royalty rates, and other terms associated with Gulf of Mexico leases (USDOI, BOEM, 2015c). Some offshore oil and gas activities are subject to partial or full royalty exemptions. BOEM's "Royalty Relief Information" webpage provides more information regarding BOEM's royalty relief programs (USDOI, BOEM, 2015d). Panels A, B, and C of **Table 4-34** presents data regarding sales volumes, sales values, and government revenues received from Federal offshore energy activities in the Gulf of Mexico (USDOI, Office of Natural Resources Revenue, 2016). Sales volumes of oil and gas were generally slightly higher in 2015 than in 2014. However, sales volumes and government revenues were generally lower in 2015 than in 2014, in part due to declines in energy prices.

Table 4-34. Sales Volumes, Sales Values, and Revenues.

Panel A: Sales Volumes							
FY	2009	2010	2011	2012	2013	2014	2015
Gas (royalty) (mcf)	3,515,174,881	1,021,163,854	1,408,872,682	1,113,924,864	950,496,444	840,771,649	901,791,829
Gas (non-royalty) (mcf)	215,256,077	1,035,853,736	323,546,478	228,996,007	249,725,032	225,115,563	243,981,082
NGL (royalty) (bbl)	38,833,183	35,291,345	44,366,261	38,612,327	36,930,555	37,108,821	43,547,877
NGL (non-royalty) (bbl)	2,672,336	14,757,582	9,066,227	6,720,387	7,920,289	10,479,880	13,600,607
Oil (royalty) (bbl)	399,610,189	245,817,393	365,315,753	327,838,813	353,301,996	380,094,970	427,893,211
Oil (non-royalty) (bbl)	44,831,343	351,281,197	154,048,513	136,239,983	99,872,228	100,214,276	117,987,854
Panel B: Sales Values							
Fiscal Year	2009	2010	2011	2012	2013	2014	2015
Gas ($)	9,042,095,734	3,635,054,218	6265443988	3,431,037,416	3,389,367,262	3,673,721,931	3,062,140,872
NGL ($)	1,340,935,987	1,683,276,019	2,203,814,139	2,443,746,995	1,345,608,945	1,396,236,694	1,104,727,436
Oil ($)	22,121,036,571	20,398,834,017	34,955,160,900	35,976,794,554	37,471,600,329	38,509,764,522	26,989,786,050
Other ($)	328,166	81,819	62,776	48,488	65,859	46,065	181,361
Total ($)	32,504,396,457	25,717,246,074	43,424,481,803	41,851,627,453	42,206,642,395	43,579,769,211	31,156,835,720
Panel C: Revenues							
Fiscal Year	2009	2010	2011	2012	2013	2014	2015
Gas royalties ($)	1,270,482,533	578,648,176	867,823,949	477,314,371	492,705,927	506,802,521	397,152,833
NGL royalties ($)	106,141,947	193,526,754	275,894,256	242,173,963	162,496,377	172,755,305	113,431,762
Oil royalties ($)	2,870,533,400	2,848,085,747	4,795,138,594	4,906,719,993	5,123,552,625	5,167,152,076	3,598,649,485
Other royalties ($)	44,168	-14,192	3,494	4,163	4,466	2,605	10,310
Rents ($)	226,228,376	236,631,251	219,119,868	217,669,757	244,699,154	229,741,396	215,683,828
Bonus ($)	1,181,075,491	979,569,294	36,751,111	663,714,729	2,675,653,773	967,365,328	642,044,899
Other ($)	-82,772,915	119,508,488	23,807,036	31,841,893	34,646,396	46,274,075	-36,537,426
Total ($)	5,571,733,000	4,955,955,519	6,218,538,306	6,539,438,869	8,733,758,719	7,090,093,306	4,930,435,692

(1) This table presents the sales volumes, sales values, and revenues received based on offshore oil and gas activities in the Gulf of Mexico.

(2) Data in this table refer to the years in which sales occurred (not to the years in which government revenues were received).

Source: USDOI, Office of Natural Resources Revenue, 2016.

4.14.2.2 Environmental Consequences

The impacts from routine activities and accidental events, and the cumulative impacts to economic factors that would arise from projected activities from a single lease sale are analyzed in this chapter. While there are some differences in the amount of activities associated with the alternatives, many of the impacts associated with the alternatives are similar. Therefore, this chapter describes the impacts that are expected to apply to all alternatives, while any deviations from these impact conclusions are discussed in **Chapters 4.14.2.2.5-4.14.2.2.9**.

For each alternative, the numerical estimates are presented for two scenarios for oil and gas development:

(1) *Low*: A scenario that corresponds to low amounts of offshore oil and gas activities, which could arise due to low oil and gas prices or other unfavorable economic conditions. This scenario also assumes that oil and gas leasing activities would be spread over two lease sales in a given year.

(2) *High*: A scenario that corresponds to high amounts of offshore oil and gas activities, which could arise due to high oil and gas prices or other favorable economic conditions. This scenario also assumes that oil and gas leasing activities would be spread over two lease sales in a given year.

It is also possible that industry could focus their leasing activities in a particular lease sale for unique circumstances rather than activity being spread over two lease sales in a given year. If this would occur, the economic impacts would be approximately double the impacts presented here. However, this is unlikely to occur, particularly as industry adjusts to the pattern of two lease sales per year.

4.14.2.2.1 Routine Activities

Routine activities arising from a proposed action would have various economic impacts. First, extraction of oil, NGLs, and natural gas generate expenditures on various goods and services. Routine activities could also generate corporate profits and government revenues, as well as have impacts on the overall energy market. Finally, a proposed action would have negative impacts (discussed below) that would partially offset the positive impacts. It is important to note that a proposed action occurs in the context of an expansive existing offshore oil and gas industry. Therefore, the various impacts (discussed below) should be interpreted as the extent to which the alternatives contribute to the impacts of the existing offshore oil and gas existing industry.

Expenditure Impacts

A proposed action would have economic impacts on a variety of businesses along the OCS industry's supply chain. For example, a proposed action would directly affect firms that drill wells, manufacture equipment, construct pipelines, and service OCS oil- and gas-related activities. The OCS oil- and gas-related activities would also impact the suppliers to those firms, as well as firms that depend on consumer spending of oil and gas industry workers. In order to estimate these impacts, BOEM has developed MAG-PLAN, which is a two-stage economic model. The first stage estimates the levels of spending in various industries that arise from a particular scenario for oil and gas exploration and development. The second stage estimates the employment, income, and value added impacts that result from oil and gas industry spending along the Gulf Coast. The OCS industry's direct spending would support activities further down the supply chain; these are referred to as "indirect" impacts. In addition, the incomes of employees along the OCS industry's supply chain would support consumer spending throughout the economy; these are referred to as "induced" impacts. These impacts are estimated using the economic modeling software and data system IMPLAN. In particular, MAG-PLAN uses IMPLAN "multipliers" to compute how OCS spending translates into various direct, indirect, and induced economic impacts. MAG-PLAN results for the various scenarios are presented in **Chapters 4.14.2.2.5-4.14.2.2.9**.

Government Revenue Impacts

A proposed action would generate government revenues through bonus bids, rental payments, and royalty payments. Revenue forecasts for the alternatives are discussed in **Chapters 4.14.2.2.5-4.14.2.2.9**. The impacts generated by these revenues depend on where and how the revenues are used. Historically, most revenues have accrued directly to the Federal Treasury. Although it is not possible to trace Federal spending to specific revenue streams, it is reasonable to assume that Federal OCS revenues would be spent in approximately the same proportions as overall Federal spending. This implies that the Federal revenue impacts of OCS oil- and gas-related activities would be fairly widespread, and thus not overly concentrated in BOEM's economic impact areas. Historically, modest portions of OCS revenues beyond those implicit in normal Federal spending have been allocated to the Gulf Coast States, including 8(g) revenues (which arise due to leasing with 3 mi [5 km] of State waters), the Coastal Impact Assistance Program, and Phase 1 revenue sharing arising from the Gulf of Mexico Energy Security Act of 2006 (GOMESA). Phase 2 of GOMESA revenue sharing, which will begin in Fiscal Year 2017, will expand revenue sharing with Texas, Louisiana, Mississippi, and Alabama. In particular, Phase 2 of GOMESA calls for 37.5 percent of qualified revenues to be disbursed to the Gulf Coast States and their political subdivisions, and 12.5 percent of revenues to be disbursed to the Land and Water Conservation Fund. Phase 2 revenue sharing will be subject to a $500 million cap through 2055 (USDOI, BOEM, 2015d). Phase 2 of GOMESA may increase the beneficial impacts to BOEM's economic impact areas arising from a proposed action, although only if the revenues occur in a year in which the cap was not reached by revenues arising from other lease sales. The economic impacts of the various revenue disbursements would depend on how and where the money is spent. The OCS oil- and gas-related activities can also induce government revenues arising from taxes on economic activities (such as taxes on profits and dividends). The USDOI (2015) provides methodologies for estimating the scales and distributions of revenue impacts of OCS oil- and gas-related activities. This report estimates that revenue impacts accounted for 26 percent of total value-added impacts in the United States in 2014. This percentage is forecast to remain roughly similar in future years, although it could vary based on oil prices and the geographic distributions of impacts would change because of GOMESA revenues.

Profit Impacts

A proposed action could also generate profits to firms along the OCS supply chain. Corporate profits can be distributed to stockholders as dividends or retained by firms for future spending on goods and services. Higher profits can also increase stock prices, which would increase the wealth of stockholders. Since stocks of most energy firms can be held by people from anywhere in the world, the wealth and dividend impacts would be fairly widespread and, thus, not overly concentrated in BOEM's economic impact areas. Similarly, it is difficult to trace specific spending by firms to increases in corporate profits, although these impacts are also likely to be widespread. The USDOI (2015) estimates that approximately 25 percent of total value-added benefit to the United States from the OCS Program arises due to corporate profits, and this percentage could vary slightly during the timeframe of a proposed action, given changes in oil prices and other factors.

Market Impacts

The oil, natural gas, and NGLs produced due to a proposed action would meet the demands of end users of those products. Increased energy supply would put downward pressure on energy prices, although the small scale of a proposed action relative to the overall energy market would make these price effects minimal. The OCS crude oil production typically has different quality measures (such as API gravity and sulfur content) than crude oil from other sources and flows through pipelines already in place, which can enhance the relative value of OCS crude to nearby refiners designed to process OCS-type crude oil. A proposed action can also contribute to U.S. policy goals of energy independence and security. Again, these impacts would be small due to the small scale of a proposed action.

Adverse Impacts

A proposed action could negatively affect various resources, as described in the other chapters of this Multisale EIS. The corresponding negative economic impacts are also discussed in their respective chapters. For example, the OCS Program could cause negative impacts to recreational fishing, commercial fisheries, recreational resources, land use and coastal infrastructure, and social factors. Industrial Economics, Inc., et al. (2015) provides information regarding the Offshore Environmental Cost Model, which incorporates methodologies for quantifying the adverse impacts to various resources. However, these adverse impacts are likely to be **minor** because of the small scale of a proposed action.

In summary, a proposed action would have various beneficial impacts, such as impacts from expenditures, government revenues, corporate profits, and market adjustments. A proposed action would also lead to minor adverse impacts that would partially offset the beneficial impacts.

4.14.2.2.2 Accidental Events

Accidental events, such as oil spills, chemical spills, and vessel collisions, can have various impacts on local economies. The most direct impacts are felt in industries that depend on resources that are damaged or rendered unusable for a period of time. For example, beach recreation, recreational fishing, and commercial fishing would be vulnerable if beach or fish resources were damaged due to an accidental event. However, since accidental events arising from a proposed action would likely be small, the impacts to economic factors would likely be **negligible** or **minor**.

More information on the impacts of accidental events on these individual resources can be found in **Chapters 4.10-4.12**. An oil spill could also impact important transportation routes or impact the operations of port facilities. However, the likelihood of a single oil spill shutting down an entire waterway or port facility is quite low.

The other economic impacts of an accidental event would be determined by indirect actions or events that occur along with an oil spill. For example, an oil spill could lead to decreased levels of oil and gas industry operations. These impacts would be most felt in coastal Louisiana and Texas since these are the primary locations where OCS oil- and gas-related employment is concentrated. The direct impacts of an oil spill on a particular industry would also ripple through that industry's supply chain; consumer spending by employees of these firms would also have impacts to the broader economy. Decreased levels of offshore oil and gas activities could also impact corporate profits and the revenue streams of the various levels of government in the impacted areas. Finally, the response and cleanup operations following an oil spill can have impacts on local economies. For example, compensation for damages could partially mitigate the economic impacts of an accidental event. The influx of response workers to local areas can have positive economic impacts, although it can also cause disruptions to the normal functioning of local economies. In addition, the people and equipment that are dedicated to oil-spill response efforts may be diverted from some existing services (such as hospitals, firefighting capability, and emergency services) available to local residents. These indirect impacts would be negligible for most spills expected to arise from a proposed action, although they could be minor in unique circumstances.

The *Deepwater Horizon* oil spill provides some insights into the impacts of oil spills, although an oil spill of the scale of the *Deepwater Horizon* is not part of a proposed action and not reasonably foreseeable; the impacts of catastrophic spills are discussed in *Catastrophic Spill Event Analysis* white paper (USDOI, BOEM, 2017). Austin et al. (2014b and 2014c) are two volumes of a recently completed study of the economic and social impacts of the *Deepwater Horizon* oil spill. This study employed an ethnographic methodology that entailed analyzing data sources, examining various sources of descriptive information, and conducting field interviews with people in Louisiana, Mississippi, and Alabama. This study documents the complex and varied impacts of the *Deepwater Horizon* oil spill during the 20 months subsequent to the spill. This study found that the impacts of the spill on a particular community depended on a number of factors, such as its proximity to the spill, its economic structure, its social and political dynamics, its organizational structure for dealing with disasters, and its ability to adapt to the structures of the oil cleanup and damage claims processes.

Overall, the economic impacts from accidental events likely to arise from a proposed action would likely be **negligible** or **minor** because any oil spills would likely be small.

4.14.2.2.3 Cumulative Impacts

A proposed action will occur in the context of numerous cumulative impacts to economic factors. This chapter analyzes these factors in various economic impact areas along the Gulf Coast.

The timeframe for the analysis is the life cycle of offshore oil and gas activities likely to arise from a proposed action; most of these activities will occur within approximately 50 years. This chapter first analyzes the impacts of the overall OCS Program, which refers to all past, present, and future lease sales (refer to **Chapter 3.3.1** for more information). This chapter then presents data from Woods and Poole Economics Inc. (2016), which provides forecasts of various economic variables over time. Finally, this chapter analyzes the cumulative impacts to the overall energy market.

OCS Oil- and Gas-Related Impacts

A proposed action would contribute to the economic impacts arising from the overall OCS Program. The OCS Program would have economic impacts on a variety of firms along the OCS industry's supply chain. BOEM uses the model MAG-PLAN (described above) to estimate the impacts of offshore oil and gas industry expenditures. MAG-PLAN's estimates of the total employment, labor income, and value-added impacts for the low and high cumulative scenarios are presented in **Tables 4-35 and 4-36**. These tables present the average values (over 50 years), peak values, and percent of peak values relative to total employment, labor income, and value-added in each EIA. In the low scenario, the OCS Program would support a peak of 110,000 jobs, $8 billion in labor income, and $14 billion in value-added benefits throughout the United States. Most of these impacts would occur in the Gulf of Mexico region, particularly in coastal Texas and Louisiana. The EIAs that would experience the highest economic impacts are TX-3, TX-2, LA-3, LA-4, LA-6, MS-1, and AL-1. In the high scenario, a proposed action would support a peak of 250,000 jobs, $15 billion in labor income, and $24 billion in value-added. The geographic distributions of impacts would be similar to those of the low scenario.

The overall OCS Program generates government revenues through bonus bids, rental payments, and royalty payments (described above). BOEM estimates the revenues associated with the OCS Program under the low- and high-case cumulative scenarios for the following time horizons: bonus bids (26 years); rental payments (35 years); and royalty payments (70 years). In the low-case scenario, the OCS Program would generate approximately $9.4 billion in bonus bids, $2.6 billion in total rental payments (with an annual peak of $151 million), and $132 billion in royalty payments (with an annual peak of $3.5 billion). In the high-case scenario, the OCS Program would generate approximately $17.8 billion in bonus bids, $4.8 billion in total rental payments (with an annual peak of $175 million), and $922.9 billion in total royalty payments (with an annual peak of $18.8 billion). The geographic distributions of impacts from these revenues would correspond to those described above.

A proposed action would also contribute to the corporate profit impacts, market impacts, adverse impacts from routine activities, and adverse impacts from accidental events that would arise from the overall OCS Program. The impacts arising from the overall OCS Program would be directly proportional to the amount of activity (discussed above). The incremental contribution of any of the alternatives relative to the overall OCS Program would be **beneficial** to **minor**.

Table 4-35. Cumulative Low: MAG-PLAN Industry Expenditure Impacts.

Economic Impact Area	Employment Impacts (number of jobs)			Labor Income Impacts ($ thousands)			Value-Added Impacts ($ thousands)		
	Average	Peak	Peak %	Average	Peak	Peak %	Average	Peak	Peak %
Texas									
TX-1	1,340	2,470	0.0%	67,000	127,000	0.0%	101,000	190,000	0.0%
TX-2	3,360	6,310	0.1%	204,000	378,000	0.1%	378,000	679,000	0.0%
TX-3	13,890	26,150	0.1%	1,276,000	2,437,000	0.1%	2,433,000	4,343,000	0.0%
TX-4	100	190	0.0%	6,000	12,000	0.0%	13,000	23,000	0.0%
TX-5	370	670	0.0%	27,000	48,000	0.0%	76,000	122,000	0.0%
TX-6	20	30	0.0%	1,000	2,000	0.0%	2,000	3,000	0.0%
All Texas EIAs	19,080	35,830	–	1,582,000	3,002,000	–	3,002,000	5,360,000	–
Rest of Texas	2,920	5,700	–	204,000	409,000	–	401,000	741,000	–
Texas Total	22,000	41,530	–	1,786,000	3,411,000	–	3,404,000	6,098,000	–
Louisiana									
LA-1	1,040	1,970	0.2%	74,000	141,000	0.2%	111,000	210,000	0.2%
LA-2	40	80	0.0%	2,000	3,000	0.0%	3,000	6,000	0.0%
LA-3	2,810	5,150	0.2%	147,000	266,000	0.1%	277,000	485,000	0.1%
LA-4	3,560	6,850	0.3%	247,000	476,000	0.3%	400,000	752,000	0.2%
LA-5	1,100	2,190	0.1%	57,000	115,000	0.0%	94,000	183,000	0.0%
LA-6	3,290	6,380	0.1%	198,000	383,000	0.1%	308,000	579,000	0.1%
LA-7	510	1,000	0.1%	26,000	51,000	0.0%	44,000	83,000	0.0%
All Louisiana EIAs	12,350	23,510	–	751,000	1,428,000	–	1,238,000	2,293,000	–
Rest of Louisiana	1,850	3,570	–	105,000	206,000	–	212,000	393,000	–
Louisiana Total	14,200	27,060	–	856,000	1,634,000	–	1,450,000	2,681,000	–
Mississippi									
MS-1	2,460	5,000	0.3%	129,000	264,000	0.3%	195,000	392,000	0.3%
MS-2	120	240	0.2%	4,000	8,000	0.1%	7,000	14,000	0.1%
All Mississippi EIAs	2,580	5,230	–	133,000	272,000	–	202,000	406,000	–
Rest of Mississippi	2,240	4,350	–	120,000	237,000	–	223,000	413,000	–
Mississippi Total	4,820	9,590	–	252,000	509,000	–	425,000	819,000	–
Alabama									
AL-1	2,810	5,900	0.2%	135,000	294,000	0.2%	227,000	473,000	0.2%
AL-2	220	450	0.1%	9,000	20,000	0.1%	18,000	35,000	0.1%
All Alabama EIAs	3,020	6,350	–	144,000	314,000	–	244,000	508,000	–
Rest of Alabama	1,760	3,540	–	104,000	218,000	–	205,000	386,000	–
Alabama Total	4,780	9,890	–	248,000	532,000	–	450,000	892,000	–
Florida									
FL-1	290	680	0.0%	21,000	53,000	0.0%	40,000	90,000	0.0%
FL-2	10	20	0.0%	0	1,000	0.0%	1,000	2,000	0.0%
FL-3	0	10	0.0%	0	0	0.0%	0	1,000	0.0%
FL-4	50	110	0.0%	3,000	7,000	0.0%	7,000	14,000	0.0%
FL-5	20	50	0.0%	1,000	3,000	0.0%	3,000	5,000	0.0%
FL-6	0	10	0.0%	0	1,000	0.0%	1,000	1,000	0.0%
All Florida EIAs	380	870	–	26,000	64,000	–	52,000	112,000	–
Rest of Florida	1,700	3,310	–	107,000	209,000	–	202,000	370,000	–
Florida Total	2,080	4,180	–	132,000	273,000	–	254,000	477,000	–

Economic Impact Area	Employment Impacts (number of jobs)			Labor Income Impacts ($ thousands)			Value-Added Impacts ($ thousands)		
	Average	Peak	Peak %	Average	Peak	Peak %	Average	Peak	Peak %
All States									
All EIAs in All States	37,410	71,780	–	2,635,000	5,080,000	–	4,738,000	8,675,000	–
All Gulf States	47,880	92,250	–	3,275,000	6,359,000	–	5,981,000	10,966,000	–
USA									
Rest of the United States	9,520	20,750	–	726,000	1,650,000	–	1,540,000	3,020,000	–
Totals									
Total Expenditure Impacts	57,400	113,000	–	4,000,000	8,009,000	–	7,521,000	13,986,000	–

EIA = Economic Impact Area.
Note: Totals may not sum due to rounding.

Source: BOEM internal modeling estimates.

Table 4-36. Cumulative High: MAG-PLAN Industry Expenditure Impacts.

Economic Impact Area	Employment Impacts (number of jobs)			Labor Income Impacts ($ thousands)			Value-Added Impacts ($ thousands)		
	Average	Peak	Peak %	Average	Peak	Peak%	Average	Peak	Peak %
Texas									
TX-1	2,306	4,118	0.22%	100,196	176,513	0.21%	152,521	268,012	0.18%
TX-2	7,726	13,158	1.62%	404,130	680,193	1.41%	589,364	994,267	1.05%
TX-3	33,440	57,743	0.63%	2,686,295	4,632,169	0.58%	3,983,622	7,002,487	0.53%
TX-4	271	441	0.36%	12,588	20,326	0.40%	22,203	36,656	0.37%
TX-5	994	1,608	0.45%	56,000	89,409	0.40%	90,764	145,189	0.37%
TX-6	29	56	0.12%	1,204	2,283	0.14%	2,268	4,302	0.13%
All Texas EIAs	44,766	76,881	--	3,260,413	5,589,107	--	4,840,743	8,432,100	--
The Rest of Texas	7,727	13,498	--	458,444	804,237	--	776,308	1,370,875	--
Texas Total	52,494	90,345	--	3,718,857	6,391,779	--	5,617,051	9,799,894	--
Louisiana									
LA-1	2,940	4,808	2.20%	205,225	334,157	2.70%	306,816	498,169	2.12%
LA-2	108	202	0.26%	3,831	7,226	0.15%	6,918	12,834	0.14%
LA-3	8,670	14,011	2.03%	430,130	697,030	1.67%	655,326	1,072,934	1.22%
LA-4	9,654	15,937	3.69%	624,946	1,032,521	3.62%	908,227	1,505,238	2.57%
LA-5	2,705	5,006	0.46%	134,179	250,781	0.40%	207,449	382,517	0.32%
LA-6	8,864	14,708	1.39%	512,714	858,553	1.29%	732,900	1,214,249	0.98%
LA-7	1,378	2,368	0.54%	64,817	112,603	0.49%	97,603	166,951	0.40%
All Louisiana EIAs	34,318	56,867	--	1,975,841	3,279,621	--	2,915,240	4,846,603	--
The Rest of Louisiana	4,778	8,528	--	223,072	396,800	--	407,120	735,751	--
Louisiana Total	39,096	65,329	--	2,198,913	3,673,893	--	3,322,359	5,577,182	--
Mississippi									
MS-1	5,678	10,844	2.62%	281,225	536,817	2.47%	414,605	786,002	2.64%
MS-2	271	501	1.26%	9,030	16,948	1.15%	15,118	27,908	1.14%
All Mississippi EIAs	5,949	11,344	--	290,255	553,732	--	429,722	813,822	--
Rest of Mississippi	5,400	9,621	--	244,382	434,227	--	416,953	747,048	--
Mississippi Total	11,349	20,909	--	534,637	987,681	--	846,676	1,559,280	--

Economic Impact Area	Employment Impacts (number of jobs)			Labor Income Impacts ($ thousands)			Value-Added Impacts ($ thousands)		
	Average	Peak	Peak %	Average	Peak	Peak%	Average	Peak	Peak %
Alabama									
AL-1	6,546	12,355	1.78%	296,500	563,585	1.72%	486,940	917,481	1.67%
AL-2	515	995	1.08%	19,949	38,513	0.89%	36,919	69,866	0.93%
All Alabama EIAs	7,061	13,347	--	316,449	602,034	--	523,859	987,207	--
The Rest of Alabama	4,478	7,839	--	222,550	389,239	--	396,062	699,634	--
Alabama Total	11,538	21,178	--	538,999	990,618	--	919,921	1,684,485	--
Florida									
FL-1	615	1,173	0.12%	37,176	72,941	0.14%	64,156	126,359	0.15%
FL-2	29	50	0.01%	1,085	1,870	0.01%	2,102	3,625	0.01%
FL-3	9	15	0.01%	321	526	0.01%	693	1,135	0.01%
FL-4	131	227	0.02%	5,876	10,302	0.02%	12,623	22,243	0.02%
FL-5	55	101	0.00%	2,816	5,136	0.00%	5,031	9,213	0.00%
FL-6	11	21	0.00%	465	863	0.00%	907	1,684	0.00%
All Florida EIAs	850	1,570	--	47,739	90,836	--	85,511	162,773	--
The Rest of Florida	4,385	7,682	--	239,657	411,534	--	400,325	702,037	--
Florida Total	5,235	9,127	--	287,395	494,655	--	485,836	851,705	--
All States									
All EIAs in all States	92,944	159,204	--	5,890,697	10,063,551	--	8,795,075	15,163,286	--
All Gulf States	119,712	206,197	--	7,278,803	12,491,355	--	11,191,843	19,398,421	--
USA									
The Rest of the United States	22,910	41,377	--	1,445,637	2,613,265	--	2,740,228	4,958,974	--
Totals									
Total Expenditure Impacts	142,622	246,535	--	8,724,440	15,022,129	--	13,932,071	24,217,942	--

EIA = Economic Impact Area.
Note: Totals may not sum due to rounding.

Source: BOEM internal modeling estimates.

Non-OCS Oil- and Gas-Related Impacts

Woods & Poole Data

Most approaches to analyzing cumulative impacts begin by assembling a list of other likely projects and actions that would be included with a proposed action for analysis. However, no such list of future projects and actions could be assembled that would be sufficiently current and comprehensive to support a cumulative analysis for all 133 of the coastal counties and parishes in the analysis area. Instead of an assemblage of future possible projects and actions, the analysis employs the economic and demographic projections from Woods & Poole Economics, Inc. (2016) to define the contributions of other likely projects, actions, and trends to the cumulative case. These projections are based on local, regional, and national data, as well as likely changes to economic and demographic conditions. Therefore, the projections include employment associated with the continuation of current patterns in OCS leasing activity, as well as the continuation of trends in other industries important to the region.

Woods & Poole Economics, Inc. (2016) provides county-level economic and demographic data for prior years, as well as forecasts of these data through 2050. **Table 4-37** aggregates Woods & Poole's forecasts for 2050 data by EIA and presents each EIA's population, employment, gross regional product, labor income, median age, male percentage, and race composition. The largest EIAs (presented in descending order of gross regional product) will be TX-3 (which includes Houston and Galveston), FL-5 (which includes Tampa), TX-1, FL-6, LA-5 (which includes Baton Rouge), and LA-6 (which includes New Orleans). The smallest EIAs (presented in ascending order of gross regional product) will be MS-2, TX-6, LA-2, AL-2, and TX-4. From 2015 through 2050, the fastest employment growth is forecast in TX-1, TX-3, FL-4, and FL-6; the slowest employment growth is forecast in AL-2, LA-6, TX-5, and MS-1.

Table 4-37. Economic and Demographic Information for BOEM's Economic Impact Areas in 2050.

	Economic Variables				Demographic Variables						
EIA	Population	Employment	Gross Regional Product[1]	Labor Income	Median Age	Male %	White	Black	Hispanic	Native American	Asian
Texas											
TX-1	3,413,196	1,655,646	139,857,198	78,299,743	37.1	49.5%	4.0%	0.5%	94.7%	0.0%	0.8%
TX-2	905,689	617,988	80,514,803	39,928,606	39.3	50.9%	26.2%	6.3%	64.6%	0.3%	2.6%
TX-3	11,596,749	7,606,527	1,167,893,945	701,659,782	37.8	50.0%	19.3%	14.4%	52.8%	0.2%	13.3%
TX-4	235,465	94,451	7,944,813	4,196,779	41.3	49.9%	61.8%	10.0%	26.4%	0.5%	1.3%
TX-5	415,258	271,986	32,211,686	18,640,535	40.3	53.2%	33.5%	23.1%	39.4%	0.4%	3.6%
TX-6	61,514	32,302	2,364,967	1,212,871	41.3	49.8%	53.6%	28.9%	15.4%	0.6%	1.6%
Louisiana											
LA-1	241,847	168,746	18,859,676	10,353,944	40.7	48.7%	65.0%	26.8%	5.1%	0.6%	2.5%
LA-2	106,352	54,764	4,945,241	3,450,122	35.9	51.6%	68.1%	15.8%	11.9%	1.5%	2.7%
LA-3	761,793	528,239	67,655,760	34,171,286	40.2	49.5%	62.2%	30.5%	5.1%	0.5%	1.6%
LA-4	423,021	318,703	41,787,836	22,427,117	41.5	49.5%	55.9%	26.0%	11.5%	3.5%	3.1%
LA-5	1,256,552	858,192	95,400,731	52,218,596	42.7	49.1%	49.3%	41.3%	6.0%	0.3%	3.1%
LA-6	939,494	756,729	89,523,947	50,440,660	39.5	49.1%	33.1%	41.9%	19.3%	0.4%	5.3%
LA-7	632,032	326,712	31,467,065	17,856,535	41.4	48.5%	64.7%	23.2%	9.6%	0.4%	2.0%
Mississippi											
MS-1	529,598	306,309	25,016,905	16,560,907	41.2	49.2%	62.7%	24.7%	9.3%	0.4%	2.9%
MS-2	89,691	30,831	2,110,264	1,166,865	41.1	52.9%	72.3%	24.5%	2.5%	0.4%	0.4%
Alabama											
AL-1	857,412	524,594	44,241,201	26,059,807	42.0	47.9%	61.7%	28.5%	6.3%	0.8%	2.7%
AL-2	114,035	61,199	5,460,995	2,974,101	46.3	50.5%	45.4%	46.5%	2.9%	4.2%	0.9%

	Economic Variables				Demographic Variables						
EIA	Population	Employment	Gross Regional Product[1]	Labor Income	Median Age	Male %	White	Black	Hispanic	Native American	Asian
Florida											
FL-1	1,320,671	790,574	65,277,669	41,474,136	42.7	52.1%	69.1%	16.9%	9.4%	0.6%	4.1%
FL-2	708,344	410,243	34,132,024	20,466,253	45.4	52.3%	53.2%	37.4%	6.1%	0.4%	2.9%
FL-3	328,245	132,454	10,349,100	6,060,294	43.9	56.5%	64.0%	26.4%	8.0%	0.4%	1.2%
FL-4	2,471,050	1,096,519	81,928,758	50,486,375	52.0	50.4%	69.4%	12.6%	14.6%	0.3%	3.1%
FL-5	6,261,022	3,686,743	348,669,486	221,877,815	45.1	49.5%	45.5%	14.1%	33.8%	0.2%	6.4%
FL-6	2,522,878	1,385,733	121,178,379	73,076,081	47.2	50.9%	51.1%	7.5%	39.7%	0.2%	1.5%

EIA = Economic Impact Area.

[1] Gross Regional Product is presented in thousands of dollars.

Source: Woods & Poole Economics, Inc., 2016 (CEDDS data).

Overall Energy Market

The oil and gas industry will be impacted by the various forces affecting supply and demand for energy products. For example, the rapid expansion of U.S. onshore energy production in recent years contributed to a noticeable decline in oil prices beginning in late 2014. Energy supply and demand has also been affected by international developments, including policy towards Iran and decisions made by the Organization for Petroleum Exporting Countries (International Energy Agency, 2016). Demand for energy products will also be affected by various factors, including economic activity, technological developments, and government policies. The Energy Information Administration provides forecasts of energy markets that incorporate these various factors. In particular, the Energy Information Administration publishes monthly short-term (2-year) forecasts (USDOE, Energy Information Administration, 2016e) and annual long-term (25-year) forecasts (USDOE, Energy Information Administration, 2016d). The incremental contribution of a proposed action relative to the outlooks described in these reports is expected to be minimal.

4.14.2.2.4 Incomplete or Unavailable Information

Even after evaluating the information above, there is still incomplete or unavailable information. This information primarily relates to the onshore geographic distributions of economic impacts arising from the OCS Program, which would allow BOEM to better estimate the impacts from routine activities and cumulative impacts. This information is difficult to obtain since most data sources do not adequately differentiate between onshore and offshore oil and gas activities. In addition, standard data sources do not trace revenue and corporate profit streams to ultimate expenditures. BOEM used reasonably accepted scientific methodologies to extrapolate from existing information in completing the relevant analysis and formulating the conclusions presented here. For example, BOEM used the model MAG-PLAN to estimate the impacts of the alternatives and OCS Program. In addition, the economic impacts arising from the OCS Program are generally positive, not adverse. Therefore, BOEM has determined that the incomplete or unavailable information, while relevant, is not essential to a reasoned choice among alternatives.

4.14.2.2.5 Alternative A—Regionwide OCS Lease Sale (The Preferred Alternative)

The impacts of Alternative A would correspond to the impacts discussed above. This chapter describes the numerical impact estimates for Alternative A. The MAG-PLAN's estimates of the total employment, labor income, and value-added expenditure impacts for the low and high scenarios are presented in **Tables 4-38 and 4-39**. These tables present the average values (over 50 years), peak values, and percent of peak values relative to total employment, labor income, and value-added in each EIA. The average values are calculated over 50 years for consistency and because that is the time horizon over which activities arising from the alternatives are expected to occur. In the low scenario, a proposed action would support a peak of 9,500 jobs, $600 million in labor income, and $970 million in value-added benefits throughout the United States. Most of these impacts would occur in the Gulf of Mexico region, particularly in coastal Texas and Louisiana. The EIAs that would experience the highest economic impacts are TX-3, TX-2, LA-3, LA-4, LA-6, MS-1, and AL-1. However, these impacts would represent a small fraction of each EIA's economy. In the high scenario, a proposed action would support a peak of 27,000 jobs, $1,7 billion in labor income, and $2.6 billion in value-added. The geographic distributions of impacts would be similar to those of the low scenario. However, these expenditure impacts would represent less than 1 percent of the economies of all EIAs. The impacts of the very high scenario would be double the impacts of the high scenario. However, as discussed previously, the very high scenario is unlikely to occur.

Table 4-38. Gulf of Mexico Single Low: MAG-PLAN Industry Expenditure Impacts.

Economic Impact Area	Employment Impacts (number of jobs)			Labor Income Impacts ($ thousands)			Value-Added Impacts ($ thousands)		
	Average	Peak	Peak %	Average	Peak	Peak %	Average	Peak	Peak %
Texas									
TX-1	20	220	0.0%	1,000	9,000	0.0%	1,000	13,000	0.0%
TX-2	60	610	0.1%	3,000	30,000	0.1%	4,000	44,000	0.0%
TX-3	250	1,900	0.1%	20,000	150,000	0.1%	31,000	241,000	0.0%
TX-4	0	20	0.0%	0	1,000	0.0%	0	2,000	0.0%
TX-5	10	50	0.0%	0	3,000	0.0%	1,000	5,000	0.0%
TX-6	0	0	0.0%	0	0	0.0%	0	0	0.0%
All Texas EIAs	340	2,660	–	25,000	185,000	–	38,000	294,000	–
Rest of Texas	70	460	–	4,000	29,000	–	7,000	51,000	–
Texas Total	410	3,120	–	28,000	213,000	–	45,000	345,000	–
Louisiana									
LA-1	20	170	0.2%	2,000	12,000	0.2%	2,000	17,000	0.2%
LA-2	0	10	0.0%	0	0	0.0%	0	0	0.0%
LA-3	50	340	0.2%	3,000	16,000	0.1%	4,000	26,000	0.1%
LA-4	70	600	0.3%	5,000	40,000	0.3%	7,000	57,000	0.2%
LA-5	20	200	0.1%	1,000	10,000	0.0%	2,000	16,000	0.0%
LA-6	60	500	0.1%	4,000	30,000	0.1%	5,000	42,000	0.1%
LA-7	10	80	0.1%	1,000	4,000	0.0%	1,000	6,000	0.0%
All Louisiana EIAs	250	1,870	–	14,000	113,000	–	21,000	163,000	–
Rest of Louisiana	40	300	–	2,000	14,000	–	4,000	28,000	–
Louisiana Total	290	2,150	–	16,000	126,000	–	25,000	190,000	–

Economic Impact Area	Employment Impacts (number of jobs)			Labor Income Impacts ($ thousands)			Value-Added Impacts ($ thousands)		
	Average	Peak	Peak %	Average	Peak	Peak %	Average	Peak	Peak %
Mississippi									
MS-1	50	470	0.3%	3,000	24,000	0.3%	4,000	35,000	0.3%
MS-2	0	20	0.2%	0	1,000	0.1%	0	1,000	0.1%
All Mississippi EIAs	60	490	–	3,000	25,000	–	4,000	36,000	–
Rest of Mississippi	50	350	–	2,000	16,000	–	4,000	29,000	–
Mississippi Total	100	830	–	5,000	41,000	–	8,000	64,000	–
Alabama									
AL-1	60	600	0.2%	3,000	28,000	0.2%	5,000	47,000	0.2%
AL-2	10	40	0.1%	0	2,000	0.1%	0	3,000	0.1%
All Alabama EIAs	70	640	–	3,000	30,000	–	5,000	51,000	–
Rest of Alabama	40	310	–	2,000	16,000	–	4,000	30,000	–
Alabama Total	110	940	–	5,000	45,000	–	9,000	80,000	–
Florida									
FL-1	10	90	0.0%	0	6,000	0.0%	1,000	11,000	0.0%
FL-2	0	0	0.0%	0	0	0.0%	0	0	0.0%
FL-3	0	0	0.0%	0	0	0.0%	0	0	0.0%
FL-4	0	10	0.0%	0	1,000	0.0%	0	1,000	0.0%
FL-5	0	0	0.0%	0	0	0.0%	0	0	0.0%
FL-6	0	0	0.0%	0	0	0.0%	0	0	0.0%
All Florida EIAs	10	100	–	1,000	7,000	–	1,000	12,000	–
Rest of Florida	40	290	–	2,000	14,000	–	4,000	27,000	–
Florida Total	50	380	–	3,000	20,000	–	5,000	37,000	–
All States									
All EIAs in All States	720	5,730	–	45,000	358,000	–	69,000	550,000	–
All Gulf States	960	7,420	–	58,000	445,000	–	91,000	713,000	–
USA									
Rest of the United States	220	2,150	–	14,000	136,000	–	27,000	262,000	–
Totals									
Total Expenditure Impacts	1,180	9,540	–	72,000	579,000	–	118,000	970,000	–

EIA = Economic Impact Area.
Note: Totals may not sum due to rounding.

Source: BOEM internal modeling estimates.

Table 4-39. Gulf of Mexico Single High: MAG-PLAN Industry Expenditure Impacts.

Economic Impact Area	Employment Impacts (number of jobs)			Labor Income Impacts ($ thousands)			Value-Added Impacts ($ thousands)		
	Average	Peak	Peak %	Average	Peak	Peak %	Average	Peak	Peak %
Texas									
TX-1	90	480	0.0%	4,000	20,000	0.0%	6,000	29,000	0.0%
TX-2	320	1,310	0.1%	17,000	66,000	0.1%	24,000	95,000	0.0%
TX-3	2,170	7,640	0.1%	178,000	617,000	0.1%	246,000	865,000	0.0%
TX-4	10	40	0.0%	1,000	2,000	0.0%	1,000	3,000	0.0%
TX-5	40	140	0.0%	2,000	8,000	0.0%	3,000	12,000	0.0%
TX-6	0	10	0.0%	0	0	0.0%	0	0	0.0%
All Texas EIAs	2,630	9,490	–	201,000	705,000	–	281,000	997,000	–
Rest of Texas	360	1,200	–	22,000	73,000	–	37,000	126,000	–
Texas Total	2,990	10,650	–	223,000	778,000	–	318,000	1,122,000	–
Louisiana									
LA-1	160	430	0.2%	11,000	30,000	0.2%	16,000	43,000	0.2%
LA-2	10	20	0.0%	0	1,000	0.0%	0	1,000	0.0%
LA-3	460	1,240	0.2%	23,000	61,000	0.1%	34,000	92,000	0.1%
LA-4	480	1,460	0.3%	31,000	95,000	0.3%	45,000	137,000	0.2%
LA-5	200	590	0.1%	10,000	28,000	0.0%	15,000	43,000	0.0%
LA-6	530	1,540	0.1%	31,000	90,000	0.1%	44,000	125,000	0.1%
LA-7	100	260	0.1%	4,000	12,000	0.0%	6,000	17,000	0.0%
All Louisiana EIAs	1,930	5,470	–	110,000	313,000	–	161,000	454,000	–
Rest of Louisiana	230	730	–	11,000	34,000	–	20,000	65,000	–
Louisiana Total	2,160	6,180	–	121,000	347,000	–	181,000	517,000	–
Mississippi									
MS-1	450	1,400	0.3%	20,000	64,000	0.3%	30,000	94,000	0.3%
MS-2	30	70	0.2%	1,000	2,000	0.1%	1,000	3,000	0.1%
All Mississippi EIAs	480	1,460	–	21,000	65,000	–	31,000	97,000	–
Rest of Mississippi	250	840	–	11,000	39,000	–	19,000	67,000	–
Mississippi Total	730	2,280	–	32,000	103,000	–	50,000	163,000	–
Alabama									
AL-1	510	1,650	0.2%	21,000	70,000	0.2%	34,000	115,000	0.2%
AL-2	40	130	0.1%	1,000	5,000	0.1%	3,000	9,000	0.1%
All Alabama EIAs	550	1,780	–	23,000	75,000	–	36,000	124,000	–
Rest of Alabama	200	710	–	10,000	35,000	–	18,000	65,000	–
Alabama Total	760	2,470	–	33,000	110,000	–	54,000	189,000	–
Florida									
FL-1	20	150	0.0%	1,000	11,000	0.0%	2,000	18,000	0.0%
FL-2	0	0	0.0%	0	0	0.0%	0	0	0.0%
FL-3	0	0	0.0%	0	0	0.0%	0	0	0.0%
FL-4	10	20	0.0%	0	1,000	0.0%	1,000	2,000	0.0%
FL-5	0	10	0.0%	0	0	0.0%	0	1,000	0.0%
FL-6	0	0	0.0%	0	0	0.0%	0	0	0.0%
All Florida EIAs	30	180	–	2,000	12,000	–	3,000	21,000	–
Rest of Florida	220	720	–	12,000	38,000	–	20,000	66,000	–
Florida Total	260	870	–	14,000	48,000	–	24,000	83,000	–
All States									
All EIAs in All States	5,630	18,360	–	356,000	1,165,000	–	512,000	1,682,000	–
All Gulf States	6,900	22,420	–	422,000	1,383,000	–	627,000	2,069,000	–

Economic Impact Area	Employment Impacts (number of jobs)			Labor Income Impacts ($ thousands)			Value-Added Impacts ($ thousands)		
	Average	Peak	Peak %	Average	Peak	Peak %	Average	Peak	Peak %
USA									
Rest of the United States	1,080	4,680	–	69,000	299,000	–	128,000	564,000	–
Totals									
Total Expenditure Impacts	7,980	27,030	–	491,000	1,669,000	–	755,000	2,605,000	–

EIA = Economic Impact Area.
Note: Totals may not sum due to rounding.

Source: BOEM internal modeling estimates.

Alternative A would generate government revenues through bonus bids, rental payments, and royalty payments. In the low scenario, a regionwide lease sale would generate approximately $260 million in bonus bids, $46 million in total rental payments (with an annual peak of $6.7 million), and $1.7 billion in royalty payments (with an annual peak of $119 million). In the high scenario, a regionwide lease sale would generate approximately $520 million in bonus bids, $98 million in total rental payments (with an annual peak of $14 million), and $19.8 billion in total royalty payments (with an annual peak of $1.2 billion). The revenue impacts of the very high scenario would be double the impacts of the high scenario. The corporate profit and market impacts, the adverse impacts arising from routine activities and accidental events, and the cumulative impacts would be proportional to the amount of activities as described above.

Overall, Alternative A would lead to beneficial impacts arising from industry expenditures, government revenues, corporate profits, and other market impacts. Alternative A would also lead to negative economic impacts arising from accidental events and disruptions to other industries. A proposed action should be viewed in light of the OCS Program, as well the numerous forces that can affect energy markets and the overall economy. Overall, Alternative A would lead to **beneficial** impacts, as well as some offsetting **negligible** to **minor** adverse impacts that may occur as a result of accidental events.

4.14.2.2.6 Alternative B—Regionwide OCS Proposed Lease Sale Excluding Available Unleased Blocks in the WPA Portion of the Proposed Lease Sale Area

Alternative B would entail leasing only in the CPA and EPA. As discussed above, the low and high scenarios assume that Alternative B is chosen in the context of typically holding two lease sales per year. If Alternative B were chosen in the context of the CPA/EPA area only being offered once in a year, the economic impacts would be approximately double those presented here because leasing activities would not be spread over the two lease sales; the maximum impacts would correspond to the very high scenario discussed above.

The positive economic impacts of Alternative B would be slightly less than for Alternative A. The MAG-PLAN's estimates of the total employment, labor income, and value-added impacts for the low and high scenarios are presented in **Tables 4-40 and 4-41**. These tables present the average values (over 50 years), peak values, and percent of peak values relative to total employment, labor income, and value-added in each EIA. In the low scenario, Alternative B would support a peak of 7,300 jobs, $440 million in labor income, and $740 million in value-added benefits throughout the United States. Most of these impacts would occur in the Gulf of Mexico region, particularly in coastal Texas and Louisiana. The EIAs that would experience the highest economic impacts are TX-3, TX-2, LA-3, LA-4, LA-6, MS-1, and AL-1. The proportion of total economic impacts would be slightly higher in Louisiana, Mississippi, and Alabama and lower in Texas compared with Alternative A. However, these impacts would represent small fractions of each EIA's economy. In the high scenario, Alternative B would support a peak of 20,000 jobs, $1.2 billion in labor income, and $1.9 billion in value-added. The geographic distributions of impacts would be similar to those of the low scenario. However, the expenditure impacts would represent <1 percent of the economies of all EIAs. The impacts of the very high scenario would be double the impacts of the high scenario. However, as discussed previously, the very high scenario is unlikely to occur. The revenue, corporate profit, market, and adverse impacts would also be proportionately lower. The nature of potential accidental events would be the same, although slightly fewer activities would likely lead to slightly fewer accidental events.

Overall, Alternative B would lead to beneficial impacts arising from industry expenditures, government revenues, corporate profits, and other market impacts. Alternative B would also lead to negative economic impacts arising from accidental events and disruptions to other industries. Alternative B should be viewed in light of the OCS Program, as well the numerous forces that can affect energy markets and the overall economy. Overall, Alternative B would lead to **beneficial** impacts, as well as some offsetting **negligible** to **minor** adverse impacts due to potential accidental events. The exact impacts will be roughly proportional to the amount of resulting oil and gas industry activity as described above.

Table 4-40. CPA/EPA Single Low: MAG-PLAN Industry Expenditure Impacts.

Economic Impact Area	Employment Impacts (number of jobs)			Labor Income Impacts ($ thousands)			Value-Added Impacts ($ thousands)		
	Average	Peak	Peak %	Average	Peak	Peak %	Average	Peak	Peak %
Texas									
TX-1	10	90	0.0%	0	4,000	0.0%	1,000	7,000	0.0%
TX-2	40	390	0.1%	2,000	19,000	0.1%	3,000	29,000	0.0%
TX-3	160	1,040	0.1%	13,000	85,000	0.1%	20,000	139,000	0.0%
TX-4	0	10	0.0%	0	0	0.0%	0	1,000	0.0%
TX-5	0	20	0.0%	0	1,000	0.0%	0	2,000	0.0%
TX-6	0	0	0.0%	0	0	0.0%	0	0	0.0%
All Texas EIAs	210	1,480	–	16,000	107,000	–	24,000	173,000	–
Rest of Texas	50	350	–	3,000	22,000	–	5,000	39,000	–
Texas Total	260	1,830	–	19,000	129,000	–	30,000	212,000	–

Economic Impact Area	Employment Impacts (number of jobs)			Labor Income Impacts ($ thousands)			Value-Added Impacts ($ thousands)		
	Average	Peak	Peak %	Average	Peak	Peak %	Average	Peak	Peak %
Louisiana									
LA-1	20	160	0.2%	2,000	12,000	0.2%	2,000	17,000	0.2%
LA-2	0	10	0.0%	0	0	0.0%	0	0	0.0%
LA-3	50	310	0.2%	2,000	14,000	0.1%	4,000	23,000	0.1%
LA-4	60	530	0.3%	4,000	36,000	0.3%	6,000	51,000	0.2%
LA-5	20	190	0.1%	1,000	10,000	0.0%	2,000	15,000	0.0%
LA-6	60	490	0.1%	4,000	29,000	0.1%	5,000	40,000	0.1%
LA-7	10	80	0.1%	0	4,000	0.0%	1,000	6,000	0.0%
All Louisiana EIAs	230	1,760	–	14,000	106,000	–	20,000	152,000	–
Rest of Louisiana	30	220	–	2,000	10,000	–	3,000	21,000	–
Louisiana Total	260	1,970	–	15,000	117,000	–	23,000	173,000	–
Mississippi									
MS-1	50	440	0.3%	3,000	23,000	0.3%	4,000	32,000	0.3%
MS-2	0	20	0.2%	0	1,000	0.1%	0	1,000	0.1%
All Mississippi EIAs	50	460	–	3,000	23,000	–	4,000	33,000	–
Rest of Mississippi	40	270	–	2,000	13,000	–	3,000	22,000	–
Mississippi Total	90	720	--	4,000	36,000	--	7,000	55,000	--
Alabama									
AL-1	60	530	0.2%	3,000	25,000	0.2%	4,000	41,000	0.2%
AL-2	0	40	0.1%	0	2,000	0.1%	0	3,000	0.1%
All Alabama EIAs	60	570	–	3,000	27,000	–	5,000	44,000	–
Rest of Alabama	30	240	–	2,000	12,000	–	3,000	24,000	–
Alabama Total	100	810	–	5,000	39,000	–	8,000	67,000	–
Florida									
FL-1	0	60	0.0%	0	4,000	0.0%	1,000	7,000	0.0%
FL-2	0	0	0.0%	0	0	0.0%	0	0	0.0%
FL-3	0	0	0.0%	0	0	0.0%	0	0	0.0%
FL-4	0	10	0.0%	0	0	0.0%	0	1,000	0.0%
FL-5	0	0	0.0%	0	0	0.0%	0	0	0.0%
FL-6	0	0	0.0%	0	0	0.0%	0	0	0.0%
All Florida EIAs	10	70	–	0	5,000	–	1,000	8,000	–
Rest of Florida	30	220	–	2,000	11,000	–	3,000	21,000	–
Florida Total	40	290	–	2,000	15,000	–	4,000	29,000	–
All States									
All EIAs in All States	560	4,340	–	35,000	269,000	–	53,000	411,000	–
All Gulf States	750	5,640	–	45,000	336,000	–	71,000	536,000	–
USA									
Rest of the United States	180	1,640	–	11,000	104,000	–	21,000	200,000	–
Totals									
Total Expenditure Impacts	930	7,280	–	56,000	440,000	–	92,000	736,000	–

EIA = Economic Impact Area.
Note: Totals may not sum due to rounding.

Source: BOEM internal modeling estimates.

Table 4-41. CPA/EPA Single High: MAG-PLAN Industry Expenditure Impacts.

Economic Impact Area	Employment Impacts (number of jobs)			Labor Income Impacts ($ thousands)			Value-Added Impacts ($ thousands)		
	Average	Peak	Peak %	Average	Peak	Peak %	Average	Peak	Peak %
Texas									
TX-1	50	140	0.0%	3,000	7,000	0.0%	4,000	11,000	0.0%
TX-2	220	630	0.1%	11,000	33,000	0.1%	16,000	47,000	0.0%
TX-3	1,740	5,220	0.1%	145,000	435,000	0.1%	199,000	591,000	0.0%
TX-4	10	20	0.0%	0	1,000	0.0%	1,000	2,000	0.0%
TX-5	10	40	0.0%	1,000	2,000	0.0%	1,000	3,000	0.0%
TX-6	0	0	0.0%	0	0	0.0%	0	0	0.0%
All Texas EIAs	2,030	6,060	–	160,000	478,000	–	221,000	654,000	–
Rest of Texas	310	860	–	19,000	53,000	–	31,000	90,000	–
Texas Total	2,340	6,930	–	179,000	531,000	–	252,000	744,000	–
Louisiana									
LA-1	160	420	0.2%	11,000	29,000	0.2%	16,000	43,000	0.2%
LA-2	10	20	0.0%	0	1,000	0.0%	0	1,000	0.0%
LA-3	420	1,110	0.2%	21,000	55,000	0.1%	31,000	81,000	0.1%
LA-4	430	1,200	0.3%	29,000	80,000	0.3%	42,000	115,000	0.2%
LA-5	200	570	0.1%	9,000	27,000	0.0%	14,000	41,000	0.0%
LA-6	510	1,470	0.1%	30,000	86,000	0.1%	42,000	119,000	0.1%
LA-7	90	250	0.1%	4,000	11,000	0.0%	6,000	16,000	0.0%
All Louisiana EIAs	1,820	5,040	–	104,000	288,000	–	152,000	417,000	–
Rest of Louisiana	190	520	–	9,000	24,000	–	17,000	46,000	–
Louisiana Total	2,010	5,540	–	113,000	312,000	–	168,000	461,000	–
Mississippi									
MS-1	440	1,290	0.3%	19,000	57,000	0.3%	29,000	85,000	0.3%
MS-2	30	70	0.2%	1,000	2,000	0.1%	1,000	3,000	0.1%
All Mississippi EIAs	470	1,360	–	20,000	59,000	–	30,000	88,000	–
Rest of Mississippi	210	590	–	9,000	27,000	–	16,000	47,000	–
Mississippi Total	680	1,950	–	29,000	86,000	–	46,000	134,000	–
Alabama									
AL-1	500	1,510	0.2%	21,000	63,000	0.2%	33,000	101,000	0.2%
AL-2	40	120	0.1%	1,000	4,000	0.1%	3,000	7,000	0.1%
All Alabama EIAs	540	1,630	–	22,000	67,000	–	35,000	108,000	–
Rest of Alabama	170	490	–	8,000	24,000	–	15,000	44,000	–
Alabama Total	710	2,120	–	30,000	92,000	–	50,000	152,000	–
Florida									
FL-1	20	90	0.0%	1,000	6,000	0.0%	2,000	11,000	0.0%
FL-2	0	0	0.0%	0	0	0.0%	0	0	0.0%
FL-3	0	0	0.0%	0	0	0.0%	0	0	0.0%
FL-4	0	10	0.0%	0	1,000	0.0%	0	1,000	0.0%
FL-5	0	10	0.0%	0	0	0.0%	0	1,000	0.0%
FL-6	0	0	0.0%	0	0	0.0%	0	0	0.0%
All Florida EIAs	30	110	–	1,000	7,000	–	3,000	13,000	–
Rest of Florida	190	510	–	10,000	27,000	–	17,000	46,000	–
Florida Total	220	610	–	12,000	33,000	–	20,000	57,000	–
All States									
All EIAs in All States	4,890	14,190	–	307,000	899,000	–	440,000	1,278,000	–
All Gulf States	5,950	17,140	–	363,000	1,054,000	–	536,000	1,549,000	–

Economic Impact Area	Employment Impacts (number of jobs)			Labor Income Impacts ($ thousands)			Value-Added Impacts ($ thousands)		
	Average	Peak	Peak %	Average	Peak	Peak %	Average	Peak	Peak %
USA									
Rest of the United States	890	2,990	–	57,000	192,000	–	106,000	358,000	–
Totals									
Total Expenditure Impacts	6,840	20,140	–	420,000	1,246,000	–	642,000	1,907,000	–

EIA = Economic Impact Area.
Note: Totals may not sum due to rounding.

Source: BOEM internal modeling estimates.

4.14.2.2.7 Alternative C—Regionwide OCS Proposed Lease Sale Excluding Available Unleased Blocks in the CPA/EPA Portions of the Proposed Lease Sale Area

Alternative C would entail leasing only in the WPA. As discussed above, the low and high scenarios assume that Alternative C is chosen in the context of typically holding two lease sales per year. If Alternative C were chosen in the context of the WPA area only being offered once in a year, the economic impacts would be approximately double those presented here because leasing activities would not be spread over the two lease sales; the maximum impacts would correspond to the very high scenario discussed above.

The positive economic impacts of Alternative C would be less than for Alternative A, particularly since less activity generally occurs in the WPA relative to the CPA. MAG-PLAN's estimates of the total employment, labor income, and value-added impacts for the low and high scenarios are presented in **Tables 4-42 and 4-43**. These tables present the average values (over 50 years), peak values, and the percent of peak values relative to total employment, labor income, and value-added in each EIA. In the low scenario, Alternative C would support a peak of 2,300 jobs, $140 million in labor income, and $230 million in value-added benefits throughout the United States. Most of these impacts would occur in the Gulf Region. The EIAs that would experience the highest economic impacts are TX-3, TX-2, TX-1, LA-4, and AL-1. The proportion of total economic impacts would be higher in Texas (and lower in the other Gulf States) compared to Alternative A. However, these impacts would represent small fractions of each EIAs economy. In the high scenario, Alternative C would support a peak of 6,900 jobs, $420 million in labor income, and $700 million in value-added. The geographic distributions of impacts would be similar to those of the low scenario. The impacts of the very high scenario would be double the impacts of the high scenario. However, as discussed previously, the very high scenario is unlikely to occur. The revenue, corporate profit, market, and adverse impacts would also be proportionately lower. The nature of potential accidental events would be the same, although slightly fewer activities would likely lead to slightly fewer accidental events.

Overall, Alternative C would lead to beneficial impacts arising from industry expenditures, government revenues, corporate profits, and other market impacts. Alternative C would also lead to negative economic impacts arising from accidental events and disruptions to other industries.

Alternative C should be viewed in light of the OCS Program, as well the numerous forces that can affect energy markets and the overall economy. Overall, Alternative C would lead to **beneficial** impacts, as well as some offsetting **negligible** to **minor** adverse impacts mostly as a result of accidental events that may be reasonably foreseeable. The exact impacts will be roughly proportional to the amount of resulting oil and gas industry activity as described above.

Table 4-42. WPA Single Low: MAG-PLAN Industry Expenditure Impacts.

Economic Impact Area	Employment Impacts (number of jobs)			Labor Income Impacts ($ thousands)			Value-Added Impacts ($ thousands)		
	Average	Peak	Peak %	Average	Peak	Peak %	Average	Peak	Peak %
Texas									
TX-1	10	130	0.0%	0	4,000	0.0%	1,000	6,000	0.0%
TX-2	20	220	0.1%	1,000	10,000	0.1%	2,000	15,000	0.0%
TX-3	100	860	0.1%	7,000	65,000	0.1%	11,000	102,000	0.0%
TX-4	0	10	0.0%	0	0	0.0%	0	0	0.0%
TX-5	0	30	0.0%	0	2,000	0.0%	0	3,000	0.0%
TX-6	0	0	0.0%	0	0	0.0%	0	0	0.0%
All Texas EIAs	130	1,180	–	9,000	77,000	–	13,000	121,000	–
Rest of Texas	10	110	–	1,000	7,000	–	1,000	12,000	–
Texas Total	150	1,290	–	10,000	84,000	–	15,000	133,000	–
Louisiana									
LA-1	0	0	0.2%	0	0	0.2%	0	0	0.2%
LA-2	0	0	0.0%	0	0	0.0%	0	0	0.0%
LA-3	0	30	0.2%	0	2,000	0.1%	0	3,000	0.1%
LA-4	10	70	0.3%	0	4,000	0.3%	1,000	6,000	0.2%
LA-5	0	10	0.1%	0	0	0.0%	0	1,000	0.0%
LA-6	0	20	0.1%	0	1,000	0.1%	0	2,000	0.1%
LA-7	0	0	0.1%	0	0	0.0%	0	0	0.0%
All Louisiana EIAs	20	110	–	1,000	7,000	–	1,000	10,000	–
Rest of Louisiana	10	80	–	0	4,000	–	1,000	7,000	–
Louisiana Total	20	180	–	1,000	9,000	–	2,000	16,000	–
Mississippi									
MS-1	0	30	0.3%	0	2,000	0.3%	0	3,000	0.3%
MS-2	0	0	0.2%	0	0	0.1%	0	0	0.1%
All Mississippi EIAs	0	30	–	0	2,000	–	0	3,000	–
Rest of Mississippi	10	90	–	0	4,000	–	1,000	7,000	–
Mississippi Total	10	110	–	1,000	5,000	–	1,000	9,000	–
Alabama									
AL-1	0	70	0.2%	0	3,000	0.2%	0	7,000	0.2%
AL-2	0	0	0.1%	0	0	0.1%	0	0	0.1%
All Alabama EIAs	0	70	–	0	3,000	–	0	7,000	–
Rest of Alabama	10	70	–	0	3,000	–	1,000	7,000	–
Alabama Total	10	120	–	1,000	6,000	–	1,000	13,000	–
Florida									
FL-1	0	30	0.0%	0	2,000	0.0%	0	4,000	0.0%
FL-2	0	0	0.0%	0	0	0.0%	0	0	0.0%
FL-3	0	0	0.0%	0	0	0.0%	0	0	0.0%
FL-4	0	0	0.0%	0	0	0.0%	0	0	0.0%
FL-5	0	0	0.0%	0	0	0.0%	0	0	0.0%

Economic Impact Area	Employment Impacts (number of jobs)			Labor Income Impacts ($ thousands)			Value-Added Impacts ($ thousands)		
	Average	Peak	Peak %	Average	Peak	Peak %	Average	Peak	Peak %
FL-6	0	0	0.0%	0	0	0.0%	0	0	0.0%
All Florida EIAs	0	30	–	0	2,000	–	0	4,000	–
Rest of Florida	10	70	–	0	3,000	–	1,000	6,000	–
Florida Total	10	90	–	1,000	5,000	–	1,000	9,000	–
All States									
All EIAs in All States	160	1,400	–	10,000	89,000	–	16,000	139,000	–
All Gulf States	210	1,790	–	13,000	109,000	–	20,000	177,000	–
USA									
Rest of the United States	50	500	–	3,000	32,000	–	6,000	62,000	–
Totals									
Total Expenditure Impacts	250	2,260	–	16,000	139,000	–	26,000	234,000	–

EIA = Economic Impact Area.
Note: Totals may not sum due to rounding.

Source: BOEM internal modeling estimates.

Table 4-43. WPA Single High: MAG-PLAN Industry Expenditure Impacts.

Economic Impact Area	Employment Impacts (number of jobs)			Labor Income Impacts ($ thousands)			Value-Added Impacts ($ thousands)		
	Average	Peak	Peak %	Average	Peak	Peak %	Average	Peak	Peak %
Texas									
TX-1	40	340	0.0%	2,000	12,000	0.0%	2,000	18,000	0.0%
TX-2	110	680	0.1%	5,000	33,000	0.1%	8,000	48,000	0.0%
TX-3	430	2,420	0.1%	32,000	182,000	0.1%	47,000	274,000	0.0%
TX-4	0	20	0.0%	0	1,000	0.0%	0	2,000	0.0%
TX-5	20	110	0.0%	1,000	5,000	0.0%	2,000	9,000	0.0%
TX-6	0	0	0.0%	0	0	0.0%	0	0	0.0%
All Texas EIAs	600	3,430	–	41,000	227,000	–	60,000	342,000	–
Rest of Texas	60	330	–	3,000	20,000	–	6,000	36,000	–
Texas Total	660	3,720	–	44,000	247,000	–	66,000	378,000	–
Louisiana									
LA-1	0	10	0.2%	0	0	0.2%	0	1,000	0.2%
LA-2	0	0	0.0%	0	0	0.0%	0	0	0.0%
LA-3	40	120	0.2%	2,000	7,000	0.1%	3,000	10,000	0.1%
LA-4	40	260	0.3%	3,000	15,000	0.3%	4,000	22,000	0.2%
LA-5	10	20	0.1%	0	1,000	0.0%	0	2,000	0.0%
LA-6	20	70	0.1%	1,000	5,000	0.1%	2,000	6,000	0.1%
LA-7	0	10	0.1%	0	1,000	0.0%	0	1,000	0.0%
All Louisiana EIAs	110	430	–	6,000	25,000	–	9,000	37,000	–
Rest of Louisiana	40	200	–	2,000	10,000	–	3,000	19,000	–
Louisiana Total	150	640	–	8,000	35,000	–	12,000	56,000	–

Economic Impact Area	Employment Impacts (number of jobs)			Labor Income Impacts ($ thousands)			Value-Added Impacts ($ thousands)		
	Average	Peak	Peak %	Average	Peak	Peak %	Average	Peak	Peak %
Mississippi									
MS-1	10	110	0.3%	1,000	7,000	0.3%	1,000	9,000	0.3%
MS-2	0	0	0.2%	0	0	0.1%	0	0	0.1%
All Mississippi EIAs	10	110	–	1,000	7,000	–	1,000	10,000	–
Rest of Mississippi	40	240	–	2,000	11,000	–	3,000	20,000	–
Mississippi Total	50	330	–	3,000	17,000	–	4,000	28,000	–
Alabama									
AL-1	10	140	0.2%	1,000	7,000	0.2%	1,000	14,000	0.2%
AL-2	0	10	0.1%	0	0	0.1%	0	1,000	0.1%
All Alabama EIAs	10	150	–	1,000	7,000	–	1,000	15,000	–
Rest of Alabama	30	220	–	2,000	11,000	–	3,000	21,000	–
Alabama Total	50	350	–	2,000	18,000	–	4,000	37,000	–
Florida									
FL-1	10	60	0.0%	0	4,000	0.0%	1,000	7,000	0.0%
FL-2	0	0	0.0%	0	0	0.0%	0	0	0.0%
FL-3	0	0	0.0%	0	0	0.0%	0	0	0.0%
FL-4	0	10	0.0%	0	0	0.0%	0	1,000	0.0%
FL-5	0	0	0.0%	0	0	0.0%	0	0	0.0%
FL-6	0	0	0.0%	0	0	0.0%	0	0	0.0%
All Florida EIAs	10	70	–	0	5,000	–	1,000	9,000	–
Rest of Florida	30	210	–	2,000	11,000	–	3,000	20,000	–
Florida Total	40	270	–	2,000	14,000	–	4,000	26,000	–
All States									
All EIAs in All States	750	4,170	–	49,000	266,000	–	72,000	404,000	–
All Gulf States	950	5,280	–	59,000	329,000	–	91,000	520,000	–
USA									
Rest of the United States	190	1,680	–	12,000	106,000	–	23,000	206,000	–
Totals									
Total Expenditure Impacts	1,130	6,890	–	71,000	423,000	–	113,000	698,000	–

EIA = Economic Impact Area.
Note: Totals may not sum due to rounding.

Source: BOEM internal modeling estimates.

4.14.2.2.8 Alternative D—Alternative A, B, or C, with the Option to Exclude Available Unleased Blocks Subject to the Topographic Features, Live Bottom (Pinnacle Trend), and/or Blocks South of Baldwin County, Alabama, Stipulations

Alternative D only slightly reduces the available areas for leasing. Therefore, the economic impacts of Alternative D would the same or only slightly less than the impacts of Alternative A, B, or C.

4.14.2.2.9 Alternative E—No Action

The selection of Alternative E would prevent the positive economic impacts described above from occurring; it would also prevent the associated negative impacts from occurring. Since the OCS Program generally supports existing oil and gas activities, Alternative E would negatively impact firms and employees that depend on recurring leases. Prices and quantities sold of energy products would adjust slightly to the removal of oil and gas from the market. The selection of Alternative E relates only to a single proposed lease sale, while decisions regarding the broader leasing program are made at the Five-Year Program stage. Therefore, the impacts of Alternative E would be **negligible** to **minor**, with some partially offsetting **beneficial** impacts.

4.14.3 Social Factors (Including Environmental Justice)

> *While the entire petroleum industry (onshore, State waters, and OCS) has developed over decades and is deeply intertwined in the Gulf of Mexico region's communities and economies, a single lease sale is like a blip on a radar screen, one tiny piece of a vastly complex social and economic structure.*

The petroleum industry as a whole in the Gulf of Mexico region has matured over several decades and is well-developed, expansive, extensive, and deeply intertwined in the regional communities and economies of the five coastal states, i.e., Texas, Louisiana, Mississippi, Alabama, and Florida. An inherent complication in conducting an impact analysis of OCS oil- and gas-related activities lies in the fact that the industry involves onshore (private and public lands), State offshore, and Federal OCS exploration, development, and production. Teasing out the OCS oil- and gas-related impacts from the impacts of activities onshore and in State waters is complex. Moreover, this long-lived, well-developed, and extensive industry functions within a much larger context, a socioeconomic framework that weaves through the region in a complex, inter-connected, grid-like manner. Nothing occurs as an isolated event, but rather results from and simultaneously triggers other events, all of which are experienced at varying degrees of a negative or positive impact. For example, when oil prices drop and then gasoline prices drop, this positively impacts individuals and businesses who buy fuel. When oil prices remain low for many months, negative impacts begin to appear. Companies start trimming costs by reducing the number of employees to cut operational costs. Laid-off employees no longer have income to make purchases and the businesses where workers would normally spend their money began to suffer and, when necessary, people began moving out of the area to find other work, leading to a negative impact on the housing market, depressing real estate prices as the number of units available for rent or sale outgrows the demand. A negative impact for some (i.e., sellers and landlords) becomes a positive impact for others (i.e., buyers and renters). This is just one example of an event unrelated to OCS oil- and gas-related activities leading to dual ripple impacts (negative and positive) through communities and illustrates the complexity of the socioeconomic framework. Within this context, and in the cumulative analysis, a single lease sale is like a blip on a radar screen, one tiny piece of a vastly complex social and economic structure. A single proposed lease sale's main impact on communities would be to contribute to the maintenance of current employment levels; not to create new jobs; not to cause a notable increase of people to move into the region; not to cause new roads, schools, or hospitals to be built; and not to cause large public works improvements. A proposed single lease sale would mostly solely help to maintain what decades of economic development have built, the complex Gulf of Mexico region that exists today.

While this chapter is titled “social factors,” the resource discussed here is essentially human beings. The list of potential impact-producing factors is, in a sense, nearly limitless because the industry involves people at all levels; it simultaneously affects and is affected by people, their communities, and their daily lives. Most of the impacts to people are positive, e.g., in the form of direct employment in the industry, indirect employment in the extensive support sectors, and employees’ spent wages and tax revenues that support the community businesses and services. After describing the affected environment, this impact analysis addresses routine activities related to the oil and gas industry and accidental events that may occur from OCS oil- and gas-related activities as a result of a single lease sale, as well as the cumulative impacts of OCS oil- and gas-related and non-OCS oil- and gas-related impact-producing factors. An environmental justice determination follows in **Chapter 4.14.3.3**.

Impact-Level Definitions

Impacts to people and communities may be positive as well as negative. For example, increased economic demand would lead to more hiring, and this additional employment would further the positive economic trend as new workers spend their wages in the community. The following scale defines the impact measures for this analysis:

- **Beneficial** – Positive impacts such as any of the following: maintaining current employment levels; creating new employment; and indirect and induced positive impacts through increased spending that stimulates local and regional economies.
- **Negligible** – Little or no measureable adverse impact.
- **Minor** – Small-scale measurable adverse impact, temporary in duration, and geographically small area (less than county/parish level).
- **Moderate** – Medium-scale measurable adverse impact, may last from a few weeks to 1 year, and geographically may affect multiple counties/parishes.
- **Major** – Large-scale measurable or potentially unmeasurable adverse impact, long lasting (1 year to many years), and may occur over a geographically large regional area.

4.14.3.1 Description of the Affected Environment

The affected environment that comprises the baseline for the social factors’ environmental impact analysis is geographically distributed across 23 BOEM-identified EIAs in all five Gulf Coast States. **Figure 4-32** shows the aggregation of 133 counties and parishes that comprise the EIAs. **Chapter 4.14.2** (Economic Factors) discusses the methodology behind the development of the EIAs and employment in the analysis area.

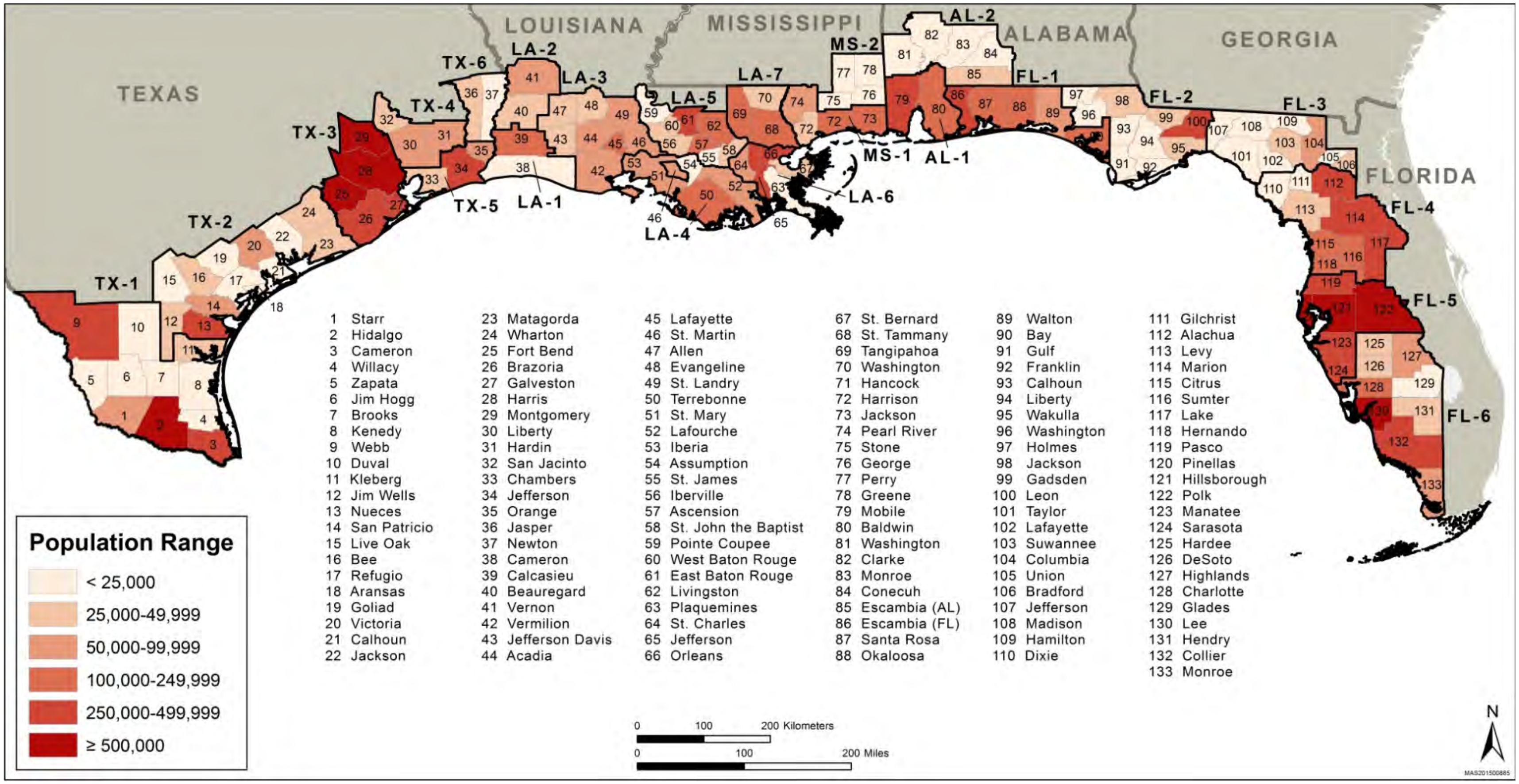

Figure 4-32. Population of BOEM's Economic Impact Areas in the Gulf of Mexico.

The U.S. Census Bureau's calculations estimate that the total population of the combined BOEM economic impact areas exceeded 22.7 million in 2014. **Figure 4-32** presents the range of population levels by county/parish across the GOM coastal region. County and parish population levels vary greatly across the coastal GOM. For example, Kenedy County, Texas, holds the low end of the range with 400 residents and Harris County, Texas, tops out the range at more than 11,000 times that number (4,441,370). At the low end of the population spectrum, 42 (or nearly one-third) of 133 counties/parishes in BOEM's EIAs have less than 25,000 residents. In the upper range, other counties with the >500,000 residents include Hillsborough County, Florida (1,316,298); Pinellas County, Florida (938,098); Hidalgo County, Texas (831,073); Fort Bend County, Texas (685,345); Lee County, Florida (679,513); Polk County, Florida (634,638); and Montgomery County, Texas (518,947) (USDOC, Census Bureau, 2014).

Population in the coastal regions of Gulf Coast States increased 150 percent from 1960 through 2008 and continues to grow. There are 23 states in the U.S. with coastline populations, and the 5 Gulf Coast States occupy over 25 percent of the total for the coastal population of the U.S. Of the eight U.S. coastal counties with the fastest growth, six Gulf Coast counties posted the highest percentage of increase—from Lee County, Florida, at 1,091.5 percent to Collier County, Florida, at 1,901.3 percent. In the nearly five decades from 1960 to 2008, the Gulf of Mexico coastal counties/parishes increased their populations by 246 percent, which is more than 52 percent greater than Pacific coastal counties (130%) and well over two-times as great as the Atlantic area (98%) (USDOC, Census Bureau, 2010a and 2010b; USDOC, NOAA, 2011).

Population density refers to the number of persons per square mile that live in a geographically defined area. In the GOM, the counties/parishes with the highest population density (persons per square mile) are Pinellas County, Florida (3,348); Harris County, Texas (2,402); Orleans Parish, Louisiana (2,029); Jefferson Parish, Louisiana (1,463); and Hillsborough County, Florida (1,205). Three of these top five counties/parishes have a high concentration of oil and gas industry in addition to hosting large cities: Harris County (Houston, Texas); and Orleans and Jefferson Parishes (Louisiana).

Of all 133 counties/parishes in BOEM's EIAs, Harris County, Texas, holds the largest number of oil- and gas-related companies and associated support infrastructure (Petterson et al., 2008; Dismukes, 2011; Kaplan, et al., 2011). Additional counties and parishes with strong ties to the oil and gas industry include Galveston, Jefferson, Brazoria, and Nueces Counties, Texas; Jefferson, Plaquemines, Orleans, St. Bernard, Lafourche, Terrebonne, St. Mary, Vermilion, Cameron, and Calcasieu Parishes, Louisiana; Jackson County, Mississippi; and Mobile County, Alabama (Kaplan et al., 2011).

In the Gulf Coast region, the annual median household income at $41,203 is about 5 percent below the national average of $43,462 (USDOC, Census Bureau, 2010b). **Figures 4-33 and 4-34** illustrate poverty levels across the GOM. Within the 133 counties/parishes that comprise BOEM's EIAs, 78 percent or 104 counties/parishes have poverty levels above the national average of 14.5 percent. The highest concentration of poverty is in TX-1 where 8 out of 11 counties have more than 30 percent of their population living below the national poverty level. Willacy County, Texas, has the highest poverty level (40%) and Fort Bend County, Texas, has the lowest poverty level (8.4%) (USDOC, Census Bureau, 2013a and 2013b).

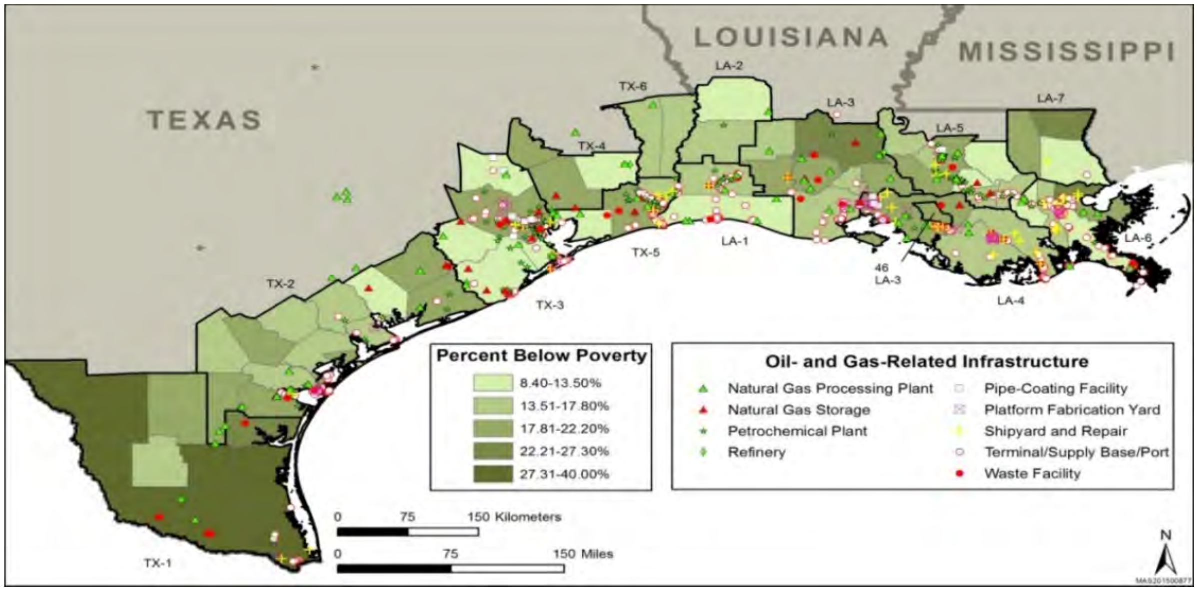

Figure 4-33. Percentage of Poverty in Texas and Louisiana.

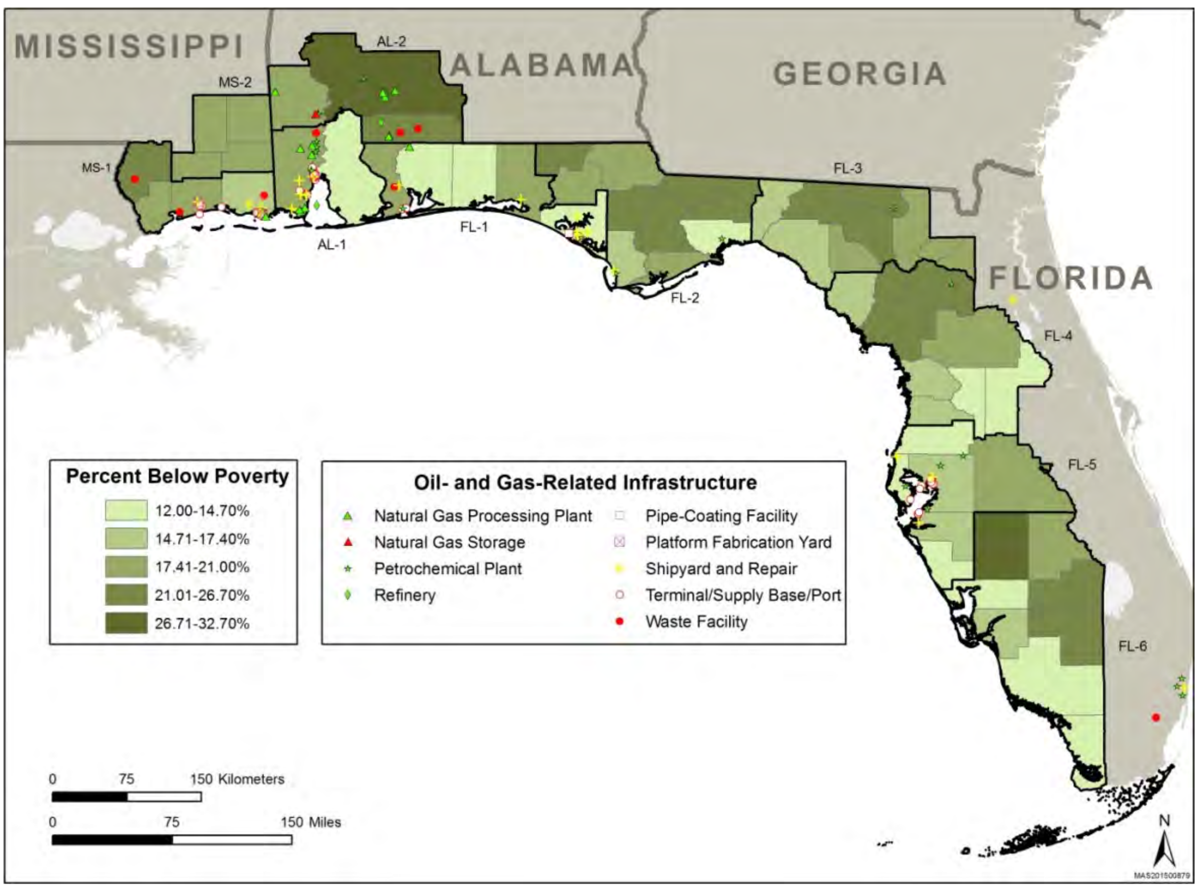

Figure 4-34. Percentage of Poverty in Mississippi, Alabama, and Florida.

The average percentage of minority residents throughout the 23 BOEM-identified EIAs is 22.9 percent, which is slightly below the national average of 26 percent. Forty-four counties/parishes have minority population levels above the national average. **Figures 4-35 and 4-36** illustrate the distribution of minority populations across the five Gulf Coast States. Five parishes in Louisiana (i.e., Orleans, St. John the Baptist, St. James, East Baton Rouge, and Iberville) and one county in Florida (Gadsden) have over a 50-percent minority population. Orleans Parish, Louisiana, has the highest concentration of minority residents at 66.4 percent, while the lowest percentage is shared by two Texas counties, Kenedy and Zapata Counties, at 1.7 percent (USDOC, Census Bureau, 2013c).

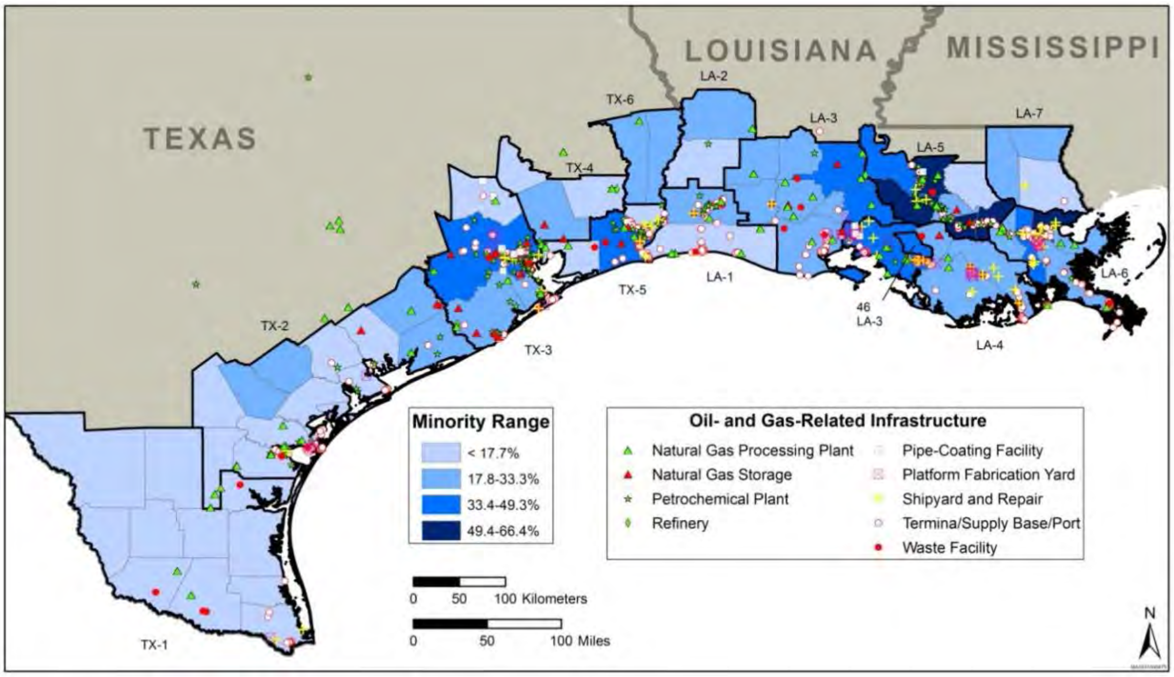

Figure 4-35. Percentage of Minority Populations in Texas and Louisiana.

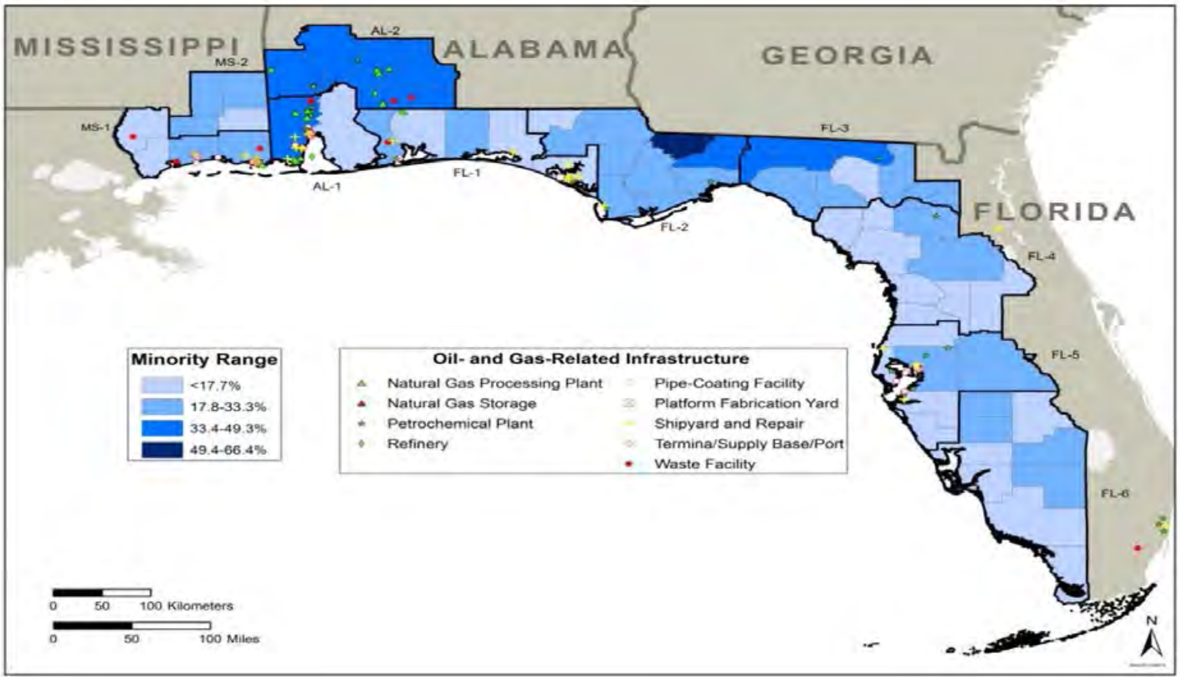

Figure 4-36. Percentage of Minority Populations in Mississippi, Alabama, and Florida.

4.14.3.2 Environmental Consequences

A regionwide proposed lease sale is the preferred alternative and, just like planning area specific lease sales, involves all of the Gulf Coast States (i.e., Texas, Louisiana, Mississippi, Alabama, and Florida) because the onshore effects operate independently of the boundaries of offshore planning areas. Particular emphasis is placed on the 133 counties and parishes that constitute the 23 BOEM-identified EIAs and that are located in the coastal areas of all five states. **Figure 4-29** shows the aggregation of counties and parishes into the EIAs used for BOEM's socioeconomic analysis. This geographic area possesses a culturally and racially diverse population. Some counties and parishes are more closely connected to the offshore oil and gas industry than others particularly Harris County, Texas, and Lafourche Parish, Louisiana. An analysis and discussion of the impact-producing factors from routine activities, accidental events, and cumulative activities is presented below. For a detailed analysis of a high-impact, low-probability catastrophic oil spill, refer to the *Catastrophic Spill Event Analysis* white paper (USDOI, BOEM, 2017).

Analysis of the various alternatives considers impact-producing factors within a distinct framework that includes frequency, duration, and geographic extent. Frequency (i.e., rare, intermittent, and continuous) refers to how often the impact-producing factor occurs over the entire analysis period of 50 years for routine activities and accidental events and for an analysis period of 70 years for cumulative impacts. Duration (i.e., low, medium, and high) refers to how long the impact-producing factor lasts (i.e., from less than a year to many years). Geographic extent refers to which areas are affected and, depending on the impact-producing factor, the size of an affected area.

4.14.3.2.1 Routine Activities

Routine activities related to a single lease sale would be incremental in nature, not expected to change existing conditions, and positive in their contribution to the sustainability of current industry and related support services and employment.

People and communities are a major part of, and provide basic support for, the oil and gas industry. An analysis of the impacts of the industry's routine activities (described in **Chapter 3.1**) on people and communities is complex because they are experienced at multiple levels that overlap, i.e., industry workers, families of workers, and the communities at large. Impacts occur in varying degrees of intensity. The interactions of industry and community are complex, resulting in a myriad of impacts, some positive and some negative. This complex relationship between industry and the community evolves over time, and the subsequent impacts evolve accordingly. Impact-producing factors related to routine activities can be experienced as positive or negative, depending on the specifics of any given situation, and cover a broad spectrum, i.e., employment stability, wages and opportunities for advancement, economic rewards in exchange for work (benefits), work scheduling patterns and how these dictate time spent off the job or with families, industry cycles and fluctuations in OCS oil- and gas-related activity levels, demographic shifts (in-migration and out- migration), commuter and truck traffic, commodity (oil/gas) price fluctuations, expansions of existing infrastructure, and new construction of infrastructure.

The oil and gas industry has evolved in the GOM for many decades, simultaneously affecting and being affected by the societal and economic conditions in the region. Because of this long-standing, complex interrelationship, the impacts of the oil and gas industry as a whole have been diverse and widespread over many years. Austin et al. (2002) and Austin and McGuire (2002) describe this complexity from the viewpoint of workers and their families, and they found that impacts are experienced at many different levels and intensities depending on what sector of the industry is involved. For example, workers in the production sector enjoy more stable employment, while the drilling sector is volatile and provides less secure employment because it is more easily affected by fluctuations in oil and gas prices.

Employment stability in the oil and gas industry and its support sectors correlates directly with fluctuations in OCS oil- and gas-related activity levels, which are, in turn, closely related the changes in oil and gas commodity prices. Scott (2014) describes how important and influential the extraction, refining, and pipeline sectors of the oil and gas industry are for the State of Louisiana, from supporting over 287,000 jobs to paying nearly $1.5 billion in taxes to the State for 1 year alone. While the residents and communities of Louisiana enjoy unquestionable economic benefits, they also are most impacted by fluctuations in OCS oil- and gas-related activity levels and oil and gas prices. Petterson et al. (2008) describe how the benefits and burdens of the oil and gas industry are distributed unevenly across Texas, Louisiana, Mississippi, Alabama, and Florida, with some states (Texas and especially Louisiana) bearing the most burdens, while others accrue the benefits without suffering the burdens of hosting oil- and gas-related activities (e.g., Florida). This is further illustrated by Donato (2004) and Aratame and Singelmann (2002), who examine demographic shifts in Louisiana and the region related to the changing labor situation in the region, from the generally positive impact of immigrant workers to the commuting and migration trends from noncoastal to coastal communities following fluctuations in labor demand across the region.

The potential impacts resulting from the industry's routine activities occur within the larger socioeconomic context of the GOM region. Given the existing, extensive, and widespread support system for the OCS oil- and gas-related industry and its associated labor force, the impacts of routine activities related to a single lease sale are expected to be **negligible**, widely distributed, and to have little impact. Routine activities related to a single lease sale would be incremental in nature, not expected to change existing conditions, and positive in their contribution to the sustainability of current industry, related support services, and associated employment.

4.14.3.2.2 Accidental Events

Accidental events related to OCS oil- and gas-related activities that could affect people and communities include oil spills, chemical/drilling-fluid spills, spill response, and vessel collisions. These events are described in **Chapter 3.2**. This section considers small-scale oil spills that have a greater probability of occurring. Potential oil spills, including surface spills and underwater well blowouts, may be associated with exploration, production, or transportation phases of a proposed lease sale. A detailed risk analysis of offshore oil spills and coastal spills associated with a proposed lease sale can be found in **Chapter 3.2.1**. Large spills (≥1,000 bbl) are much less frequent but may be reasonably foreseeable and are therefore considered within this Multisale EIS; in contrast, a catastrophic event of a magnitude similar to the *Deepwater Horizon* explosion, oil spill, and response is not reasonably foreseeable and not part of a proposed action. Because spills <1,000 bbl are not expected to persist as a slick on the surface of the water beyond a few days and because spills on the OCS would occur at least 3-10 nmi (3.5-11.5 mi; 5.6-18.5 km) from shore, it is unlikely that any spills would make landfall prior to breaking up. . The combined probabilities for an offshore spill ≥1,000 bbl occurring and contacting coastal and offshore areas for each alternative can be found in the figures in **Appendix E**. For a proposed action, the probabilities of an oil spill ≥1,000 bbl occurring and contacting the shoreline within 10 days range from <0.5-1 percent to 2-8 percent, with the highest probability in Plaquemines Parish, Louisiana, at 1-6 percent (**Figure E-2**). The probabilities of oil spills ≥1,000 bbl occurring and contacting the shoreline within 30 days range from <0.5-1 percent to 2-8 percent, with the highest probability in Plaquemines Parish, Louisiana, at 2-8 percent (**Figure E-3**). Oil spills that occur in coastal or nearshore waters have a greater chance of directly affecting people and communities. Most small-scale oil spills are short in duration and have impacts ranging from **negligible** to **moderate**. Similarly, the impacts of chemical and drilling-fluid spills depend on the location of the spill, with closer to shore proximity increasing the likelihood of negative impacts, which can range from **negligible** to **moderate**, depending on the specific characteristics of the event. Vessel collisions also may affect local populations as they often result in oil or chemical spills and may interrupt transportation along waterways or roadways if a bridge is involved. Small-scale, noncatastrophic events involve varying degrees of spill response and containment. Spill-response activities are expected to have **negligible** to **moderate** impacts to people and communities, and these impacts also depend on the location and scale of the event being addressed. For example, if an accidental event is very small (not measurable) in size, affects a small geographic area, and is of short duration, its impact would be **negligible**. If an accidental event is measurable, covers a larger geographic area, and lasts a few days to a month, then its impact would be **minor**. If an accidental event affects a more than one county or parish, is measurable with impacts lasting up to 1 year, then the impact would be **moderate**.

For a detailed discussion of a low-probability, catastrophic oil spill, refer to the *Catastrophic Spill Event Analysis* white paper (USDOI, BOEM, 2017). Also, a BOEM-funded study (Austin et al., 2014b and 2014c) researched and documented the complex and varied social impacts of the *Deepwater Horizon* explosion, oil spill, and response. This study found that the impacts of the spill on a particular community depended on a number of factors, such as social and political dynamics, proximity to the spill, economic structure, organizational structure for dealing with disasters, and ability to adapt to the oil cleanup and damage claims processes. With the exception of a catastrophic accidental event, such as the *Deepwater Horizon* explosion, oil spill, and response, the impacts of oil spills, chemical/drilling-fluid spills, vessel collision, and spill-response activities are not likely to be of sufficient duration to have adverse and disproportionate long-term impacts for people and communities in the analysis area.

4.14.3.2.3 Cumulative Impacts

People and communities experience cumulative impacts that include all human activities and natural processes and events. The cumulative analysis considers the incremental contribution of a proposed lease sale when combined with the natural baseline conditions and the cumulative effects of all past, present, and future OCS oil- and gas-related lease sales and activities, as well as all past, present, and reasonably foreseeable future actions that are external to OCS oil- and gas-related activities (described in **Chapter 3.3**).

The cumulative analysis geographically includes all 133 counties that comprise the 23 BOEM-identified EIAs, covering the coastal areas of all five Gulf Coast States from the southern tip of Texas to the Florida Keys. Temporally, the nautral baseline conditions were those in existence before the first Federal OCS lease sale in 1954, several decades ago. At that time, population in the five Gulf Coast States was only 19.8 million, much less than half of the 60.3 million residents in 2015 (USDOC, Census Bureau, 2015a, 2015b, 2015c, 2015d, and 2015e) (**Table 4-32**).

The coastal areas experienced the greater proportion of population growth over the years (USDOC, NOAA, 2011). Though coastal areas were less developed and more rural in 1954, there was much cultural variation across the region, especially in Louisiana (White, 1998). However, the oil and gas industry had been thirving in Texas and Louisiana since 1901 with the Beaumont, Texas, Spindletop discovery and the first Louisiana oil well in Jennings (Austin et al., 2008; Texas Almanac, n.d.; State of Louisiana, Dept. of Natural Resources, n.d.). All manner of oil and gas infrastructure developed over the decades from 1901 to 1954. The onshore oil and gas industry developed and matured from 1901 to 1954, bringing many jobs and economic opportunity to the area. The 1950's marked one of the most prosperous time periods for the United States, with more wealth being created from 1950 to 1965 than in any previous era (Arabe, 2003). When the Federal Government decided to formalize its control over the OCS in 1953, the oil and gas industry was already booming onshore and in coastal waters along the Gulf Coast.

The Submerged Lands Act and the OCSLA, both passed in 1953, laid the foundation for the creation of the Federal OCS Program. The first lease sale of OCS lands in the Gulf of Mexico occurred on October 13, 1954. Since that time, in the Gulf of Mexico region, the Federal OCS Program has held over 120 lease sales, leasing in excess of 143 million ac (58 million ha), with over $66 billion in total bonuses for leased blocks (USDOI, BOEM, 2016g). The past and present OCS Programs (with >120 lease sales) have occurred simultaneously with numerous non-OCS oil- and gas-related past and present activities that, when taken in their entirety, have resulted in the current make-up of the analysis area (refer to **Figure 4-29 and Figures 4-32 through 4-36** and the "Description of the Affected Environment" above). BOEM adds to this all reasonably forseeable future OCS oil- and gas-related and non-OCS oil- and gas-related activities to complete the cumulative analysis within the geographical bounds of the 23 BOEM-identified EIAs spanning across 133 counties and parishes.

Incremental Contribution

This complex analytical framework is divided into discussions of OCS oil-and gas-related and non-OCS oil- and gas-related impacts. The largest quantity of impact-producing factors for people and communities occur as non-OCS oil- and gas-related impacts because OCS oil- and gas-related activities form such a small part of the greater, complex socioeconomic structure in the GOM. The incremental contribution to cumulative impacts of a proposed action (i.e., a single proposed lease sale) would be **minor** for communities and people in the Gulf Coast region.

OCS Oil- and Gas-Related Impacts

A proposed lease sale, when combined with natural baseline conditions and the cumulative effects of all past, present, and future OCS oil- and gas-related lease sales and activities resulting from the OCS Program, contributes to the following impacts:

- employment and wage stability;
- opportunities for advancement;
- economic rewards in exchange for work (benefits);
- work scheduling patterns and how these dictate time spent off the job or with families;
- industry cycles with fluctuations in OCS oil- and gas-related activity levels;
- demographic shifts (in-migration and out- migration);
- commuter and truck traffic; commodity (oil/gas) price fluctuations;

- expansions of existing infrastructure;
- new construction of infrastructure;
- coastal and offshore oil spills;
- chemical/drilling-fluid spills;
- spill-response activities; and
- vessel collisions.

The OCS Program could result in only minor economic changes and generally contributes to maintaining current employment levels. Consisting of 10 proposed regionwide lease sales between 2017 and 2022, the current Gulf of Mexico OCS Program, when combined with all past, present and future programs, would contribute cumulatively to employment and population fluctuations, infrastructure changes, and/or traffic impacts because of local concentrations of fabrication and supply operations. Given its extensive oil-related support system and dependence on revenues generated by the industry, Louisiana is likely to experience more positive or negative employment impacts related to a proposed lease sale and the OCS Program than are the other coastal states. For example, Lafourche Parish, Louisiana, already services about 90 percent of all deepwater oil production and 45 percent of all shallow-water oil and gas production in the Gulf, and it is likely to continue experiencing benefits from the OCS Program (Scott, 2014). The OCS Program in the cumulative analysis would serve to maintain current activity levels, which is expected to be beneficial to the GOM as a whole.

With the exception of a low-probability catastrophic accidental event, such as the *Deepwater Horizon* explosion, oil spill, and response, which is not reasonably foreseeable and is not part of a proposed action, the impacts of oil spills, chemical/drilling-fluid spills, vessel collision, and spill-response activities are not or are not likely to be of sufficient duration to have adverse and disproportionate long-term impacts for people and communities in the analysis area (refer to *Catastrophic Spill Event Analysis* white paper, USDOI, BOEM, 2017). Research into possible long-term health impacts of the *Deepwater Horizon* explosion, oil spill, and response is ongoing (National Institute of Environmental Health Science, 2014; National Center for Disease Preparedness, 2013 and 2014; Substance Abuse and Mental Health Services Administration and Centers for Disease Control and Prevention, 2013).

In the unlikely case of a large-scale catastrophic accidental event, which is statistically unlikely and therefore not part of a proposed action, short-term and long-term health impacts may occur. However, BOEM has prepared a *Catastrophic Spill Event Analysis* white paper to disclose the potential impacts associated with such an event (USDOI, BOEM, 2017). Comments were received on the Draft Multisale EIS regarding the impacts of the *Deepwater Horizon* explosion, oil spill, and response on public health, especially workers and people living in coastal communities. Studies conducted since the 2010 oil spill have been evaluating potential physical and psychological health impacts of response workers and people in coastal communities (Blackmon et al., 2016;

Gould et al., 2016; Gratten et al., 2011; Hansel et al., 2015; Peres et al., 2016). Early worker and shoreline monitoring data indicated that the concentrations of oil and dispersants to which low-income and minority communities may have been exposed were unlikely to result in adverse health effects (King and Gibbons, 2011; Middlebrook et al., 2011; U.S. Dept. of Labor, OSHA, 2010a and 2010b). Later studies looking at lung health reached different conclusions about the effects of dispersants on those exposed to airborne particles (Liu et al., 2015; Major et al., 2016). Another concern was that heavy subsistence users may have faced higher than expected and potentially harmful exposure rates to PAHs from the *Deepwater Horizon* explosion, oil spill, and response. However, fisheries closures may have temporarily limited access to subsistence foods, thereby also reducing the potential of oil dispersant exposure, especially since fisheries were not reopened until testing indicated that the waters were safe for fishing. Extensive seafood testing for PAHs and dispersant compounds found levels that were within the risk assessment protocol established by the U.S. Food and Drug Administration, NOAA, and the Gulf Coast States (Kang et al., 2012; Dickey, 2012). However, there has been some dispute within the scientific community over the validity of the risk assessment protocol that was used and concern that the levels of concern established by the protocol may have underestimated the risk from seafood contaminants among vulnerable populations such as pregnant women and children (Rotkin-Ellman et al., 2012; Rotkin-Ellman and Soloman, 2012). Many of these short-term studies reach conflicting conclusions about the physical health effects, but the psychological studies generally agree that there are negative short-term effects in the mental health of people most affected by the spill. BOEM will continue monitoring post-spill health research studies for cumulative effects.

Non-OCS Oil- and Gas-Related Impacts

Non-OCS oil- and gas-related impacts (described in **Chapter 3.3.2**) cover a wide range of potential impact-producing factors, including all human activities and natural events and processes that are not related to OCS oil- and gas-related activities. Some of the human activities that may include people and communities include, but are not limited to, the following:

> *Non-OCS oil- and gas-related factors are greater in number and actually contribute much more to the cumulative impacts on people and communities than do factors related to OCS oil- and gas-related activities because of the analysis area's complex socioeconomic framework.*

- State-based and onshore oil and gas activities;
- commercial/residential/agricultural development;
- urbanization; pollution;
- zoning ordinances;
- expansions to the Federal, State, and local highway systems;
- expansions to regional port facilities;
- demographic shifts;
- shifts on the national, State, and local levels;

- military activities;
- government functions;
- educational systems;
- family support systems;
- public health;
- contraction or expansion of the tourism industry;
- State renewable energy activities;
- river channelization; and
- dredging of waterways.

State offshore oil and gas programs and onshore oil and gas activities pose the same potential issues as does the OCS Program, although since State leases are closer to land, their petroleum-related activities are generally viewed as having greater potential for directly impacting coastal communities. BOEM assumes that sitings of any future facilities associated with State programs would be based on the same economic, logistical, zoning, and permitting considerations that determined past sitings. Revenues from oil programs in State waters have produced several positive impacts, and the steady stream of oil exploration and development have produced positive cumulative impacts that include increased funding for infrastructure, higher incomes, better health care, and improved educational facilities. This is certainly true for Texas, which has historically used oil and gas revenues on State lands to equalize education district disparities across the State. While offshore leasing in shallow waters has been in a general decline, Louisiana is attempting to incentivize increased activity closer to the shore. In 2006, the Louisiana Legislature authorized the Louisiana Dept. of Environmental Quality to implement an Expedited Processing Program, which has so far resulted in a 55 percent reduction in coastal permitting time (State of Louisiana, Dept. of Natural Resources, 2009).

Ongoing for decades, urbanization continues to impact people and communities, involving demographic shifts as people move into or out of the more densely populated areas. Impacts that result include strains on public infrastructure, habitat fragmentation, and reduced air and water quality, as well as the urban heat island effect. Closely related, but not limited to urban areas, are pollution impacts such as garbage dumping, air, light and noise pollution, and contaminated runoff, which also impact people and the communities in which they live. **Chapter 4.1** discusses air quality and **Chapter 4.2** discusses water quality. Zoning ordinances and land development, whether residential, commercial, or agricultural, can have negative and positive impacts on people, depending on how they stand to benefit or not from various proposed projects. When highway systems (whether local, State, or Federal) and port facilities are expanded, there is a tradeoff between the benefits of expansion and the potential negative impact to the local environment, people, and communities.

Economic conditions contribute to cumulative impacts on people and communities. When there is an economic downturn, some people lose their jobs and unemployment rises; people have less money to spend, causing a negative ripple effect through the local/regional/national economy as a result of direct, indirect, and induced economic impacts on communities. Military activities also contribute to cumulative impacts, whether through base closures that result in job losses or infrastructure expansion at military bases that may produce both positive (jobs) and negative (habitat loss) impacts.

Other human activities that also have cumulative impacts on Gulf Coast populations are related to local, State, and Federal government functions, which are numerous and expansive. Two of the more crucial government responsibilities for basic community functioning involve municipal waterworks and sewage systems. If these are not maintained in good condition with adequate capacity, negative impacts to the residents and community result. Similarly, the status of a community's educational system may be a positive or negative benefit to these populations, depending on the quality of the educational facilities and infrastructure, the teacher-to-student ratios, the standardized test scores, the amount and extent of busing across cities and towns, and the availability of special education services in the public schools (National Education Association, 2015; FSG Social Impact Consultants, 2011). Another very important non-OCS oil- and gas-related impact-producing factor involves public health and family support services systems, namely their availability, proximity, and quality (CommonHealth ACTION, 2015). Social services such as public health clinics, mental health support, charity hospitals, addictive disorder rehabilitation, foster care, head start programs, and family planning services are often hard to find in rural areas, but these services may be more accessible in larger cities, towns, and urban areas.

Another important factor to consider is the contraction and expansion of the tourism industry, which is very important to the economies of the Gulf of Mexico region. When there is a contraction in the tourism sector, the negative impacts are felt by all, whether directly or indirectly. BOEM funded a study (Eastern Research Group, Inc., 2014a) that developed methodologies for estimating the scales of recreation and tourism in a particular area. This entailed defining which industries comprise recreation and tourism, as well as estimating the percent of each industry that supports tourism. For example, the hotel industry is primarily supported by tourists, while the restaurant industry is supported by both tourists and local residents. **Chapter 4.13** provides a complete discussion of tourism as a part of recreational resources. State renewable energy programs are non-OCS oil- and gas-related and may also contribute to cumulative impacts due to their potential placement in areas that conflict with local uses, such as preferred fishing grounds. River channelization and dredging of other waterways also contribute to cumulative impacts for local populations, especially low- income and minority populations who may have traditionally fished and tended oyster beds negatively impacted by the disruption of the natural balance of the delicate ecosystem.

While human activities are extensive and nearly all-encompassing, there are many natural events and processes that may be classified as non-OCS oil- and gas-related impact-producing factors. Some of the natural events and processes that coastal populations may be affected by include, but are not limited to, the following:

- oyster reef degradation;
- saltwater intrusion;
- sedimentation of rivers;
- sediment deprivation;
- barrier island migration and erosion;
- fish kills;
- red tide;
- coastal erosion/subsidence;
- sea-level rise;
- coastal storms; and
- climate change.

When degradation of oyster reefs occurs, it may negatively impact people and communities, especially minority and low-income populations, by decreasing the number of oysters that are able to harvest for both economic and subsistence uses. Saltwater intrusion affects oyster reefs and the overall wetlands ecosystem. In some places too much sediment is deposited in waterways, and in others there is sediment deprivation; both of these negatively impact the delicate ecosystem upon which coastal populations depend. Barrier islands are very important for fishing, but the barrier islands in the region have been migrating and eroding for decades. This natural process is one of the challenges faced in the region and contributes to cumulative impacts. Also, fish kills and red tide interfere with people's use and enjoyment of the natural environment and contribute to negative cumulative impacts on GOM coastal populations.

Coastal erosion and subsidence in some parts of the southeastern coastal plain amplify the vulnerability of communities, infrastructure, and natural resources to storm-surge flooding (Dalton and Jones, 2010). Submergence in the GOM area is occurring most rapidly along the Louisiana coast and more slowly in other coastal states. Depending on local geologic conditions, the subsidence rate varies across coastal Louisiana from 3 to over 10 mm/yr (0.12 to over 0.39 in/yr). Natural drainage patterns along many areas of the Gulf Coast areas have been severely altered by construction of the Gulf Intracoastal Waterway and other channelization projects associated with its development. Saltwater intrusion resulting from land loss, river channelization, and canal dredging is a major cause of coastal habitat deterioration (Tiner, 1984; National Wetlands Inventory Group, 1985; Cox et al., 1997). Coastal erosion, subsidence, sea-level rise, and storm surge damage can increase community vulnerability to future hazards and can also threaten traditional ways of life. Saltwater intrusion reduces the productivity and species diversity associated with wetlands and coastal marshes (Stutzenbaker and Weller, 1989; Cox et al., 1997). While users of coastal waters may appear to trend towards the relatively affluent, low-income and minority groups may be more dependent on the resources of the Gulf Coast. Several ethnic minority and low-income groups rely substantially on these resources (e.g., refer to Hemmerling and Colten [2003] for an evaluation of environmental justice considerations for south Lafourche Parish).

Coastal land loss from erosion, subsidence, sea-level rise, and storm surge also affect the larger society as a whole, with significant land loss occurring in coastal areas, especially Louisiana, which has created a Coastal Master Plan focused on resolving the land loss crisis (State of Louisiana, Coastal Protection and Restoration Authority, 2012). This affects people and communities by impacting residential areas as well as local businesses and public infrastructure. **Figure 4-29** shows the amount of land that coastal Louisiana has lost from 1932 to 2010. Produced for Louisiana's Coastal Master Plan (2012), **Figuref 4-30 and 4-31** illustrate scientists' projections for future land loss in Louisiana. The moderate projection (**Figure 4-30**) assumes more mitigating measures, and the less optimistic projection (**Figure 4-31**) shows the projected impact if extensive mitigating measures are not instituted. As evident from these visual depictions, coastal land loss is one of the greatest threats to the stability and future of coastal populations. The Louisiana's 2012 Coastal Master Plan captures the urgency of the land loss crisis: "Every day Louisiana citizens are affected by this catastrophe in ways small and large. Whether it's a family forced to leave a cherished community to move out of harm's way, a local businesses that has trouble obtaining insurance, or investments that lose value because of uncertainty about the future of our landscape, Louisiana's land loss disaster takes a heavy toll" (State of Louisiana, Coastal Protection and Restoration Authority, 2012). **Chapter 4.3.1** provides a detailed discussion of coastal land loss. A U.S. Geological Survey study published in 2013, *Economic Vulnerability to Sea-Level Rise along the Northern U.S. Gulf Coast*, applied a coastal economic vulnerability index (CEVI) to the northern Gulf coastal region in order to measure economic vulnerability to sea-level rise (Thatcher et al., 2013). The study attempted to determine which coastal communities may face the greatest challenges with regard to the economic and physical impacts of relative sea-level rise and revealed areas along the Gulf Coast that could most benefit from long-term resiliency planning. Within an area, the presence of a concentration of economically valuable infrastructure combined with physical vulnerability to inundation from sea-level rise resulted in the highest vulnerability rankings (CEVI score). The highest average CEVI score in the GOM coastal region appeared in Lafourche Parish, Louisiana, where there is an extensive amount of valuable infrastructure related to the oil and gas industry, along with high relative sea-level rise rates and high coastal erosion rates. Terrebonne Parish, Louisiana, also received a high CEVI value because of its high level of physical vulnerability and high concentration of energy infrastructure. Due to limitations within the CEVI model, such as subjective weighting of variables, researchers caution that results of the study should remain within a vulnerability context and that CEVI results should only be considered relative measures that are best utilized to provide decisionmakers with a better understanding of the vulnerability of the coastal region's critical infrastructure when making decisions about modifying, protecting, or building new infrastructure in these coastal communities (Thatcher et al., 2013). Critical coastal infrastructure also bears the threat of extentive storm surge generated by hurricanes and tropical storms.

Hurricanes, tropical storms, and other wind-driven tidal or storm events are a fact of life for communities living along the Gulf of Mexico coastal zone. The intensity and frequency of hurricanes in the GOM over the last several years has greatly impacted the system of protective barrier islands, beaches, and dunes and associated wetlands along the Gulf Coast. Within the last several years, the Gulf Coast of Texas, Louisiana, Mississippi, Alabama, and to some degree Florida have experienced five major hurricanes (Ivan, Katrina, Rita, Gustav, and Ike), as well as minor hurricanes (Humberto and Isaac). According to a U.S. Geological Survey 5-year, post-Katrina survey, the wetland loss in Louisiana from all four storms (i.e., Hurricanes Katrina, Rita, Gustav, and Ike) totaled 340 mi^2 (881 km^2). The U.S. Geological Survey projects that coastal Louisiana has undergone a net change in land area of about 1,883 mi^2 (4,877 km^2) from 1932 to 2010 (Couvillion et al., 2011). Impacts from future hurricanes and tropical storm events are uncertain. Hazard mitigation funds available through individual states and the Federal Emergency Management Agency also seek to mitigate potential damage to homes in flood zones throughout the GOM. While hurricanes and tropical storms are inevitable, lessons learned from Hurricanes Katrina, Rita, Gustav, and Ike are shaping local and national policies, as well as nongovernmental organizations efforts to protect vulnerable communities. In the decade since Hurricanes Katrina and Rita, the New Orleans Metro Area has been recovering gradually, but unevenly. Population before the 2005 storms was 1.386 million, dropped to 1.040 million in 2006, and increased to 1.252 million in 2014. The number of grocery stores, pharmacies, and drug stores is still lower than 2005 numbers, but the number of gasoline stations, hotels, and restaurants have increased to greater than pre-storm levels (USDOC, Census Bureau, 2015f; USDOC, Economics and Statistics Administration, 2015).

Within the last few decades, climate change has become recognized as a serious issue. A study conducted by Petkova et al. (2015) focused on the impacts of climate change on the U.S. Gulf Coast and public health. The study found that numerous variables have contributed to the likelihood of extreme climate change impacts to the Gulf coastal region, including subsidence, severe erosion, changing water-use patterns, sea-level rise, storm surge, potential for large-scale industrial accidents, increasing population, and large numbers of vulnerable populations in the region. Climate change impacts may exacerbate existing public health issues and also create new health hazards. Identified climate change impacts include heat-related morbidity/mortality, drought-related malnutrition, flood-related injuries and death, increases in vector-borne diseases, and large-scale migrations. The study suggests various public health adaptation measures such as the creation of educational programs and improved risk communication for vulnerable persons such as the elderly, minority, and low-income populations (Petkova et al., 2015).

4.14.3.2.4 Incomplete or Unavailable Information

BOEM has identified unavailable information that is relevant to people and communities regarding the impacts of the *Deepwater Horizon* explosion, oil spill, and response. This information cannot be obtained because long-term health impact studies, subsistence studies, and the NRDA process are ongoing, and data from these efforts would be unavailable and unobtainable for some time. In order to fill this data gap, BOEM has used existing information and reasonably accepted scientific methodologies to extrapolate from available information in completing the relevant analysis, including information that has been released after the *Deepwater Horizon* explosion, oil spill, and response and studies of past oil spills, which indicate that a low-probability, catastrophic oil spill, which is not part of a proposed lease sale and not likely expected to occur, may have adverse impacts on residents in GOM coastal communities. Research into possible long-term health impacts of the *Deepwater Horizon* explosion, oil spill, and response continues (National Institute of Environmental Health Science, 2014; National Center for Disease Preparedness, 2013 and 2014; Substance Abuse and Mental Health Services Administration and Centers for Disease Control and Prevention, 2013). Because long-term health impacts to coastal populations are unknown, this information may be relevant to the evaluation of impacts from the *Deepwater Horizon* explosion, oil spill, and response; therefore, BOEM would continue to seek additional information as it becomes available and bases the previous analysis on the best information currently available. Although long-term health impacts to people and communities may be relevant to this analysis, BOEM has determined that the unavailable information is not essential to a reasoned choice among alternatives based on the information discussed above.

4.14.3.2.5 Alternative A—Regionwide OCS Lease Sale (The Preferred Alternative)

The potential impacts resulting from the industry's routine activities occur within the larger socioeconomic context of the GOM region. Given the existing, extensive, and widespread support system for the OCS oil- and gas-related industry and its associated labor force, the impacts of routine events related to a proposed lease sale are expected to be **negligible**, widely distributed, and to have little impact. Routine activities related to a single lease sale would be incremental in nature, not expected to change existing conditions, and positive in their contribution to the sustainability of current industry, related support services, and associated employment.

With the exception of a catastrophic accidental event, such as the *Deepwater Horizon* explosion, oil spill, and response (which is not reasonably foreseeable and not part of a proposed action), the impacts of oil spills, chemical/drilling-fluid spills, vessel collision, and spill-response activities are not or are not likely to be of sufficient scale or duration to have adverse and disproportionate long-term impacts for people and communities in the analysis area.

Coastal populations experience cumulative impacts that include all human activities and natural processes and events. The cumulative analysis includes impacts that could result from a proposed lease sale combined with baseline conditions, all past, present, and future Federal OCS oil- and gas-related lease sales and activities, as well as all past, present, and reasonably foreseeable future actions that are external to Federal OCS oil- and gas-related activities. Within this divided analytical framework of OCS oil-and gas-related and non-OCS oil- and gas-related impacts, the largest quantity, by far, of impact-producing factors for coastal populations occur as non-OCS oil- and gas-related impacts because OCS oil- and gas-related activities form a very small part of the greater, complex socioeconomic structure in the GOM.

4.14.3.2.6 Alternative B—Regionwide OCS Lease Sale Excluding Available Unleased Blocks in the WPA Portion of the Proposed Lease Sale Area

Impacts for social factors are directly related to the level of OCS oil- and gas-related activity in the Gulf of Mexico. Alternative B would result in less OCS oil- and gas-related activity than Alternative A because the WPA (approximately 23 million ac) would not be available for leasing. Alternative A includes the WPA, CPA, and EPA. Alternative B includes the CPA and EPA. Therefore, Alternative B would produce proportionately smaller OCS oil- and gas-related activity than Alternative A, and the impacts of Alternative B would be proportionately less than Alternative A but greater than Alternative C, as described below.

4.14.3.2.7 Alternative C—Regionwide OCS Proposed Lease Sale Excluding Available Unleased Blocks in the CPA/EPA Portions of the Proposed Lease Sale Area

Impacts for social factors are directly related to the level of OCS oil- and gas-related activity in the Gulf of Mexico. Alternative C would result in less OCS oil- and gas-related activity than Alternative A or B because the CPA and EPA (approximately 49 million ac) would not be available for leasing. Alternative A includes the WPA, CPA, and EPA, and Alternative B includes the CPA and EPA. In contrast, Alternative C includes only the WPA. Therefore, Alternative C would produce proportionately smaller OCS oil- and gas-related activity than Alternatives A and B, and the impacts of Alternative C would be proportionately less than either Alternative A or B.

4.14.3.2.8 Alternative D—Alternative A, B, or C, with the Option to Exclude Available Unleased Blocks Subject to the Topographic Features, Live Bottom (Pinnacle Trend), and/or Blocks South of Baldwin County, Alabama, Stipulations

Impacts for social factors are directly related to the level of OCS oil- and gas-related activity in the Gulf of Mexico. Alternative D would have minimal impact on social factors because there are so few unleased blocks subject to the Topographic Features, Live Bottom (Pinnacle Trend), and/or Blocks South of Baldwin County, Alabama, Stipulations. The difference between Alternatives A, B, and C, with and without the exclusionary stipulations is negligible for social factors. The impacts under Alternative D would not be much different and likely not even measurable when compared with the other alternatives. To the extent that Alternative D would generate less OCS oil- and gas-related activities due to the reduced number of blocks available for lease, the impacts of Alternative D would be less than Alternative A, B or C, but this difference would likely be indiscernible.

4.14.3.2.9 Alternative E—No Action

Alternative E would result in no lease sale and, thus, **no** incremental contribution of impacts to social factors beyond a potential negligible to minor negative economic impact on jobs because a single lease sale only contributes to the maintenance of existing employment. Any potential negative impact would be short lived and may not even be measurable.

4.14.3.3 Environmental Justice Determination

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," directs Federal agencies to make a determination as to whether their actions have disproportionate environmental impacts on minority or low- income people. These environmental impacts encompass human health, and social and economic consequences. In 1997, President Clinton issued Executive Order 13045, "Protection of Children from Environmental Health Risks and Safety Risks," directing Federal agencies to identify and assess environmental health risks and safety risks of its policies, programs, and activities that may disproportionately affect children. In accordance with NEPA and the Executive Orders, BOEM provides opportunities for community input during the NEPA process.

One example of BOEM's efforts to foster an inclusive and transparent public process are the meetings BOEM has held with the Vietnamese fisherfolk community in Mississippi. BOEM has provided Vietnamese translations of relevant portions of this Multisale EIS to maximize participation. Additional avenues of public outreach employed by BOEM include specific types of notices that are (1) mailed to public libraries; interest groups; industry; ports and docks; local, State, and Federal agencies; and federally recognized Indian Tribes; (2) published in local newspapers; (3) posted on the Internet; and (4) published in the *Federal Register*. The formal scoping process is initiated by the publication of a Notice of Intent, and public scoping meetings are held in several geographically separate cities to allow the public to submit comments and to identify all stakeholders' concerns. All public comments and responses to comments are published in the Draft and Final Supplemental EISs. A detailed discussion of the complete scoping process can be found in **Chapter 5.3**. A summary of the scoping comments for this Multisale EIS can be found in **Chapter 5.3.1**.

In accordance with 40 CFR §§ 1508.7 and 1508.8, BOEM has considered potential cumulative, direct, and indirect impacts to minority and low-income populations in the analysis area. Furthermore, in reaching this considered environmental justice determination, BOEM utilized guidance from CEQ (1997), USEPA (1998), and the Federal Interagency Working Group on Environmental Justice & NEPA Committee (2016). The OCS lease sales occur in Federal waters 9 nmi (10.36 mi; 16.67 km) offshore Texas and Florida, and 3 nmi (3.5 mi; 536 km) offshore Louisiana, Mississippi, and Alabama. Thus, the permitted activities of petroleum exploration, extraction, and production that occur on these leaseholds are distant from human habitation, and these activities would not have any direct impacts on low-income and minority populations. State offshore oil and gas leasing occurs in waters closer to land were petroleum-related activities are generally viewed as having a greater potential for directly impacting coastal communities. Indirect impacts to minority and low-income populations would occur onshore and would result from the operations of the extensive infrastructure system that supports all onshore and offshore oil and gas activities. This downstream infrastructure moves hydrocarbon product to market and includes gas processing facilities, petrochemical plants, transportation corridors, petroleum bulk storage facilities, and gas and petroleum pipelines. These components comprise a mature, widespread, and concentrated infrastructure system (refer to **Chapter 4.14.1**). Much infrastructure is located in coastal Louisiana and Texas, and to a lesser extent 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 in industrial corridors farther inland (Dismukes, 2011; Kaplan et al., 2011). The onshore downstream infrastructure exists to support all oil- and gas-related activities regardless of source (onshore, offshore and imported product). The proportion of Federal OCS contribution to downstream infrastructure use has not yet and, most likely, may never be possible to determine as it is dependent on highly unpredictable maket demands and prices. Potential environmental justice impacts that may arise from downstream support activities cannot be influenced by BOEM's decisionmaking because BOEM has no regulatory authority over any onshore activities, including their location. Many other Federal and State agencies regulate onshore oil- and gas-related infrastructure through air and wastewater discharge permitting and stream and wetland permitting. Through these permitting processes, the Federal agencies are required to consider environmental justice impacts for their proposed Federal actions. Therefore, BOEM has determined that a proposed lease sale would not adversely affect minority and low-income populations.

4.15 Unavoidable Adverse Impacts of a Proposed Action

Unavoidable adverse impacts associated with a proposed action are expected to be primarily short term and localized in nature and are summarized below. Adverse impacts from low-probability catastrophic events, which are not part of a proposed action and not likely expected to occur, could be of longer duration and extend beyond the local area. All OCS oil- and gas-related activities involve temporary and exclusive use of relatively small areas of the OCS over the lifetimes of specific projects. Lifetimes for these activities can be days, as in the case of seismic surveys, or decades, as in the case of a production structure or platform. No activities in the OCS Program involve the permanent or temporary use or "taking" of large areas of the OCS. Cumulatively, however, a multitude of individual projects results in a major use of OCS space.

Air Quality: Unavoidable short-term impacts on air quality could occur after large oil spills because of evaporation and volatilization of the lighter components of crude oil, combustion from surface burning, and aerial spraying of dispersant chemicals. Mitigation of long-term impacts from offshore engine combustion during routine operations would be accomplished through existing regulations and the development of new control emission technology. Short-term impacts from spill events could occur and are likely to be aggravated or mitigated by the time of year the spills take place.

Water Quality: Routine offshore operations would cause some unavoidable adverse impacts to varying degrees on the quality of the surrounding water. Drilling, construction, overboard discharges of drilling mud and cuttings, and pipelaying activities would cause an increase in the turbidity of the affected waters for the duration of the activity periods. This, however, would only affect water in the immediate vicinity of the construction activity or in the vicinity of offshore structures, rigs, and platforms. Mitigation of impacts from these activities would be accomplished through existing NPDES regulations. Accidental spills from platforms and the discharge of produced waters could result in increases of hydrocarbon levels and trace metal concentrations in the water column in the vicinity of the platforms. Spilled oil from a tanker collision would affect the water surface in combination with dispersant chemicals used during spill response. A subsurface spill would subject the surface, water column, and near-bottom environment to spilled oil and gas released from solution, dispersant chemicals, or emulsions of dispersed oil droplets and dispersant chemicals.

Unavoidable impacts to onshore water quality would occur as a result of chronic point- and nonpoint-source discharges such as runoff and effluent discharges from existing onshore infrastructure used in support of lease sale activities. Vessel traffic contributes to the degradation of water quality by chronic low-quantity oil leakage, treated sanitary and domestic waste, bilge water, and contaminants known to exist in ship paints. Regulatory requirements of the State and Federal water authorities and some local jurisdictions would be applicable to point-source discharges from support facilities such as refineries and marine terminals.

Coastal Habitats: If an oil spill contacts beaches or barrier islands, the removal of beach sand during cleanup activities could result in adverse impacts if the sand is not replaced, and a beach could experience several years of small surface residue balls (also called tarballs) washing ashore over time, causing an aesthetic impact. Sand borrowing on the OCS for coastal restorations involves the taking of a quantity of sand from the OCS and depositing it onshore, essentially moving small products of the deltaic system to another location. If sand is left where it is, it would eventually be lost to the deltaic system by redeposition or burial by younger sediments; if transported onshore, it would be lost to burial and submergence caused by subsidence and sea-level rise.

If an oil spill contacts coastal wetlands, adverse impacts could be high in localized areas. In more heavily oiled areas, wetland vegetation could experience suppressed productivity for several years; in more lightly oiled areas, wetland vegetation could experience die-back for one season. Epibionts (organisms growing) on wetland vegetation and grasses in the tidal zone could be killed, and the productivity of tidal marshes for the vertebrates and invertebrates that use them to spawn and develop could be impaired. Much of the wetland vegetation would recover over time, but some wetland areas could be converted to open water. Some unavoidable impacts could occur during pipeline and other related coastal construction, but regulations are in place to avoid and minimize these impacts to the maximum extent practicable. Unavoidable impacts resulting from dredging, wake erosion, and other secondary impacts related to channel use and maintenance would occur as a result of a proposed action.

Offshore Biological Habitats: Unavoidable adverse impacts would take place if an oil spill occurred and contacted offshore biological habitats, such as *Sargassum* at the surface; fish, turtles, and marine mammals in the water column; or benthic habitats on the bottom. There could be some adverse impacts on organisms contacted by oil, dispersant chemicals, or emulsions of dispersed oil droplets and dispersant chemicals that, at this time, are not completely understood, particularly in subsurface environments.

Fish and Invertebrate Resources: Unavoidable adverse impacts from routine operations would take place from discharges from vessels and platforms. These would be minor given the available area for fish habitat. If a large oil spill occurs, the oil, dispersant chemicals, or emulsions of oil droplets and dispersant chemicals could temporarily displace mobile fish species on a population or local scale. There could also be impacts on prey and sublethal impacts on fish.

Birds: Unavoidable adverse impacts from routine operations on birds could result from noise, helicopter and OCS service-vessel traffic, coastal facility and platform lighting, and floating trash and debris. Trans-Gulf migrating species could be affected by lighted platforms, helicopter and vessel traffic, and floating trash and debris. If a large oil spill occurs and contacts bird habitats, some birds could experience lethal and sublethal impacts from oiling, and birds feeding or resting in the water could be oiled and die. Birds coming into contact with oil may migrate more deeply into marsh habitats, out of reach from spill responders seeking to count them or collect them for rehabilitation. Oil spills and oil-spill cleanup activities could also affect the food species for bird species. Depending on the time of year, large oil spills could decrease the nesting success of species that concentrate nests in coastal environments due to direct impacts of the spill and also disruption from oil-spill cleanup activities.

Threatened and Endangered Species: Because a proposed lease sale does not in and of itself make any irreversible or irretrievable commitment of resources that would foreclose the development or implementation of any reasonable and prudent measures to comply with the Endangered Species Act, BOEM may proceed with publication of this Multisale EIS and finalize a decision among these alternatives even if consultation is not complete, as described in Section 7(d) of the ESA (also refer to **Chapter 5.7**). Irreversible loss of individuals that are ESA-listed species may occur after a large oil spill from the acute impact of being oiled or the chronic impact of oil having eliminated, reduced, or rendered suboptimal the food species upon which they were dependent.

Marine Mammals: Unavoidable adverse impacts to marine mammals would be those that also affect endangered and threatened marine mammal species. Routine operation impacts (such as seismic surveys, water quality and habitat degradation, helicopter disturbance, vessel collision, and discarded trash and debris) would be negligible or minor to a population, but they could be lethal to individuals as in the case of a vessel collision. A large oil spill would temporarily degrade habitat if spilled oil, dispersant chemicals, or emulsions of dispersed oil droplets and dispersant chemicals contact free-ranging pods or calving grounds.

Commercial Fisheries and Recreational Fishing: Unavoidable adverse impacts from routine operations are loss of open ocean or bottom areas desired for fishing by the presence or construction of OCS oil- and gas-related facilities and pipelines. Loss of gear could occur from bottom obstructions around platforms and subsea production systems. If a large oil spill occurs, it is unlikely that fishermen would want, or be permitted, to harvest fish in the area of an oil spill, as spilled oil could coat or contaminate commercial fish species, rendering them unmarketable.

Recreational Resources: Unavoidable adverse impacts from routine operations may result in the accidental loss overboard of some floatable debris that may eventually come ashore on frequented recreational beaches. A large oil spill could make landfall on recreational resources, leading to local or regional economic losses and stigma effects, causing potential users to avoid the area after acute impacts have been removed. Some recreational resources become temporarily soiled by weathered crude oil, and small surface residue balls (also called tarballs) may come ashore long after stranded oil has been cleaned from shoreline areas. Impacts on recreational resources from a large oil spill may, at the time, seem irreversible, but the impacts are generally temporary. Beaches fouled by a large oil spill would be temporarily unavailable to the people who would otherwise frequent them, but only during the period between landfall and cleanup of the oil, followed by an indefinite lag period during which stigma effects recede from public consciousness.

Archaeological Resources: Unavoidable adverse impacts from routine operations could lead to the loss of unique or significant archaeological. It is BOEM's policy to not approve any EP or DOCD plan with known or potential archaeological resources within 500 ft (152 m) of the planned activity or a pipeline application with known or potential archaeological resources within the pipeline corridor or right-of-way (the 200-ft [61-m] corridor in which the pipeline is to be constructed). For decommissioning activities, all known or potential (i.e., sidescan-sonar targets) archaeological resources must be investigated before site clearance activities take place, and if the presence of archaeological resources is confirmed, exceptions to the site clearance requirements at that location would be granted. Complete archaeological data recovery (excavation) would be required if BOEM decided that a permitted activity must take place that would cause an adverse impact to an archaeological resource.

Economic and Social Factors: Net economic, political, and social benefits to the U.S. accrue from the production of hydrocarbon resources. Once these benefits become routine, unavoidable adverse impacts from routine operations follow trends in supply and demand based on the commodity prices for oil, gas, and refined hydrocarbon products. Declines in oil and gas prices can lead to activity ramp downs by operators until prices rise. A large oil spill would cause temporary increases in economic activity associated with spill-response activity. An increase in economic activity from the response to a large spill could be offset by temporary work stoppages that are associated with spill-cause investigations and would involve a transfer or displacement of demand to different skill sets. Routine operations affected by new regulations that are incremental would not have much effect on the baseline of economic activity; however, temporary work stoppages or the introduction of several new requirements at one time, which are costly to implement, could cause a drop-off of activity as operators adjust to new expectations or use the opportunity to move resources to other basins where they have interests.

4.16 Irreversible and Irretrievable Commitment of Resources

Irreversible or irretrievable commitment of resources refers to impacts or losses to resources that cannot be reversed or recovered. Examples are when a species becomes extinct or when wetlands are permanently converted to open water. In either case, the loss is permanent.

4.16.1 Coastal Habitats

An irreversible or irretrievable loss of wetlands and associated biological resources could occur if wetlands are permanently lost because of impacts caused by dredging and construction activities that displace existing wetlands or from oil spills severe enough to cause permanent die-back of vegetation and conversion to open water. Construction and emplacement of onshore pipelines in coastal wetlands displace coastal wetlands in disturbed areas that are then subject to indirect impacts like saltwater intrusion or erosion of the marsh soils along navigation channels and canals. Regulatory requirements of the State and Federal water authorities and some local jurisdictions would be applicable to these activities to mitigate these impacts. Ongoing natural and anthropogenic processes in the coastal zone, only one of which is an OCS oil- and gas-related activity, can result in direct and indirect loss of wetlands. Natural losses as a consequence of the coastal area becoming hydrologically isolated from the Mississippi River that built it, sea-level rise, and subsidence of the delta platform in the absence of new sediment added to the delta plain appear to be much more dominant processes impacting coastal wetlands.

4.16.2 Biological Resources

An irreversible loss or degradation of ecological habitat caused by cumulative activity tends to be incremental over the short term. Irretrievable loss may not occur unless or until a critical threshold is reached. It can be difficult or impossible to identify when that threshold is, or would be, reached. Oil spills and chronic low-level pollution can injure and kill organisms at virtually all trophic levels. Mortality of individual organisms can be expected to occur, and possibly a reduction or even elimination of a few small or isolated populations. The proposed biological stipulations, however, are expected to eliminate most of these risks.

4.16.2.1 Threatened and Endangered Species

Irreversible loss of individuals that are protected species may occur after a large oil spill from the acute impact of being oiled or the chronic impact of oil having eliminated, reduced, or rendered suboptimal the food species upon which they were dependent.

4.16.2.2 Fish and Invertebrate Resources, Deepwater Benthic Communities, Commercial Fisheries, and Recreational Fishing

Irreversible loss of fish and invertebrate resources, including commercial and recreational species, are caused by structure removals using explosives. Fish in proximity to an underwater explosion can be killed. Without the structure to serve as habitat area, sessile, attached invertebrates and the fish that live among them are absent. Removing structures eliminates these special and local habitats and the organisms living there, including such valuable species as red snapper. Continued structure removal, regardless of the technique used, would reduce the net benefits to commercial fishing due to the presence of these structures. However, the Rigs-to-Reef Program would help offset these impacts.

4.16.3 Archaeological Resources

Any loss of undiscovered archaeological resources on or below the seafloor of the OCS in developed areas would be an irreversible and irretrievable commitment of resources. A resource can be completely destroyed, severely damaged, or the scientific context badly impaired by well drilling, subsea completions, and platform and pipeline installation, or sand borrowing. An archaeological survey, avoidance through development design, documentation, and/or other mitigation would be accomplished prior to development, so as to minimize impacts.

4.16.4 Oil and Gas Development

Leasing and subsequent development and extraction of hydrocarbons as a result of a proposed action represents an irreversible and irretrievable commitment by the removal and consumption of nonrenewable oil and gas resources. The estimated amount of resources to be recovered as a result of a proposed action is presented in **Chapter 3.1**.

4.16.5 Loss of Human and Animal Life

The OCS oil and gas exploration, development, production, and transportation are carried out under comprehensive, state-of-the-art, enforced regulatory procedures designed to ensure public and work place safety and environmental protection. Nevertheless, some loss of human and animal life may be inevitable from unpredictable and unexpected acts of man and nature (i.e., unavoidable accidents, accidents caused by human negligence or misinterpretation, human error, and adverse weather conditions). Some normal and required operations, such as structure removal, can kill sea life in proximity to explosive charges or by removal of the structure that served as the framework for invertebrates living on it and the fish that lived with it.

4.17 Relationship Between the Short-term Use of Man's Environment and the Maintenance and Enhancement of Long-term Productivity

The short-term impacts on various components of the environment in the vicinity of the proposed action are related to long-term impacts and the maintenance and enhancement of long-term productivity.

4.17.1 Short-Term Use

Short-term refers to the total duration of oil and gas exploration and production activities. Extraction and consumption of offshore oil and natural gas is a short-term benefit. Discovering and producing domestic oil and gas now reduces the Nation's dependency on foreign imports. Depleting a nonrenewable resource now removes these domestic resources from being available for future use. The production of offshore oil and natural gas as a result of a proposed action would provide short-term energy, and as it delays the increase in the Nation's dependency on foreign imports, it can also allow additional time for ramp-up and development of long-term renewable energy sources or substitutes for nonrenewable oil and gas. Economic, political, and social benefits would accrue from the availability of these natural resources.

The principle short-term use of the leased areas in the Gulf of Mexico would be for the production of up to 0.211-1.118 BBO and 0.547-4.424 Tcf of gas from a proposed action. The cumulative impacts scenario in this Multisale EIS extends approximately from 2017 to 2066. The 50-year time period is used because it is the approximate longest life span of activities conducted on an individual lease. The 50 years following a proposed lease sale is the period of time during which the activities and impacting factors that follow as a consequence of a proposed lease sale would be influencing the environment.

The specific impacts of a proposed action vary in kind, intensity, and duration according to the activities occurring at any given time (**Chapter 3**). Initial activities, such as seismic surveying and exploration drilling, result in short-term, localized impacts. Development drilling and well workovers occur sporadically throughout the life of a proposed action but also result in short-term, localized impacts. Activities during the production life of a platform may result in chronic impacts over a longer period of time (over 25 years), potentially punctuated by more severe impacts as a result of accidental events or a spill. Platform removal is also a short-term activity with localized impacts, including removal of the habitat for encrusting invertebrates and fish living among them. Many of the impacts on physical, biological, and socioeconomic resources discussed in **Chapter 4** are considered to be short term (being greatest during the construction, exploration, and early production phases). These impacts would be further reduced by the mitigating measures discussed in **Chapter 2.2.4**.

The OCS development off Texas and Louisiana has enhanced recreational and commercial fishing activities, which in turn has stimulated the manufacture and sale of larger private fishing vessels and specialized recreational fishing equipment. Commercial enterprises such as charter boats have become heavily dependent on offshore structures for satisfying recreational customers. A proposed action could increase these incidental benefits of offshore development. Offshore fishing and diving have gradually increased in the past three decades, with offshore structures and platforms becoming the focus of much of that activity. As mineral resources become depleted, platform removals would occur and may result in a decline in these activities, but this could be offset by the Rigs-to-Reef program.

The short-term exploitation of hydrocarbons for the OCS Program in the Gulf of Mexico may lead to long-term impacts on biologically sensitive resources and areas if a large oil spill occurs. A spill and spill-response activity could temporarily interfere with commercial and recreational fishing, beach use, and tourism in the area where the spill makes landfall and in a wider area based on stigma effects. The proposed leasing may also result in onshore development and population increases that could cause very short-term adverse impacts to local community infrastructure, particularly in areas of low population and minimal existing industrial infrastructure (refer to **Chapter 4.14**).

4.17.2 Relationship to Long-Term Productivity

Long-term refers to an indefinite period beyond the termination of oil and gas production. Over a period of time after peak oil production has occurred in the Gulf of Mexico, a gradual easing of the specific impacts caused by oil and gas exploration and production would occur as the productive reservoirs in the Gulf have been discovered and produced, and have become depleted. The BSEE estimates that oil production in the GOM peaked at 1.6 MMbbl/day in 2002, declined for a few years and then peaked again in 2009 and 2010 at 1.6 MMbbl/day before declining again. Production rates in 2015 indicate that it was another high year (1.5 MMbbl/day), and gas production in the GOM peaked at 14.4 Bcf/day in 1997 and has declined since then to 3.6 Bcf/day in 2015 (USDOI, BSEE, 2016). Production has shifted from many smaller reserves on the continental shelf to fewer larger reserves in deep water. Large deepwater oil discoveries have the potential to alter the oil production rate, but the exact effect any one discovery would have or when that discovery would be made is difficult to project due to the difficulties that may be encountered producing these prospects because of their geologic age; burial depth and high-temperature, high-pressure *in-situ* conditions; lateral continuity of reservoirs; and the challenges of producing from ultra-deepwater water depths.

The Gulf of Mexico's large marine ecosystem is considered a Class II, moderately productive ecosystem (mean phytoplankton primary production 150-300 gChlorophyll *a*/m^2-yr [The Encyclopedia of Earth, 2008]) based on Sea-viewing Wide Field-of-view Sensor (SeaWiFS) global primary productivity estimates (USDOC, NASA, 2003). After the completion of oil and gas production, a gradual ramp-down to economic conditions without OCS oil- and gas-related activity would be experienced, while the marine environment is generally expected to remain at or return to its normal long-term productivity levels that, in recent years, has been described as stressed (The Encyclopedia of Earth, 2008). The Gulf of Mexico's large marine ecosystem shows signs of ecosystem stress in bays, estuaries, and coastal regions (Birkett and Rapport, 1999). There is shoreline alteration, pollutant discharge, oil and gas development, and nutrient loading. The overall condition for the U.S. section of this large marine ecosystem, according to the USEPA's seven primary indicators (Jackson et al., 2000), is good dissolved oxygen, fair water quality, poor coastal wetlands, poor eutrophic condition, and poor sediment, benthos, and fish tissue (The Encyclopedia of Earth, 2008).

To help sustain the long-term productivity of the Gulf of Mexico ecosystem, the OCS Program provides structures to be used as site-specific artificial reefs and fish-attracting devices for the benefit of commercial and recreational fishermen and for sport divers and spear fishers. Approximately 10 percent of the oil and gas structures removed from the OCS are eventually used for State artificial reef programs. Additionally, the OCS Program continues to improve the knowledge and mitigation practices used in offshore development to enhance the safe and environmentally responsible development of OCS oil and gas resources.

CHAPTER 5

CONSULTATION AND COORDINATION

What's in This Chapter?

- BOEM is undertaking consultation and other activities to comply with laws and Executive Orders.
- BOEM coordinated the prelease process with key agencies and organizations.
- The prelease and NEPA process has included the following to date: publication of the Notice of Intent to Prepare an EIS (NOI); the Call for Information (Call); and the Area Identification (Area ID) memorandum.
- BOEM conducted internal and public scoping to determine the content of this Multisale EIS.
- The USEPA (Regions 4 and 6) is a cooperating agency on this Multisale EIS.
- BOEM solicited comments on the Draft Multisale EIS from April 22-June 7, 2016.
- Several changes were made between the Draft and Final Multisale EISs; these changes were the result of new information becoming available, editorial suggestions, and comments received on the Draft Multisale EIS.

5 CONSULTATION AND COORDINATION

5.0 INTRODUCTION

BOEM is undertaking consultation and other activities to comply with the following laws, including but not limited to, the following: the development of consistency determinations (CDs) under the Coastal Zone Management Act (CZMA); consultation under the Endangered Species Act (ESA) for potential impacts to listed species or designated critical habitat; completion of an Essential Fish Habitat assessment pursuant to the Magnuson-Stevens Fishery Conservation and Management Act; and a request for comments and consultation with federally recognized Indian Tribes pursuant to the National Historic Preservation Act and Executive Order 13175. Pursuant to NEPA, BOEM has conducted numerous public involvement activities during scoping for and review of the Draft Multisale EIS. This chapter describes the processes with which BOEM worked with other Federal and State agencies, Tribal governments, and the public during the development of the this Multisale EIS.

5.1 COASTAL ZONE MANAGEMENT ACT

The Federal agency performs a consistency review pursuant to the CZMA, and CDs are prepared for each coastal State along the Gulf of Mexico with a federally approved Coastal Management Program (CMP) prior to each of the proposed lease sales. To prepare the CDs, BOEM reviews each State's approved Coastal Management Plan and analyzes the potential impacts as outlined in this Multisale EIS, new information, and applicable studies as they pertain to the enforceable policies of each CMP. The CZMA requires that Federal actions that have reasonably foreseeable coastal effects (i.e., effects to any coastal use or resource of the coastal zone) be "consistent to the maximum extent practicable" with relevant enforceable policies or guidelines of the State's federally approved coastal management program (15 CFR part 930 subpart C).

Based on these and other analyses, BOEM's Gulf of Mexico OCS Region's Regional Director makes an assessment of consistency, which is then sent to the States of Texas, Louisiana, Mississippi, Alabama, and Florida for proposed regionwide lease sales; to Texas and Louisiana for proposed WPA lease sales; or Louisiana, Mississippi, Alabama, and Florida for proposed CPA and/or EPA lease sales. If the State concurs, BOEM can proceed with the proposed lease sale. A State's concurrence may be presumed when a State does not provide a response within the 60-day review period. A State may request an extension of time to review the CD within the 60-day period, which the Federal agency shall approve for an extension of 15 days or less. If a State objects, it must do the following under the CZMA:

(1) indicate how BOEM's prelease proposal is inconsistent with the State's federally approved CMP and suggest alternative measures to bring BOEM's proposal into consistency with the State's CMP; or

(2) describe the need for additional information that would allow a determination of consistency. In the event of an objection, the Federal and State agencies should use the remaining portion of the 90-day review period to attempt to resolve their differences (15 CFR § 930.43(b)).

At the end of the 90-day review period, the Federal agency shall not proceed with the activity over a State agency's objection unless the Federal agency concludes that, under the "consistent to the maximum extent practicable" standard described in 15 CFR § 930.32, consistency with the enforceable policies of the CMP is prohibited by existing law applicable to the Federal agency and the Federal agency has clearly described, in writing, to the CZMA State agency the legal impediments to full consistency; or, the Federal agency has concluded that its proposed action is fully consistent with the enforceable policies of the CMP, though the State agency objects. Unlike the consistency process for specific OCS plans and permits, there is no procedure for administrative appeal to the Secretary of Commerce for a Federal CD for prelease activities. In the event that there is a serious disagreement between BOEM and a State, either agency may request mediation. Mediation is voluntary, and the Secretary of Commerce would serve as the mediator. Whether there is mediation or not, the final CD is made by DOI, and it is the final administrative action for the prelease consistency process. Each Gulf State's CMP is described in **Appendix J**.

5.2 ENDANGERED SPECIES ACT

The Endangered Species Act of 1973 (16 U.S.C. §§ 1531 *et seq.*) establishes a national policy designed to protect and conserve threatened and endangered species and the ecosystems upon which they depend. BOEM and BSEE are currently in consultation with NMFS and FWS regarding the OCS oil and gas program in the Gulf of Mexico. BOEM is acting as the lead agency in the ongoing consultation, with BSEE's assistance and involvement. The programmatic consultation was expanded in scope after reinitiation of consultation by BOEM in 2010 following the *Deepwater Horizon* explosion and oil spill, and it will include both existing and future OCS oil and gas leases in the Gulf of Mexico over a 10-year period. This consultation also considers any changes in baseline environmental conditions following the *Deepwater Horizon* explosion, oil spill, and response. The programmatic consultation includes postlease activities associated with OCS oil- and gas-related activities in the Gulf of Mexico, as well as G&G and decommissioning activities. While the programmatic Biological Opinion is in development, BOEM and NMFS have agreed to interim consultations on postlease approvals. BOEM has received a draft Biological Opinion from FWS and is currently reviewing it. BOEM is awaiting a Biological Opinion from NMFS.

With consultation ongoing, BOEM and BSEE will continue to comply with all reasonable and prudent measures and the terms and conditions under the existing consultations, along with implementing the current BOEM- and BSEE-required mitigation, monitoring, and reporting requirements. Based on the most recent and best available information at the time, BOEM and BSEE will also continue to closely evaluate and assess risks to listed species and designated critical habitat in upcoming environmental compliance documentation under NEPA and other statutes. Refer to **Appendix K** for copies of the consultation letters.

5.3 Magnuson-Stevens Fishery Conservation and Management Act

Pursuant to Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act, Federal agencies are required to consult with NMFS on any action that may result in adverse effects to EFH. The NMFS published the final rule implementing the EFH provisions of the Magnuson-Stevens Fisheries Conservation and Management Act (50 CFR part 600) on January 17, 2002. Certain OCS oil- and gas-related activities authorized by BOEM may result in adverse effects to EFH and therefore require EFH consultation.

BOEM prepared a 2017-2022 *EFH Assessment* on behalf of BOEM and BSEE; it describes the Gulf of Mexico OCS Region's OCS proposed activities, analyzes the effects of the proposed activities on EFH, and identifies proposed mitigating measures (USDOI, BOEM, 2016d). This Assessment was sent to NMFS on June 8, 2016, with a letter requesting formal consultation. This regional programmatic EFH consultation will cover the proposed Gulf of Mexico lease sales analyzed in the Five-Year Program and the related activities (i.e., decommissioning and geological and geophysical). The *EFH Assessment*, the formalized conservation, and the recommendations put forth by NMFS and accepted by BOEM/BSEE or NMFS' concurrence will complete the EFH consultation. However, all agencies will continue to communicate for the duration of the EFH consultation (2017-2022).

5.4 National Historic Preservation Act

In accordance with the National Historic Preservation Act (54 U.S.C. §§ 300101 *et seq.*), Federal agencies are required to consider the effects of their undertakings on historic properties. The implementing regulations for Section 106 of the National Historic Preservation Act, issued by the Advisory Council on Historic Preservation (36 CFR part 800), specify the required review process. In accordance with 36 CFR § 800.8(c), BOEM intends to use the NEPA substitution process and documentation for preparing a prelease EIS and Record of Decision or a postlease environmental assessment and Finding of No Significant Impact to comply with Section 106 of the National Historic Preservation Act in lieu of 36 CFR §§ 800.3-800.6. Because of the extensive geographic area analyzed in this Multisale EIS and because identification of historic properties will take place after leases are issued, BOEM will complete its Section 106 review process once BOEM has performed the necessary site-specific analysis of postlease activities prior to issuing a permit or approving these activities. Additional consultations with the Advisory Council on Historic Places, State Historic Preservation Offices, federally recognized Indian Tribes, and other consulting parties may take place at that time, if appropriate. Refer to **Chapter 4.13** for more information on this review process and **Appendix K** for copies of the State Historic Preservation Offices' concurrence letters.

As an early planning effort, BOEM initiated a request for comment on the NOI for the Multisale EIS via a formal letter to each of the affected Gulf Coast States on April 3, 2015. A 30-day comment period was provided. The State Historic Preservation Officers for Alabama, Florida, and Louisiana responded via formal letters, all concurring that no historic properties will be affected. The Florida State Historic Preservation Officer further requested to be notified and given the opportunity to comment should any cultural resources be identified off the Florida coast. No additional responses were received.

BOEM also solicited Tribal comment on the *2017-2022 Outer Continental Shelf Oil and Gas Leasing: Draft Proposed Program* via a formal letter on March 4, 2015, and on the *Gulf of Mexico OCS Oil and Gas Lease Sales: 2017-2022; Gulf of Mexico Lease Sales 249, 250, 251, 252, 253, 254, 256, 257, 259, and 261—Draft Environmental Impact Statement* via a formal letter on May 19, 2016. Those letters were addressed to each of the Gulf Coast State-affiliated federally recognized Indian Tribes, including the Alabama-Coushatta Tribe of Texas, Caddo Nation of Oklahoma, Chitimacha Tribe of Louisiana, Choctaw Nation of Oklahoma, Coushatta Tribe of Louisiana, Jena Band of Choctaw Indians, Miccosukee Tribe of Indians of Florida, Mississippi Band of Choctaw Indians, Poarch Band of Creek Indians, Seminole Tribe of Florida, Seminole Nation of Oklahoma, and Tunica-Biloxi Indian Tribe of Louisiana. The May 2016 letter was also sent to the Muscogee (Creek) Nation. No comments or requests to consult have yet been received; however, BOEM continues to invite Tribal consultation on all of its activities and will be responsive to any Tribal concerns that may arise.

Historic Preservation Fund

In 1977 the Historic Preservation Fund (54 U.S.C. §§ 303101-303103) was established to assist State and Tribal Historic Preservation Officers in their efforts to protect and preserve historic properties as set forth in the requirements of the National Historic Preservation Act. The Historic Preservation Fund is authorized at $150 million per year and is fully funded from OCS oil and gas revenues payable to the United States under Section 9 of the OCSLA (43 U.S.C. § 1338). However, these funds are available for expenditure only when appropriated by Congress, which has never fully appropriated the available funds. Since its inception, approximately $3.3 billion of the Historic Preservation Fund remains unappropriated (National Conference of State Historic Preservation Officers, 2015).

The Historic Preservation Fund's monies may be used directly by State Historic Preservation Officers/Tribal Historic Preservation Officers or passed on as subgrants and contracts to public and private agencies, nonprofit organizations, educational institutions, and individuals. Eligible preservation projects include historic properties' survey and inventory, National Register of Historic Places' nominations, preservation education, architectural planning, historic structure reports, community preservation planning, and brick and mortar repairs to buildings (USDOI, NPS, 2014b). These historic preservation programs can further catalyze community and neighborhood revitalization, job creation, and economic development, primarily through heritage tourism and the rehabilitation of historic properties through the Historic Tax Credit, which is administered by State Historic Preservation Officers. Since the Historic Preservation Fund was implemented in 1977, the Historic Tax Credit program nationwide has rehabilitated nearly 39,000 buildings, created 2.4 million jobs, created 140,000 low- and moderate-income housing units, and leveraged $109 billion in non-Federal investment (National Conference of State Historic Preservation Officers, 2014; USDOI, NPS, 2014b). In FY 2015, Congress allocated a total of $56.41 million from the Historic Preservation Fund, of which $46.925 million was awarded to State Historic Preservation Officers and $8.985 million was awarded to Tribal Historical Preservation Officers. An additional $500,000 was awarded for projects that will increase diversity in the National Register of Historic Places and the National Historic Landmarks Programs (National Conference of State Historic Preservation Officers, 2015).

5.5 GOVERNMENT-TO-GOVERNMENT TRIBAL CONSULTATION

In accordance with Executive Order 13175, "Consultation and Coordination with Indian Tribal Governments," Federal agencies are required to establish regular and meaningful consultation and collaboration with Tribal officials in the development of Federal policies that have Tribal implications to strengthen the United States' government-to-government relationships with Indian Tribes, and to reduce the imposition of unfunded mandates upon Indian Tribes. On March 4, 2015, BOEM sent a formal letter to federally recognized Indian Tribes notifying them of the development of the *2017-2022 Outer Continental Shelf Oil and Gas Leasing: Draft Proposed Program* and the *Gulf of Mexico OCS Proposed Geological and Geophysical Activities: Western, Central, and Eastern Planning Areas—Final Programmatic Environmental Impact Statement*. That letter was addressed to each of the Gulf Coast State-affiliated Indian Tribes, including the Alabama-Coushatta Tribe of Texas, Caddo Nation of Oklahoma, Chitimacha Tribe of Louisiana, Choctaw Nation of Oklahoma, Coushatta Tribe of Louisiana, Jena Band of Choctaw Indians, Miccosukee Tribe of Indians of Florida, Mississippi Band of Choctaw Indians, Poarch Band of Creek Indians, Seminole Tribe of Florida, Seminole Nation of Oklahoma, and Tunica-Biloxi Indian Tribe of Louisiana. The letter was intended to be the first step of a long-term and broad consultation effort between BOEM and the Gulf-area Tribes, inclusive of all BOEM activities that may occur under the Draft Proposed Program, as well as ongoing activities. On May 19, 2016, another formal letter was sent announcing and soliciting consultation on the release of the 2017-2022 Proposed Program, Draft Five-Year Program EIS, and Draft 2017-2022 GOM Multisale EIS. That letter was sent to each of the above-listed Tribes, as well as to the Muscogee (Creek) Nation. As of this writing, no formal responses have been received in response to either the March 2015 or May 2016 letters; however, informal discussions with designated Tribal representatives are ongoing to determine if any of the individual Tribes desire continued consultations on these issues.

The Poarch Band of Creek Indians has indicated that they do not have any specific concerns with BOEM's activities on the OCS, but they would like to continue to receive notifications on BOEM's activities (McCullers, official communication, 2015). Additionally, the Jena Band of Choctaw has indicated a general concern over adverse effects to documented or undocumented prehistoric and historic sites in the CPA and requests to be notified should such effects occur, as well as to continue being notified on BOEM's activities (Shively, official communication, 2015a).

BOEM has also analyzed environmental justice issues for minority and low-income populations, which is broadly applicable to federally recognized Indian Tribes. Further information on that analysis can be found in **Chapter 4.14.3.3**.

5.6 NATIONAL ENVIRONMENTAL POLICY ACT

5.6.1 Development of the Proposed Actions

This Multisale EIS addresses 10 proposed regionwide Federal OCS oil and gas lease sales, as tentatively scheduled in the Proposed Final Program. BOEM conducted early coordination with appropriate Federal and State agencies and other concerned parties to discuss and coordinate the prelease process for the proposed lease sales and this Multisale EIS. Key agencies and organizations included FWS, NOAA, NOAA's National Marine Fisheries Service, National Park Service, U.S. Coast Guard, U.S. Department of Defense, USEPA, State governors' offices, federally recognized Indian Tribes, industry, and nongovernmental organizations. The timeline for coordination with these agencies and concerned parties throughout the development of this Multisale EIS is illustrated in **Figure 5-1**.

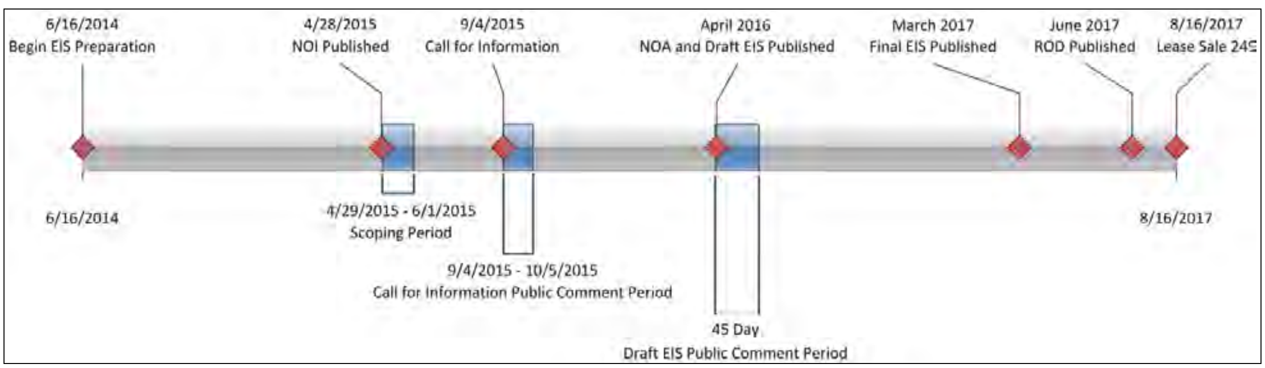

Figure 5-1. Timeline for the Development of the Multisale EIS.

5.6.1.1 Notice of Intent to Prepare an EIS and Call for Information

On April 29, 2015, the Notice of Intent to Prepare an EIS (NOI) for the proposed regionwide lease sales was published in the *Federal Register* (2015h). Additional public notices, including individual consultation invitations to federally recognized Indian Tribes, were distributed via the U.S. Postal Service, local newspapers, and the Internet. A 30-day comment period was provided; it closed on June 1, 2015. Federal, State, and local governments, federally recognized Indian Tribes, nongovernmental organizations, other interested parties, and the public at large were invited to send written comments on the scope of the Multisale EIS to the Gulf of Mexico OCS Region. BOEM received 10 comment letters in response to the NOI. These comments are summarized below in **Chapter 5.6.2.2**.

Pursuant to the Outer Continental Shelf Lands Act of 1953, as amended (OCSLA), BOEM published a Call for Information (Call) to request and gather information to determine the Area Identification (Area ID) for each proposed lease sale. The Call was published in the *Federal Register* (2015a) on September 4, 2015. The Call invited potential bidders to nominate areas of interest within the program area(s) included in the 2017-2022 Draft Proposed Program. The Call was also an opportunity for the public to provide information on environmental, socioeconomic, and other considerations relevant to determining the Area ID.

The comment period for the Call closed on October 5, 2015. BOEM received one comment letter in response to the Call from the Louisiana Department of Natural Resources. This comment is summarized below in **Chapter 5.6.1.2**.

5.6.1.2 Summary of Comments Received in Response to the Call for Information

In response to the Call, BOEM received one letter from the Louisiana Department of Natural Resources.

Louisiana Department of Natural Resources, Office of Coastal Management (letter dated September 29, 2015)

- The Louisiana Office of Coastal Management requests that BOEM consider secondary and cumulative impacts of OCS lease sales on coastal environments.
- BOEM should identify, quantify, and mitigate (e.g., compensatory mitigation) secondary and cumulative harm that occurs to Louisiana's coastal wetlands.
- BOEM should implement plans for validating predictions of social and environmental effects on coastal resources.
- Offshore exploration and development of hydrocarbon resources has been and continues to be of significant value to Louisiana and coastal communities.

5.6.1.3 Area ID Memorandum

Using information provided in response to the Call and from scoping comments, BOEM then developed an Area ID recommendation memorandum. The Area ID is an administrative prelease step that describes the geographical area for environmental analysis and consideration for leasing. All of this information is being used to develop the proposed action and a reasonable range of alternatives for this Multisale EIS.

On November 20, 2015, the Area ID decision was made. One Area ID was prepared for all proposed lease sales. The Area ID memo recommended keeping the entire regionwide area of the

GOM included in the Draft Proposed Program for consideration in this Multisale EIS. The area identified for lease includes all of the unleased blocks in the GOM not subject to Congressional moratorium pursuant to the Gulf of Mexico Energy Security Act of 2006.

5.6.2 Development of the Draft Multisale EIS

5.6.2.1 Scoping

Scoping for the Draft Multisale EIS was conducted in accordance with CEQ regulations for implementing NEPA. Internal scoping provides BOEM an opportunity to update the BOEM Gulf of Mexico OCS Region's environmental and socioeconomic information base. The internal scoping process for the Draft Multisale EIS yielded the following:

- effort to make the document more reader-friendly by reducing the amount of text, optimizing the layout, and increasing the us e of graphics;
- a workshop was held for all subject-matter experts to reevaluate their resources and conclusions from prior lease sale EISs;
- several resources have been reorganized or renamed to increase document readability and reduce redundancies:
  - Coastal Habitats (Estuarine Systems [Wetlands and Seagrasses/Submerged Vegetation] and Coastal Barrier Beaches and Associated Dunes);
  - Deepwater Benthic Communities (Chemosynthetic Communities and Deepwater Coral Communities);
  - Nonchemosynthetic Communities has been renamed to Deepwater Coral Communities;
  - *Sargassum* Communities was renamed *Sargassum* and Associated Communities;
  - Live Bottom Habitats (Topographic Features and Pinnacles and Low-Relief Features);
  - Invertebrate Resources were added to the resource description for Fishes (i.e., Fishes and Invertebrate Resources);
  - Coastal and Marine Birds was renamed to Birds;
  - Protected Species (Marine Mammals, Sea Turtles, Beach Mice, Protected Birds, and Protected Corals);
  - Commercial Fisheries will be re-focused on industry trends as the biological aspects are being addressed in the Fishes and Invertebrate Resources chapter; and
  - Social Factors (Demographics and Environmental Justice);

- after careful consideration, the diamondback terrapin was eliminated from further analysis as a species of special concern as they are neither listed as endangered nor threatened by FWS nor are they likely to be impacted by a proposed action. Any potential impacts to diamondback terrapins would likely be as a result of their habitat location and, therefore, they are generally considered as part of the wetlands community. BOEM reserves the right to add them at a future date as designations and overall environmental indicators may change following consultations with, and concerns of, FWS; but at present, their inclusion is not warranted since the potential for impacts are speculative at best; and
- several white papers, which are incorporated by reference, were created and publicly released to reduce the amount of technical information contained in an EIS, such as the catastrophic spill event analysis, the description of essential fish habitats, and the OCS regulatory framework.

Public scoping provides those with an interest in the OCS Program an opportunity to provide comments on the proposed actions. Public scoping meetings were held in Texas, Louisiana, Mississippi, Alabama, and Florida on the following dates and at the times and locations indicated below:

Tuesday, April 12, 2015
1:00 p.m. CDT
Bureau of Ocean Energy Management
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, Louisiana 70123
2 registered attendees
0 speakers
0 verbal comments received
0 written comments received

Thursday, April 14, 2015
1:00 p.m. CDT
Hilton Garden Inn Houston/Bush Intercontinental Airport
15400 John F. Kennedy Boulevard
Houston, Texas 77032
1 registered attendee
0 speakers
0 verbal comments received
0 written comments received

Tuesday May 19, 2015
6:00 p.m. CDT
Hilton Garden Inn Panama City
1101 US Highway 231
Panama City, Florida 32405
2 registered attendees
0 speakers
0 verbal comments received
0 written comments received

Wednesday May 20, 2015
3:00 p.m. CDT
Hilton Garden Inn Mobile West
828 West I-65 Service Road South
Mobile, Alabama 36609
1 registered attendee
0 speakers
0 verbal comments received
0 written comments received

Thursday May 21, 2015
3:00 p.m. CDT
Courtyard by Marriott
Gulfport Beachfront MS Hotel
1600 East Beach Boulevard
Gulfport, Mississippi 39501
1 registered attendee
0 speakers
0 verbal comments received
0 written comments received

5.6.2.2 Summary of Scoping Comments

In addition to accepting oral and written comments at each public meeting, BOEM accepted written comments by mail, email, and through the regulations.gov web portal (http://www.regulations.gov). BOEM received a total of 10 comments: 5 were mailed formal letters; 3 were emails; and 2 were received through the regulations.gov web portal. Comments came from Federal and State agencies, interest groups, industry, and the general public on the scope of the this Multisale EIS, significant issues that should be addressed, alternatives that should be considered, and mitigating measures. Each comment was read and categorized according to its source and the nature of the information included. All scoping comments received that were relevant for a lease sale NEPA document were considered in the preparation of the Draft Multisale EIS. The scope and content of this Multisale EIS was formulated to ensure that the relevant issues and concerns expressed by stakeholders during the scoping process were fully addressed. Summaries of comments received follow.

United States Environmental Protection Agency, Regions 4 and 6 (letter dated September 8, 2015)

- The USEPA formally requested Cooperating Agency status for this Multisale EIS. As a cooperating agency, the USEPA will
  - provide expertise on NEPA compliance and other applicable subject matters;
  - provide timely technical reviews and comments on preliminary documents, reports, analyses, and sections of the Draft and Final Multisale EISs;
  - participate in meetings as resources allow;
  - provide available information during preparation of the Draft and Final Multisale EISs in areas in which the USEPA has expertise; and
  - review and comment on the Draft and Final Multisale EISs pursuant to USEPA regulatory responsibilities under Section 309 of the Clean Air Act.

Louisiana Department of Natural Resources, Office of Coastal Management (letter dated May 22, 2015)

- The Louisiana Office of Coastal Management requests that BOEM revisit the predictions of social and environmental effects on coastal resources made for earlier lease sales and compare them to existing environmental conditions.
- The State of Louisiana expressed that indirect and cumulative impacts to Louisiana's coastal resources are not adequately addressed in previous EISs.
- The State of Louisiana is also concerned that Louisiana's coastal wetlands are disproportionately bearing the impacts from OCS oil- and gas-related activities and requests compensatory mitigation.
- Louisiana supports the expansion of exploration and development of Gulf of Mexico energy resources.

Louisiana Department of Culture, Recreation, and Tourism; State Historic Preservation Office (letter dated May 12, 2015)

- The Louisiana State Historic Preservation Office determined that the proposed actions will have no adverse effect on historic properties.

Florida Department of State, Division of Historical Resources (letter dated April 15, 2015 and email dated May 12, 2015)

- The State of Florida determined that BOEM's proposed 2017-2022 GOM lease sales will have no effect on historic properties but requested to be notified if any cultural resources are identified (April 15, 2015).
- Florida clarified that they are primarily interested in resources that are identified off Florida that cannot be avoided (May 12, 2015).

Alabama Historical Commission (letter dated April 30, 2015)

- The State of Alabama agreed that the proposed phased approach to meeting Section 106 requirements is reasonable and appropriate for the proposed actions.

Conoco Philips (email dated April 28, 2015)

- Conoco Philips recommends that this Multisale EIS address the effects of the GOM lease sales using alternatives that are formulated to mitigate known risks or adverse impacts.
- BOEM must try to reach an appropriate balance of all oil and gas exploration and production, environmental protection, and potential impacts to coastal zone factors when implementing the Five-Year Program.

- BOEM should apply its best available scientific analysis to operating scenarios that accurately reflects actual OCS oil- and gas-related activities that occur on a day-to-day basis.
- Conoco Philips opposes the use of mitigations based on the use of dated technologies for new studies or the reapplication of findings from previous studies that used out-of-date technology, as well as the use of studies outside normal parameters of oil and gas development.

The American Petroleum Institute (email dated May 29, 2015)

- The American Petroleum Institute recommends that the Multisale EIS be designed specifically with the idea that it will be used as a reference for future NEPA analysis.
- BOEM should consider the extensive safety improvements implemented by industry and new requirements imposed on offshore operations since the *Deepwater Horizon* explosion, oil spill, and response, particularly the formation of many well containment companies and their ability to assist in any potential future incidents.

Save the Manatee Club (regulations.gov submission dated May 29, 2015)

- The Save the Manatee Club requests NEPA analysis of the EPA in a separate process.
- The Multisale EIS analysis should assess the impacts from all aspects of offshore oil and gas development and the cultural value of resources, and it should differentiate the risks of deepwater drilling from those of less technologically difficult operations.
- BOEM should analyze an alternative that includes a buffer around the portions of the EPA that are under Congressional Moratorium.

Center for Biological Diversity (regulations.gov submission dated May 29, 2015)

- The Center for Biological Diversity asked BOEM to delay leasing until after the effects of the *Deepwater Horizon* explosion, oil spill, and response are known and the ecosystem has recovered.
- The Multisale EIS should consider the direct, indirect, and cumulative impacts of oil spills, including catastrophic spills, and consider the science that has been released since the *Deepwater Horizon* explosion, oil spill, and response.
- BOEM must also analyze the direct, indirect, and cumulative effects of oil and gas activities, particularly air, water, noise, and light pollution, and increased vessel traffic in relation to sensitive biological resources.

- The Center for Biological Diversity requested that BOEM consider the impacts of offshore fracking and a reasonable range of alternatives.

Jean Public (email dated April 29, 2015)

- Jean Public opposes the proposed actions due to the lack of safety changes since the *Deepwater Horizon* explosion, oil spill, and response.

5.6.2.3 Additional Public Input Opportunities

Although scoping is a formal, defined process initiated by the publication of the NOI and Call with an identified closing date, public input and other coordination meetings continue to proceed throughout this NEPA process. Public input and coordination opportunities were also available during BOEM's requests for information, comments, input, and review of its other NEPA documents, including the following:

- Request for Information on the *2017-2022 Outer Continental Shelf Oil and Gas Leasing: Draft Proposed Program*;
- Notice of Availability for the *2017-2022 Outer Continental Shelf Oil and Gas Leasing: Draft Proposed Program*; and
- Scoping for the 2017-2022 Five-Year Program EIS.

Comments from these additional public input opportunities are incorporated, where relevant, in the Multisale EIS through the tiering process. One comment from the NPS was identified by BOEM's 2017-2022 Five-Year Program EIS project team as more relevant to a regional NEPA review. Therefore, it was considered during the preparation of this Multisale EIS. The NPS comment requested an exclusion zone south and within 15 mi (24 km) of the Mississippi portion of the Gulf Islands National Seashore.

5.6.2.4 Cooperating Agencies

According to Part 516 of the DOI Departmental Manual, BOEM must invite eligible government entities to participate as cooperating agencies when developing an EIS in accordance with the requirements of NEPA and CEQ regulations. BOEM must also consider any requests by eligible government entities to participate as a cooperating agency with respect to a particular EIS, and must either accept or deny such requests.

The NOI, which was published on April 29, 2015, included an invitation to other Federal agencies and State, Tribal, and local governments to consider becoming cooperating agencies in the preparation of this Multisale EIS. In a letter dated September 8, 2015, USEPA Regions 4 and 6 requested cooperating agency status for this Multisale EIS. On December 16, 2015, a Memorandum of Agreement between BOEM and USEPA Regions 4 and 6 was initiated, which defines the roles and responsibilities for each agency (**Appendix C**).

5.6.2.5 Distribution of the Draft Multisale EIS for Review and Comment

BOEM sent copies of the Draft Multisale EIS to the government, public, and private agencies and groups listed below. Local libraries along the Gulf Coast were provided copies of this document; a list of these libraries is available on BOEM's website at http://www.boem.gov/nepaprocess/.

Federal Agencies

Congress
- Congressional Budget Office
- House Resources Subcommittee on Energy and Mineral Resources
- Senate Committee on Energy and Natural Resources

Department of Commerce
- National Oceanic and Atmospheric Administration
  - National Marine Fisheries Service

Department of Defense
- Department of the Air Force
- Department of the Army
  - Corps of Engineers
- Department of the Navy
  - Naval Mine and Anti-Submarine Warfare Command

Department of Energy
- Strategic Petroleum Reserve PMD

Department of Homeland Security
- U.S. Coast Guard

Department of State
- Bureau of Oceans and International Environmental and Scientific Affairs

Department of the Interior
- Bureau of Ocean Energy Management
- Bureau of Safety and Environmental Enforcement
- Fish and Wildlife Service
- Geological Survey
- National Park Service
- Office of Environmental Policy and Compliance
- Office of the Solicitor

Department of Transportation
- Pipeline and Hazardous Materials Safety Administration
  - Office of Pipeline Safety

Environmental Protection Agency
- Region 4
- Region 6

Marine Mammal Commission

State and Local Agencies

Alabama
- Governor's Office
- Alabama Highway Department
- Alabama Historical Commission and State Historic Preservation Officer
- Alabama Public Library Service
- Alabama Public Service Commission
- City of Mobile
- City of Montgomery
- Department of Conservation and Natural Resources
- Department of Environmental Management
- Geological Survey of Alabama
- South Alabama Regional Planning Commission
- State Legislature Natural Resources Committee
- Town of Dauphin Island

Florida
- Governor's Office
- Bay County
- Citrus County
- City of Destin
- City of Fort Walton Beach
- City of Gulf Breeze
- City of Panama City
- City of Pensacola
- Department of Agriculture and Consumer Services
- Department of Environmental Protection
- Department of State Archives, History and Records Management
- Escambia County
- Florida Emergency Response Commission
- Florida Fish and Wildlife Conservation Commission
- Franklin County
- Gulf County
- Hernando County
- Hillsborough City-County Planning Commission

- Lee County
- Monroe County
- North Central Florida Regional Planning Council
- Okaloosa County
- Pasco County
- Santa Rosa County
- Sarasota County
- Southwest Florida Regional Planning Council
- State Legislature Agriculture and Natural Resources Committee
- Tampa Bay Regional Planning Council
- Walton County
- West Florida Regional Planning Council
- Withlacoochee Regional Planning Council

Louisiana

- Governor's Office
- Calcasieu Parish
- Cameron Parish
- City of Grand Isle
- City of Lake Charles
- City of Morgan City
- City of New Orleans
- Department of Culture, Recreation, and Tourism
- Department of Economic Development
- Department of Environmental Quality
- Department of Natural Resources
- Department of Transportation and Development
- Department of Wildlife and Fisheries
- Houma-Terrebonne Chamber of Commerce
- Jefferson Parish Director
- Jefferson Parish President
- Lafourche Parish Coastal Zone Management
- Lafourche Parish Water District #1
- Louisiana Geological Survey
- South Lafourche Levee District
- St. Bernard Planning Commission
- State House of Representatives, Natural Resources Committee
- State Legislature, Natural Resources Committee
- State of Louisiana Library
- Terrebonne Parish

Mississippi

- Governor's Office
- City of Bay St. Louis
- City of Gulfport
- City of Pascagoula
- Department of Archives and History
- Department of Environmental Quality
- Department of Marine Resources
- Department of Wildlife, Fisheries, and Parks
- Jackson-George Regional Library System
- Mississippi Development Authority
- State Legislature Oil, Gas, and Other Minerals Committee

Texas

- Governor's Office
- Aransas Pass Public Library
- Attorney General of Texas
- Chambers County Library System
- City of Lake Jackson
- General Land Office
- Southeast Texas Regional Planning Commission
- State Legislature Natural Resources Committee
- State Senate Natural Resources Committee
- Texas Historical Commission
- Texas Legislation Council
- Texas Parks and Wildlife Department
- Texas Sea Grant
- Texas State Library and Archives
- Texas Water Development Board

Federally Recognized Indian Tribes

- Alabama-Coushatta Tribe of Texas
- Caddo Nation of Oklahoma
- Chitimacha Tribe of Louisiana
- Choctaw Nation of Oklahoma
- Coushatta Tribe of Louisiana
- Jena Band of Choctaw Indians
- Miccosukee Tribe of Indians of Florida
- Mississippi Band of Choctaw Indians
- Poarch Band of Creek Indians
- Seminole Tribe of Florida
- Seminole Nation of Oklahoma
- Tunica-Biloxi Indian Tribe of Louisiana

Industry

- Adams and Reese, LLP
- Alabama Petroleum Council

American Petroleum Institute
Applied Technology Research Corporation
Area Energy LLC
Associated Gas Distributors of Florida
Baker Atlas
Baker Energy
Bepco, Inc.
C.H. Fenstermaker & Associates, Inc.
Century Exploration N.O., Inc.
Chet Morrison Contractors
Chevron U.S.A. Inc.
C-K Associates, LLC
Coastal Conservation Association
Coastal Environments, Inc.
Columbia Gulf Transmission
Continental Shelf Associates, Inc.
De Leon & Associates
Ecological Associates, Inc.
Ecology and Environment
Ecosystem Management, Inc.
Energy Partners, Ltd.
EOG Resources, Inc.
Exxon Mobil Production Company
Florida Natural Gas Association
Florida Petroleum Council
Florida Power and Light
Florida Propane Gas Association
Freeport-McMoRan, Inc.
General Insulation, Inc.
Global Industries, Ltd.
Gulf of Mexico Newsletter
Halliburton Corporation
Han & Associates, Inc.
Horizon Marine, Inc.
Industrial Vehicles International, Inc.
J. Connor Consultants
John Chance Land Surveys, Inc.
L&M Botruc Rental, Inc.
Lampl Herbert Consultants
Larose Intercoastal Lands, Inc.
Linder Oil Company
Louisiana Oil and Gas Association
Magnum Steel Services Corp.
Marine Safety Office
Mid-Continent Oil and Gas Association
Nature's Way Marine, LLC
Newfield Exploration Company
Offshore Process Services, Inc.
Oil and Gas Property Management, Inc.
Phoenix International Holdings, Inc.
Project Consulting Services
R.B. Falcon Drilling
Raintree Resources, Inc.
Science Applications International Corporation
Seneca Resources Corporation
SEOT, Inc.
Shell Exploration & Production Company
Shell Offshore, Inc.
Stone Energy Corporation
Strategic Management Services-USA
T. Baker Smith, Inc.
Texas Geophysical Company, Inc.
The SJI, LLC
The Times-Picayune
The Washington Post
URS Corporation
W & T Offshore, Inc.
Waring & Associates
WEAR-TV

Special Interest Groups

1000 Friends of Florida
Alabama Oil & Gas Board
Alabama Nature Conservancy
Alabama Wildlife Federation
American Cetacean Society
Apalachee Regional Planning Council
Apalachicola Riverkeeper
Audubon Louisiana Nature Center
Audubon of Florida
Barataria-Terrebonne National Estuary Program
Bay County Chamber of Commerce
Bay Defense Alliance
Capital Region Planning Commission
Center for Marine Conservation
Citizens Association of Bonita Beach
Clean Gulf Associates
Coalition to Restore Coastal Louisiana
Coastal Conservation Association
Concerned Shrimpers of America
Conservancy of Southwest Florida
Earthjustice
Florida Chamber of Commerce
Florida Natural Area Inventory
Florida Wildlife Federation
Gulf and South Atlantic Fisheries Foundation, Inc.
Gulf Coast Environmental Defense
Gulf Coast Fisherman's Coalition
Gulf Restoration Network
Houma-Terrebonne Chamber of Commerce

LA 1 Coalition, Inc.
League of Women Voters of the Pensacola Bay Area
Louisiana Wildlife Federation
Manasota-88
Marine Mammal Commission
Mobile Bay National Estuary Program
Natural Resources Defense Council
Nature Conservancy
Offshore Operators Committee
Organized Fishermen of Florida
Panama City Beach Convention and Visitors Bureau
Pensacola Archaeological Society
Perdido Key Association
Perdido Key Chamber of Commerce
Perdido Watershed Alliance
Restore or Retreat
Roffers Ocean Fishing Forecast Service
Save the Manatee Club
Sierra Club
South Central Industrial Association
Surfrider Foundation
The Nature Conservancy
The Ocean Conservancy

Ports/Docks

Alabama
- Alabama State Port Authority
- Port of Mobile

Florida
- Manatee County Port Authority
- Panama City Port Authority
- Port of Pensacola
- Port St. Joe Port Authority
- Tampa Port Authority

Louisiana
- Abbeville Harbor and Terminal District
- Grand Isle Port Commission
- Greater Baton Rouge Port Commission
- Greater Lafourche Port Commission
- Lake Charles Harbor and Terminal District
- Plaquemines Port, Harbor and Terminal District
- Port of Baton Rouge
- Port of Iberia District
- Port of New Orleans
- Twin Parish Port Commission
- St. Bernard Port, Harbor and Terminal District
- West Cameron Port Commission

Mississippi
- Mississippi State Port Authority

Texas
- Brownsville Navigation District—Port of Brownsville
- Port Freeport
- Port Mansfield/Willacy County Navigation District
- Port of Beaumont
- Port of Corpus Christi Authority
- Port of Galveston
- Port of Houston Authority
- Port of Isabel—San Benito Navigation District
- Port of Port Arthur Navigation District

Educational Institutions/Research Laboratories

Abilene Christian University
Dauphin Island Sea Laboratory
Florida A&M University
Florida Institute of Oceanography
Florida Institute of Technology
Florida Sea Grant College
Florida State University
Foley Elementary School
Gulf Coast Research Laboratory
Gulf Coast State College
Harbor Branch Oceanography
Louisiana Sea Grant College Program
Louisiana State University
Louisiana Tech University
Louisiana Universities Marine Consortium
Loyola University
McNeese State University
Mississippi State University
Mississippi-Alabama Sea Grant Consortium
Mote Marine Laboratory
Nicholls State University
Pensacola Junior College
Tulane University
University of Alabama
University of Florida
University of Louisiana at Lafayette
University of Miami

University of Mississippi
University of New Orleans
University of South Alabama
University of South Florida
University of Southern Mississippi
University of Texas at Arlington
University of Texas at Austin
University of Texas Law School
University of Texas Libraries
University of West Florida

5.6.3 Development of the Final Multisale EIS

5.6.3.1 Major Differences Between the Draft and Final Multisale EISs

Several changes were made between the Draft and Final Multisale EISs. These changes were the result of new information becoming available, editorial suggestions, and comments received on the Draft Multisale EIS. Most notably, the air quality analysis in **Chapter 4.1** has been updated with the recently available results of a modeling effort undertaken by BOEM. **Chapter 5** has been reorganized to more clearly convey the consultations and coordination that took place during the preparation of this Multisale EIS. Comments on the Draft Multisale EIS were received via verbal, written, and electronic correspondence. As a result of these comments, changes have been made between the Draft and Final Multisale EISs. Where appropriate, the text in this Final Multisale EIS has been verified or expanded to provide clarification on specific issues, as well as to provide updated information. Some of the revisions made between the Draft and Final Multisale EISs changed the impact conclusion for the physical, environmental, and/or socioeconomic resources analyzed in this Multisale EIS, i.e., water quality (**Chapter 4.2**), coastal habitats (**Chapter 4.3**), marine mammals (**Chapter 4.9.1**), sea turtles (**Chapter 4.9.2**), and land use and coastal infrastructure (**Chapter 4.14.1**). For more information, refer to those respective chapters.

5.6.3.2 Public Meetings

In accordance with 30 CFR § 556.26, BOEM scheduled public meetings soliciting comments on the Draft Multisale EIS. The meetings were conducted to solicit information from interested parties in order to provide the Secretary of the Interior with information to help in the evaluation of the potential effects of the proposed lease sales. An announcement of the dates, times, and locations of the public meetings was included in the Notice of Availability of the Draft Multisale EIS. A copy of the public meetings' notice was included with the Draft Multisale EIS that was mailed to the parties indicated above, was published in local newspapers, and was posted on BOEM's website at http://www.boem.gov/nepaprocess/.

Public meetings were held in Texas, Louisiana, Florida, Alabama, and Mississippi on the dates and at the times and locations indicated below:

Monday, May 9, 2016
4:30 p.m. – 7:30 p.m. CDT
Holiday Inn Hotel and Suites Beaumont-Plaza
3950 I-10 South at Walden Road
Beaumont, Texas 77705
12 registered attendees
3 speakers
1 written comment received

Thursday, May 12, 2016
1:00 p.m. – 4:00 p.m. CDT
Sheraton Metairie-New Orleans Hotel
4 Galleria Boulevard
Metairie, Louisiana 70001
19 registered attendees
4 speakers
7 written comments received

Tuesday, May 17, 2016
4:30 p.m. – 7:30 p.m. CDT
Bay Point Golf Resort and Spa
4114 Jan Cooley Drive
Panama City Beach, Florida 32408
19 registered attendees
5 speakers
1 written comment received

Wednesday, May 18, 2016
4:30 p.m. – 7:30 p.m. CDT
Renaissance Mobile Riverview Plaza Hotel
64 South Water Street
Mobile, Alabama 36602
13 registered attendees
3 speakers
1 written comment received

Thursday, May 19, 2016
4:30 p.m. – 7:30 p.m. CDT
Courtyard by Marriott,
Gulfport Beachfront MS Hotel
1600 East Beach Boulevard
Gulfport, Mississippi 39501
21 registered attendees
8 speakers
3 written comments received

5.6.3.3 Comments Received on the Draft Multisale EIS and BOEM's Responses

The Notice of Availability and the announcement of public meetings were published in the *Federal Register* on April 22, 2016; were posted on BOEM's website; and were mailed to interested parties. The comment period ended on June 7, 2016. BOEM received over 250 distinct comments in response to the Draft Multisale EIS via letter, email, written and verbal comments at public meetings, and the regulations.gov website. BOEM also received 1,678 copies of a form letter, and a petition signed by 132,689 individuals requesting no new leases. All comments (i.e., letters, court reporter transcripts, emails, etc.) were analyzed to identify all substantive issues raised by the public. Each issue within an individual's comment was assigned a unique identifier and then grouped into 10 major categories. Within these 10 categories, responses are provided for each issue. When similar issues were raised by several commenters, a single response has been provided for multiple comments. The comments and responses are presented in a matrix in **Appendix L** and are organized by the following 10 topics:

Topic 1 – "NEPA Process and Public Involvement" contains those issues related to the process of preparing this Multisale EIS and the public's engagement.

Topic 2 – “NEPA Analysis” includes comments about how BOEM carried out its analysis under NEPA.

Topic 3 – “Alternatives” includes all of the comments related to the alternatives considered in the preparation of this Multisale EIS. A majority of these comments included a statement of the commenter’s preference for a particular alternative, with some including a reason why. A “Stated Preference” subtopic was included to group those comments.

Topic 4 – “Environmental Issues and Concerns” contains 16 subcategories that include the following:

- Climate Change
- Greenhouse Gases
- Well Stimulation
- Renewable Energy
- Alternative Use of the OCS
- Natural Stressors
- Air Quality
- Coastal Habitats
- Biologically Sensitive Areas
- Fish and Invertebrates
- Birds and Protected Birds
- Marine Mammals
- Sea Turtles
- Infrastructure
- Socioeconomics
- Environmental Justice

Topic 5 – “Cumulative Analysis” includes the comments BOEM received regarding the analysis of past, present, and reasonably foreseeable activities in this Multisale EIS.

Topic 6 – “Oil Spills” includes comments related to concerns over oil spills and their impact on the environment.

Topic 7 – “Mitigation” includes all of the comments that relate to how BOEM plans to minimize environmental impacts.

Topic 8 – “Regulations and Safety” includes comments on how BOEM and BSEE regulate offshore energy production and safety.

Topic 9 – “Statutory Compliance” includes all of the comments BOEM received about how it satisfied its statutory obligations under the OCSLA, NEPA, ESA, and several other acts.

Topic 10 – “Other” includes a wide range of comments that did not fall into one of the above categories (e.g., halting all future activities, questions about leasing procedures, and concern for industry practices).

CHAPTER 6

REFERENCES CITED

6 REFERENCES CITED

Adams, J.A. 1960. A contribution to the biology and postlarval development of the *Sargassum* fish, *Histrio histrio* (Linnaeus), with a discussion of the *Sargassum* complex. Bulletin of Marine Sciences of the Gulf and Caribbean 10:55-82.

Adcroft, A., R. Hallberg, J.P. Dunne, B.L. Samuels, J.A. Galt, C.H. Barker, and D. Payton. 2010. Simulations of underwater plumes of dissolved oil in the Gulf of Mexico. Geophysical Research Letters 37, L18605. doi:10.1029/2010GL044689.

Addis, D.T., W.F. Patterson III, M.A. Dance, and G.W. Ingram Jr. 2013. Implications of reef fish movement from unreported artificial reef sites in the northern Gulf of Mexico. Fisheries Research 147:349-358.

Agardy, M.T. 1990. Preliminary assessment of the impacts of Hurricane Hugo on sea turtle populations of the eastern Caribbean. In: Richardson, T.H., J.I. Richardson, and M. Donnelly, comps. Proceedings of the 10th Annual Workshop on Sea Turtle Biology and Conservation, February 20-24, Hilton Island, SC. NOAA Technical Memorandum NMFS-SEFSC-278.

Aguilar-Perera, A. and A. Tuz-Sulub. 2010. Non-native, invasive red lionfish (*Pterois volitans* [Linnaeus 1758]: Scorpaenidae), is the first recorded in the southern Gulf of Mexico, off the Northern Yucatan Peninsula, Mexico. Aquatic Invasions, Volume 5, Supplement 1:S9-S12.

Air Force Air Armament Center. 2002. Eglin Gulf test and training range, final programmatic environmental assessment. RCS 97-048. Prepared by Science Applications International Corporation and submitted to Air Force Air Armament Center. Air Force Air Armament Center, Range Environmental Planning Office, Eglin Air Force Base, FL. 277 pp.

Ajemian, M., J. Wetz, B. Shipley-Lozano, J.D. Shively, and G. Stunz. 2015. An analysis of artificial reef community structure along the northwestern Gulf of Mexico shelf: Potential impacts of "Rigs-to-Reefs" programs. PLOS ONE 10(5):e0126354. doi:10.1371/journal.pone.0126354.

Al-Dahash, L.M. and H.M. Mahmoud. 2013. Harboring oil degrading bacteria: A potential mechanism of adaptation and survival in corals inhabiting oil-contaminated reefs. Marine Pollution Bulletin 72:364-374.

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, 1988. Baltimore, MD. Washington, DC: American Petroleum Institute. Pp. 445-450.

Ali, S., D. Norman, D. Wagner, J Ayoub, J Desroches, H. Morales, P. Price, D. Shepherd, E. Toffanin, J. Troncoso, and S. White. 2002. Combined stimulation and sand control. Oilfield Review 14(2):30-47. Summer 2002. Internet website: http://www.slb.com/~/media/Files/resources/oilfield_review/ors02/sum02/p30_47.pdf. Accessed February 19, 2016.

Allen, A. 2010. Observations & lessons learned: Offshore operations, *Deepwater Horizon* oil spill. Spiltec. 9 slides. Internet website: http://www.bsee.gov/BSEE-Newsroom/Publications-

Library/Drilling-Forums---Aug-2010/Anchorage,-Alaska--August-26,-2010/Panel_II_Presentation_3_anchorage/. Posted Summer 2010. Accessed December 23, 2010.

Almeda, A., S. Baca, C. Hyatt, and E.J. Buskey. 2014. Ingestion and sublethal effects of physically and chemically dispersed crude oil on marine planktonic copepods. Ecotoxicology 23:988-1003.

Alves-Stanley, C.D., G.A.J. Worthy, and R.K. Bomde. 2010. Feeding preferences of West Indian manatees in Florida, Belize, and Puerto Rico as indicated by stable isotope analysis. Marine Ecology Progress Series 402:255-267.

American Bureau of Shipping (ABS) Consulting, Inc. 2016. 2016 Update of occurrence rates for offshore oil spills. Report to the Oil Spill Preparedness Division of the U.S. Dept. of the Interior, Bureau of Safety and Environmental Enforcement. 95 pp.

American Petroleum Institute (API). 2011. High production volume (HPV) chemical challenge program: Crude oil category assessment document. API Petroleum HPV Testing Group, January 14, 2011. 108 pp.

American Petroleum Institute (API). 2015. Offshore sand control and well stimulation technology. Briefing paper. Washington, DC: American Petroleum Institute. 2 pp. Internet website: http://www.energynation.org/wp-content/uploads/2015/03/Offshore-Sand-Control-Well-Stimulation-Technology.pdf.

Anchor Environmental CA, L.P. 2003. Literature review of effects of resuspended sediments due to dredging operations. Prepared for the Los Angeles Contaminated Sediments Task Force, Los Angeles, CA. 140 pp.

Anderson, C.M. and R.P. LaBelle. 1990. Estimated occurrence rates for analysis of accidental oil spills on the U.S. outer continental shelf. Oil & Chemical Pollution 6:21-35.

Anderson, C.M. and R.P. LaBelle. 1994. Comparative occurrence rates for offshore oil spills. Spill Science & Technology Bulletin 1(2):131-141.

Anderson, C.M. and R.P. LaBelle. 2000. Update of comparative occurrence rates for offshore oil spills. Spill Science & Technology Bulletin 6(5/6):302-321.

Anderson, C., M. Mayes, and R. Labelle. 2012. Update of occurrence rates for offshore oil spills. U.S. Dept. of the Interior, Bureau of Ocean Energy Management and Bureau of Safety and Environmental Enforcement, Herndon, VA. OCS Report BOEM 2012-069 or BSEE 2012-069. 87 pp.

Andrew, R.K., B.M. Howe, and J.A. Mercer. 2002. Ocean ambient sound: Comparing the 1960s with the 1990s for a receiver off the California coast. Acoustics Research Letters Online, February 2002. Pp. 65-70.

Antweiler, R.C., D.A. Goolsby, and H.E. Taylor. 1995. Nutrients in the Mississippi River. U.S. Dept. of the Interior, Geological Survey, Reston, VA. USGS Circular 1133.

Arabe, K. 2003. How oil refining transformed U.S. history & way of life. ThomasNet Industry News. Internet website: http://news.thomasnet.com/imt/2003/01/17/how_oil_refinin. Accessed August 24, 2016.

Aratame, N. and J. Singelmann. 2002. Effect of the oil and gas industry on commuting and migration patterns in Louisiana: 1960-1990. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2002-072. 43 pp.

Argonne National Laboratory, J.A. Veil, T.A. Kimmeol, and A.C. Rechner, 2005. Characteristics of produced water discharged to the Gulf of Mexico hypoxic zone. Prepared for the U.S. Dept. of Energy, National Energy Technology Laboratory. 69 pp.

Aridjis, H. 1990. Mexico proclaims total ban on harvest of turtles and eggs. Marine Turtle Newsletter 50:1.

Aronson, R.B., W.F. Precht, T.J.T. Murdoch, and M.L. Robbart. 2005. Long-term persistence of coral assemblages on the Flower Garden Banks, northwestern Gulf of Mexico: Implications for science and management. Gulf of Mexico Science 2005(1):84-94.

Atauz, A.D., W. Bryant, T. Jones, and B. Phaneuf. 2006. Mica shipwreck project: Deepwater archaeological investigation of a 19th century shipwreck in the Gulf of Mexico. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2006-072. 116 pp.

Atkins, M., S. Mirza, J. Skinner, A. Mathew, and T. Edward. 2006. Pipeline damage assessment from Hurricane Ivan in the Gulf of Mexico. U.S. Dept. of the Interior, Minerals Management Service, Herndon, VA. TA&R 553.

Atkins, M., T. Edward, D. Johnson, and M. Dance. 2007. Pipeline damage assessment from Hurricanes Katrina and Rita in the Gulf of Mexico. U.S. Dept. of the Interior, Minerals Management Service, Herndon, VA. TA&R 581.

Atlas, R.M. and T.C. Hazen. 2011. Oil bioremediation: A tale of the two worst spills in U.S. history. Environmental Science and Technology 45:6709-6715.

Auburn University. Samuel Ginn College of Engineering. 2012. Research brief-II: Impact of Hurricane Isaac on mobilizing Deepwater Horizon oil spill residues along Alabama's coastline – a physicochemical characterization study. September 20, 2012. 11 pp. Internet website: http://www.eng.auburn.edu/files/acad_depts/civil/oil-research-hurricane-isaac.pdf. Accessed March 26, 2015.

Austin, D. and T. McGuire. 2002. Social and economic impacts of Outer Continental Shelf activities on individuals and families. Volume 2: Case studies of Morgan City and New Iberia, Louisiana. Prepared by the University of Arizona, Bureau of Applied Research in Anthropology, Tucson. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2002-023. 197 pp.

Austin, D., A. Gardner, R. Higgins, J. Schrag-James, S. Sparks, and L. Stauber. 2002. Social and economic impacts of outer continental shelf activities on individuals and families. Volume II: Case studies of Morgan City and New Iberia, Louisiana. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2002-023. 197 pp.

Austin, D.E., T. Priest, L. Penney, J. Pratt, A.G. Pulsipher, J. Abel, and J. Taylor. 2008. History of the offshore oil and gas industry in southern Louisiana. Volume I: Papers on the evolving offshore industry. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2008-042. 264 pp.

Austin, D., T. McGuire, and D. Woodson. 2014a. Gulf Coast communities and the fabrication and shipbuilding industry: a comparative community study. Volume 3: Technical papers. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Gulf of Mexico OCS Region, New Orleans, LA. OCS BOEM 2014-611. 241 pp.

Austin, D., B. Marks, K. McClain, T. McGuire, B. McMahan, V. Phaneuf, P. Prakash, B. Rogers, C. Ware, and J. Whalen. 2014b. Offshore oil and *Deepwater Horizon*: Social effects on Gulf Coast communities. Volume I: Methodology, timeline, context, and communities. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study BOEM 2014-617.

Austin, D., S. Dosemagen, B. Marks, T. McGuire, P. Prakash, and B. Rogers. 2014c. Offshore oil and *Deepwater Horizon*: Social effects on Gulf Coast communities. Volume 2: Key economic sectors, NGOs, and ethnic groups. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study BOEM 2014-618.

Baca, B.J., T.E. Lankford, and E.R. Gundlach. 1987. Recovery of Brittany coastal marshes in the eight years following the *Amoco Cadiz* incident. In: Proceedings of the 1987 International Oil Spill Conference. Washington, DC: American Petroleum Institute. Pp. 459-464.

Baguley, J.G., P.A. Montagna, C. Cooksey, J.L. Hyland, H.W. Bang, C. Morrison, A. Kamikawa, P. Bennetts, G. Saiyo, E. Parsons, M. Herdener, and M. Ricci. 2015. Community response of deep-sea soft-sediment metazoan meiofauna to the *Deepwater Horizon* blowout and oil spill. Marine Ecology Progress Series 528:127-140.

Bahreini, R., A.M. Middlebrook, C.A. Brock, J.A. de Gouw, S.A. McKeen, L.R. Williams, K.E. Daumit, A.T. Lambe, P. Massoli, M.R. Canagaratna, R. Ahmadov, A.J. Carrasquillo, E.S. Cross, B.Ervens, J.S. Holloway, J.F. Hunter, T.B. Onasch, I.B. Pollack, J.M. Roberts, T.B. Ryerson, C. Warneke, P. Davidovits, D.R. Worsnop, and J.H. Kroll. 2012. Mass spectral analysis of organic aerosol formed downwind of the *Deepwater Horizon* oil spill: Field studies and laboratory confirmations. Environmental Science & Technology 46:8025-8034. doi:10.1021/es301691k.

Bailey H. and P. Thompson. 2010. Effect of oceanographic features on fine-scale foraging movements of bottlenose dolphins. Marine Ecology Progress Series 418:223-233.

Baker, J.M., M.L. Guzman, P.D. Bartlett, D.I. Little, and C.M. Wilson. 1993. Long-term fate and effects of untreated thick oil deposits on salt marshes. In: Proceedings of the 1993 International Oil Spill Conference. Washington, DC: American Petroleum Institute. Pp. 395-399.

Baker, K., D. Epperson, G. Gitschlag, H. Goldstein, J. Lewandowski, K. Skrupky, B. Smith, and T. Turk. 2013. National standards for a protected species observer and data management program: A model using geological and geophysical surveys. NOAA Technical Memorandum NMFS-OPR-49. 73 pp.

Bakhtyar, S. and M.M. Gagnon. 2012. Improvements to the environmental performance of synthetic-based drilling muds. In: Anastas, P.T., R. Boethling, and A. Voutchkova, eds. Handbook of green chemistry: Green processes. Volume 9: Designing safer chemicals. Weinheim, Germany: Wiley-VCH Verlag & Co. Pp. 309-328.

Balazs, G.H. 1985. Impact of ocean debris on marine turtles: Entanglement and ingestion. In: Shomura, R.S. and H.O. Yoshida, eds. Proceedings of the Workshop on the Fate and Impact of Marine Debris, 26-29 November 1984, Honolulu, HI. NOAA Technical Memorandum NMFS-NOAA-TM-NMFS-SWFC-54. Pp. 387-429.

Barbier, C.J. and S. Shushan. 2015. In the United States District Court for the Eastern District of Louisiana; In re: Oil spill by the oil rig “Deepwater Horizon” in the Gulf of Mexico, on April 20, 2010, this document applies to: No. 10-2771, In re: The Complaint and Petition of Triton Asset Leasing GmbH, et al. and No. 10-4536, United States of America v. BP Exploration & Production, Inc., et al. MDL 2179, Section J, Judge Barbier, Mag. Judge Shushan. Case 2:10-md-02179-CJB-SS; Document 14021; filed January 15, 2015. 44 pp.

Barras, J.A. 2006. Land area change in coastal Louisiana after the 2005 hurricanes: A series of three maps. U.S. Dept. of the Interior, Geological Survey. Open-File Report 2006-1274. Internet website: http://pubs.usgs.gov/of/2006/1274/. Posted October 6, 2006.

Barras, J.A. 2007. Land area changes in coastal Louisiana after Hurricanes Katrina and Rita (Chapter 5). In: Farris, G.S., G.J. Smith, M.P. Crane, C.R. Demas, L.L. Robbins, and D.L. Lavoie, eds. Science and the storms: The USGS response to the hurricanes of 2005. U.S. Dept. of the Interior, Geological Survey. Geological Survey Circular 1306. Pp. 97-112. Internet website: http://pubs.usgs.gov/circ/1306/pdf/c1306_ch5_b.pdf.

Barras, J.A., S. Beville, D. Britsch, S. Hartley, S. Hawes, J. Johnston, P. Kemp, Q. Kinler, A. Martucci, J. Porthouse, D. Reed, K. Roy, S. Sapkota, and J. Suhayda. 2003. Historical and projected coastal Louisiana land changes: 1978-2050. U.S. Dept. of the Interior, Geological Survey. Open-File Report 03-334.

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. NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-154. 746 pp.

Bartol, S.M., J.A. Musick, and M. Lenhardt. 1999. Auditory evoked potentials of the loggerhead sea turtle (*Caretta caretta*). Copeia 3:836-840.

Batubara, D.S., D.D. Adrian, M.S. Miles, and R.F. Malone. 2014. A laboratory mesocosm as a tool to study PAH degradation in a coastal marsh wetland. In: Proceedings, International Oil Spill Conference, May 5-8, 2014, Savannah, GA. Washington, DC: American Petroleum Institute. Pp. 400-407.

Baumann, R.H. and R.E. Turner. 1990. Direct impacts of outer continental shelf activities on wetland loss in the central Gulf of Mexico. Environmental Geology and Water Sciences 15(3):189-198.

Baumgartner, M.F. 1995. The distribution of select species of cetaceans in the northern Gulf of Mexico in relation to observed environmental variables. M.S. thesis, University of Southern Mississippi.

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, Offshore Technical Conference, Houston, TX, May 1983. OTC 4586. Pp. 49 62.

Bearden, D.M. 2007. U.S. disposal of chemical weapons in the ocean: Background and issues for Congress; updated January 3, 2007. Congressional Research Service Report for Congress. Order Code RL33432. 22 pp. Internet website: https://www.fas.org/sgp/crs/natsec/RL33432.pdf.

Beaubouef, B. 2015. Lower oil prices begin to take toll on Gulf drilling. Offshore Magazine 75(6). Internet website: http://www.offshore-mag.com/articles/print/volume-75/issue-6/gulf-of-mexico/lower-oil-prices-begin-to-take-toll-on-gulf-drilling.html. Accessed August 31, 2015.

Beerens, J.M., S.S. Romañach, and M. McKelvy. 2016. Evaluating water management scenarios to support habitat management for the Cape Sable seaside sparrow (No. 2016-1107). U.S. Dept. of the Interior, Geological Survey.

Behrens, E.W. 1988. Geology of a continental slope oil seep, northern Gulf of Mexico. American Association of Petroleum Geologists Bulletin 72(2):105-114.

Bell, I. and D.A. Pike. 2012. Somatic growth rates of hawksbill turtles *Eretmochelys imbricata* in a northern Great Barrier Reef foraging area. Marine Ecology Progress Series 446. Pp. 275-283.

Benfield, M.C. and T.J. Minello. 1996. Relative effects of turbidity and light intensity on reactive distance and feeding of an estuarine fish. Environmental Biology of Fishes 46:211-216.

Bergmann, M., L. Gutow, and M. Klages. 2015. Marine anthropogenic litter. Springer Open Access. University of Gothenburg. doi:10.1007/978-3-319-16510-3.

Berman, A.E. 2005. The debate over subsidence in coastal Louisiana and Texas. Houston Geological Society. Internet website: http://www.hgs.org/node/4080. Posted November 24, 2005. Accessed March 13, 2016.

Bernhardt, S., S. Brody, H. Grover, C. Spence, Z. Tang, and B. Whitaker. 2006. Identifying potential conflict associated with oil and gas exploration in Texas state coastal waters: A multi-criteria spatial analysis. Environmental Management 38:597-617.

Berns, D.M. 2003. Physiological responses of *Thalassia testudinum* and *Ruppia maritima* to experimental salinity levels. M.Sc. Thesis, University of South Florida, St. Petersburg, FL. 71 pp.

Berryhill, H.L., J.R. Suter, and N.S. Hardin. 1987. Late Quaternary facies and structure, northern Gulf of Mexico: Interpretations from seismic data. American Association of Petroleum Geologists. 289 pp.

Best, P.B., P.A.S. Canham, and N. Macleod. 1984. Patterns of reproduction in sperm whales, *Physeter macrocephalus*. Report International Whaling Commission (Special Issue 8):51-79.

Betz, C. 2010. Official communication. Email regarding data from the National Survey on Recreation and the Environment. September 24, 2010.

Bierman, V.J., S.C. Hinz, D. Justic, D. Scavia, J.A. Veil, K. Satterlee, M.E. Parker, and S. Wilson. 2008. Predicted impacts from offshore produced water discharges on hypoxia in the Gulf of Mexico. Society of Petroleum Engineers. SPE Projects, Facilities & Construction (No. 106814, June 2008).

Billings, R. and D. Wilson. 2004. Data quality control and emissions inventories of OCS oil and gas production activities in the Breton area of the Gulf of Mexico: Final report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2004-071.

Bindoff, N.L., J. Willebrand, V. Artale, A, Cazenave, J. Gregory, S. Gulev, K. Hanawa, C. Le Quéré, S. Levitus, Y. Nojiri, C.K. Shum, L.D. Talley, and A. Unnikrishnan. 2007. Observations; oceanic climate change and sea level. In: Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Avery, M. Tignor and H.L. Miller, eds. Climate change 2007: The physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate. Cambridge, United Kingdom and New York, NY: Cambridge University Press.

Birkett, S.H. and D.J. Rapport. 1999. A stress-response assessment of the northwestern Gulf of Mexico ecosystem. In: Kumpf, H., K. Steidinger, and K. Sherman, eds. The Gulf of Mexico large marine ecosystem: Assessment, sustainability, and management. Malden, MA: Blackwell Science, Inc. Pp. 438-458.

Bittner, J.E. 1996. Cultural resources and the *Exxon-Valdez* oil spill: An overview. In: Proceedings of the *Exxon-Valdez* Oil Spill Symposium. American Fisheries Society Symposium 18:814-818.

Bjorndal, K.A. 1997. Foraging ecology and nutrition of sea turtles. In: Lutz, P.L. and J.A. Musick, eds. The biology of sea turtles. Pp. 199-231.

Bjorndal, K.A., A.B. Bolten, and C.J. Lagueux. 1994. Ingestion of marine debris by juvenile sea turtles in coastal Florida habitats. Marine Pollution Bulletin 28(3):154-158.

Bjorndal, K.A., B.A. Schroeder, A.M. Foley, B.E. Witherington, M. Bresette, D. Clark, R.M. Herren, M.D. Arendt, J.R. Schmid, A.B. Meylan, P.A. Meylan, J.A. Provancha, K.M. Hart, M.M. Lamont, R.R. Carthy, and A.B. Bolten. 2013. Temporal, spatial, and body size effects on growth rates of loggerhead sea turtles (*Caretta caretta*) in the northwest Atlantic. Marine Biology. 13 pp. doi:10.1007/s00227-013-2264-y.

Blackmon, B.J., J. Lee, D.M. Cochran, Jr., B. Kar, T.A. Rehner, and A.M. Baker, Jr. 2016. Adapting to life after Hurricane Katrina and the Deepwater Horizon oil spill: An examination of psychological resilience and depression on the Mississippi Gulf Coast. Social Work in Public Health. July 28, 2016. Internet website: http://www.ncbi.nlm.nih.gov/pubmed/27467596. Accessed August 24, 2016.

Blake, N.J. and D.L. Johnson. 1976. Oxygen production-consumption of the pelagic *Sargassum* community in a flow-through system with arsenic additions. Deep Sea Research and Oceanographic Abstracts 23(8):773-778. doi:10.1016/S0011-7471(76)80020-4.

Blum, M.D. and H.H. Roberts. 2009. Drowning of the Mississippi Delta due to insufficient sediment supply and global sea-level rise. Nature Geoscience 2:488-491.

Boehm, P.D. and D.L. Fiest. 1982. Subsurface distributions of petroleum from an offshore well blowout. The *Ixtoc I* blowout, Bay of Campeche. Environmental Science & Technology 16(2):67-74.

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 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.

Boesch, D.F., M.N. Josselyn, A.J. Mehta, J.T. Morris, W.K. Nuttle, C.A. Simestad, and D.J.P. Swift. 1994. Scientific assessment of coastal wetland loss, restoration and management in Louisiana. Journal of Coastal Research, Special Issue No. 20.

Bologna, P.A.X. and K.L. Heck, Jr. 1999. Macrofaunal associations with seagrass epiphytes: Relative importance of trophic and structural characteristics. Journal of Experimental Marine Biology and Ecology 242(1):21-39.

Borkhataria, R.R., P.C. Frederick, R. Hylton, A.L. Bryan, Jr., and J.A. Rodgers, Jr. 2008. A preliminary model of wood stork population dynamics in the southeastern United States. Waterbirds 31(Special Publication 1):S42-S49.

Borrell, A. 1993. PCB and DDTs in blubber of cetaceans from the northeastern North Atlantic. Marine Pollution Bulletin 26:146-151.

Bortone, S.A., P.A. Hastings, and S.B. Collard. 1977. The pelagic *Sargassum* ichthyofauna of the eastern Gulf of Mexico. Northeast Gulf Science 1:60-67.

Bossart, G.D. 2006. Marine mammals as sentinel species for oceans and human health. Oceanography 19(2):134-137.

Boulon, R., Jr. 1989. Virgin Islands turtle tag recoveries outside the U.S. Virgin Islands. In: Eckert, S.A., K.L. Eckert, and T.H. Richardson, comps. Proceedings of the 9th Annual Workshop on Sea Turtle Conservation and Biology. NOAA Technical Memorandum NMFS/SEFC-232. Pp. 207-209.

Boulon, R., Jr. 1994. Growth rates of wild juvenile hawksbill turtles, *Eretmochelys imbricata*, in St. Thomas, U.S. Virgin Islands. Copeia 1994(3):811-814.

Boulon, R., Jr. 2000. Trends in sea turtle strandings, US Virgin Islands: 1982 to 1997. NOAA Technical Memorandum NMFS-SEFSC-436. Pp. 261-263.

Boulton, R.L., J.L. Lockwood, and M.J. Davis. 2009. Recovering small Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*) subpopulations: Breeding and dispersal of sparrows in the eastern Everglades 2008. A report to the U.S. Dept. of the Interior, Fish and Wildlife Service, South Florida Ecological Service Office, Vero Beach, FL, and the U.S. Dept. of the Interior, National Park Service, Everglades National Park, Homestead, FL.

Bounds, J.K. 2012. Drilling by the numbers, again: The economic impact of gas exploration offshore of Mississippi. Published January 23, 2012, and updated February 13, 2012. 18 pp. Internet website: http://www.healthygulf.org/sites/default/files/DrillbyNos.pdf. Accessed September 10, 2015.

Bowen, W.W. 1968. Variation and evolution of Gulf coast populations of beach mice, *Peromyscus polionotus*. Bulletin of the Florida State Museum, Biological Sciences 12(1):1-91.

Bowers, Q.D. 2008. The treasure ship S.S. *New York*: Her story, 1837-1846. New York, NY: Stacks. 94 pp.

Bozlaker A., J.M. Prospero, M.P. Frazer, and S. Chellam. 2013. Quantifying the contribution of long-range Saharan dust transport on particulate matter concentrations in Houston, Texas, using detailed elemental analysis. Environmental Science & Technology 47:10179-10187.

Brady, S. and J. Boreman. 1994. Sea turtle distributions and documented fishery threats off the northeastern United States coast. In: Proceedings, 13th Annual Symposium on Sea Turtle Biology and Conservation, February 23-27, Jekyll Island, GA. NOAA Technical Memorandum NMFS-SEFSC-341. Pp. 31-34.

Brenner, J., C. Voight, and D. Mehlman. 2016. Migratory species in the Gulf of Mexico large marine ecosystem: Pathways, threats and conservation. The Nature Conservancy, Arlington. 93 pp. Internet website: http://www.nature.org/media/gulfofmexico/migratory_species_full_report.pdf. Accessed December 29, 2016.

Bresette, M., J. Gorham, and B. Peery. 1998. Site fidelity and size frequencies of juvenile green turtles (*Chelonia mydas*) utilizing near shore reefs in St. Lucie County, Florida. Marine Turtle Newsletter 82(5).

Brewton, R.A., R. Fulford, and R.J. Griffitt. 2013. Gene expression and growth as indicators of effects of the BP Deepwater Horizon oil spill on spotted seatrout (*Cynoscion nebulosus*). Journal of Toxicology and Environmental Health, Part A, 76:1198-1209.

Brierley, A.S. and M.J. Kingsford. 2009. Impacts of climate change on marine organisms and ecosystems. July 28, 2009. Current Biology 19:R602-R614.

Bright, T.J. and R. Rezak. 1978. Northwestern Gulf of Mexico topographic features study: Final report. U.S. Dept. of the Interior, Bureau of Land Management, New Orleans OCS Office, New Orleans, LA. Contract No. AA.550-CTZ-15. Publication No. 1978-4. 692 pp. Internet website: http://www.data.boem.gov/PI/PDFImages/ESPIS/3/4069.pdf.

Bright, T.J., R. Rezak, A.H. Bouma, W.R. Bryant, and W.E. Pequegnat. 1976. A biological and geological reconnaissance of selected topographical features on the Texas continental shelf. Final report to the U.S. Dept. of the Interior, Bureau of Land Management, New Orleans OCS Office, New Orleans, LA. Contract No. 08550-CT5-4. Publication No. 1976-2. 381 pp. Internet website: http://www.data.boem.gov/PI/PDFImages/ESPIS/4/4106.pdf.

British Petroleum. 2015. BP Exploration and Production, Inc., Development and Operations Coordination Document Plan S-7706 (public information copy). 58 pp.

Britsch, L.D. and J.B. Dunbar. 1993. Land loss rates: Louisiana coastal plain. Journal of Coastal Research 9(2):324-338.

Brock, C.A., R. Bahreini, A.M. Middlebrook, J.A. de Gouw, S.A. McKeen, L.R. Williams, K.E. Daumit, A.T. Lambe, P. Massoli, M.R. Canagaratna, R. Ahmadov, A.J. Carrasquillo, E.S. Cross, B. Ervens, J.S. Holloway, J.F. Hunter, T.B. Onasch, I.B. Pollack, J.M. Roberts, T.B. Ryerson, C. Warneke, P. Davidovits, D.R. Worsnop, and J.H. Kroll. 2012. Mass spectral analysis of organic aerosol formed downwind of the *Deepwater Horizon* oil spill: Field studies and laboratory confirmations. Environmental Science & Technology 46:8025-8034. doi:10.1021/es301691k.

Broecker, W.S. and T. Takahashi. 1977. Neutralization of fossil fuel CO_2 by marine calcium carbonate. In: Andersen, N.R. and A. Malahoff, eds. The fate of fossil fuel CO_2 in the oceans. New York, NY: Plenum Press. Pp. 213-248.

Brooks, J.M., ed. 1991. Mississippi-Alabama continental shelf ecosystem study: Data summary and synthesis. Volume I: Executive summary and Volume II: Technical summary. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 91-0062 and 91-0063. 43 and 368 pp., respectively.

Brooks, J.M. and R.M. Darnell. 1991. Executive summary. In: Brooks, J.M. and C.P. Giammona, eds. Mississippi-Alabama continental shelf ecosystem study: Data summary and synthesis.

Volume I: Executive summary. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS-91-0062. 43 pp.

Brooks W.B. and T. Dean. 2008. Measuring the biological status of the U.S. breeding population of wood storks. Waterbirds 31(Special Publication):50-59.

Brost, B., B. Witherington, A. Meylan, E. Leone, L. Ehrhart, and D. Bagley. 2015. Sea turtle hatchling production from Florida (USA) beaches, 2002-2012, with recommendations for analyzing hatching success. Endangered Species Research 27:53-68.

Brown, S., C. Hickey, B. Harrington, and R. Gill, eds. 2001. The U.S. shorebird conservation plan. 2nd edition. Manomet, MA: Manomet Center for Conservation Sciences. 64 pp. Internet website: http://www.shorebirdplan.org/wp-content/uploads/2013/01/USShorebirdPlan2Ed.pdf. Accessed March 14, 2016.

Brown-Peterson, N.J., M. Krasnec, R. Takeshita, C.N. Ryan, K.J. Griffitt, C. Lay, G.D. Mayer, K.M. Bayha, W.E. Hawkins, I. Lipton, J. Morris, and R.J. Griffitt. 2015. A multiple endpoint analysis of the effects of chronic exposure to sediment contaminated with *Deepwater Horizon* oil on juvenile southern flounder and their associated microbiomes. Aquatic Toxicology 165:197-209.

Bruseth, J.E. and T.S. Turner. 2005. From a watery grave: The discovery and excavation of La Salle's shipwreck *La Belle*. Texas Historical Commission, Austin, TX.

Bryan, A.L., Jr., W.B. Brooks, J.D. Taylor, D.M. Richardson, C.W. Jeske and I.L. Brisbin, Jr. 2008. Satellite tracking large-scale movements of wood storks captured in the Gulf Coast region. Waterbirds 31(Special Publication 1): 35-41.

Buchanan, J.B., C.T. Schick, L.A. Brennan, and S.G. Herman. 1988. Merlin predation on wintering dunlins: Hunting success and dunlin escape tactics. The Wilson Bulletin (1988):108-118.

Buckley, P.A. and F.G. Buckley. 2002. Royal tern (*Thalasseus maximus*). In: Poole, A., ed. The birds of North America online. Ithaca, NY: Cornell Lab of Ornithology; retrieved from The Birds of North America Online. Internet website: http://bna.birds.cornell.edu/bna/species/700doi:10.2173/bna.609.

Bugoni, L., L. Krause, and M.V. Petry. 2001. Marine debris and human impacts on sea turtles in southern Brazil. Marine Pollution Bulletin 42(12):1330-1334.

Burks, C.M., W.B. Driggers, and K.D. Mullin. 2006. Abundance and distribution of whale sharks (*Rhincodon typus*) in the northern Gulf of Mexico. Fisheries Bulletin 104:579-584.

Burns, K.A. and J.M. Teal. 1973. Hydrocarbons in the pelagic *Sargassum* community. Deep Sea Research and Oceanographic Abstracts 20(2):207-211. doi:10.1016/0011-7471(73)90051-X.

Burns, K.A., S.D. Garrity, and S.C. Levings. 1993. How many years until mangrove ecosystems recover from catastrophic oil spills? Marine Pollution Bulletin 26(5):239-248.

Byrnes, M.R., J.D. Rosati, S.F. Griffee, and J.L. Berlinghoff. 2012. Littoral sediment budget for the Mississippi Sound barrier islands (No. ERDC/CHL-TR-12-9). Engineer Research and Development Center, Coastal and Hydraulics Lab, Vicksburg, MS.

Caetano, M., M.J. Madureira, and C. Vale. 2003. Metal remobilization during resuspension of anoxic contaminated sediment: Short-term laboratory study. Water, Air, and Soil Pollution 143:23-40.

Caillouet, C.W., Jr., D.J. Shaver, W.G. Teas, J.M. Nance, D.B. Revera, and A.C. Cannon. 1996. Relationship between sea turtle stranding rates and shrimp fishing intensity in the northwestern Gulf of Mexico: 1986-1989 versus 1990-1993. Fishery Bulletin 94:237-249.

Cairns, S.D. 1982. Stony corals (Cnidaria: Hydrozoa, Scleractinia) of Carrie Bow Cay, Belize. Smithsonian Contributions to the Marine Sciences 12: 272-302.

Cairns, S.D. 2007. Deep-water corals: An overview with special reference to diversity and distribution of deep-water scleractinian corals. Bulletin of Marine Science 81: 311-322.

Caldwell, J. 2001. Acoustic activities of the seismic industry. In: McKay, M, J. Nides, W. Lang, and D. Vigil, eds. Gulf of Mexico Marine Protected Species Workshop, June 1999. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2001-039. Pp. 55-68.

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, UK: Academic Press. Pp. 235-260.

Camacho, M., L.D. Boada, J. Oros, P. Calabuig, M. Zumbado, and O. Luzardo. 2012. Comparative study of polycyclic aromatic hydrocarbons (PAHs) in plasma of Eastern Atlantic juvenile and adult nesting loggerhead sea turtles (*Caretta caretta*). Marine Pollution Bulletin 64:1974-1980.

Camacho, M., O.P. Luzardo, L.D. Boada, L.F. Fopez-Juardo, M. Medina, M. Zumbado, and J. Oros. 2013. Potential adverse health effects of persistent organic pollutants on sea turtles: Evidences from a cross-sectional study on Cape Verde loggerhead sea turtles. Science of the Total Environment, Volumes 458-460:283-289.

Camacho, M., L.D. Boada, J. Oros, P. Lopez, M. Zumbado, M. Almeida-Gonzalez, and O.P. Luzardo. 2014. Monitoring organic and inorganic pollutants in juvenile live sea turtles: Results from a study of *Chelonia mydas* and *Eretmochelys imbricata* in Cape Verde. Science of the Total Environment 481:303-310.

Cameron, B., Jr. and T. Matthews. 2016. OCS regulatory framework for the Gulf of Mexico region. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Gulf of Mexico OCS Region, New Orleans, LA. OCS Report BOEM 2016-014. 24 pp.

Campbell, T., L. Benedict, and C.W. Finkl. 2005. Regional strategies for coastal restoration along Louisiana barrier islands. Journal of Coastal Research, Special Issue 44. Pp. 245-267.

Candler, J.E. and R.J. Primeaux. 2003. Field measurements of barite discharges in the Gulf of Mexico. Society of Petroleum Engineers, Inc. SPE 80568.

Carls, M.G., G.D. Marty, T.R. Meyers, R.E. Thomas, and S.D. Rice. 1998. Expression of viral hemorrhagic septicemia virus in prespawning Pacific herring (*Clupea pallasi*) exposed to weathered crude oil. Canadian Journal of Fisheries and Aquatic Sciences 55(10):2300-2309.

Carlson, P.R., Jr. and K. Madley. 2007. Statewide summary for Florida. In: Handley, D.A., D. Altsman, and R. DeMay, eds. Seagrass status and trends in the northern Gulf of Mexico: 1940-2002. U.S. Dept. of the Interior, Geological Survey, Scientific Investigations Report 2006-5287 and U.S. Environmental Protection Agency, 855-R-04-003. Pp. 99-114. Internet website: http://pubs.usgs.gov/sir/2006/5287/pdf/StatewideSummaryforFlorida.pdf.

Carmichael, R.H., W.M. Graham, A. Aven, G. Worthy, and S. Howden. 2012. Were multiple stressors a 'perfect storm' for northern Gulf of Mexico bottlenose dolphins (*Tursiops truncatus*) in 2011? PLOS ONE *7*(7):e41155.

Carney, R. 1993. Presentation at the Thirteenth Gulf of Mexico Information Transfer Meeting, December 4-6, 1993. Sponsored by the U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA.

Carney, R.S. 1997. Workshop on environmental issues surrounding deepwater oil and gas development: Final report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 98-0022. 148 pp.

Carney, R.S. 1999. Status of environmental and physical oceanography information on the continental slope in the Gulf of Mexico—results of a workshop. 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. 419 pp.

Carpenter, E.J. and J.L. Cox. 1974. Production of pelagic *Sargassum* and a blue-green epiphyte in the western Sargasso Sea. Limnology and Oceanography 19(3):429-436.

Carr, A.F., Jr. 1980. Some problems of sea turtle ecology. American Zoologist 20:489-498.

Carr, A. 1987a. New perspectives on the pelagic stages of sea turtle development. Conservation Biology 1:103-121.

Carr, A. 1987b. Impact of non-degradable marine debris on the ecology and survival outlook of sea turtles. Marine Pollution Bulletin 18:352-356.

Carr, M.H. and M.A. Hixon. 1997. Artificial reefs: The importance of comparisons with natural reefs. Fisheries 22(4):28-3.

Carr, A. and A.B. Meylan. 1980. Evidence of passive migration of green turtle hatchlings in Sargassum. American Society of Ichthyologists and Herpetologists 2:366-368.

Carr, R.S., D.C. Chapman, B.J. Presley, J.M. Biedenbach, L. Robertson, P. Boothe, R. Kilada, T. Wade, and P. Montagna. 1996. Sediment porewater toxicity assessment studies in the vicinity of offshore oil and gas production platforms in the Gulf of Mexico. Canadian Journal of Fisheries and Aquatic Science 53:2618-2682.

Carroll, M., B. Gentner, S. Larkin, K. Quigley, N. Perlot, L. Dehner, and A. Kroetz. 2016. An analysis of the impacts of the *Deepwater Horizon* oil spill on the Gulf of Mexico seafood industry. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study BOEM 2016-020. 196 pp.

Casselman, B. 2010. Aging oil rigs, pipelines expose Gulf to accidents. *The Wall Street Journal*. December 14, 2010. Internet website: http://www.wsj.com/articles/SB10001424052748704584804575644463302701660.

Castellanos, D.L. and L.P. Rozas. 2001. Nekton use of submerged aquatic vegetation, marsh, and shallow unvegetated bottom in the Atchafalaya River Delta, a Louisiana tidal freshwater ecosystem. Estuaries 24(2):184-197.

Castro, G. 2015. Official communication. Email regarding Port Dolphin project information request.

Center for Biological Diversity v. U.S. Department of the Interior. 2009. Case Nos. 07-1247 and 07-1344. F.3d 466. Argued October 17, 2008. Decided April 17, 2009.

Center for Sustainable Economy v. Sally Jewell. 2015. Case No. 12-1431. 779 F.3d 588. Argued September 11, 2014. Decided March 6, 2015.

Chan, E.H. and H.C. Liew. 1988. A review of the effects of oil-based activities and oil pollution on sea turtles. In: Sasekumar, A., R. D'Cruz, and S.L.H. Lim, eds. Thirty years of marine science research and development. Proceedings of the 11th Annual Seminar of the Malaysian Society of Marine Science, 26 March 1988, Kuala Lumpur, Malaysia. Pp. 159-168.

Chapman, P.M., E.A. Power, R.N. Dexter, and H.B. Andersen. 1991. Evaluation of effects associated with and oil platform, using the sediment quality triad. Environmental Toxicology and Chemistry 10:407-424.

Chen, T., C. LaCerte, S. Wise, A. Holmes, J. Martino, J. Wise Jr., W.D. Thompson, and J. Wise, Sr. 2012. Comparative cytotoxicity and genotoxicity of particulate and soluble hexavalent chromium in human and sperm whale (*Physeter macrocephalus*) skin cells. Comparative Biochemistry and Physiology, Part C 155. Pp. 143-150.

Cheniere Energy. 2015. Corpus Christi liquefaction project. Internet website: http://www.cheniere.com/terminals/corpus-christi-project/. Accessed September 14, 2015.

Chesney, E.J., D.M. Baltz, and R.G. Thomas. 2000. Louisiana estuarine and coastal fisheries and habitats: Perspectives from a fish's eye view. Ecological Applications 10(2):350-366.

Chevron. 2015. Chevron Pascagoula refinery – a success story. Internet website: http://pascagoula.chevron.com/home/abouttherefinery.aspx. Accessed September 25, 2015.

Chin, C.S. and J. Church. 2010. Field report: Fort Livingston, Grand Terre Island (September 9-10, 2010. National Center for Preservation Technology and Training, Natchitoches, LA. Internet website: http://www.ncptt.nps.gov/2011/field-report-fort-livingston-grand-terre-island/. Accessed March 18, 2011.

Cho, H.J. and C.A. May. 2008. Short-term spatial variations in the beds of *Ruppia maritima* (*Ruppiaceae*) and *Halodule wrightii* (*Cymodoceaccae*) at Grand Bay National Estuarine Research Reserve, Mississippi, USA. Journal of the Mississippi Academy of Sciences 53(2-3):133-145.

Christian, R., F. Steimle, and R. Stone. 1998. Evolution of marine artificial reef development – A philosophical review of management strategies. Gulf of Mexico Science 1998(1):32-36.

Church, R.A. and D.J. Warren. 2008. Viosca Knoll wreck: Discovery and investigation of an early nineteenth-century sailing ship in 2,000 feet of water. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2008-018. 41 pp.

Church, J.A. and N.J. White. 2011. Sea-level rise from the late 19th to the early 21st century. Surveys in Geophysics 32:4-5:585-602.

Church, R., D. Warren, R. Cullimore, L. Johnston, W. Schroeder, W. Patterson, T. Shirley, M. Kilgour, N. Morris, and J. Moore. 2007. Archaeological and biological analysis of World War II shipwrecks in the Gulf of Mexico: Artificial reef effect in deep water. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2007-015. 387 pp.

Clark, C.E. and J.A. Veil. 2009. Produced water volumes and management practices in the United States. U.S. Dept. of Energy, Office of Fossil Energy, National Energy Technology Laboratory. ANL/EVS/R-09/1. 64 pp. Internet website: http://www.ipd.anl.gov/anlpubs/2009/07/64622.pdf.

Clark, C.W., W.T. Ellison, B.L. Southall, L. Hatch, S.M. Van Parijs, A. Frankel, and D. Ponirakis. 2009. Acoustic masking in marine ecosystems: Intuitions, analysis, and implication. Marine Ecology Progress Series 395:201-222. Internet website: http://www.int-res.com/articles/theme/m395p201.pdf. Accessed October 5, 2011.

Clarke M.R. 1962. Significance of cephalopod beaks. Nature 193:560-561.

Clarke, M.R. 1976. Observation on sperm whale diving. Journal of the Marine Biological Association of the United Kingdom 56:809-810.

Clarke, M.R. 1979. The head of the sperm whale. Scientific American 240(1):106-117.

Clausen, C.J. and J.B. Arnold III. 1975. Magnetic delineation of individual shipwreck sites; a new control technique. Bulletin of the Texas Archaeological Society 46:69-86.

Clean Gulf Associates. 2015. Equipment. Internet website: http://www.cleangulfassoc.com/equipment. Accessed June 11, 2015.

Coastal Environments, Inc. (CEI). 1977. Cultural resources evaluation of the northern Gulf of Mexico continental shelf. Prepared for the U.S. Dept. of the Interior, National Park Service, Office of Archaeology and Historic Preservation, Interagency Archaeological Services, Baton Rouge, LA. 4 vols.

Coastal Environments, Inc. (CEI). 1982. Sedimentary studies of prehistoric archaeological sites. Prepared for the U.S. Dept. of the Interior, National Park Service, Division of State Plans and Grants, Baton Rouge, 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, Gulf of Mexico OCS Region, New Orleans, LA.

Coastal Response Research Center. 2007. Submerged oil—state of the practice and research needs. Prepared by the Coastal Response Research Center, Durham, NH. 29 pp. + app.

Colborn, T., F.S. vom Saal, and A.M. Soto. 1993. Developmental effects of endocrine-disrupting chemicals in wildlife and humans. Environmental Health Perspectives 101:378-384.

Cole, D.N. 2012. Wilderness visitor experiences: Progress in research and management; 2011 April 4-7; Missoula, MT. Proceedings RMRS-P-66. Fort Collins, CO. U.S. Dept. of Agriculture, Forest Service, Rocky Mountain Research Station. 219 pp.

Colegrove, K.M., S. Venn-Watson, J. Litz, M.J. Kinsel, K.A. Terio, E. Fourgeres, R. Ewing, D.A. Pabst, W.A. McLellan, S. Raverty, J. Saliki, S. Fire, G. Rappucci, S. Bowen-Stevens, L Noble, A. Costidis, M. Barbieri, C. Field, S. Smith, R.H. Carmichael, C. Chevis, W. Hatchett, D. Shannon, M. Tumlin, G. Lovewell, W. McFee, and T.K. Rowles. 2016. Fetal distress and in utero pneumonia in perinatal dolphins during the northern Gulf of Mexico unusual mortality event. Diseases of Aquatic Organisms 119:1-16.

Coleman, A.T., J.L. Pitchford, H. Bailey, and M. Solangi. 2016. Seasonal movements of immature Kemp's ridley sea turtles (*Lepidochelys kempii*) in the northern Gulf of Mexico. Aquatic Conservation: Marine and Freshwater Ecosystems. May 23, 2016. doi:10.1002/aqc.2656.

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. Bulletin of Marine Science 47(1):464-491.

CommonHealth ACTION. 2015. Mississippi Gulf Coast community portrait final report. National Cancer Health Disparities Geographic Intervention Project. Internet website: http://c-changetogether.org/Websites/cchange/images/Disparities/GIP/MS_Gulf_Coast_Community_Portrait.pdf. Accessed September 9, 2015.

Conant, T.A., P.H. Dutton, T. Eguchi, S.P. Epperly, C.C. Fahy, M.H. Godfrey, S.L. MacPherson, E.E. Possardt, B.A. Schroeder, J.A. Seminoff, M.L. Snover, C.M. Upite, and B.E. Witherington. 2009. Loggerhead sea turtle (*Caretta caretta*) 2009 status review under the U.S. Endangered Species Act. Report of the Loggerhead Biological Review Team to the U.S. Dept. of Commerce, National Marine Fisheries Service, August 2009. 222 pp.

Congdon, J.D. 1989. Proximate and evolutionary constraints on energy relations of reptiles. Physiological Zoology 62:356-373.

Continental Shelf Associates, Inc. (CSA). 1992. Preliminary report of potential effects of oil spilled from Texaco's proposed pipeline from Platform A in Garden Banks Block 189 to the subsea tie-in with High Island Pipeline System's (HIPS) existing pipeline in High Island Area Block A-377 (modified route). Prepared for Texaco Pipeline, Inc., Jupiter, FL.

Continental Shelf Associates, Inc. (CSA). 2002. Deepwater program: Bluewater fishing and OCS activity, interactions between the fishing and petroleum industries in deep waters of the Gulf of Mexico. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2002-078. 193 pp. + apps.

Continental Shelf Associates, Inc. (CSA). 2004a. Gulf of Mexico comprehensive synthetic based muds monitoring program: Final report. Volume II: Technical. 224 pp. Internet website: http://www.data.boem.gov/PI/PDFImages/ESPIS/2/3051.pdf.

Continental Shelf Associates, Inc. (CSA). 2004b. Geological and geophysical exploration for mineral resources on the Gulf of Mexico outer continental shelf: Final programmatic environmental assessment. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS EA/EIS MMS 2004-054. 466 pp.

Continental Shelf Associates, Inc. (CSA). 2006. Effects of oil and gas exploration and development at selected continental slope sites in the Gulf of Mexico. Volume II: Technical report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2006-045. 636 pp.

Continental Shelf Associates, Inc. (CSA) and LGL Ecological research Associates, Inc. 2014. Gulf of Mexico cooling water intake structure entrainment monitoring study: Final report. Prepared for the Offshore Operators Committee participants of the industry-wide cooling water intake structure entrainment monitoring study in fulfillment of the requirements for entrainment monitoring under USEPA Region 6 NPDES permit GMG290000.

Continental Shelf Associates, Inc. (CSA) and Texas A&M University, Geochemical and Environmental Research Group (GERG). 2001. Mississippi/Alabama pinnacle trend ecosystem monitoring: Final synthesis report. U.S. Dept. of the Interior, Geological Survey, Biological Resources Division, USGS/BRD/CR-2001-0007 and Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2001-080. 415 pp. + apps.

Cook, C.B. and A.H. Knap. 1983. Effects of crude oil and chemical dispersant on photosynthesis in the brain coral *Diploria strigosa*. Marine Biology 78:21-27.

Cordes, E.E., M.P. McGinley, E.L. Podowski, E.L. Becker, S. Lessard Pilon, S.T.Viada, and C.R. Fisher. 2008. Coral communities of the deep Gulf of Mexico. Deep Sea Research Part I: Oceanographic Research Papers 55(6):777-787. doi:10.1016/j.dsr.2008.03.005.

Cordes, E.E., E.L. Becker, S. Hourdez, and C.R. Fisher. 2010. Influence of foundation species, depth, and location on biodiversity and structure of cold seep macrofaunal communities on the lower slope of the Gulf of Mexico. Deep-Sea Research Part II: Topical Studies in Oceanography 57:1870-1881.

Coston-Clements, L. and D.E. Hoss. 1983. Synopsis of data on the impact of habitat alteration on sea turtles around the southeastern United States. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Center, Beaufort Laboratory, Beaufort, NC.

Coston-Clements, L., L.R. Settle, D.E. Hoss, and F.A. Cross. 1991. Utilization of the *Sargassum* habitat by marine invertebrates and vertebrates, a review. U.S. Dept. of the Interior, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Southeast Fisheries Science Center, Beaufort Laboratory, Beaufort, NC. 32 pp.

Cottingham, D. 1988. Persistent marine debris: Challenge and response; the federal perspective. Alaska Sea Grant College Program. 41 pp.

Coulter, M.C., J.A. Rodgers, J.C. Ogden, and F.C. Depkin. 1999. Wood stork (*Mycteria americana*). The birds of North America online (A. Poole, ed.). Ithaca: Cornell Lab of Ornithology, retrieved from the Birds of North America Online. Internet website: http://bna.birds.cornell.edu/bna/species/409. doi:10.2173/bna.409.

Council on Environmental Quality (CEQ). 1981. Memorandum for general counsels, NEPA liaisons and participants in scoping. April 30, 1981. 16 pp. Internet website: https://ceq.doe.gov/nepa/regs/scope/scoping.htm. Accessed October 7, 2015.

Council on Environmental Quality (CEQ). 1997. Environmental justice: Guidance under the National Environmental Policy Act. Executive Office of the President. Internet website: http://www.energy.gov/sites/prod/files/nepapub/nepa_documents/RedDont/G-CEQ-EJGuidance.pdf. Accessed August 29, 2016.

Council of Environmental Quality (CEQ). 2010. Report regarding the Minerals Management Service's National Environmental Policy Act policies, practices, and procedures as they relate to outer continental shelf oil and gas exploration and development, August 16, 2010. 41 pp. Internet website: http://www.whitehouse.gov/sites/default/files/microsites/ceq/20100816-ceq-mms-ocs-nepa.pdf.

Couvillion, B.R., J.A. Barras, G.D. Steyer, W. Sleavin, M. Fischer, H. Beck, N. Trahan, B. Griffin, and D. Heckman. 2011. Land area change in coastal Louisiana from 1932 to 2010: U.S. Geological Survey Scientific Investigations Map 3164, scale 1:265,000. 12 pp.

Couvillion, B.R., G.D. Steyer, H. Wang, H.J. Beck, and J.M. Rybczyk. 2013. Forecasting the effects of coastal protection and restoration projects on wetland morphology in coastal Louisiana under multiple environmental uncertainty scenarios. In: Peyronnin, N. and D. Reed, eds. Louisiana's 2012 coastal master plan technical analysis. Journal of Coastal Research, Special Issue 67. Pp. 29-50. ISSN 0749-0208.

Cox, S.A., E.H. Smith, and J.W. Tunnell, Jr. 1997. Macronektonic and macrobenthic community dynamics in a coastal saltmarsh: Phase I. Texas A&M University-Corpus Christi, Center for Coastal Studies. Technical Report No. TAMU-CC-9701-CCS. Corpus Christi, TX. 81 pp.

Cox, J., C. Coomes, S. DiMarco, K. Donohue, G.Z. Forristall, P. Hamilton, R.R. Leben, and D.R. Watts. 2010. Study of deepwater currents in the eastern Gulf of Mexico. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation and Enforcement, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study BOEMRE 2010-041. 473 pp.

Cranford, T.W. 1992. Directional asymmetry in the odontocete forehead. American Zoological 32(5):104.

Cranswick, D. 2001. Brief overview of Gulf of Mexico OCS oil and gas pipelines: Installation, potential impacts, and mitigation measures. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Report MMS 2001-067. 19 pp.

Crecelius, E., J. Trefry, J. McKinley, B. Lasorsa, and R. Trocine. 2007. Study of barite solubility and the release of trace components to the marine environment. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2007-061. 176 pp.

Creef, E. 2011. Official communication. Email updates on dredged material placement and volume. U.S. Dept. of the Army, Corps of Engineers, Operations Division, New Orleans District, New Orleans, LA.

Cripps, G., K.J. Flynn, and P.K. Lindeque. 2016. Ocean acidification affects the phyto-zoo plankton trophic transfer efficiency. PLOS ONE 11(4):e0151739. doi:10.1371/journal.pone.0151739.

Crouse, D.T. 1982. Incidental capture of sea turtles by U.S. commercial fisheries. Unpublished report to the Center for Environmental Education, Washington, DC.

Crowder, L.B., S.R. Hopkins-Murphy, and J.A. Royle. 1995. Effects of turtle excluder devices (TEDs) on loggerhead sea turtle strandings with implications for conservation. Copeia 1995(4):773-779.

Cullinane-Thomas, C., C. Huber, and L. Koontz. 2015. 2014 National park visitor spending effects: Economic contributions to local communities, states, and the nation. Natural Resource Report NPS/NRSS/EQD/NRR-2015/947. U.S. Dept. of the Interior, National Park Service, Fort Collins, CO.

Cummings, W.C. 1985. Bryde's whale—*Balaenoptera edeni*. In: Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 3: The sirenians and baleen whales. London, UK: Academic Press. Pp. 137-154.

Cummins, R., Jr., J.B. Rivers, and P.J. Struhsaker. 1962. Exploratory fishing off the coast of North Carolina, September 1959 - July 1960. Commercial Fish Review 24(1):1-9.

Cunnigham, N. 2016. After 350,000 layoffs oil companies now face worker shortages. OilPrice.com. June 8, 2016. Internet website: http://oilprice.com/Energy/Energy-General/After-350000-Layoffs-Oil-Companies-Now-Face-Worker-Shortages.html. Accessed August 25, 2016.

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.

Curtiss, D. and A.R. Pierce. 2016. Evaluation of wintering waterbird habitats on Louisiana barrier islands. Journal of Coastal Research 32:567-574.

Dagleish, M.P., J. Barley, J. Finlayson, R.J. Reid, and G. Foster. 2008. Brucella ceti associated pathology in the testicle of a harbour porpoise (*Phocoena phocoena*). Journal of Comparative Pathology 139:54-59.

Dahl, T.E. 2005. Florida's wetlands: An update on status and trends 1985 to 1996. U.S. Dept. of the Interior, Fish and Wildlife Service, Washington, DC. 80 pp.

Dahl, T.E. 2011. Status and trends of wetlands in the conterminous United States 2004 to 2009. U.S. Dept. of the Interior, Fish and Wildlife Service, Washington, DC. 107 pp. Internet website: http://www.fws.gov/wetlands/Documents/Status-and-Trends-of-Wetlands-in-the-Conterminous-United-States-2004-to-2009.pdf.

Dahl, K.A. and W.F. Patterson III. 2014. Habitat-specific density and diet of rapidly expanding invasive red Lionfish, *Pterois volitans*, populations in the northern Gulf of Mexico. PLOS ONE 9(8):1-13.

Dahl, T.E. and S.M. Stedman. 2013. Status and trends of wetlands in the coastal watersheds of the conterminous United States 2004 to 2009. U.S. Dept. of the Interior, Fish and Wildlife Service and U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. 46 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. Volume 6: Second book of dolphins. San Diego, CA: Academic Press. Pp. 281-322.

Dalton, M.S. and S.A. Jones, comps. 2010. Southeast regional assessment project for the National Climate Change and Wildlife Center, U.S. Geological Survey. U.S. Dept. of the Interior, Geological Survey. Open-File Report 2010-1213. 38 pp. Internet website: http://pubs.usgs.gov/of/2010/1213/. Accessed September 14, 2015.

Dance, M.A., W.F. Patterson, and D.T. Addis. 2011. Fish community and trophic structure at artificial reef sites in the northeastern Gulf of Mexico. Bulletin of Marine Science 87(3):301-324.

Davenport, J., J. Wrench, J. McEnvoy, and V. Camacho-Ibar. 1990. Metal and PCB concentrations in the “Harlech” leatherback. Marine Turtle Newsletter 48:1-6.

Davis, G.E. 1982. A century of natural change in coral distribution at the Dry Tortugas: A comparison of reef maps from 1881 and 1976. Bulletin of Marine Science 32(2): 608-623.

Davis, C. 2014. Mississippi offshore drilling plan rejected as inadequate. Internet website: http://www.naturalgasintel.com/articles/98782-mississippi-offshore-drilling-plan-rejected-as-inadequate. Accessed June 30, 2014.

Davis, R.W. and G.S. Fargion, eds. 1996. Distribution and abundance of cetaceans in the north-central western Gulf of Mexico: Final report. Volume II: Technical report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 96-0027. 355 pp.

Davis, R.W., G.S. Fargion, N. May, T.D. Leming, M. Baumgartner, W.E. Evans, L.J. Hansen, and K. Mullin. 1998. Physical habitat of cetaceans along the continental slope in the north-central and western Gulf of Mexico. Marine Mammal Science 14(3):490-507.

Davis, R.W., W.E. Evans, and B. Würsig, eds. 2000. Cetaceans, sea turtles and seabirds in the northern Gulf of Mexico: Distribution, abundance and habitat associations. Volume II: Technical report. U.S. Dept. of the Interior, Geological Survey, Biological Resources Division, USGS/BRD/CR-1999-0006 and U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2000-002. 346 pp. Internet website: www.data.boem.gov/PI/PDFImages/ESPIS/3/3153.pdf. Accessed July 31, 2015.

Davis, R.W., J.G. Ortega-Ortiz, C.A. Ribie, W.E. Evans, D.C. Biggs, P.H. Ressler, R.B. Cady, R.L. Leben, K.D. Mullin, and B. Würsig. 2002. Cetacean habitat in the northern Gulf of Mexico. Deep Sea Research: Oceanographic Research Papers 49:121-142. doi:10.1016/S0967-0637(01)00035-8.

de Robertis, A., C.H. Ryer, A. Veloza, and R.D. Brodeur. 2003. Differential effects of turbidity on prey consumption of piscivorous and planktivorous fish. Canadian Journal of Fisheries and Aquatic Sciences 60:1517-1526.

de Soto, N.A., N. Delorme, J. Atkins, S. Howard, J. Williams, and M. Johnson. 2013. Anthropogenic noise causes body malformations and delays development in marine larvae. Scientific Reports 3(2831):1-5.

DeepFlex. 2014. DeepFlex new facility. Internet website: http://www.deepflex.com/news/82-deepflex-new-facility. Accessed September 24, 2015.

Deepwater Horizon Natural Resource Damage Assessment Trustees. 2016. *Deepwater Horizon* oil spill: Final programmatic damage assessment and restoration plan and final programmatic environmental impact statement. 495 pp. Internet website: http://www.gulfspillrestoration.noaa.gov/restoration-planning/gulf-plan/. Accessed June 15, 2016.

Dehart, J. 2013. Northwest Florida's ports see a bright future on the world stage. 850 Business Magazine. December-January 2013. Internet website: http://www.850businessmagazine.com/December-January-2013/Northwest-Floridas-Ports-See-a-Bright-Future-on-the-World-Stage/. Accessed September 24, 2015.

DeLaune, R.D. and A.L. Wright. 2011. Projected impact of *Deepwater Horizon* oil spill on U.S. Gulf Coast wetlands. Soil Science Society of America Journal 75(5):1602-1612.

DeLaune, R.D., W.H. Patrick, and R.J. Buresh. 1979. Effect of crude oil on a Louisiana *Spartina alterniflora* salt marsh. Environmental Pollution 20:21-31.

DeLeo, D.M. D.V.Ruiz-Ramos, I.B. Baums, and E.E. Cordes. 2015. Response of deep-water corals to oil and chemical dispersant exposure. Deep Sea Research Part II: Topical Studies in Oceanography. doi:10.1016/j.dsr2.2015.02.028.

Dennis, G.D. and T.J. Bright. 1988. Reef fish assemblages on hard banks in the northwestern Gulf of Mexico. Bulletin of Marine Science 43:280-307.

Dewald, J.R. and D.A. Pike. 2013. Geographical variation in hurricane impacts among sea turtle populations. Journal of Biogeography 2013:1-10.

Dickey, R.W. 2012. FDA risk assessment of seafood contamination after the BP oil spill. Environmental Health Perspectives 120(2):A54-A-55. February 2012. Internet website: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3279456/pdf/ehp.1104539.pdf. Accessed August 29, 2016.

Diercks, A-R., R.C. Highsmith, V.L. Asper, D.J. Joung, Z. Zhou, L. Guo, A.M. Shiller, S.B. Joye, A.P. Teske, N. Guinasso, T.L. Wade, and S.E. Lohrenz. 2010. Characterization of subsurface polycyclic aromatic hydrocarbons at the *Deepwater Horizon* site. Geophysical Research Letters, Volume 37, L20602. doi:10.1029/2010GL045046.

Dillehay, T.D. 1989. Monte Verde: A late Pleistocene settlement in Chile. Washington, DC: Smithsonian Institution Press.

Dinsdale, E.A. and V.J. Harriott. 2004. Assessing anchor damage on coral reefs: A case study in selection of environmental indicators. Environmental Management 33(1):126-139.

Dismukes, D.E. 2010. Fact book: Offshore oil and gas industry support sectors. U.S. Dept. of the Interior, Bureau of Ocean Energy, Management, Regulation and Enforcement, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study BOEMRE 2010-042.

Dismukes, D.E. 2011. OCS-related infrastructure fact book. Volume I: Post-hurricane impact assessment. U.S. Dept. of the Interior, Bureau of Ocean Energy, Management, Regulation and Enforcement, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study BOEMRE 2011-043.

Dismukes, D. 2011a. Official communication. Email regarding scenario projections. Associate Director, Louisiana State University, Center for Energy Studies, Baton Rouge, LA. June 29, 2011.

Dismukes, D. 2011b. Official communication. Email regarding tanker port areas scenario. Associate Director, Louisiana State University, Center for Energy Studies, Baton Rouge, LA. August 25, 2011.

Dismukes, D. 2015. Official communication. Email regarding scenario projections. Director, Louisiana State University, Center for Energy Studies, Baton Rouge, LA. August 20, 2015.

Dismukes, D.E., M. Barnett, D. Vitrano, and K. Strellec. 2007. Gulf of Mexico OCS oil and gas scenario examination: Onshore waste disposal. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Report MMS 2007-051. 5 pp.

Ditton, R.B., H.R. Osburn, T.L. Baker, and C.E. Thailing. 2002. Demographics, attitudes, and reef management preferences of sport divers in offshore Texas waters. ICES Journal of Marine Science, 59:S186-S191.

Dodd Jr, C.K. 1988. Synopsis of the biological data on the loggerhead sea turtle *Caretta caretta* (Linnaeus 1758). FWS-88(14). Florida Cooperative Fish and Wildlife Research Unit, Gainesville, FL.

Dodge, R.E., S.C. Wyers, A.H. Knap, H.R. Frith, T.D. Sleeter, and S.R. Smith. 1984. The effects of oil and oil dispersants on hermatypic coral skeletal growth (extension rate). Coral Reefs 3:191-198.

Doherty, P. and T. Fowler. 1994. An empirical test of recruitment limitation in a coral reef fish. Science 263:935-939.

Dokka, R. 2006. Modern-day tectonic subsidence in coastal Louisiana. Geology 34(4):281-284.

Dokken, Q., R. Lehman, J. Prouty, C. Adams, and C. Beaver. 1993. A preliminary survey of Sebree Bank (Gulf of Mexico, Port Mansfield, TX), August 23-27, 1993. Texas A&M University, Center for Coastal Studies, Corpus Christi, TX. Center for Coastal Studies Technical Report No. TAMU-CC-9305-CCS. 13 pp.

Donato, K.M. 2004. Labor migration and the deepwater oil industry. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2004-057. 123 pp.

Doney, S.C., V.J. Fabry, R.A. Feely, and J.A. Kleypas. 2009. Ocean acidification: The other CO_2 problem. Annual Review of Marine Science 1:169-192.

Donohue, K., P. Hamilton, R. Leben, R.Watts, and E. Waddell. 2008. Survey of deepwater currents in the northwestern Gulf of Mexico. Volume II: Technical report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2008-031. 375 pp.

Dooley, J.K. 1972. Fishes associated with the pelagic *Sargassum* complex, with a discussion of the *Sargassum* community. Contributions in Marine Science 16:1-32.

Dorn, P.B., D.C.L Wong, J. Ye, and V.A. Martin. 2011. Chemical properties affecting the environmental performance of synthetic based drilling fluids for the Gulf of Mexico. Society of Petroleum Engineers, Inc. SPE 142008.

Doughty, C.L., A.M. Quattrini, and E.E. Cordes. 2014. Insights into the population dynamics of the deep-sea coral genus *Paramuricea* in the Gulf of Mexico. Deep Sea Research Part II: Topical Studies in Oceanography 99:71-82. doi:10.1016/j.dsr2.2013.05.023

Dow Piniak, W.E., S.A. Eckert, C.A. Harms, and E.M. Stringer. 2012. Underwater hearing sensitivity of the leatherback sea turtle (*Dermochelys coriacea*): Assessing the potential effect of anthropogenic noise. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Herndon, VA. OCS Study BOEM 2012-01156. 35 pp.

Duarte, C.M., J.J. Middelburg, and N. Caraco. 2005. Major role of marine vegetation on the oceanic carbon cycle. Biogeosciences 2:1-8.

Dunnet, G.M., D.J. Crisp, G. Conan, and W.R.P. Bourne. 1982. Oil pollution and seabird populations [and discussion]. Philosophical Transactions of the Royal Society of London B: Biological Sciences 297(1087):413-427.

Dunton, K.H., S.V. Shonberg, S. Herzka, P.A. Montagna, and S.A. Holt. 1998. Characterization of anthropogenic and natural disturbance on vegetated and nonvegetated bay bottom habitats in the Corpus Christi Bay National Estuarine Program Study Area. Volume II: Assessment of scarring in seagrass beds. CCBNEP-25B. 23 pp.

Duronslet, M.J., C.W. Caillouet, S. Manzella, K.W. Indelicato, C.T. Fontaine, D.B. Revera, T. Williams, and D. Boss. 1986. The effects of an underwater explosion on the sea turtles *Lepidochelys kempi* and *Caretta caretta* with observations of effects on other marine organisms (trip report). U.S. Dept. of Commerce, National Marine Fisheries Service, Southeast Fisheries Center, Galveston, TX.

Eastern Research Group, Inc. 2011. Analysis of the oil services contract industry in the Gulf of Mexico region. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation and Enforcement, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study BOEMRE 2011-001. 216 pp.

Eastern Research Group, Inc. 2014a. Measuring county-level tourism and recreation in the Gulf of Mexico region: Data, methods, and estimates. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study BOEM 2014-660. 59 pp.

Eastern Research Group, Inc. 2014b. Assessing the impacts of the *Deepwater Horizon* oil spill on tourism in the Gulf of Mexico region. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study BOEM 2014-661. 188 pp.

Eaton, C. 2016. Oil company bankruptcies accelerate despite rise in crude prices. Houston Chronicle. May 10, 2016. Internet website: http://www.houstonchronicle.com/business/energy/article/Oil-company-bankruptcies-accelerate-7423978.php. Accessed August 24, 2016.

Eckert, S.A., K.L. Eckert, P. Ponganis, and G.L. Kooyman. 1989. Diving and foraging behavior of leatherback sea turtles (*Dermochelys coriacea*). Canadian Journal of Zoology 67:2834-2840. doi:10.1139/z89-399.

Ecometrica. 2012. Greenhouse gases, CO_2, CO_2e, and carbon: What do all these terms mean? August 2012. 3 pp.

Edney, J. 2006. Impacts of recreational scuba diving on shipwrecks in Australia and the Pacific: A review. Micronesian Journal of the Humanities and Social Sciences 5(1/2):201-233.

Ehrhart, L.M. 1978. Choctawhatchee beach mouse. In*:* Layne, J.N., ed. Rare and endangered biota of Florida. Volume I: Mammals. Gainesville, FL: University Presses of Florida. Pp. 18-19.

Ehrhart, L.M. and B.E. Witherington. 1992. Green turtle *Chelonia mydas* (Linnaeus). In: Moler, P.E., ed. Rare and endangered biota of Florida. Volume 3. University Press of Florida. Pp. 90-94.

Ehrhart, L.M., P.W. Raymond, J.L. Guseman, and R.D. Owen. 1990. A documented case of green turtles killed in an abandoned gill net: The need for better regulation of Florida's gill net fisheries. In: Richardson, T.H., J.I. Richardson, and M. Donnelly, compilers. Proceedings of the Tenth Annual Workshop on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFC-278. Pp. 55-58.

Ehrhart, L.M., D.A. Bagley, and W.E. Redfoot. 2003. Loggerhead turtles in the Atlantic Ocean: Geographic distribution, abundance, and population status. In: Bolten, A.B. and B.E. Witherington, ed. Loggerhead sea turtles. Washington, DC: Smithsonian Books. Pp. 157-174.

Elango V, M. Urbano, K.R. Lemelle, and J.H. Pardue. 2014. Biodegradation of MC252 oil in oil: Sand aggregates in a coastal headland beach environment. Frontiers in Microbiology 5:161. doi:10.3389/fmicb.2014.00161.

Elderd, B.D. and M.P. Nott. 2008. Changing landscapes, changing demography: An individual-based model for the endangered Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*). Journal of Applied Ecology 45:258-268.

Elgershuizen, J.H.B.W. and H.A.M. De Kruijf. 1976. Toxicity of crude oils and a dispersant to the stony coral *Madracis mirabilis*. Marine Pollution Bulletin 7(2):22-25.

Elsner, J.B., T.H. Jagger, M. Dickinson, and D. Rowe. 2008. Improving multiseason forecasts of North Atlantic hurricane activity. American Meteorological Society 21:1210-1219. doi:10.1175/2007JCLI1731.1. Internet website: http://myweb.fsu.edu/jelsner/PDF/Research/ElsnerJaggerDickinsonRowe2008.pdf.

Emery, W.J., K. Cherkauer, B. Shannon, and R.W. Reynolds. 1997. Hull-mounted sea surface temperatures from ships of opportunity. American Meteorological Society, Boston, MA. Journal of Atmospheric and Oceanic Technology 14:1237-1251.

Energo Engineering. 2010. Assessment of damage and failure mechanisms for offshore structures and pipelines in Hurricanes Gustav and Ike. U.S. Dept. of the Interior, Minerals Management Service, Herndon, VA. TA&R 642.

Engås, A., S. Løkkeborg, E. Ona, and A.V. Soldal. 1996. Effects of seismic shooting on local abundance and catch rates of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*). Canadian Journal of Fisheries and Aquatic Science 53:2238-2249.

Engelhaupt, D., A.R. Hoelzel, C. Nicholson, A. Frantzis, S. Mesnick, S. Gero, H. Whitehead, L. Rendell, P. Miller, R. De Stefanis, A. Cañadas, S. Airoldi, and A.A. Mignucci-Giannoni. 2009. Female philopatry in coastal basins and male dispersion across the North Atlantic in a highly mobile marine species, the sperm whale (*Physeter microcephalus*). Molecular Ecology 18:4193-4205.

Engler, R.E. 2012. The complex interaction between marine debris and toxic chemicals in the ocean. Environmental Science and Technology 46:12302-12315.

Environment Canada. 2013. Oil properties database. Environmental Technology Centre. Internet website: http://www.etc-cte.ec.gc.ca/databases/OilProperties/Default.aspx. Accessed April 24, 2013.

Epperly, S.P. and W.G. Teas. 2002. Turtle excluder devices--Are the escape openings large enough? Fishery Bulletin 100(3):466-474.

Epperly, S.P., J. Braun, and A. Veishlow. 1995. Sea turtles in North Carolina waters. Conservation Biology 9(2):384-394. doi:10.1046/j.1523-1739.1995.9020384.x.

Epperly, S.P., J. Braun, A.J. Chester, F.A. Cross, J.V. Merriner, P.A. Tester, and J.H. Churchill. 1996. Beach strandings as an indicator of at-sea mortality of sea turtles. Bulletin of Marine Science 59(2):289-297.

Epperly, S., L. Avens, L. Garrison, T. Henwood, W. Hoggard, J. Mitchell, J. Nance, J. Poffenberger, C. Sasso, E. Scott-Denton, and C. Yeung. 2002. Analysis of sea turtle bycatch in the commercial shrimp fisheries of southeast U.S. waters and the Gulf of Mexico. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-SEFSC-490. 88 pp.

Epperly, S.P., J. Braun-McNeill, and P.M. Richards. 2007. Trends in catch rates of sea turtles in North Carolina, USA. Endangered Species Research 3(3):283-293.

Erftemeijer, P.L.A. and R.R.R. Lewis III. 2006. Environmental impacts of dredging on seagrass: A review. Marine Pollution Bulletin 52:1553-1572.

Ernst, C.H., R.W. Barbour, and J.E. Lovich. 1994. Turtles of the United States and Canada. Washington, DC: Smithsonian Institution Press. 578 pp.

Etnoyer, P.J. and J. Warrenchuk. 2007. A catshark nursery in a deep gorgonian field in the Mississippi Canyon, Gulf of Mexico. Bulletin of Marine Science 81(3):553-559.

Evans, D. 2006. Satellite tracking of leatherbacks reveals unexpected foraging ground. Sea Turtle Conservancy Newsletter "Velador" Issue 4, 2 pp. Internet website: http://www.conserveturtles.org/velador.php?page=velart66.

Evans, P. and A. Bjørge. 2013. Impacts of climate change on marine mammals. MCCIP Science Review 2013:134-148.

Evans, P.G.H., G.J. Pierce, and S. Panigada. 2010. Climate change and marine mammals. Journal of the Marine Biological Association of the UK 90:1483-1488.

Fahrig, L. 1997. Relative effects of habitat loss and fragmentation on population extinction. The Journal of Wildlife Management 61(3):603-610.

Fahrig, L. 1998. When does fragmentation of breeding habitat affect population survival? Ecological Modelling 105(2):273-292.

Fahrig, L. 2001. How much habitat is enough? Biological Conservation 100(1):65-74.

Fair, P.A., J. Adams, G. Mitchum, T.C. Hulsey, J.S. Refi, M. Houde, D. Muir, E. Wirth, D. Wetzel, E. Zolman, W. McFee, and G.D. Bossart. 2010. Contaminant blubber burdens in Atlantic bottlenose dolphins (*Tursiops truncates*) from two southeastern US estuarine areas: Concentrations and patterns of PCBs, pesticides, PBDEs, PFCs, and PAHs. Science of the Total Environment 408:1577-1597.

Fais, A., M. Johnson, M. Wilson, N. Aguilar Soto, and P.T. Madsen. 2016a. Sperm whale predator-prey interactions involve chasing and buzzing, but no acoustic stunning. Scientific Reports 6:28562. doi:10.1038/srep28562.

Fais, A., T.P. Lewis, D.P. Zitterbart, O. Álvarez, A. Tejedor, and N. Aguilar Soto. 2016b. Abundance and distribution of sperm whales in the Canary Islands: Can sperm whales in the Archipelago sustain the current level of ship-strike mortalities? PLOS ONE 11(3):e0150660. Internet website: http://doi.org/10.1371/journal.pone.0150660.

Falcy, M.R. 2011. Individual and population-level responses of the Alabama beach mouse (*Peromyscus polionotus ammobates*) to environmental variation in space and time. Iowa State University. Graduate Theses and Dissertations. Paper 12192.

Fangman, M.S. and K.A. Rittmaster. 1994. Effects of human beach usage on the temporal distribution of loggerhead nesting activities. In: Proceedings, 13th Annual Symposium on Sea Turtle Biology and Conservation, 23-27 February, Jekyll Island, GA. NOAA Technical Memorandum NMFS-SEFSC-341.

Fannin, M. and D. Varnado. 2015. Official communication. Memorandum titled, Overview of Bureau of Ocean Energy Management (BOEM) economic impact area procedures. Delivered as part of Cooperative Agreement #M12AC00021 with Louisiana State University.

Fanning, K., K.L. Carder, and P.R. Betzer. 1982. Sediment resuspension by coastal waters: A potential mechanism for nutrient re-cycling on the ocean's margins. Deep Sea Research Part A: Oceanographic Research Papers 29(8):953-965. doi:10.1016/0198-0149(82)90020-6.

Farrell, P. and K. Nelson. 2013. Trophic level transfer of microplastic: *Mytilus edulis* (L.) to *Carcinus maenas* (L.). Environmental Pollution 177:1-3.

Federal Register. 1967. Office of the Secretary, Native fish and wildlife: Endangered species. Final rule. March 11, 1967. 32 FR 48, pp. 4001.

Federal Register. 1970a. Conservation of endangered species and other fish or wildlife: List of endangered foreign fish or wildlife. Final rule. July 30, 1970. 35 FR 18319, pp. 18319-18322.

Federal Register. 1970b. Conservation of endangered species and other fish or wildlife: List of endangered foreign fish and wildlife. Listing of Kemp's ridley (Atlantic ridley), leatherback and hawksbill sea turtles as "endangered." Final rule. December 2, 1970. 35 FR 18319, pp. 18319-18322.

Federal Register. 1973a. Secondary National Ambient Air Quality Standards for sulfur dioxide. Final rule. September 14, 1973. 38 FR 25678.

Federal Register. 1973b. Conservation of endangered species and other fish or wildlife: Amendments to lists of endangered fish and wildlife. Final rule. June 4, 1973. 38 FR 106, p. 14678.

Federal Register. 1975. Mississippi sandhill crane: Determination of critical habitat. Proposed rule. September 3, 1975. 40 FR 40521-40522.

Federal Register. 1977a. Endangered and threatened wildlife and plants: Determination of critical habitat for Mississippi sandhill crane. Final rule. August 8, 1977. 42 FR 152, pp. 39985-39988.

Federal Register. 1977b. Endangered and threatened wildlife and plants: Determination of critical habitat for six endangered species. Final rule. August 11, 1977. 42 FR 155, pp. 40685-40690.

Federal Register. 1978a. Listing and protecting loggerhead sea turtles as "threatened species" and population of green and olive ridley sea turtles as threatened species or "endangered species." Final rule. July 28, 1978. 43 FR 146, pp. 32800-32811.

Federal Register. 1978b. Determination of critical habitat for whooping crane. Final rule. May 15, 1978. 40 FR 94, pp. 20938-20942.

Federal Register. 1980. Ocean discharge criteria source. October 3, 1980. 45 FR 194, p. 65942.

Federal Register. 1984. Endangered and threatened wildlife and plants: U.S. breeding population of the wood stork determined to be endangered. Final rule. February 28, 1984. 49 FR 40, pp. 7332-7335.

Federal Register. 1985. Endangered and threatened wildlife and plants; determination of endangered and threatened status for the piping plover. Final rule. December 11, 1985. 50 FR 238, pp. 50726-50734.

Federal Register. 1987. Endangered and threatened wildlife and plants; determination of endangered and threatened status for two populations of the roseate tern. Final rule. November 2, 1987. 52 FR 211, pp. 42064-42068.

Federal Register. 1993. Oil and gas extraction point source category; offshore subcategory effluent limitations guidelines and new source performance standards. Final rule. March 4, 1993. 58 FR 41, pp. 12454-12512.

Federal Register. 1996. National Ambient Air Quality Standards for nitrogen dioxide. Final decision. October 8, 1996. 61 FR 196, pp. 52852-52856.

Federal Register. 1997. Hydrogen sulfide requirements for operations in the outer continental shelf. Final rule. January 27, 1997. 62 FR 17, pp. 3793-3800.

Federal Register. 1998. Endangered and threatened wildlife and plants; determination of endangered status for the St. Andrew beach mouse. Final rule. December 18, 1998. 63 FR 243, pp. 70053-70062.

Federal Register. 2006a. National Ambient Air Quality Standards for particulate matter. Final rule. October 17, 2006. 71 FR 200, pp. 61144-61233.

Federal Register. 2006b. Endangered and threatened wildlife and plants; designation of critical habitat for the Perdido Key beach mouse, Choctawhatchee beach mouse, and St. Andrew beach mouse. Final rule. October 12, 2006. 71 FR 197, pp. 60238-60370.

Federal Register. 2006c. Endangered and threatened species: Final listing determinations for elkhorn and staghorn corals. Final rule. November 26, 2008. 71 FR 26852, pp. 26852-26861.

Federal Register. 2007. Endangered and threatened wildlife and plants; critical habitat revised designation for the Cape Sable Seaside Sparrow. Final rule. November 6, 2007. 72 FR 214, pp. 62736-62766.

Federal Register. 2008a. Record of decision for the final programmatic environmental impact statement for alternative energy development and production and alternate use of facilities on the outer continental shelf. January 10, 2008. 73 FR 7, pp. 1894-1895.

Federal Register. 2008b. National Ambient Air Quality Standards for lead. Final rule. November 12, 2008. 73 FR 219, pp. 66964-67062.

Federal Register. 2008c. Endangered and threatened species; critical habitat for threatened elkhorn and staghorn corals. Final rule. November 26, 2008. 73 FR 72210, pp. 72210-72240.

Federal Register. 2009. Renewable energy and alternate uses of existing facilities on the outer continental shelf. Final rule. April 29, 2009. 74 FR 81, pp. 19638-19871.

Federal Register. 2010a. Primary National Ambient Air Quality Standards for nitrogen dioxide. Final rule. February 9, 2010. 75 FR 26, pp. 6474-6537.

Federal Register. 2010b. Primary National Ambient Air Quality Standard for sulfur dioxide. Final rule. June 22, 2010. 75 FR 119, pp. 35520-35603.

Federal Register. 2011a. Review of National Ambient Air Quality Standards for carbon monoxide. Final rule. August 31, 2011. 76 FR 169, pp. 54294-54343.

Federal Register. 2011b. Endangered and threatened species; determination of nine distinct population segments of loggerhead sea turtles as endangered or threatened. Final rule. September 22, 2011. 76 FR 58867, pp. 58867-58952.

Federal Register. 2011c. Endangered and threatened wildlife and plants; establishment of a nonessential experimental population of endangered whooping cranes in southwestern Louisiana. Final rule. February 3, 2011. 76 FR 23, pp. 6066-6084.

Federal Register. 2012. Standards for living organisms in ship's ballast water discharged in U.S. waters. March 23, 2012. 77 FR 57, pp. 17254-17320.

Federal Register. 2013. National Ambient Air Quality Standards for particulate matter. Final rule. January 15, 2013. 78 FR 10, pp. 3086-3287.

Federal Register. 2014a. Endangered and threatened species; critical habitat for the northwest Atlantic Ocean loggerhead sea turtle distinct population segment (DPS) and determination regarding critical habitat for the North Pacific Ocean loggerhead DPS. Final rule (50 CFR 226). July 10, 2014. 79 FR 132, pp. 39855-39912.

Federal Register. 2014b. Endangered and threatened wildlife and plants; final listing determinations on proposal to list 66 reef-building coral species and to reclassify elkhorn and staghorn corals. Final rule. October 10, 2014. 79 FR 53851, pp. 53851-54123.

Federal Register. 2014c. Endangered and threatened wildlife and plants; designation of critical habitat for the northwest Atlantic Ocean distinct population segment of the loggerhead sea turtle. Final rule. July 10, 2014. 79 FR 39855, pp. 39755-39854.

Federal Register. 2014d. Endangered and threatened wildlife and plants; threatened species status for the rufa red knot (*Calidris canutus Rufa*). Final rule. December 11, 2014. 79 FR 238, pp. 73706-73748.

Federal Register. 2014e. Endangered and threatened wildlife and plants; reclassification of the U.S. breeding population of the wood stork from endangered to threatened. Final rule. June 30, 2014. 79 FR 125, pp. 37078-37103.

Federal Register. 2015a. Outer continental shelf, region-wide Gulf of Mexico oil and gas lease sales for years 2017-2022. Call for information and nominations. September 4, 2015. 80 FR 172, pp. 53565-53567.

Federal Register. 2015b. Outer continental shelf, 2017-2022 oil and gas leasing program. Notice of Intent (NOI) to prepare a programmatic environmental impact statement (EIS) and Notice of Scoping. January 29, 2015. 80 FR 19, pp. 4939-4941.

Federal Register. 2015c. National oil and hazardous substances pollution contingency plan. Proposed rule. January 22, 2015. 80 FR 14, pp. 3380-3446.

Federal Register. 2015d. Deepwater port license application: Delfin LNG, LLC, Delfin LNG deepwater port. Notice of application. July 16, 2015. 80 FR 136, pp. 42162-42165.

Federal Register, 2015e. RESTORE Act spill impact component allocation. September 29, 2015. 80 FR 188, pp. 58417-58421.

Federal Register, 2015f. National Ambient Air Quality Standards for ozone. Final rule. October 26, 2015. 80 FR 206, pp. 65292-65468.

Federal Register. 2015g. Endangered and threatened species; identification and proposed listing of eleven distinct population segments of green sea turtles (*Chelonia mydas*) as endangered or threatened and revision of current listings. Proposed rule. March 23, 2015. 80 FR 15271, pp. 15271-15337.

Federal Register. 2015h. Outer continental shelf (OCS), Gulf of Mexico (GOM), oil and gas lease sales for 2017-2022. Notice of intent to prepare an environmental impact statement and notice of public scoping meetings. April 29, 2015. 80 FR 82, pp. 23818-23820.

Federal Register. 2016a. Outer continental shelf, Gulf of Mexico, oil and gas lease sales for 2017-2022; notice of availability (NOA) of a draft environmental impact statement. April 22, 2016. 81 FR 78, pp. 23747-23748.

Federal Register. 2016b. Notice of draft National Pollutant Discharge Elimination System (NPDES) general permit for the eastern portion of the Outer Continental Shelf (OCS) of the Gulf of Mexico (GEG460000); availability of draft environmental assessment. August 18, 2016. 81 FR 160, pp. 55196-55199.

Federal Register. 2016c. Fisheries of the Caribbean, Gulf, and South Atlantic; aquaculture. Final rule. January 13, 2016. 81 FR 8, pp. 1762-1800.

Federal Register. 2016d. Endangered and threatened wildlife and plants; 12-month finding on a petition to downlist the West Indian manatee, and proposed rule to reclassify the West Indian manatee as threatened. Proposed rule. January 8, 2016. 81 FR 5, pp. 999-1026.

Federal Register. 2016e. Endangered and threatened wildlife; 12-month finding on a petition to list the Gulf of Mexico Bryde's whale as endangered under the Endangered Species Act. Proposed rule. December 8, 2016. 81 FR 88639, pp. 88639-88656.

Federal Register. 2016f. 50 CFR parts 223 and 224; endangered and threatened wildlife and plants; final rule to list eleven distinct population segments of the green sea turtle (*Chelonia mydas*) as endangered or threatened and revision of current listings under the Endangered Species Act. Final rule. April 6, 2016. 81 FR 66, pp. 20058-20090.

Federal Register. 2016g. 50 CFR parts 600 and 622; fisheries of the Caribbean, Gulf, and South Atlantic; aquaculture. Final rule. January 13, 2016. 81 FR 8, pp. 1762-1800.

Feely, R.A., S.C. Doney, and S.R. Cooley. 2009. Ocean acidification; present conditions and future changes in a high-CO_2 world. Oceanography 22(4):36-47.

Felder, D.L., D.K. Camp, and J.W. Tunnell Jr. 2009. An introduction to Gulf of Mexico biodiversity assessment. In: Felder, D.L. and D.K. Camp, eds. Gulf of Mexico origin, waters, and biota. Volume 1: Biodiversity. College Station, TX: Texas A&M University Press.

Felder, D.L., B.P. Thoma, W.E. Schmidt, T. Sauvage, S. Self-Krayesky, A. Chistoserdov, H.D. Bracken-Grissom, and S. Fredericq. 2014. Seaweeds and decapod crustaceans on Gulf deep banks after the Macondo oil spill. BioScience 64:808-819.

Ferguson, M.C., C. Curtice, J. Harrison, and S.M. Van Parijs. 2015. Biologically important areas for cetaceans within U.S. waters - overview and rationale. Aquatic Mammals 41:2-16.

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., A.J. Shiro, G.T. Regan, C.A. Beck, N. Adimey, L. Price-May, A. Amos, G.A.J. Worthy, and R. Crossland. 2005. Manatee occurrence in the northern Gulf of Mexico, west of Florida. Gulf and Caribbean Research 17:69-94.

Fikes, R. 2013. Artificial reefs in the Gulf of Mexico: A review of Gulf state programs and key considerations. National Wildlife Federation staff report.

Fingas, M. 1995. Oil spills and their cleanup. Chemistry and Industry 24:1005-1008.

Fingas, M. 2013. The basics of oil spill cleanup, 3rd edition. Boca Raton, FL: CRC Press. 286 pp.

Finkbeiner, E.M., B.P. Wallace, J.E. Moore, R.L. Lewison, L.B. Crowder, and A.J. Read. 2011. Cumulative estimates of sea turtle bycatch and mortality in USA fisheries between 1990 and 2007. Biological Conservation 144: 2719-2727.

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. Pp. 383-387.

Fish, M.R., I.M. Cote, J.A. Gill, A.P. Jones, S. Renshoff, and A.R. Watkinson. 2005. Predicting the impact of sea-level rise on Caribbean Sea turtle nesting habitat. Conservation Biology 19(2):482-491.

Fisher, C.R. 1990. Chemoautotrophic and methanotrophic symbioses in marine invertebrates. Reviews in Aquatic Science 2:399-436.

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, M. 2016. Official communication. Excel files regarding recreational fishing data from the Texas Parks and Wildlife Department. September 6, 2016.

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.

Fisher, C.R., H. Roberts, E. Cordes, and B. Bernard. 2007. Cold seeps and associated communities of the Gulf of Mexico. Oceanography 20(4):6879.

Fisher, C.R., A.W.J. Demopoulos, E.E. Cordes, I.B. Baums, H.K. White, and J.R. Bourque. 2014a. Coral communities as indicators of ecosystem-level impacts of the *Deepwater Horizon* spill. BioScience 64(9):796-807.

Fisher, C.R., P-Y Hsing, C.L. Kaiser, D.R. Yoerger, H.H. Roberts, W.W. Shedd, E.E. Cordes, T.M. Shank, S.P. Berlet, M.G. Saunders, E.A. Larcom, and J.M. Brooks. 2014b. Footprint of *Deepwater Horizon* blowout impact to deep-water coral communities. Proceedings of the National Academy of Science. doi:10.1073/pnas.1403492111.

Flynn, K.J., D.R. Clark, A. Mitra, H. Fabian, P.J. Hansen, P.M. Glibert, G.L. Wheeler, D.K. Stoeker, J.C. Blackford, and C. Brownlee. 2015. Ocean acidification with (de) eutrophication will alter future phytoplankton growth and succession. Proceedings of the Royal Society of London B: Biological Sciences 282(1804):20142604.

Fodrie, F.J. and K.L. Heck Jr. 2011. Response of coastal fishes to the Gulf of Mexico oil disaster. PLOS ONE 6(7):e21609.

Fodrie, F.J., K.W. Able, F. Galvez, K.L. Heck, O.P. Jensen, P.C. López-Duarte, C.W. Martin, R.E. Turner, and A. Whitehead. 2014. Integrating organismal and population responses of estuarine fishes in Macondo spill research. BioScience 64(9):778-788.

Foley, A.M., B.A. Schroeder, R. Hardy, S.L. MacPherson, M. Nicholas, and M.S. Coyne. 2013. Postnesting migratory behavior of loggerhead sea turtles *Caretta caretta* from three Florida rookeries. Endanger Species Research 21:129-142.

Foley, A.M., B.A. Schroeder, R. Hardy, S.L. MacPherson, and M. Nicholas. 2014. Long-term behavior at foraging sites of adult female loggerhead sea turtles (*Caretta caretta*) from three Florida rookeries. Marine Biology 161(6):1251-1262. doi:10.1007/s00227-014-2415-9.

Ford, B., A. Borgens, W. Bryant, D. Marshall, P. Hitchcock, C. Arias, and D. Hamilton. 2008. Archaeological excavation of the Mardi Gras shipwreck (16GM01), Gulf of Mexico continental slope. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Report MMS 2008-037. 313 pp.

Forrest, J., E.E. Marcucci, and P. Scott. 2007. Geothermal gradients and subsurface temperatures in the northern Gulf of Mexico. Search and Discovery Article #30048. Internet website: http://www.searchanddiscovery.com/documents/2007/07013forrest/images/forrest.pdf.

Francaviglia, R.V. 1998. From sail to steam. Austin, TX: University of Texas Press. 324 pp.

Franci, C.D., M. Guillemette, É. Pelletier, O. Chastel, S. Bonnefoi, and J. Verreault. 2014. Endocrine status of a migratory bird potentially exposed to the Deepwater Horizon oil spill: A case study of northern gannets breeding on Bonaventure Island, Eastern Canada. Science of the Total Environment,473:110-116.

Frankovich, T.A., D. Morris, and J.W. Fourqurean. 2011. Benthic macrophyte distribution and abundance in estuarine mangrove lakes and estuaries: Relationships to environmental variables. Estuaries and Coasts 34(1):20-31.

Fraser, S.B. and G.R. Sedberry. 2008. Reef morphology and invertebrate distribution at continental shelf edge reefs in the South Atlantic Bight. Southeastern Naturalist 7:191-206.

Frazer, N.B., J.W. Gibbons, and J.L. Greene. 1989. Life tables of a slider turtle population. In: Gibbons, J.W., ed. Life history and ecology of the slider turtle. Washington, DC: Smithsonian Institution Press.

Frazer, T.K., S.K. Notestein, C.A. Jacoby, C.J. Littles, S.R. Keller, and R.A. Swift. 2006. Effects of storm-induced salinity changes on submersed aquatic vegetation in Kings Bay, Florida. Estuaries and Coasts 29(6A):943-953.

Frazier, D.E. 1967. Recent deltaic deposits of the Mississippi River: Their development and chronology. In: Sandridge, J.R., ed. Transactions Gulf Coast Association of Geological Societies 27:287-315. Internet website: http://search.datapages.com/data/gcags/data/017/017001/pdfs/0287.pdf.

Frazier, J.G. 1980. Marine turtles and problems in coastal management. In: Edge, B.C., ed. Coastal Zone '80: Proceedings of the Second Symposium on Coastal and Ocean Management. Volume 3. New York, NY: American Society of Civil Engineers. Pp. 2395-2411.

Frazier, J., T. Linton, and R. Webster. 2015. Advanced prediction of the Intra-Americas *Sargassum* season through analysis of the *Sargassum* Loop System using remote sensing technology. American Shore and Beach. Internet website: http://seas-forecast.com/Pages/stories%20article/Papers/JeffFrazierthesisformatedforpublishingNEW.pdf.

Fredericq, S., N. Arakaki, O. Camacho, D. Gabriel, D. Krayesky, S. Self-Krayesky, G. Rees, J. Richards, T. Sauvage, D. Venera-Ponton, and W.E. Schmidt. 2014. A dynamic approach to the study of Rhodoliths: A case study for the northwestern Gulf of Mexico. Cryptogamie 35:77-98.

Freese, L., P.J. Auster, J. Heifetz, and B.L. Wing. 1999. Effects of trawling on seafloor habitat and associated invertebrate taxa in the Gulf of Alaska. Marine Ecology Progress Series 182:119-126.

Freiwald, A., J.H. Fosså, A. Grehan, T. Koslow, and J.M. Roberts. 2004. Coldwater coral reefs. UNEPWCMC, Cambridge, UK.

French-McCay, D.P. 2004. Oil spill impact modeling: Development and validation. Environmental Toxicology and Chemistry 23(10):2441-2456.

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.

Fry, B. and L.C. Anderson. 2014. Minimal incorporation of *Deepwater Horizon* oil by estuarine filter feeders. Marine Pollution Bulletin 80:282-287.

FSG Social Impact Consultants. 2011. Gulf Coast regional overview. February 2011. Internet website: http://greatertexasfoundation.org/wp-content/uploads/2011/03/Gulf-Coast-Full-Research-Loop-FINAL.pdf. Accessed September 9, 2015.

Fucik, K.W., T.J. Bright, and K.S. Goodman. 1984. Measurements of damage, recovery, and rehabilitation of coral reefs exposed to oil. In: Cairns, J. and A.L. Buikema, Jr., eds. Restoration of habitats impacted by oil spills. Boston, MA: Butterworth Publishers.

Fucik, K.W., K.A. Carr, and B.J. Balcom. 1995. Toxicity of oil and dispersed oil to the eggs and larvae of seven marine fish and invertebrates from the Gulf of Mexico. In: Lane, P., ed. The use of chemicals in oil spill response. ASTM 1252. American Society for Testing and Materials, Philadelphia, PA. 343 pp.

Gagliano, S.M. 1999. Faulting, subsidence and land loss in coastal Louisiana. In: Louisiana Coastal Wetlands Conservation and Restoration Task Force and Wetlands Conservation and Restoration Authority, Coast 2050: Toward a Sustainable Coastal Louisiana, Appendix B—Technical methods. Louisiana Dept. of Natural Resources, Baton Rouge, LA.

Gagliano, S.M. 2005a. Effects of earthquakes, fault movements, and subsidence on the south Louisiana landscape. Reprinted from The Louisiana Civil Engineer, Journal of the Louisiana Section of The American Society of Civil Engineers, Baton Rouge, LA. February 2005, 13(2):5-7 and 19-22. Internet website: http://www.coastalenv.com/EffectofEarthquakeFaultMovementsandSubsidence.pdf.

Gagliano, S.M. 2005b. Effects of natural fault movement on land submergence in coastal Louisiana. In: Proceedings, 14th Biennial Coastal Zone Conference, New Orleans, LA, July 17-21, 2005. 5 pp.

Gales, R.S. 1982. Effects of noise of offshore oil and gas operations on marine mammals—an introductory assessment. U.S. Dept. of the Navy, Navy Oceans Systems Center, San Diego, CA. Technical Report 844.

Gallaway, B.J. and M.C. Kennicutt II. 1988. Chapter 2. The characterization of benthic habitats of the northern Gulf of Mexico. In: Gallaway, B.J., ed. Northern Gulf of Mexico continental slope study, final report: Year 4. Volume II: Synthesis report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 88-0053. Pp. 2-1 to 2-45.

Gallaway, B.J., L.R. Martin, and R.L. Howard, eds. 1988. Northern Gulf of Mexico continental slope study, annual report: Year 3. Volume II: Technical narrative. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 87-0060. 586 pp.

Gallaway, B., S. Szedlmayer, and W. Gazey. 2009. A life history review for red snapper in the Gulf of Mexico with an evaluation of the importance of offshore petroleum platforms and other artificial reefs. Reviews in Fisheries Science 17(1):48-67.

Gannier, A. and G. Marty. 2015. Sperm whales ability to avoid approaching vessels is affected by the sound reception in stratified waters. Marine Pollution Bulletin 95:283-288.

Garber, S.D. 1985. The integration of ecological factors affecting marine turtle nesting beach management. In: Proceedings of the Ninth Annual Conference of the Coastal Society, October 14-17, 1984. Atlantic City, NJ: The Coastal Society.

Gardner, J.V., P. Dartnell, and K.J. Sulak. 2002. Multibeam mapping of the pinnacles region, Gulf of Mexico. U.S. Dept. of the Interior, Geological Survey. USGS Open File Report OF02-006. Internet website: http://geopubs.wr.usgs.gov/open-file/of02-006/.

Gannier, A. and G. Marty. 2015. Sperm whales ability to avoid approaching vessels is affected by the sound reception in stratified waters. Marine Pollution Bulletin 95:283-288.

Garrison, E.G., C.P. Giammona, F.J. Kelly, A.R. Tripp, and G.A. Wolf. 1989. Historic shipwrecks and magnetic anomalies of the northern Gulf of Mexico: Reevaluation of archaeological resource management. Volume II: 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.

Garrison, L.P., L. Stokes, and C. Fairfield. 2009. Estimated bycatch of marine mammals and turtles in the U.S. Atlantic pelagic longline fleet during 2008. NOAA Technical Memorandum NMFS-SEFSC-591. 63 pp.

Gaston, K.J., T.W. Davies, J. Bennie, and J. Hopkins. 2012. Reducing the ecological consequences of night-time light pollution: Options and developments. Journal of Applied Ecology 49:1256-1266. doi:10.1111/j.1365-2664.2012.02212.x.

Gazioğlu, C., A.E. Müftüoğlu, V. Demir, A. Aksu, and V. Okutan. 2015. Connection between ocean acidification and sound propagation. International Journal of Environment and Geoinformatics 2(2).

Gearhart II, R., D. Jones, A. Borgens, S. Laurence, T. DeMunda, and J. Shipp. 2011. Impacts of recent hurricane activity in historic shipwrecks in the Gulf of Mexico outer continental shelf. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation and Enforcement, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study BOEMRE 2011-003.

Gentner Consulting Group. 2010. Economic impacts of recreational fishing closures resulting from the Deepwater Horizon oil spill: Preliminary estimates.

Gentner, B. and S. Steinback. 2008. The economic contribution of marine angler expenditures in the United States, 2006. NOAA Technical Memorandum NMFS-F/SPO-94.

Geological Survey of Alabama. 1998. Governor's report: Options for development of potential natural gas reserves from central Gulf of Mexico, Mobile Area Blocks 826 and 829.

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. 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. 274 pp.

Geraci J.R. and D.J. St. Aubin. 1983. Effects of outer continental shelf oil and gas development on marine mammals and reptiles. Wildlife Section Dept. of Pathology, Ontario Veterinary College Draft Technical Report. 57 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. and D.J. St. Aubin, eds. 1990. Sea mammals and oil: Confronting the risks. San Diego, CA: Academic Press, Inc. 282 pp.

Geraci, J.R., D.J. St. Aubin, and R.J. Reisman. 1983. Bottlenose dolphins, *Tursiops truncatus*, can detect oil. Canadian Journal of Fisheries and Aquatic Science 40(9):1,515-1,522.

Gero, S., J. Gordon, C. Carlson, P. Evans, and H. Whitehead. 2007. Population estimate and inter-island movement of sperm whales, *Physeter macrocephalus*, in the eastern Caribbean Sea. Journal of Cetacean Research and Management 9(2):143-150.

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 105:3,575-3,583.

Getter, C.D., G. Cintron, B. Kicks, R.R. Lewis III, and E.D. Seneca. 1984. The recovery and restoration of salt marshes and mangroves following an oil spill. In: Cairn, J., Jr. and A.L. Buikema, Jr., eds. Restoration of habitats impacted by oil spills. Boston, MA: Butterworth Publishers, Ann Arbor Science Book. Pp. 65-104.

Gilmore, M.D. and B.R. Hall. 1976. Life history, growth habits, and constructional roles of *Acropora cervicornis* in the patch reef environment. Journal of Sediment Petrology 46:519-522.

Gitschlag, G.R. and B.A. Herczeg. 1994. Sea turtle observations at explosive removals of energy structures. Marine Fisheries Review 56(2):1-8.

Gitschlag, G., M. Schirripa, and J. Powers. 2001. Estimation of fisheries impacts due to underwater explosives used to sever and salvage oil and gas platforms in the U.S. Gulf of Mexico. Prepared under Interagency Agreement Number 17912 between the U.S. Dept. of the Interior, Minerals Management Service and the U.S. Dept. of Commerce, National Marine Fisheries Service.

Gittings, S.R., G.S. Boland, K.J.P. Deslarzes, D.K. Hagman, and B.S. Holland. 1992a. Long-term monitoring at the East and West Flower Garden Banks. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 92-0006. 206 pp.

Gittings, S.R., T.J. Bright, W.W. Schroeder, W.W. Sager, J.S. Laswell, and R. Rezak. 1992b. Invertebrate assemblages and ecological controls on topographic features in the northeast Gulf of Mexico. Bulletin of Marine Science 50(3):435-455.

Gochfeld, M., J. Burger, and I.C. Nisbet. 1998. Roseate tern (*Sterna dougallii*). In: Poole, A., ed. The birds of North America online. Number 370. Cornell Lab of Ornithology, Ithaca, NY. doi:10.2173/bna.370. Internet website: http://bna.birds.cornell.edu/bna/species/370. Accessed April 23, 2012.

Goldberg, W.M. 1973. The ecology of the coral-octocoral communities off the southeast Florida coast: geomorphology, species composition, and zonation. Bulletin of Marine Science 23(3):465-488.

Good, B., J. Buchtel, D. Meffert, J. Radford, K. Rhinehart, and R. Wilson. 1995. Louisiana's major coastal navigation channels. Louisiana Dept. of Natural Resources, Baton Rouge, LA. 35 pp. Internet website: http://www.ocpr.louisiana.gov/crm/D%20R%20S%20Reports/General/La.%20Navigation%20Channels/Channels_1.pdf.

Goodbody-Gringley, G., R.M. Woollacott, and G. Giribet. 2012. Population structure and connectivity in the Atlantic scleractinian coral *Montastraea cavernosa* (Linnaeus, 1767). Marine Ecology 33:32-48.

Goodbody-Gringley G, D.L. Wetzel, D. Gillon, E. Pulster, A. Miller, and K.B. Ritchie. 2013. Toxicity of *Deepwater Horizon* source oil and the chemical dispersant, CorexitH 9500, to coral larvae. PLOS ONE 8(1):e45574. doi:10.1371/journal.pone.0045574.

Goodyear, A.C. 2005. Evidence for pre-Clovis sites in the eastern United States. In: Bonnichsen, R., B.T. Lepper, D. Stanford, and M.R. Waters, eds. Paleoamerican origins: Beyond Clovis. College Station, TX: Center for the Study of the First Americans, distributed by Texas A&M University Press. Pp. 103-112.

Goold, J.C. and S.E. Jones. 1995. Time and frequency domain characteristics of sperm whale clicks. Journal of the Acoustical Society of America 98:1279-1291.

Gordon, J. and A. Moscrop. 1996. Underwater noise pollution and its significance for whales and dolphins. In: Simmonds, M.P. and J.D. Hutchinson, eds. The conversation of whales and dolphins. New York, NY: John Wiley and Sons. Pp. 281-319.

Gore, R.H. 1992. The Gulf of Mexico. Sarasota, FL: Pineapple Press.

Gore, J. and T. Schaeffer. 1993. Santa Rosa beach mouse survey final performance report. 21 pp.

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 Service. FWS/OBS-78/9 through 78/11.

Gould, D.W., J.L. Teich, M.R. Pemberton, C. Pierannunzi, and S. Larson. 2015. Behavioral health in the Gulf Coast region following the Deepwater Horizon oil spill: Findings from two Federal surveys. Journal of Behavioral Health Services & Research 42(1):6-22.

Govoni, J.J., M.A. West, L.R. Settle, R.T. Lynch, and M.D. Greene. 2008. Effects of underwater explosions on larval fish: implications for a coastal engineering project. Journal of Coastal Research 24(2B):228-233.

Gower, J. and S. King. 2008. Satellite images show the movement of floating *Sargassum* in the Gulf of Mexico and Atlantic Ocean. Nature Proceedings, hdl:10101/npre.2008.1894.1.

Gower, J.F.R. and S.A. King. 2011. Distribution of floating *Sargassum* in the Gulf of Mexico and the Atlantic Ocean mapped using MERIS. International Journal of Remote Sensing, 32(7):1917-1929

Gower, J., C. Hu, G. Borstad, and S. King. 2006. Ocean color satellites show extensive lines of floating *Sargassum* in the Gulf of Mexico. IEEE Transactions on Geoscience and Remote Sensing 44(12):3619-3625.

Gower, J., E. Young, and S. King. 2013. Satellite images suggest a new *Sargassum* source region in 2011. Remote Sensing Letters 4:764-773.

Gramentz, D. 1988. Involvement of loggerhead turtle with the plastic, metal, and hydrocarbon pollution in the central Mediterranean. Marine Pollution Bulletin 19:11-13.

Gramling, R. 1984. Housing in the coastal zone parishes. In: Gramling, R.B. and S. Brabant, eds. The role of outer continental shelf oil and gas activities in the growth and modification of Louisiana's coastal zone. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration; Louisiana Dept. of Natural Resources, Lafayette, LA. Interagency Agreement NA-83-AA-D-CZ025; 21920-84-02. Pp. 127-134.

Gratten, L., S. Roberts, W.T. Mahan Jr., P.K. McLaughlin, W.S. Otwell, and J.G. Morris. 2011. The early psychological impacts of the Deepwater Horizon oil spill on Florida and Alabama communities. Environmental Health Perspectives 119:838-843.

Gratto-Trevor, C., D. Amirault-Langlais, D. Catlin, F. Cuthbert, J. Fraser, S. Maddock, E. Roche, and F. Shaffer. 2009. Winter distribution of four different piping plover breeding populations. Report to U.S. Dept. of the Interior, Fish and Wildlife Service.

Gray, J. 2002. Biomagnification in marine systems: The perspective of an ecologist. Marine Pollution Bulletin 45:46-52.

Gray, S.M., L.J. Chapman, and N.E. Mandrak. 2012. Turbidity reduces hatching success in threatened spotted gar (*Lepisosteus oculatus*). Environmental Biology of Fishes 75(4):1-6.

Greater New Orleans, Inc. 2011. A study of the economic impact of the Deepwater Horizon oil spill. 144 pp.

Green S.J., J.L. Akins, A. Maljković, and I.M. Côté. 2012. Invasive lionfish drive Atlantic coral reef fish declines. PLOS ONE 7:e32596. doi:10.1371/journal.pone.0032596.

Greene, C.M., K. Blackhart, J. Nohner, A. Candelmo, and D.M. Nelson. 2014. A national assessment of stressors to estuarine fish habitats in the contiguous USA. Estuaries and Coasts 38(3):782-799.

Groom, M.J. and M.A. Pascual. 1998**.** The analysis of population persistence: An outlook on the practice of viability analysis. In: Fiedler, P.L. and P.M. Kareiva, eds. Conservation biology. 2nd edition. New York, NY: Chapman and Hall. Pp. 4-27.

Gulf Coast Ecosystem Restoration Council. 2013. Final initial comprehensive plan – restoring the Gulf Coast's ecosystem and economy. Gulf Coast Ecosystem Restoration Council. 32 pp.

Gulf Coast Ecosystem Restoration Council. 2014. FY 2014 annual report to Congress. Gulf Coast Ecosystem Restoration Council. 20 pp.

Gulf Coast Ecosystem Restoration Council. 2015. Resources and ecosystems sustainability, tourist opportunities and revived economies of the Gulf Coast States Act (RESTORE Act) draft initial funded priorities list. Internet website: https://restorethegulf.gov/sites/default/files/Draft_Initial_FPL_0.pdf#overlay-context=our-work/draft-initial-funded-priorities-list-draft-fpl. Accessed November 10, 2011.

Gulf of Mexico Fishery Management Council. 1998. Generic amendment for addressing essential fish habitat requirements. Gulf of Mexico Fishery Management Council, Tampa, FL. NOAA Award No. NA87FC0003. 244 pp.

Gulf of Mexico Fishery Management Council. 2005. Generic amendment number 3 for addressing essential fish habitat requirements, habitat areas of particular concern, and adverse effects of fishing in the following fishery management plans of the Gulf of Mexico: Shrimp fishery of the Gulf of Mexico, United States waters red drum fishery of the Gulf of Mexico, reef fish fishery of the Gulf of Mexico coastal migratory pelagic resources (mackerels) in the Gulf of Mexico and South Atlantic, stone crab fishery of the Gulf of Mexico, spiny lobster in the Gulf of Mexico and South Atlantic, coral and coral reefs of the Gulf of Mexico. Gulf of Mexico Fishery Management Council, Tampa, FL. 106 pp.

Gulf of Mexico Fishery Management Council. 2010. Final report Gulf of Mexico Fishery Management Council 5-year review of the final generic amendment number 3 addressing essential fish habitat requirements, habitat areas of particular concern, and adverse effects of fishing in the fishery management plans of the Gulf of Mexico. Gulf of Mexico Fishery Management Council, Tampa, FL. 105 pp.

Gulf of Mexico Fishery Management Council. 2015. Gulf of Mexico Fishery Management Council. Internet website: http://www.gulfcouncil.org/. Accessed June 30, 2015.

Guo, W.J., Y. Hao, L. Zhang, T. Xu, X. Ren, F. Cao, and S. Wang. 2014. Development and application of an oil spill model with wave-current interactions in coastal areas. Marine Pollution Bulletin 84:213-224.

Guzmán, H.M. and I. Holst. 1993. Effects of chronic oil-sediment pollution on the reproduction of the Caribbean reef coral *Siderastrea siderea*. Marine Pollution Bulletin 26:276-282.

Guzmán-Verri, C., R. González-Barrientos, G. Hernández-Mora, J.A. Morales, E. Baquero-Calvo, E. Chaves-Olarte, and E. Moreno. 2012. Brucella ceti and brucellosis in cetaceans. Frontiers in Cellular and Infection Microbiology 2:3.

Haag, W.G. 1992. The Monte Sano site. In: Jeter, M.D., ed. Southeastern Archaeological Conference: Abstracts of the Forty-ninth Annual Meeting, Arkansas' Excelsior Hotel, October 21-24, 1992. Little Rock, AR. 18 pp.

Haig, S.M., C.L. Ferland, F.J. Cuthbert, J. Dingledine, J.P. Goossen, A. Hecht, and N. McPhillips. 2005. A complete species and evidence for regional declines in piping plovers. Journal of Wildlife Management 69:160-173.

Hale, L.F., S.J.B. Gulak, and J.K. Carlson. 2009. Characterization of the shark bottom longline fishery, 2008. U.S. Dept. of Commerce, National Marine Fisheries Service, Southeast Fisheries Science Center, Panama City, FL. NOAA Technical Memorandum NMFS-SEFC-586.

Hall, R.J., A.A. Belisle, and L. Sileo. 1983. Residues of petroleum hydrocarbons in tissues of sea turtles exposed to the *Ixtoc I* oil spill. Journal of Wildlife Diseases 19(2):106-109.

Halligan, J.J., M.R. Waters, A. Perrotti, I.J. Owens, J.M. Feinburg, M.D. Bourne, B. Fenetry, B. Winsborough, D. Carlson, D.C. Fisher, T.W. Stafford Jr., and J.S. Dunbar. 2016. Pre-Clovis occupation 14,550 years ago at the Page-Ladson site, Florida, and the peopling of the Americas. May 13, 2016. Science Advances 2(5):e1600375. doi:10.1126/sciadv.1600375.

Hamilton, P. and A. Lugo-Fernandez. 2001. Observations of high speed deep currents in the northern Gulf of Mexico. Geophysical Research Letters 28:2767-2870.

Hamilton, P., J.J. Singer, E. Waddell, and K. Donuhue. 2003. Deepwater observations in the northern Gulf of Mexico from in-situ current meters and PIES: Final report. Volume II: Technical report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2003-049. 95 pp.

Handley, D.A., D. Altsman, and R. DeMay, eds. 2007. Seagrass status and trends in the northern Gulf of Mexico: 1940-2002. U.S. Dept. of the Interior, Geological Survey Scientific Investigations Report 2006-5287 and U.S. Environmental Protection Agency 855-R-04-003. Internet website: http://pubs.usgs.gov/sir/2006/5287/.

Haney, J.C. 1986. Seabird patchiness in tropical oceanic waters: The influence of *Sargassum* "reefs." Auk 103:141-151.

Haney, J.C., H.J. Geiger, and J.W. Short. 2014a. Bird mortality from the *Deepwater Horizon* oil spill. I. Exposure probability in the offshore Gulf of Mexico. Marine Ecology Progress Series 513:225-237.

Haney, J.C., H.J. Geiger, and J.W. Short. 2014b. Bird mortality from the *Deepwater Horizon* oil spill. II. Carcass sampling and exposure probability in the coastal Gulf of Mexico. Marine Ecology Progress Series 513:239-252.

Hansel, T.D., H.J. Osofsky, J.D.Osofsky, and A. Speier. 2015. Longer-term mental and behavioral health effects of the Deepwater Horizon Gulf oil spill. Journal of Marine Science and Engineering 3(4):1260-1271. doi:10.3390/jmse3041260.

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.

Hansen, J., M. Sato, P. Hearty, R. Ruedy, M. Kelley, V. Masson-Delmotte, G. Russell, G. Tselioudis, J. Cao, E. Rignot, I. Velicogna, B. Tormey, B. Donovan, E. Kandiano, K. von Schuckmann, P. Kharecha, A.N. Legrande, M. Bauer, and K. Lo. 2016. Ice melt, sea level rise and superstorms: Evidence from paleoclimate data, climate modeling, and modern observations that 2 °C global warming could be dangerous. Atmospheric Chemistry and Physics 16:3761-3812.

Hart, A.D., K.D. Spring, J.M. Brooks, B.J. Presley, and B.A. Vittor. 1989. Fate and effects of drilling fluid and cutting discharges in shallow, nearshore waters. Washington, DC: American Petroleum Institute.

Hart, K.M., D.G. Zawada, I. Fujisaki, and B.H. Lidz. 2010. Inter-nesting habitat-use patterns of loggerhead sea turtles: Enhancing satellite tracking with benthic mapping. Aquatic Biology 11(1):77-90.

Hart, K.M., M.M. Lamont, I. Fujisaki, A.D. Tucker, and R.R. Carthy. 2012. Common coastal foraging areas for loggerheads in the Gulf of Mexico: Opportunities for marine conservation. Biological Conservation 145(1):185-194.

Hart, K.M., D.G. Zawada, I. Fujisaki, and B.H. Lidz. 2013a. Habitat use of breeding green sea turtles *Chelonia mydas* tagged in Dry Tortugas National Park: Making use of local and regional MPAs. Biological Conservation 161(2013):142-154.

Hart, K.M., M.M. Lamont, A.R. Sartain, I. Fujisaki, and B.S. Stephens. 2013b. Movements and habitat-use of loggerhead sea turtles in the northern Gulf of Mexico during the reproductive period. PLOS ONE 8(7):e66921. doi:10.1371/journal.pone.0066921.

Hartman, D.D. 1979. Ecology and behavior of the manatee (*Trichechus manatus*) in Florida. American Society of Mammalogists Special Publication No. 5.

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.

Hausfather, Z. 2013. IPCC's new estimates for increased sea-level rise. Internet website: http://www.yaleclimateconnections.org/2013/10/ipccs-new-estimates-for-increased-sea-level-rise/. Posted October 23, 2013. Accessed July 2, 2014.

Hawkins, A.D., A.E. Pembroke, and A.N. Popper. 2014. Information gaps in understanding the effects of noise on fishes and invertebrates. Reviews in Fish Biology and Fisheries 25(1):39-64.

Hayes, M.O., D.D. Domeracki, C.D. Getter, T.W. Kana, and G.I. Scott. 1980. Sensitivity of coastal environments to spilled oil, south Texas coast. Research Planning Institute, Inc. Report No. RPI/R/80/4/11-12. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Office of Marine Pollution Assessment, Columbia, SC. 89 pp.

Hayworth, J.S., T.P. Clement, and J.F. Valentine. 2011. *Deepwater Horizon* oil spill impacts on Alabama beaches. Hydrology and Earth System Sciences 15(12):3639.

Heck, K.L., G. Hays, and R.J. Orth. 2003. Critical evaluation of the nursery role hypothesis for seagrass meadows. Marine Ecology Progress Series 253:123-136.

Heck, K.L., Jr., J.F. Valentine, J.R. Pennock, G. Chaplin, and P.M. Spitzer. 2006. Effects of nutrient enrichment and grazing on shoalgrass *Halodule wrightii* and its epiphytes: Results of a field experiment. Marine Ecology Progress Series 326:145-156. Internet website: http://www.int-res.com/articles/meps2006/326/m326p145.pdf.

Helicopter Safety Advisory Conference, 2010. Offshore (VFR) operating altitudes for helicopters. Internet website: http://www.hsac.org/portals/45/rp/rp93_1new.pdf. Accessed November 6, 2015.

Helicopter Safety Advisory Conference. 2015. 2014 Helicopter Safety Advisory Conference (HSAC) Gulf of Mexico offshore helicopter operations and safety review. Internet website: http://hsac.org/portals/45/HSAC_2014_Report.pdf. Updated April 19, 2015. Accessed September 10, 2015.

Helix Well Containment Group. 2015. Our response system and capabilities. Internet website: http://www.hwcg.org/responsesystem/. Accessed June 11, 2015.

Hemmerling, S.A. and C.E. Colten. 2003. Environmental justice considerations in Lafourche Parish, Louisiana. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2003-038. 354 pp.

Henkel, J.R., B.J. Sigel, and C.M. Taylor. 2014. Oiling rates and condition indices of shorebirds on the northern Gulf of Mexico following the *Deepwater Horizon* oil spill. Journal of Field Ornithology 85:408-420.

Hennige, S.J., L.C. Wicks, N.A. Kamenos, G. Perna, H.S. Findlay, and J.M. Roberts. 2015. Hidden impacts of ocean acidification to live and dead coral framework. Proceedings of the Royal Society of London B 282:20150990.

Henriksen, J., M. Warwick, R. Munger, and S. Kay. 2015. Engineering analysis of turtle exclusion device. Proceedings of Western Dredging Association and Texas A&M University Center for Dredging Studies. Dredging Summit and Expo 2015, Houston, TX, USA, June 22-25, 2015.

Herbst, L.H. 1994. Fibropapillomatosis in marine turtles. Annual Review of Fish Diseases 4:389-425.

Herbst, L. 2014. Effective well control-prevention and response. U.S. Dept. of the Interir, Bureau of Safety and Environmental Enforcement, Gulf of Mexico OCS Region, New Orleans, LA. 25 slides.

Hernandez, F.J., Jr., R.F. Shaw, J.C. Cope, J.G. Ditty, M.C. Benfield, and T. Farooqi. 2001. Across-shelf larval, postlarval, and juvenile fish communities collected at offshore oil and gas platforms and a coastal rock jetty west of the Mississippi River Delta. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2001-077. 144 pp.

Hernández-Mora, G., J.D. Palacios-Alfaro, and R. Gonzalez-Barrientos. 2013. Wildlife reservoirs of brucellosis: Brucella in aquatic environments. Scientific and Technical Review OIE 32(1):89-103.

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.

Hickerson, E.L., G.P. Schmahl, M. Robbart, B. Precht, and C. Caldow. 2008. The state of coral reef ecosystems of the Flower Garden Banks, Stetson Bank, and other banks in the northwestern Gulf of Mexico. In: Waddell, J.E. and A.M. Clarke, eds. State of coral reef ecosystems of the United States and Pacific freely associated states: 2008. NOAA Technical Memorandum NOS-NCCOS 73. Pp. 189-218.

Hiett, R.L. and J.W. Milon. 2002. Economic impact of recreational fishing and diving associated with offshore oil and gas structures in the Gulf of Mexico: Final report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2002-010. 98 pp.

Hildebrand, J.A. 2009. Anthropogenic and natural sources of ambient noise in the ocean. Marine Ecology Progress Series 395:5-20. Internet website: http://www.int-res.com/articles/theme/m395p005.pdf.

Hillestad, H.O., J.I. Richardson, C. McVea, Jr., and J.M. Watson, Jr. 1982. Worldwide incidental capture of sea turtles. In: Bjorndal, K.A., ed. Biology and conservation of sea turtles. Washington, DC: Smithsonian Institution Press. Pp. 489-495.

Hine, A.C., R.B. Halley, S.D. Locker, B.D. Jarrett, W.C. Jaap, D.J. Mallinson, K.T. Ciembronowicz, N.B. Ogden, B.T. Donahue, and D.F. Naar. 2008. Coral reefs, present and past, on the West Florida shelf and platform margin. In: Riegl, B.M. and R.E. Dodge, eds. Coral reefs of the USA. Dordrecht: Springer. Pp. 127-173.

Hoff, R.Z. and G. Shigenaka. 2003. Response consideration for sea turtles. In: Shigenaka, G., ed. Oil and sea turtles: Biology, planning, and response. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Office of Response and Restoration. P. 49.

Hoffman, G.E., J.P. Barry, P.J. Edmunds, R.D. Gates, D.A. Hutchins, T. Klinger, and M.A. Sewell. 2010. The effect of ocean acidification on calcifying organisms in marine ecosystems: An organism-to-ecosystem perspective. Annual Review of Ecology, Evolution, and Systematics 41:127-47. doi:10.1146/annurev.ecolsys.110308.120227.

Holeywell, R. 2014. Fuelfix: Time may be coming for subsea well replacements. Internet website: http://fuelfix.com/blog/2014/05/08/time-may-be-coming-for-subsea-well-replacements/. Accessed October 6, 2015.

Hönisch, B., N.G. Hemming, D. Archer, M. Siddall, and J.F. McManus. 2009. Atmospheric carbon dioxide concentration across the mid-Pleistocene transition. Science 324(5934):1551-1554. Internet website: http://128.135.10.93/~archer/reprints/honisch.2009.mid_pleist_co2.pdf.

Horel, A., B. Mortazavi, and P.A. Sobecky. 2012. Seasonal monitoring of hydrocarbon degraders in Alabama marine ecosystems following the *Deepwater Horizon* oil spill. Water, Air, & Soil Pollution 223(6):3145-3154. doi:10.1007/s11270-012-1097-5.

Houde, M., R.S. Wells, P.A. Fair, G.D. Bossart, A.A. Hohn, T.K. Rowles, J.C. Sweetney, K.R. Solomon, and D.C.G. Muir. 2005. Polyfluoroalkyl compounds in free-ranging bottlenose dolphins (*Tursiops truncatus*) from the Gulf of Mexico and the Atlantic Ocean. Environmental Science & Technology 39:6591-6598.

Hourigan, T.F. 2014. A strategic approach to address fisheries impacts on deep-sea coral ecosystems. In: Bortone, S.A., ed. Interrelationships between corals and fisheries. Boca Raton, FL: CRC Press. 321 pp.

Houser, C., P. Wemette, E. Rentschlar, H. Jones, B. Hammond, and S. Trimble. 2015. Post-storm beach and dune recovery: Implications for barrier island resilience. Geomorphology 234(April 1, 2015):54-63.

Howard, R.K. and F.T. Short. 1986. Seagrass growth and survivorship under the influence of epiphyte grazers. Aquatic Botany 24(3):287-302.

Hsing, P.-Y., B. Fu, E.A. Larcom, S.P. Berlet, T.M. Shank, A.G. Govindarajan, A.J. Lukasiewicz, P.M. Dixon, and C.R. Fisher. 2013. Evidence of lasting impact of the Deepwater Horizon oil spill on a deep Gulf of Mexico coral community. Elementa: Science of the Anthropocene 1:000012. 15 pp.

Hudson, J.H. and D.M. Robbin. 1980. Effects of drilling mud on the growth rate of reef-building coral, *Montastraea annularis*. The R&D Program for OCS Oil and Gas Operations. U.S. Dept. of the Interior, Geological Survey, Fisher Island Station, Miami Beach, FL.

Hudson, J.H., E.A. Shinn, and D.M. Robbin. 1982. Effects of offshore oil drilling on Philippine reef corals. Bulletin of Marine Science 32(4):890-908.

Huffard, C.L., S. Thun, A.D. Sherman, K. Sealy, and K.L. Smith, Jr. 2014. Pelagic *Sargassum* community change over a 40-year period: temporal and spatial variability. Marine Biology 161:2735-2751.

Humphrey, S.R. and D.B. Barbour. 1981. Status and habitat of three subspecies of *Peromyscus polionotus* in Florida. J. Mammal. 62(4):840-844.

Hunter, W.C., W. Golder, S. Melvin, and J. Wheeler. 2006. Southeast United States regional waterbird conservation plan. U.S. Department of the Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Atlanta, GA, USA. 134 pp. Internet website: http://www.pwrc.usgs.gov/nacwcp/pdfs/regional/seusplanfinal906.pdf. Accessed January 20, 2011.

Huntington, H.P. and S.E. Moore. 2008. Arctic marine mammals and climate change. Ecological Applications 18(2)(supplement):S1-174.

Hurka, M. 1971. Factors influencing the gas composition in the vesicles of *Sargassum*. Marine Biology 11:82-89.

Hutchinson, J. and M. Simmonds. 1991. A review of the effects of pollution on marine turtles. Greenpeace International. 27 pp.

Hyne, N.J. 2012. Nontechnical guide to petroleum geology, exploration, drilling, and production. 3rd ed. Tulsa, OK: PenWell Corporation.

IMPLAN Group, LLC. 2015. 2013 county dataset.

Incardona, J.P., L.D. Gardner, T.L. Linbo, T.L. Brown, A.J. Esbaugh, E.M. Mager, J.D. Stieglitz, B.L. French, J.S. Labenia, C.A. Laetz, M. Tagal, C.A. Sloan, A. Elizur, D.D. Bennetti, M. Grosell, B.A. Block, and N.L. Scholz. 2014. *Deepwater Horizon* crude oil impacts the developing hearts of large predatory pelagic fish. Proceedings of the National Academy of Sciences 111(15):E1510-E1518.

Industrial Economics, Inc. 2015a. Estimating the offshore mortality of birds killed by DWH oil. Deepwater Horizon/Mississippi Canyon 252 oil spill Natural Resource Damage Assessment technical report. Prepared for the Deepwater Horizon Natural Resource Damage Assessment and Restoration Program and U.S. Dept. of the Interior, Fish and Wildlife Service. August 31, 2015. Internet website: https://pub-dwhdatadiver.orr.noaa.gov/dwh-ar-documents/788/DWH-AR0011784.pdf. Accessed July 8, 2016.

Industrial Economics, Inc. 2015b. Quantification of nearshore avian mortality using the shoreline deposition model and lost at sea factor. Deepwater Horizon/Mississippi Canyon 252 oil spill Natural Resource Damage Assessment technical report. Prepared for the Deepwater Horizon Natural Resource Damage Assessment and Restoration Program and U.S. Dept. of the Interior, Fish and Wildlife Service. September 3, 2015. Internet website: https://pub-dwhdatadiver.orr.noaa.gov/dwh-ar-documents/788/DWH-AR0279240.pdf. Accessed December 30, 2015.

Industrial Economics, Inc., Applied Science Associates, Inc., Northern Economics, N.Z. Muller, and SC&A, Inc. 2015. Forecasting environmental and social externalities associated with OCS oil and gas development. Volume 1: The 2015 revised offshore environmental cost model (OECM). U.S. Dept. of the Interior, Bureau of Ocean Energy Management. OCS Study BOEM 2015-052. 333 pp.

Ingalls Shipbuilding. 2015. Ingalls shipbuilding facilities. Internet website: http://ingalls.huntingtoningalls.com/about/facilities. Accessed September 25, 2015.

Inoue, M., S.E. Welsh, L.J. Rouse, Jr., and E. Weeks. 2008. Deepwater currents in the eastern Gulf of Mexico: Observations at 25.5ºN and 87ºW. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2008-001. 95 pp.

Intergovernmental Panel on Climate Change (IPCC). 2012. Managing the risks of extreme events and disasters to advance climate change adaptation. A special report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Cambridge, UK, and New York, NY: Cambridge University Press. 582 pp. Internet website: http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4_wg1_full_report.pdf.

Intergovernmental Panel on Climate Change (IPCC). 2014. Climate change 2014 synthesis report summary for policymakers. Internet website: http://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf.

Intergovernmental Panel on Climate Change (IPCC). 2016. Fifth assessment report (AR5). Internet website: http://www.ipcc.ch/. Accessed March 8, 2016.

International Association of Oil and Gas Producers. 2003. Environmental aspects of the use and disposal of non aqueous drilling fluids associated with offshore oil and gas operations. Report No. 342. 105 pp. Internet website: http://www.ogp.org.uk/pubs/342.pdf.

International Energy Agency. 2016. Oil market report: October 2016. Internet website: https://www.iea.org/oilmarketreport/omrpublic/currentreport/. Accessed November 14, 2016.

International Tanker Owners Pollution Federation Limited (ITOPF). 2002. Fate of marine oil spills. Technical Information Paper. London, UK. 8 pp. Internet website: http://www.itopf.com/_assets/documents/tip2.pdf. Accessed December 2, 2010.

International Tanker Owners Pollution Federation Limited (ITOPF). 2010. Containment and recovery. Internet website: http://www.itopf.com/spill-response/clean-up-and-response/containment-and-recovery/. Accessed December 23, 2010.

International Whaling Commission. 1997. Report of the IWC workshop on climate change and cetaceans. Report of the International Whaling Commission 47:293-313.

International Whaling Commission. 2009. Report of the IWC workshop on cetaceans and climate change. Report of the International Whaling Commission 61(4):1-31.

Irion, J.B. and R.J. Anuskiewicz. 1999. MMS seafloor monitoring project: First annual technical report, 1997 field season. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico Region, New Orleans, LA. OCS Report MMS 99-0014. 63 pp.

Irion, J.B. and D.A. Ball. 2001. The *New York* and the *Josephine*: Two steamships of the Charles Morgan Line. International Journal of Nautical Archaeology 30(1):48-56.

Irvine, G. 2000. Persistence of spilled oil on shores and its effects on biota. In: Seas at the millennium: An environmental evaluation. Volume III: Global issues and processes. Elsevier Science Ltd.

Jaap, W.C. 1984. The ecology of south Florida coral reefs: A community profile. U.S. Dept. of the Interior, Fish and Wildlife Service. FWS/OBS-82/08.

Jaap, W.C. 2015. Stony coral (Milleporidae and Scleractinia) communities in the eastern Gulf of Mexico: A synopsis with insights from the Hourglass collections. Bulletin of Marine Science 91(2):207-253. Internet website: http://dx.doi.org/10.5343/bms.2014.1049.

Jackson, L.E., J.C. Kurtz, and W.S. Fisher. 2000. Evaluation guidelines for ecological indicators. U.S. Environmental Protection Agency, Research Triangle Park, NC. EPA/620/R-99/005. Internet website: http://www.epa.gov/emap/html/pubs/docs/resdocs/ecol_ind.pdf.

Jacobson, E.R. 1990. An update on green turtle fibropapilloma. Marine Turtle Newsletter 49:7-8.

Jacobson, E.R., S.B. Simpson, Jr., and J.P. Sundberg. 1991. Fibropapillomas in green turtles. In: Balazs, G.H. and S.G. Pooley, eds. Research plan for marine turtle fibropapilloma. NOAA Technical Memorandum NMFS-SWFSC-156. Pp. 99-100.

Jacobsen J.K., L. Massey L., and F. Gulland. 2010. Fatal ingestion of floating net debris by two sperm whales (*Physeter macrocephalus*). Marine Pollution Bulletin 60(5):765-767.

Jaquet, N. 2006. A simple photogrammetric technique to measure sperm whales at sea. Marine Mammal Science 22(4):862-879.

Jasny, M. 1999. Sounding the depths: Supertankers, sonar and the rise of undersea noise. Natural Resources Defense Council. 75 pp.

Jefferson, T.A. and A.J. Schiro. 1997. Distributions of cetaceans in the offshore Gulf of Mexico. Mammal Review 27(1):27-50.

Jefferson, T.A., S. Leatherwood, L.K.M. Shoda, and R.L. Pitman. 1992. Marine mammals of the Gulf of Mexico: A field guide for aerial and shipboard observers. Texas A&M University Printing Center, College Station, TX. 92 pp.

Jefferson, T.A., S. Leatherwood, and M.A. Webber. 1993. FAO species identification guide, marine mammals of the world. Food and Agriculture Organization of the United Nations, Rome, Italy. 320 pp.

Jefferson, T.A., M.A. Webber, and R.L. Pitman. 2008. Marine mammals of the world: A comprehensive guide to their identification. Amsterdam Elsevier. Pp. 112-115.

Jenkins, C. 2011. Dominant bottom types and habitats in the Gulf of Mexico Data Atlas. Stennis Space Center, MS: National Coastal Data Development Center. Internet website: http://gulfatlas.noaa.gov/. Accessed July 29, 2015.

Jervis, R. 2015. Plunging oil prices, Gulf on brink of boom. USA Today. Internet website: http://www.usatoday.com/story/money/markets/2015/01/06/deep-water-oil-production-gulf/20752155/. Accessed August 20, 2015.

Ji, Z-G., W.R. Johnson, and G.L. Wikel. 2014. Statistics of extremes in oil spill risk analysis. Environmental Scientific Technology 48(17):10505-10510. doi:10.1021/es501515j.

Jochens, A.E., L.C. Bender, S.F. Di Marco, J.W. Morse, M.C. Kennicutt II, M.K. Howard, and W.D. Nowlin, Jr. 2005. Understanding the processes that maintain the oxygen levels in the deep Gulf of Mexico. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2005-032. 129 pp.

Jochens, A., D. Biggs, K. Benoit-Bird, D. Engelhaupt, J. Gordon, C. Hu, N. Jaquet, M. Johnson, R. Leben, B. Mate, P. Miller, J. Ortega-Ortiz, A. Thode, P. Tyack, and B. Würsig. 2008. Sperm whale seismic study in the Gulf of Mexico: Synthesis report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2008-006. 341 pp.

Johansen, O., H. Rye, and C. Cooper. 2001. DeepSpill JIP—field study of simulated oil and gas blowouts in deep water. In: Proceedings from the Fifth International Marine Environment Modeling Seminar, October 9-11, 2001, New Orleans, LA. 377 pp.

Johnson, S. and M. Ziccardi. 2006. Marine mammal oil spill response guidelines. U.S. Dept. of Commerce, National Marine Fisheries Service Guidance Document.

Johnson, S.A., K.A. Bjorndal, and A.B. Bolten. 1996. Effects of organized turtle watches on loggerhead (*Caretta caretta*) nesting behavior and hatchling production in Florida. Conservation Biology 10(2):570-577.

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.

Johnston, J.B., D.R. Cahoon, and M.K. La Peyre. 2009. Outer continental shelf (OCS)-related pipelines and navigation canals in the Western and Central Gulf of Mexico: Relative impacts on wetland habitats and effectiveness of mitigation. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2009-048. 200 pp.

Johnston, M.A., M.F. Nuttall, R.J. Eckert, J.A. Embesi, N.C. Slowey, E.L. Hickerson, and G.P. Schmahl. 2013. Long-term monitoring at the East and West Flower Garden Banks National Marine Sanctuary, 2009-2010. Volume 1: Technical report. U.S. Dept. of Interior, Bureau of Ocean Energy Management, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study BOEM 2013-214. 219 pp.

Johnston, M.A., M.F. Nuttall, R.J. Eckert, J.A. Embesi, N.C. Slowey, E.L. Hickerson, and G.P. Schmahl. 2015. Long-term monitoring at East and West Flower Garden Banks National Marine Sanctuary, 2011-2012. Volume 1: Technical report. U.S. Dept. of Interior, Bureau of Ocean Energy Management, Gulf of Mexico OCS Region, New Orleans, Louisiana. OCS Study BOEM 2015-027. 194 pp.

Johnston, M.A., J.A. Embesi, R.J. Eckert, M.F. Nuttall, E.L. Hickerson, and G.P. Schmahl. 2016. Persistence of coral assemblages at East and West Flower Garden Banks, Gulf of Mexico. Coral Reefs 35(2016):821-826.

Joint Analysis Group. 2010. Review of R/V *Brooks McCall* data to examine subsurface oil. Internet website: http://www.noaa.gov/sciencemissions/PDFs/JAG_Report_1_BrooksMcCall_Final_June20.pdf. Accessed October 14, 2010.

Jönsson, M., L. Ranåker, P.A. Nilsson, and C. Brönmark. 2013. Foraging efficiency and prey selectivity in a visual predator: Differential effects of turbid and humic water. Canadian Journal of Fisheries and Aquatic Sciences 70(12):1685-1690.

Jordan, S.J., T. O'Higgins, and J.A. Dittmar. 2012. Ecosystem services of coastal habitats and fisheries: Multiscale ecological and economic models in support of ecosystem-based management. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 4:573-586.

Judy, C.R., S.A. Graham, Q. Lin, A. Hou, and I.A. Mendelssohn. 2014. Impacts of Macondo oil from *Deepwater Horizon* spill on the growth response of the common reed *Phragmites australis*: A mesocosm study. Marine Pollution Bulletin 79(1):69-76.

Kaiser, M.J. 2010. An integrated systems framework for service vessel forecasting in the Gulf of Mexico. Energy 35: 2777-2795.

Kaiser, M.J. 2015a. Hurricane clean-up activity in the Gulf of Mexico, 2004-2013. Marine Policy 51:512-526.

Kaiser, M.J. 2015b. Offshore service vessel activity forecast and regulatory modeling in the U.S. Gulf of Mexico, 2012-2017. Marine Policy 57:132-146.

Kaiser, M.J., B. Snyder, and A.G. Pulsipher. 2013. Offshore drilling industry and rig construction market in the Gulf of Mexico. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study BOEM 2013-0112. 375 pp.

Kang, X., G. Hagood, C. Childers, J. Atkins, B. Rogers, L. Ware, K. Armburst, J. Jewell, D. Diaz, N. Gatian, and H. Folmer. 2012. Polycyclic aromatic hydrocarbons (PAHs) in Mississippi seafood from areas affected by the Deepwater Horizon oil spill. Environmental Science and Technology 46:5310-5318.

Kaplan, M.F., A Laughland, and J. Mott. 2011. OCS-related infrastructure fact book. Volume 2: Communities in the Gulf of Mexico. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study BOEM 2011-044. 163 pp.

Karl, T.R., J.M. Melillo, and T.C. Peterson, eds. 2009. Global climate change impacts in the United States. New York, NY: Cambridge University Press. 180 pp. Internet website: http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf.

Kaschner, K., D.P. Tittensor, J. Ready, T. Gerrodette, and B. Worm. 2011. Current and future patterns of global marine mammal biodiversity. PLOS ONE 6(5):e19653. doi:10.1371/journal.pone.0019653.

Keenan, S.F., M.C. Benfield, and J. K. Blackburn. 2007. Importance of the artificial light field around offshore petroleum platforms for the associated fish community. Marine Ecology Progress Series 311:219-231.

Keevin, T.M. and G.L. Hempen. 1997. The environmental effects of underwater explosions with methods to mitigate impacts. U.S. Dept. of the Army, Corps of Engineers, St Louis District, St. Louis, MO. 99 pp.

Kemball-Cook S., A. Bar-Ilan, J. Grant, L. Parker, J. Jung, W. Santamaria, J. Mathews, and G. Yarwood. 2010. Ozone impacts of natural gas development in the Haynesville shale. Environmental Science and Technology 44(24):9357-9363.

Kemp, W.M. 1989. Estuarine seagrasses. In: Day, J.W., Jr., C.A.S. Hall, W.M. Kemp, and A. Yanez-Arancibia, eds. Estuarine ecology. New York, NY: John Wiley & Sons. 558 pp.

Kendall, J.J. and G. Rainey. 1991. Produced waters: Findings of recent studies in the coastal waters of Louisiana; session introduction. In: Geo-Marine, Inc., comp. Proceedings: Eleventh Annual Gulf of Mexico Information Transfer Meeting, November 1990. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 91-0040. 524 pp.

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.

Kennicutt II, M.C., P.N. Boothe, T.L. Wade, S.T. Sweet, R. Rezak, F.J. Kelly, J.M. Brooks, B.J. Presley, and D.A. Wiesenburg. 1996. Geochemical patterns in sediments near offshore production platforms. Canadian Journal of Fisheries and Aquatic Science 53:2554-2566.

Kenworthy, W.J. and M.S. Fonseca. 1996. Light requirements of seagrasses *Halodule wrightii* and *Syringodium filiforme* derived from the relationship between diffuse light attenuation and maximum depth distribution. Estuaries 19(3):740-750.

Ketten, D.R. 1998. Marine mammal auditory systems: A summary of audiometric and anatomical data and its implications for underwater acoustic impacts. NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-256.

King, B.S. and J.D. Gibbons. 2011. Health hazard evaluation of *Deepwater Horizon* response workers. Health hazard evaluation report HETA 2010-0115 & 2010-0129-3138. National

Institute for Occupational Safety and Health. Internet website: http://www.cdc.gov/niosh/hhe/reports/pdfs/2010-0115-0129-3138.pdf. Accessed August 29, 2016.

Kingston, P.F., I.M.T. Dixon, S. Hamilton, and D.C. Moore. 1995. The impact of the *Braer* oil spill on the macrobenthic infauna of the sediments off the Shetland Isles. Marine Pollution Bulletin 189:159-170.

Kinlan B.P., M. Poti, P. Etnoyer, L. Siceloff, C. Jenkins, D. Dorfman, and C. Caldow. 2013. Digital data: Predictive models of deep-sea coral habitat suitability in the Western U.S. Gulf of Mexico. Downloadable digital data package. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, National Centers for Coastal Ocean Science, Center for Coastal Monitoring and Assessment, Biogeography Branch. Released August 2013. Internet website: http://coastalscience.noaa.gov/projects/detail?key=35. Accessed April 16, 2015.

Kirkham, I.R. and I.C.T. Nettleship. 1987. Status of the roseate tern in Canada. Journal of Field Ornithology 58:505-515.

Knap, A.H., T.D. Sleeter, R.E. Dodge, S.C. Wyers, H.R. Frith, and S.R. Smith. 1983. The effects of oil spills and dispersant use on corals: A review and multidisciplinary approach. Oil and Petrochemical Pollution 1(3):157-169. doi:10.1016/S0143-7127(83)90134-5.

Knap, A.H., S.C. Wyers, R.E. Dodge, T.D. Sleeter, H.R. Frith, S.R. Smith, and C.B. Cook. 1985. The effects of chemically and physically dispersed oil on the brain coral *Diploria strigosa* (Dana)—a summary review. In: Proceedings, 1985 Oil Spill Conference, February 25-28, 1985, Los Angeles, CA. Washington, DC: American Petroleum Institute. Pp. 547-551.

Ko, J-Y. and J.W. Day. 2004. Wetlands: Impacts of energy development in the Mississippi Delta. Encyclopedia of Energy 6:397-408.

Ko, J-Y. and J.W. Day. 2004b. A review of ecological impacts of oil and gas development on coastal ecosystems in the Mississippi delta. Ocean and Coastal Management 47(11-12):597-623.

Kokaly, R.F., D. Heckman, J. Holloway, S. Piazza, B. Couvillion, G.D. Steyer, C. Mills, and T.M. Hoefen. 2011. Shoreline surveys of oil impacted marsh in southern Louisiana, July to August 2010. U.S. Dept. of the Interior, Geological Survey. Open-File Report 2011-1022. 124 pp.

Kostka, J.E., O. Prakash, W.A. Overholt, S.J. Green, G. Freyer, A. Canion, J. Delgardio, N. Norton, T.C. Hazen, and M. Huettel. 2011. Hydrocarbon-degrading bacteria and the bacterial community response in Gulf of Mexico beach sands impacted by the Deepwater Horizon oil spill. Applied and Environmental Microbiology 77(22):7962-7974.

Kovacs, K.M. and C. Lyderson. 2008. Climate change impacts on seals and whales in the North Atlantic Arctic and adjacent shelf seas. Science Progress 92:117-150.

Krapu, G.L., J.L. Eldridge, C.L. Gratto-Trevor, and D.A. Buhl. 2006. Fat dynamics of Arctic-nesting sandpipers during spring in mid-continental North America. Auk 123:323-334.

Krasnec, M.O., J.M. Morris, and C. Lay. 2015. An evaluation of the toxicity of deep sea sediment collected after the *Deepwater Horizon* oil spill on the amphipod *Leptocheirus plumulosus*. (TOX_TR.25). Boulder, CO. DWH Toxicity NRDA Technical Working Group Report.

Krivor, M.C., J. de Bry, N.J. Linville, and D.J. Wells. 2011. Archival investigations for potential Colonial-era shipwrecks in ultra-deepwater in the Gulf of Mexico. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation and Enforcement, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study BOEMRE 2011-004. 158 pp.

Kroeker, K.J., R.L. Kordas, R. Crim, I.E. Hendriks, L. Ramajo, G.S. Singh, G.S. Duarte, and J.P. Gattuso. 2013. Impacts of ocean acidification on marine organisms: Quantifying sensitivities and interaction with warming. Global Change Biology 19:1884-1896.

Kucklick, J., L. Schwacke, R. Wells, A. Hohn, A. Guichard, J. Yordy, L. Hansen, E. Zolman, R. Wilson, J. Litz, D. Nowacek, T. Rowles, R. Pugh, B. Balmer, C. Sinclair, and P. Rosel. 2011. Bottlenose dolphins as indicators of persistent organic pollutants in the western North Atlantic Ocean and northern Gulf of Mexico. Environmental Science & Technology 45(10):4270-4277.

Kushlan, J.A. and P.C. Frohring. 1986. The history of the southern Florida wood stork population. Wilson Bulletin 98:368-386.

Kushmaro, A., G. Henning, D.K. Hofmann, and Y. Benayahu. 1997. Metamorphosis of *Heteroxenia fuscescens* Plaunlae (Cnidaria: Octocorallia) is inhibited by crude oil: A novel short-term toxicity bioassay. Marine Environmental Research 43(4):295-302.

Kvenvolden, K.A. and C.K. Cooper. 2003. Natural seepage of crude oil into the marine environment. Geo-Marine Letters (2003) 23:140-146.

LA1 Coalition. 2015. Governor approves $12.5 million in capital outlay for Phase 2 of LA 1 project. One-to-One newsletter, July 16, 2015. Internet website: http://www.la1coalition.org/news/125-million-in-capital-outlay-for-phase-2-of-la-1-project. Accessed August 24, 2016.

LA1 Coalition. 2016. The Louisiana Highway 1 (LA1) corridor in southern Lafourche Parish is America's access to energy. Internet website: http://www.la1coalition.org/phire-content/assets/files/2016%209pg%20World%20Oil%20Port%20Fourchon%20Special%20Report%20ONLY.pdf.

LaBrecque, E., C. Curtice, J. Harrison, S.M. Van Parijs, and P.N. Halpin. 2015. Biologically important areas for cetaceans within U.S. waters – Gulf of Mexico Region. Aquatic Mammals 41:30-38.

LaCoast.gov. 2011. Atchafalaya Basin: Summary of basin plan. Internet website: http://lacoast.gov/new/About/Basin_data/at/Default.aspx. Accessed January 28, 2011.

LaCoast.gov. 2016. CWPPRA projects. Internet website: http://www.lacoast.gov/projects/list.asp. Accessed July 2016.

LaDeau, S.L., A.M. Kilpatrick, and P.P. Marra. 2007. West Nile virus emergence and large-scale declines of North American bird populations. Nature 447(7145):710-713.

Ladich, F. 2013. Effects of noise on sound detection and acoustic communication in fishes. In: Brumm, H., ed. Animal communication and noise. Berlin Heidelberg: Springer-Verlag. Pp. 65-90.

Laffoley, D., H.S. Roe, M.V. Angel, J. Ardron, N.R. Bates, I.L. Boyd, S. Brooke, K.N. Buck, C.A. Carlson, B. Causey, M.H. Conte, S. Christiansen, J. Cleary, J. Donnelly, S.A. Earle, R. Edwards, K.M. Gjerde, S.J. Giovannoni, S. Gulick, M. Gollock, J. Hallett, P. Halpin, R. Hanel, A. Hemphill, R.J. Johnson, A.H. Knap, M.W. Lomas, S.A. McKenna, M.J. Miller, P. Miller, F.W. Ming, R. Moffitt, N.B. Nelson, L. Parson, A.J. Peters, J. Pitt, P. Rouja, J. Roberts, J. Roberts, D.A. Seigel, A.N. Siuda, D.K. Steinberg, A. Stevenson, V.R. Sumaila, W. Swartz, S. Thorrold, T.M. Trott, and V. Vats. 2011. The protection and management of the Sargasso Sea: The golden floating rainforest of the Atlantic Ocean. Summary Science and Supporting Evidence Case. Sargasso Sea Alliance. 44 pp.

Laidre, K.L., I. Stirling, L. Lowry, Ø. Wiig, M.P. Heide-Jørgensen, and S.H. Ferguson. 2008. Quantifying the sensitivity of arctic marine mammals to climate-induced habitat change. In: Huntington, H.P. and S.E. Moore, eds. Arctic marine mammals and climate change. Ecological Applications 18(2)Supplement, 2008:S97-S125.

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, NY: Spring-Verlag. Pp. 99-139.

Laist, D.W., A.R. Knowlton, J.G. Mead, A.S. Collet, and M. Podesta. 2001. Collisions between ships and whales. Marine Mammal Science 17:35-75.

Lambersten, R.H., J.P. Sundberg, and C.D. Buergelt. 1987. Genital papillomatosis in sperm whale bulls. Journal of Wildlife Disease 23(3):361-367.

Lamont, M.M., R.R. Carthy, and I. Fujisaki. 2012. Declining reproductive parameters highlight conservation needs of loggerhead turtles (*Caretta caretta*) in the northern Gulf of Mexico. Chelonian Conservation and Biology 11(2):190-196. doi:http://dx.doi.org/10.2744/CCB-1006.1.

Lamont, M.M., N. Putman, I. Fujisaki, and K. Hart. 2015. Spatial requirements of different life-stages of the loggerhead turtle (*Caretta caretta*) from a distinct population segment in the northern Gulf of Mexico. Herpetological Conservation and Biology 10(1):26-43.

Lange, R. 1985. A 100-ton experimental oil spill at Halten Bank, off Norway. In: Proceedings, 1985 Oil Spill Conference, February 25-28, 1985, Los Angeles, CA. Washington, DC: American Petroleum Institute.

Langtimm, C.A., M.D. Krohn, J.P. Reid, B.M. Stith, and C.A. Beck. 2006. Possible effects of the 2004 and 2005 hurricanes on manatee survival rates and movement. Estuaries Coasts 29:1026-1032.

Lapointe, B.E. 1986. Phosphorus-limited photosynthesis and growth of *Sargassum natans* and *Sargassum fluitans* (Phaeophyceae) in the western North Atlantic. Deep Sea Research Part A: Oceanographic Research Papers 33(3):391-399. doi:10.1016/0198-0149(86)90099-3.

Larino, J. 2015. Baker Hughes closes Houma plant, lays off 60 workers amid oil slump. TimesPicayune-NOLA.com, February 6, 2015. Internet website: http://www.nola.com/business/index.ssf/2015/02/baker_hughes_closes_houma_plan.html. Accessed September 7, 2015.

Lavender, A.L., S.M. Bartol, and I.K. Bartol. 2014. Ontogenetic investigation of underwater hearing capabilities in loggerhead sea turtles (*Caretta caretta*) using a dual testing approach. The Journal of Experimental Biology 217:2580-2589. doi:10.1242/jeb.096651.

Le Henáff, M., V.H. Kourafalou, C.B. Paris, J. Helgers, Z.M. Aman, P.J. Hogan, and A. Srinivasan. 2012. Surface evolution of the *Deepwater Horizon* oil spill patch: Combined effects of circulation and wind-induced drift. Environmental Science & Technology 46:7267-7273.

Learmonth, J.A., C.D. Macleod, M.B. Santos, G.J. Pierce, H.Q.P. Crick, and R.A. Robinson. 2006. Potential effects of climate change on marine mammals. Oceanography and Marine Biology 44:431-464.

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. The Sierra Club handbook of whales and dolphins. San Francisco, CA: Sierra Club Books. 302 pp.

Leblanc, D.J. 1985. Environmental and construction techniques involved with the installation of a gas pipeline across Timbalier Island, Louisiana. In: Proceedings, Sixth Annual Gulf of Mexico Information Transfer Meeting, October 22-24, 1985. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 86-0073. Pp. 203-205.

Lee, D.S. and M.L. Moser. 1998. Importance des Sargasses pelagiques pour la recherché alimentaire des oiseaux marins. El Pitirre 11(3):111-112.

Lee, D.S., and M. Walsh-McGehee. 1998. White-tailed tropicbird (*Phaethon lepturus*). In: Rodewald, P.G., ed. The birds of North America. Ithaca, NY: Cornell Lab of Ornithology.

Leighton, F.A. 1993. The toxicity of petroleum oils to birds. Environmental Reviews 1:92-103.

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 induced behaviors in captive loggerhead marine turtles (*Caretta caretta*). In: Bjorndal, K.A., A.B. Bolten, D.A. Johnson, and P.J. Eliazar, comps. Fourteenth annual symposium on sea turtle biology and conservation. NOAA Technical Memorandum NMFS-SEFSC351. Pp. 238-241.

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.

Lessard, R.R. and G. Demarco. 2000. The significance of oil spill dispersants. Spill Science & Technology Bulletin 6:59-68.

Levin, P.S. and G.W. Stuntz. 2005. Habitat triage for exploited fishes: Can we identify essential "Essential Fish Habitat?" Estuarine, Coastal and Shelf Science 64:70-78.

Lewis, A. and D. Aurand. 1997. Putting dispersants to work: Overcoming obstacles. 1997 International Oil Spill Conference. API 4652A. Technical Report IOSC-004.

Lewis, J.B. 1971. Effect of crude oil and an oil-spill dispersant on reef corals. Marine Pollution Bulletin 2:59-62.

Lewison, R.L., S.A. Freeman, and L.B. Crowder. 2004. Quantifying the effects of fisheries on threatened species: The impact of pelagic longlines on loggerhead and leatherback sea turtles. Ecology letters 7(3):221-231.

Lewison R, B. Wallace, J. Alfaro-Shigueto, J.C. Mangel, S.M. Maxwell, and E.L. Hazen. 2013. Fisheries bycatch of marine turtles: Lessons learned from decades of research and conservation. In: Wyneken, J., K.J. Lohmann, and J.A. Musick. The biology of sea turtles. Volume III. Pp. 329-351.

Lewison, R.L., L.B. Crowder, B.P. Wallace, J.E. Moore, T. Cox, R. Zydelis, S. McDonald, A. DiMatteo, D.C. Dunn, C.Y. Kot, R. Bjorkland, S. Kelez, C. Soykan, K.R. Stewart, M. Sims, A. Boustany, A.J. Read, P. Halpin, and W.J. Nichols. 2014. Global patterns of marine mammal, seabird, and sea turtle bycatch reveal taxa-specific and cumulative megafauna hotspots. Proceedings of the National Academy of Sciences. 6 pp.

LGL Ecological Research Associates, Inc. 2009. Gulf of Mexico cooling water intake structure: Source water biological baseline characterization study. Prepared for the Offshore Operators Committee, Environmental Sciences Subcommittee.

Lightsey, J.D., S.A. Rommel, A.M. Costidis, and T.D. Pitchford. 2006. Methods used during gross necropsy to determine watercraft-related mortality in the Florida manatee (*Trichechus manatus latirostris*). Journal of Zoo and Wildlife Medicine 37(3):262-275. doi:10.1638/04-095.1.

Lin, Q. and I.A. Mendelssohn. 1996. A comparative investigation of the effects of south Louisiana crude on the vegetation of fresh, brackish and salt marshes. Marine Pollution Bulletin 32:202-209.

Lindo-Atichati, D., F. Bringas, G. Goni, B. Muhling, F.E. Muller-Karger, and S. Habtes. 2012. Varying mesoscale structures influence larval fish distribution in the northern Gulf of Mexico. Marine Ecology Progress Series 463:245-257.

Lissner, A.L., G.L. Taghon, D.R. Diener, S.C. Schroeter, and J.D. Dixon. 1991. Recolonization of deep-water hard-substrate communities: Potential impacts from oil and gas development. Ecological Applications 1:258-267.

Littler, D.S. and M.M. Littler. 2000. Caribbean reef plants; an identification guide to the reef plants of the Caribbean, Bahamas, Florida and Gulf of Mexico. OffShore Graphics Inc., Florida. Pp. 280-290.

Liu, Z., J. Liu, W.S. Gardner, G.C. Shank, E.O. Nathaniel. 2014. The impact of *Deepwater Horizon* oil spill on petroleum hydrocarbons in surface waters of the northern Gulf of Mexico. Deep Sea Research Part II: Topical Studies in Oceanography. doi:10.1016/j.dsr2.2014.01.013.

Liu, Y., A.M. Roy-Engel, M.C. Baddoo, E.K. Flemington, G.Wang, and H. Wang. 2015. The impact of oil spill to lung-health – insights from an RNA-seq study of human airway epithelial cells. Elsevier, October 20, 2015. Internet website: http://www.ncbi.nlm.nih.gov/pubmed/26692141. Accessed August 29, 2016.

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.

Løkkeborg, S., E. Ona, A. Vold, and A. Salthaug. 2012. Sounds from seismic air guns: gear-and species specific effects on catch rates and fish distribution. Canadian Journal of Fisheries and Aquatic Sciences 69:1,278-1,291.

Long, B.F. and J.H. Vandermuelen. 1983. Geomorphological impact of cleanup of an oiled salt marsh (Ile Grande, France). In: Proceedings, 1983 Oil Spill Conference, February 28-March 3, 1983, San Antonio, TX. Washington, DC: American Petroleum Institute. Pp. 501-505.

Long, M.C., C. Deutsch, and T. Ito. 2016. Finding forced trends in oceanic oxygen. Global Biogeochemical Cycles 30:381-397.

Longcore, T. and C. Rich. 2004. Ecological light pollution. Frontiers in Ecology and the Environment 2:191-198.

Loren C. Scott & Associates. 2008. The economic impacts of Port Fourchon on the national and Houma MSA economies. 31 pp. Internet website: http://www.portfourchon.com/site100-01/1001757/docs/port_fourchon_economic_impact_study.pdf.

Loss, S.R., T. Will, and P.P. Marra. 2013. The impact of free-ranging domestic cats on wildlife of the United States. Nature Communications. 7 pp.

Loss, S.R., T. Will, and P.P. Marra. 2014a. Estimation of bird-vehicle collision mortality on U.S. roads. Journal of Wildlife Management 78:763-771.

Loss, S.R., T. Will, S.S. Loss, and P.P. Marra. 2014b. Bird-building collisions in the United States: Estimates of annual mortality and species vulnerability. Condor 116:8-23.

Louisiana Coastal Wetlands Conservation and Restoration Task Force. 2006. The 2006 evaluation report to the U.S. Congress on the effectiveness of Coastal Wetlands Planning, Protection and Restoration Act projects. Submitted by the Chairman of the Louisiana Coastal Wetlands

Conservation and Restoration Task Force, U.S. Dept. of the Army, Corps of Engineers, New Orleans District, New Orleans, LA. 73 pp.

Louisiana Offshore Oil Port, LLC. 2015. The LOOP story. Internet website: https://www.loopllc.com/About-Loop/Story.aspx. Accessed July 1, 2015.

Louisiana Universities Marine Consortium (LUMCON). 2014. Press release: Louisiana Universities Marine Consortium, August 4, 2014. 7 pp. Internet website: http://www.gulfhypoxia.net/research/shelfwide%20cruises/2014/hypoxia_press_release_2014.pdf.

Louisiana Universities Marine Consortium (LUMCON). 2015. 2015 forecast: Summer hypoxic zone size, northern Gulf of Mexico. 13 pp. Internet website: http://www.gulfhypoxia.net/Research/Shelfwide%20Cruises/2015/2015_hypoxia_forecast.pdf.

Lowe, M.R. and M.S. Peterson. 2014. Effects of coastal urbanization on salt-marsh faunal assemblages in the northern Gulf of Mexico. Marine and Coastal Fisheries 6(1):89-107.

Lowe, M. and S. Stokes. 2013. Wildlife tourism and the Gulf Coast economy. 57 pp.

Lubchenco, J.L., M. McNutt, B. Lehr, M. Sogge, M. Miller, S. Hammond, and W. Conner. 2010. BP *Deepwater Horizon* oil budget: What happened to the oil? Internet website: http://www.noaanews.noaa.gov/stories2010/PDFs/OilBudget_description_%2083final.pdf. Accessed September 8, 2010.

Lubowski, R.N., M. Vesterby, S. Bucholtz, A. Baez, and M. Roberts. 2006. Major uses of land in the United States, 2002. U.S. Dept. of Agriculture, Economic Research Service. Economic Information Bulletin No. (EIB-14). 54 pp. Internet website: http://www.ers.usda.gov/publications/eib-economic-information-bulletin/eib14.aspx. Accessed September 6, 2015.

Ludwick, J.C. and W.R. Walton. 1957. Shelf-edge, calcareous prominences in the northeastern Gulf of Mexico. Bulletin of the American Association of Petroleum Geologists 41(9):2054-2101.

Lugo-Fernández, A, K.J.P. Deslarzes, J.M. Price, G.S. Boland, and M.V. Morin. 2001. Inferring probable dispersal of Flower Garden Banks coral larvae (Gulf of Mexico) using observed and simulated drifter trajectories. Continental Shelf Research 21:47-67.

Lugo-Fernandez, A., D.A. Ball, M. Gravois, C. Horrell, and J.B. Irion. 2007. Analysis of the Gulf of Mexico’s Veracruz-Havana route of La Flota de la Nueva España. Journal of Maritime Archaeology 2(1):24-47.

Lukens, R.R. and C. Selberg. 2004. Guidelines for marine artificial reel materials. Joint Publication of the Gulf and Atlantic States Marine Fisheries Commissions. No. 121.

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.

Lunden, J.J., S.E. Georgian, and E.E. Cordes. 2013. Aragonite saturation states at cold-water coral reefs structured by *Lophelia pertusa* in the northern Gulf of Mexico. Limnology and Oceanography 58:354-362.

Lunden, J.J., C.G. McNicholl, C.R. Sears, C.L. Morrison, and E.E. Cordes. 2014. Acute survivorship of the deep sea coral *Lophelia pertusa* from the Gulf of Mexico under acidification, warming, and deoxygenation. Frontiers in Marine Science 1.

Lunt, J. and D.L. Smee. 2014. Turbidity influences trophic interactions in estuaries. Limnology and Oceanography 59(6):2002-2012.

Lutcavage, M.E., P.L. Lutz, G.D. Bossart, and D.M. Hudson. 1995. Physiologic and clinicopathologic effects of crude oil on loggerhead sea turtles. Archives of Environmental Contamination and Toxicology 28:417-422.

Lutcavage, M.E., P. Plotkin, B. Witherington, and P.L. Lutz. 1997. Human impacts on sea turtle survival. The Biology of Sea Turtles 1:387-409.

Luthi, D., M. Le Floch, B. Bereiter, T. Blunier, J.-M. Barnola, U. Siegenthaler, D. Raynaud, J. Jouzel, H. Fischer, K. Kawamura, and T.F. Stocker. 2008. High-resolution carbon dioxide concentration record 650,000-800,000 years before present. Nature 453:379-381.

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. NOAA Technical Memorandum 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., eds. Proceedings of the First International Symposium on Kemp's Ridley Sea Turtle Biology, Conservation and Management. Texas A&M University Sea Grant College Program, Galveston, TX. TAMU-SG-89-105. Pp. 52-54.

Lyn, H., A. Coleman, M. Broadway, J. Klaus, S. Finerty, D. Shannon, and M. Solangi. 2012. Displacement and site fidelity of rehabilitated immature Kemp's ridley sea turtles (*Lepidochelys kempii*). Marine Turtle Newsletter 135:10-13.

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.

MacDonald, I.R., ed. 1992. Chemosynthetic ecosystems study literature review and data synthesis, northern Gulf of Mexico: 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, 92-0034, and 92-0035. 25, 218, and 263 pp., respectively.

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. Journal of Geophysical Research 98(C9):16,351-16,364.

MacDonald, I.R., N.L. Guinasso, R. Sassen, J.M. Brooks, S. Lee, and K.T. Scott. 1994. Gas hydrates that breach the sea-floor and intersect with the water column on the continental slope of the Gulf of Mexico. Geology 22:699-702.

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.

MacLeod, C.D. 2009. Global climate change, range changes and potential implications for the conservation of marine cetaceans, a review and synthesis. Endangered Species Research 7:125-136.

Mager, E.M., A.J. Esbaugh, J.D Stieglitz, R. Hoenig, C. Bodinier, J.P. Incardona, N.L. Scholz, D.D. Bennetti, and M. Grosell. 2014. Acute embryonic or juvenile exposure to *Deepwater Horizon* crude oil impairs the swimming performance of mahi-mahi (*Coryphaena hippurus*). Environmental Science & Technology 48(12):7053-7061.

Magnuson, J.J., K.A. Bjorndal, W.D. DuPaul, G.L. Graham, D.W. Owens, C.H. Peterson, P.C.H. Pritchard, J.I. Richardson, G.E. Saul, and C.W. West. 1990. Decline of the sea turtles: Causes and prevention. National Research Council, National Academy of Sciences Press, Washington DC. 190 pp.

Maiaro, J.L. 2007. Disturbance effects on nekton communities of seagrasses and bare substrates in Biloxi Marsh, Louisiana. Master's thesis, Louisiana State University, Baton Rouge, LA. 78 pp. Internet website: http://etd.lsu.edu/docs/available/etd-07032007-101237/unrestricted/Maiaro_thesis.pdf.

Major, D., R.S. Derbes, H. Wang, and A.M. Roy-Engel. 2016. Effects of corexit oil dispersants and the WAF of dispersed oil on DNA damage and repair in cultures human bronchial airway cells. Internet website: https://www.researchgate.net/publication/256539394_Effects_of_Corexit_Dispersants_on_Cytotoxicity_Parameters_in_a_Cultured_Human_Bronchial_Airway_Cells_BEAS-2B. Accessed August 29, 2016.

Mallman, E.P. and M.D. Zoback. 2007. Subsidence in the Louisiana coastal zone due to hydrocarbon production. In: Proceedings, 9th International Coastal Symposium. Journal of Coastal Research, Special Issue 50:443-449. Gold Coast, Australia. Internet website: http://www.cerf-jcr.org/images/stories/Subsidence%20in%20the%20Louisiana%20coastal%20zone%

20due%20to%20hydrocarbon%20production.%20E.%20P.%20Mallman%20and%20M.%20D.%20Zoback.%20Pg%20443-448.pdf.

Manzella, S., J. Williams, B. Schroeder, and W. Teas. 2001. Juvenile head-started Kemp's ridleys found in floating grass mats. Marine Turtle Newsletter 52:5-6.

Marcano, L.A. and J.J. Alio-M. 2000. Incidental capture of sea turtles by the industrial shrimping fleet off northwestern Venezuela. NOAA Technical Memorandum NMFS-SEFSC-436-107.

Marine Cadastre. 2015. Data registry. Internet website: http://marinecadastre.gov/data/. Accessed December 9, 2015.

Marine Spill Response Corporation. 2015a. Marine Spill Response Corporation's containment systems overview. Internet website: http://www.marinewellcontainment.com/containment–system/. Accessed June 11, 2015.

Marine Spill Response Corporation. 2015b. Marine Spill Response Corporation major equipment list. Internet website: https://www-msrc-org-documents.s3.amazonaws.com/major-equipment-list/MSRC_Major_Equipment_List.pdf?download=1425092063. Accessed June 11, 2015.

Marinevesseltraffic.com. 2015. Vessel traffic maps. Internet website: http://www.marinevesseltraffic.com/2013/06/gulf-of-mexico-marine-traffic.html. Accessed October 9, 2015.

Marquenie, J., M. Donners, H. Poot, W. Steckel, and B. de Wit. 2013. Bird-friendly light sources: Adapting the spectral composition of artificial lighting. Industry Applications Magazine, IEEE, 19(2):56-62.

Marsh, H. 1989. Mass stranding of dugongs by a tropical cyclone in northern Australia. Marine Mammal Science 5:78-84.

Marsh, B. 2016. Official communication. Email granting permission to use photographs of the Mississippi barrier islands in the U.S. Dept. of the Interior, Bureau of Ocean Energy Management's NEPA documents. February 1, 2016.

Marshall, B. 2013. New research: Louisiana faces highest rate of sea-level rise worldwide. The lens. February 21, 2013. Internet website: http://thelensnola.org/2013/02/21/new-research-louisiana-coast-faces-highest-rate-of-sea-level-rise-on-the-planet/. Accessed August 24, 2016.

Marshall, B. 2015. Moving mouth of Mississippi River among startling suggestions for Louisiana. *The Advocate*. September 25, 2015. Internet website: http://www.theadvocate.com/baton_rouge/news/article_59726f5d-be4f-54a1-a31d-80ce2f708ba3.html. Accessed August 24, 2016.

Marszalek, D.S. 1981. Impact of dredging on a subtropical reef community, southeast Florida, USA. In: Proceedings of the Fourth International Coral Reef Symposium. Volume 1. May 18-22, 1981. Manila, Philippines.

Martin, J., H.H. Edwards, C.J. Fonnesbeck, S.M. Koslovsky, and C.W. Harmak. 2015. Combining information for monitoring at large spatial scales: First statewide abundance estimate of the Florida manatee. Biological Conservation 186:44-51. doi:10.1016/j.biocon.2015.02.029.

Martínez, M.L., R.A. Feagin, K.M. Yeager, J. Day, R. Costanza, J.A. Harris, R.J. Hobbs, J. López-Portillo, I.J. Walker, E. Higgs, P. Moreno-Casasola, J. Sheinbaum, and A. Yáñez-Arancibia. 2012. Artificial modifications of the coast in response to the *Deepwater Horizon* oil spill: Quick solutions or long-term liabilities? Frontiers in Ecology and the Environment 10(1)February 2012:44-49.

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.

Matkin, C.O., E.L. Saulitis, G.M. Ellis, P. Olesiuk, and S.D. Rice. 2008. Ongoing population-level impacts on killer whales *Orcinus orca* following the "Exxon Valdez" oil spill in Prince William Sound, Alaska. Marine Ecology Progress Series 356:269-281.

Mays, J.L. and D.J. Shaver. 1998. Nesting trends of sea turtles in national seashores along Atlantic and Gulf Coast waters of the United States. 61 pp.

Maze-Foley, K. and K.D. Mullin. 2006. Cetaceans of the oceanic northern Gulf of Mexico: Distributions, group sizes and interspecific associations. Journal of Cetacean Research and Management 8(2):203-213.

McAuliffe, C.D., A.E. Smalley, R.D. Groover, W.M. Welsh, W.S. Pickle, and G.E. Jones. 1975. Chevron Main Pass Block 41 oil spill: Chemical and biological investigation. In: Proceedings, 1975 Conference on Prevention and Control of Oil Pollution, March 25-27, 1975, San Francisco, CA. Washington, DC: American Petroleum Institute.

McAuliffe, C.D., B.L. Steelman, W.L. Leek, D.E. Fitzgerald, J.P. Ray, and C.D. Baker. 1981a. The 1979 southern California dispersant treated research oil spills. In: Proceedings, 1981 Oil Spill Conference, March 2-5, 1981, Atlanta, GA. Washington DC: American Petroleum Institute. Pp. 269-282.

McAuliffe, C.D., G.P. Canevari, T.D. Searl, J.C. Johnson, and S.H. Greene. 1981b. The dispersion and weathering of chemically treated crude oils on the sea surface. In: Petroleum and the Marine Environment. Proceedings of Petromar '80. London, UK: Graham and Trotman Ltd.

McBride, R.A., S. Penland, M.W. Hiland, S.J. Williams, K.A. Westphal, B.J. Jaffe, and A.H. Sallenger. 1992. Analysis of barrier shoreline change in Louisiana from 1853 to 1989. In: Williams, S.J., S. Penland, and A.H. Sallenger, eds. Atlas of shoreline changes in Louisiana from 1853 to 1989. U.S. Dept. of the Interior, Geological Survey. Miscellaneous Investigation Series I-2150-A. Pp. 36-47.

McCauley, R.D., J. Fewtrell, A.J. Duncan, C. Jenner, M.N. Jenner, J.D. Penrose, R.I.T. Prince, A. Adhita, J. Murdoch, and K. McCabe. 2000. Marine seismic surveys: Analysis and propagation of air-gun signals; and effects of air-gun exposure on humpback whales, sea turtles, fishes and squid. A report prepared for the Australian Production Exploration Association. Project CMST 163, Report R99-15. 198 pp.

McClellan, C.M. and A.J. Read. 2007. Complexity and variation in loggerhead sea turtle life history. Biological Letters 3:592-594.

McClenachan, G., R.E. Turner, and A.W. Tweel. 2013. Effects of oil on the rate and trajectory of Louisiana marsh shoreline erosion. Environmental Research Letters 8 (2013) 044030. 8 pp. doi:10.1088/1748-9326/8/4/044030.

McCullers, R. 2015. Official communication. Email communication with the Environmental Director of the Poarch Band of Creek Indians regarding OCS activities. June 3, 2015.

McDaniel, C.N. and D.N. Borton. 2002. Increased human energy use causes biological diversity loss and undermines prospects for sustainability. Bioscience 52:929-936.

McDonald, D., P. Dutton, D. Mayer, and K. Merkel. 1994. Review of the green turtles of South San Diego Bay in relation to the operations of the SDG&E South Bay Power Plant. Document 94-045-01. Prepared for San Diego Gas & Electric Co., San Diego, CA. C941210311.

McEachran, J.D. 2009. Fishes (Vertebrata: Pisces) of the Gulf of Mexico. In: Felder, D.L. and D.K. Camp, eds. Gulf of Mexico origin, waters, and biota. 1, Biodiversity. College Station, TX: Texas A&M University Press.

McEachran, J.D. and J.D. Fechhelm. 1998. Fishes of the Gulf of Mexico: Volume 1. Austin, TX: University of Texas Press. 1,112 pp.

McGlade, C. and P. Ekins. 2015. The geographical distribution of fossil fuels unused when limiting global warming to 2 °C. Nature 517(7533):187-190. doi:10.1038/nature14016.

McGrail, D. 1982. Water and sediment dynamics at the Flower Garden Banks. In: Norman, R., ed. Environmental studies at the Flower Gardens and selected banks: Northwestern Gulf of Mexico, 1979-1981. Executive summary. Technical Report No. 82-8-T. Pp. 27-29.

McGurrin, J.M., R.B. Stone, and R.J. Sousa. Profiling United States artificial reef development. Bulletin of Marine Science 44(2):1004-1989.

McKenna, M.F., D. Ross, S.M. Wiggins, and J.A. Hildebrand. 2012. Underwater radiated noise from modern commercial ships. Journal of the Acoustical Society of America 131(1):92-103.

McNutt, M., R. Camilli, G. Guthrie, P. Hsieh, V. Labson, B. Lehr, D. Maclay, A. Ratzel, and M. Sogge. 2011. Assessment of flow rate estimates for the *Deepwater Horizon*/Macondo well oil spill. Flow Rate Technical Group report to the National Incident Command, Interagency Solutions Group, March 10, 2011.

Mead, J.G. 2002. Beaked whales, overview. In: Perrin, W.F., B. Wursig, and G.M. Thewissen, eds. Encyclopedia of Marine Mammals. San Diego, CA: Academic Press. Pp. 81-84.

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, CA: Academic Press. Pp. 165-195.

Meckel, T.A., U.S. ten Brink, and S.J. Williams. 2006. Current subsidence rates due to compaction of Holocene sediments in southern Louisiana. Geophysical Research Letters Volume 33, L11403. 5 pp. doi:10.1029/2006GL026300. Internet website: http://woodshole.er.usgs.gov/staffpages/utenbrink/my%20publications/Meckel_GRL.pdf.

Melton, H.R., J.P. Smith, H.L. Mairs, R.F. Bernier, E. Garland, A Glickman, F.V. Jones, J.P. Ray, D. Thomas, and J.A. Campbell. 2004. Environmental aspects of the use and disposal of non aqueous drilling fluids associated with offshore oil and gas operations. Society of Petroleum Engineers, Inc. SPA 86696.

Meltzer, D.J., D.K. Grayson, G. Ardila, A.W. Barker, D.F. Dincauze, C.V. Hanes, F. Mina, L. Nunez, and D.J. Stanford. 1997. On the Pleistocene antiquity of Monte Verde, Chile. American Antiquity 62(4):659-663.

Mendelssohn, I.A. and K.L. McKee. 1987. Chapter 8: Experimental field and greenhouse verification of the influence of saltwater intrusion and submergence on marsh deterioration—Mechanisms of action. In: Turner, R.E. and D.R. Cahoon, eds. Causes of wetland loss in the coastal central Gulf of Mexico. Volume II: Technical narrative. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 87-0120. Pp.145-180.

Mendelssohn, I.A., M.W. Hester, and J.M. Hill. 1993. Effects of oil spills on coastal wetlands and their recovery. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 93-0045. 46 pp.

Meylan, A.B. 1988. Spongivory in hawksbill turtles: A diet of glass. Science 239:393-395.

Meylan, A.B. 1999. International movements of immature and adult hawksbill turtles (*Eretmochelys imbricata*) in the Caribbean region. Chelonian Conservation and Biology 3(2):189-194.

Michel J., E.H. Owens, S. Zengel, A. Graham, Z. Nixon, T. Allard, W. Holton, P.D. Reimer, A. Lamarche, M. White, N. Rutherford, C. Childs, G. Mauseth, G. Challenger, and E. Taylor. 2013a. Extent and degree of shoreline oiling: *Deepwater Horizon* oil spill, Gulf of Mexico, USA. PLOS ONE 8(6):e65087.

Michel, J., A.C. Bejarano, C.H. Peterson, and C. Voss. 2013b. Review of biological and biophysical impacts from dredging and handling of offshore sand. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Herndon, VA. OCS Study BOEM 2013-0119. 258 pp.

Michot , T.C., C.W. Jeske, J.C. Mazourek, W.G. Vermillion, and R.S. Kemmerer. 2003. Atlas and census of wading bird and seabird nesting colonies in south Louisiana, 2001. Barataria-Terrebonne National Estuary Program Report No. 32. Thibodaux, LA. 93 pp.

Middlebrook, A.M., D.M. Murphy, R. Ahmadov, E.L. Atlas, R. Bahreini, D.R. Blake, J. Brioud, J.A. de Gouw, F.C. Fehsenfeld, G.J. Frost, J.S. Holloway, D.A. Lack, J.M. Langridge, R.A. Lueb, S.A. McKeen, J.F. Meagher, S. Meinardi, J.A. Neuman, J.B. Nowak, D.D. Parrish, J. Peischl, A.E. Perring, I.B. Pollack, J.M. Roberts, T.B. Ryerson, J.P. Schwarz, J.R. Spackman, C. Warneke, and A.R. Ravishankara. 2012. Air quality implications of the *Deepwater Horizon* oil spill. Proceedings of the National Academy of Sciences of the United States of America. 109(50):20280-20285. doi:10.1073/pnas.1110052108.

Mielke, H.W., C.R. Gonzales, M.K. Smith, and P.W. Mielke. 2000. Quantities and associations of lead, zinc, cadmium, manganese, chromium, nickel, vanadium, and copper in fresh Mississippi delta alluvium and New Orleans alluvial soils. The Science of the Total Environment 246:249-259.

Mignucci-Giannoni A.A., G.M. Toyos-González, J. Pérez-Padilla, M.A. Rodríguez-López, and J. Overing. 1999. Mass stranding of pygmy killer whales (*Feresa attenuata*) in the British Virgin Islands. Journal of Marine Biology Association of the United Kingdom 79:383-384.

Millemann, D.R., R.J. Portier, G. Olson, C.S. Bentivegna, and K.R. Cooper. 2015. Particulate accumulations in the vital organs of wild *Brevoortia patronus* from the northern Gulf of Mexico after the *Deepwater Horizon* oil spill. Ecotoxicology 1-17.

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, TX. 40 pp.

Miller, W.G., L.G. Adams, T.A. Ficht, N.F. Cheville, J.P. Payeur, D.R. Harley, C. House, and S.H. Ridgway. 1999. Brucella-induced abortions and infection in bottlenose dolphins (*Tursiops truncatus*). Journal of Zoo and Wildlife Medicine 30:100-110.

Miller, S.L., M. Chiappone, L.M. Rutten, and D.W. Swanson. 2008. Population status of Acropora corals in the Florida Keys. Proceedings of the 11th International Coral Reef Symposium. Pp. 775-779.

Miller, L.J., A.D. Mackey, T. Hoffland, M. Solangi, and S.A. Kuczaj, II. 2010. Potential effects of a major hurricane on Atlantic bottlenose dolphin (*Tursiops truncatus*) reproduction in the Mississippi Sound. Marine Mammal Science 26:707-715.

Mills, P. 2006. Barium minerals. In: Kogel, J.E., N.C. Trivedi, J.M Barker, and S.T. Krukowski, eds. Industrial minerals and rocks. 7th ed. Littleton, CO: Society for Mining, Metallurgy, and Exploration, Inc. Pp. 219-226.

Milton, S.L., S. Leone-Kabler, A.A. Schulman, and P.L. Lutz. 1994. Effects of Hurricane Andrew on the sea turtle nesting beaches of South Florida. Bulletin of Marine Science 54:974-981.

Minello, T.J., R.J. Zimmerman, and E.X. Martinez. 1987. Fish predation on juvenile brown shrimp, *Penaeus aztecus* Ives: Effects of turbidity and substratum on predation rates. Fishery Bulletin 85(1):59-70.

Mississippi Development Authority. 2011. Press release: Mississippi Development Authority publishes draft rules and regulations for offshore seismic surveying, mineral leasing. Internet website: http://www.mississippi.org/press-room/mda-publishes-draft-rules-and-regulations-for-offshore-seismic-surveying-mineral-leasing.html. Posted December 19, 2011. Accessed March 6, 2012.

Mitchell, R., I.R. MacDonald, and K.A. Kvenvolden. 1999. Estimation of total hydrocarbon seepage into the Gulf of Mexico based on satellite remote sensing images. Transactions, American Geophysical Union 80(49), Ocean Sciences Meeting OS242.

Mitsch, W.J. and J. Gosselink. 2000. Wetlands. New York, NY: John Wiley & Sons, Inc. 600 pp.

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. Volume 5: First book of dolphins. San Diego, CA: Academic Press. Pp. 1-21.

Moein, S., M. Lenhardt, D. Barnard, J. Keinath, and J. Musick. 1993. Marine turtle auditory behavior. Journal of the Acoustical Society of America 93(4, Pt 2):2,378.

Montagna, P.A. and D.E. Harper, Jr. 1996. Benthic infaunal long-term response to offshore production platforms in the Gulf of Mexico. Canadian Journal of Fisheries and Aquatic Science 53:2567-2588.

Montagna, P.A., J.G. Baguley, C. Cooksey, I. Hartwell, L. Hyde, J.L. Hyland, R.D. Kalke, L.M. Kracker, M. Reuscher, and A.C.E. Rhodes. 2013. Deep-sea benthic footprint of the *Deepwater Horizon* blowout. PLOS ONE 8(8):e70540. doi:10.1371/journal.pone.0070540.

Moody, R.M., J. Cebrian, and K.L. Heck Jr. 2013. Interannual recruitment dynamics for resident and transient marsh species: Evidence for a lack of impact by the Macondo oil spill. PLOS ONE 8:e58376.

Mooney, T.A., R. Hanlon, P.T. Madsen, J. Christensen-Dalsgaard, D.R. Ketten, and P.E. Nachtigall. 2012. Potential for sound sensitivity in cephalopods. In: Popper, A.N. and A. Hawkins, eds. The effects of noise on aquatic life. New York, NY: Springer. Pp. 125-128.

Moore, D.R. and H.R. Bullis, Jr. 1960. A deep-water coral reef in the Gulf of Mexico. Bulletin of Marine Science 10(1):125-128.

Morreale, S.L. and E.A. Standora. 1995. Cumulative evidence of southward migration of juvenile sea turtles from temperate northeastern waters. NOAA Technical Memorandum NMFS-SEFSC-36.

Moridis, G.J., T.S. Collett, R. Boswell, M. Kurihara, M.T. Reagan, C. Koh, and E.D. Sloan. 2008. Toward production from gas hydrates: Current status, assessment of resources, and simulation-based evaluation of technology and potential. Society of Petroleum Engineers. Unconventional Reservoirs Conference, Keystone, CO, February 10-12, 2008. 43 pp. Internet website: http://www.netl.doe.gov/technologies/oil-gas/publications/Hydrates/reports/G308_SPE114163_Feb08.pdf.

Morris, J.A., Jr. and J.L. Akins. 2009. Feeding ecology of invasive lionfish (*Pterois volitans*) in the Bahamian archipelago. Environmental Biology of Fishes 86(3):389-398.

Mortimer, J.A. and M. Donnelly. 2008. Hawksbill turtle (*Eretmochelys imbricata*) in IUCN 2012 red list status of threatened species. Version 2012.2. Internet website: http://jr.iucnredlist.org/documents/attach/Reptiles/8005_Eretmochelys_imbricata.pdf.

Morton, R.A. 1982. Effects of coastal structures on shoreline stabilization and land loss—the Texas experience. In: Boesch, D.F., ed. Proceedings of the Conference on coastal erosion and wetland modification in Louisiana: Causes, consequences, and options. Washington, DC: U.S. Dept. of the Interior, Fish and Wildlife Service, Biological Services Program. FWS/OBS-82/59.

Morton, R.A. 2003. An overview of coastal land loss: With emphasis on the southeastern United States. U.S. Dept. of the Interior, Geological Survey. Open-File Report 03-337. Internet website: http://pubs.usgs.gov/of/2003/of03-337/intro.html. Accessed May 11, 2010.

Morton, R.A. 2008. Historical changes in the Mississippi-Alabama barrier-island chain and the roles of extreme storms, sea level, and human activities. Journal of Coastal Research 24(6):1587-1600. West Palm Beach (Florida), ISSN 0749-0208.

Morton, R.A., N. Buster, and M. Krohn. 2002. Subsurface controls on historical subsidence rates and associated wetland loss in south-central Louisiana. Transactions Gulf Coast Association of Geological Societies 52:767-778.

Morton, R.A., T.L. Miller, and L.J. Moore. 2004. National assessment of shoreline change: Part 1: Historical shoreline changes and associated coastal land loss along the U.S. Gulf of Mexico. U.S. Dept. of the Interior, Geological Survey. Open-File Report 2004-1043. 45 pp.

Morton, R.A., J.C. Bernier, J.A. Barras, and N.F. Ferina. 2005. Rapid subsidence and historical wetland loss in the Mississippi Delta plain: Likely causes and future implications. U.S. Dept. of the Interior, Geological Survey. Open-File Report 2005-1216. 116 pp. Internet website: http://pubs.usgs.gov/of/2005/1216/ofr-2005-1216.pdf.

Moser, M.L. and D.S. Lee. 2012. Foraging over *Sargassum* by western North Atlantic seabirds. Wilson Journal of Ornithology 124:66-72.

Mosier, A. 1998. The impact of coastal armoring structures on sea turtle nesting behavior at three beaches on the east coast of Florida.

Moulton, D.W., T.E. Dahl, and D.M. Dall. 1997. Texas coastal wetlands. Status and trends mid 1955 to early 1990's. U.S. Dept. of the Interior, Fish and Wildlife Service, Southwest Region.

Moyers, J.E. 1996. Food habits of Gulf Coast subspecies of beach mice (*Peromyscus polionotus* spp.). M.S. Thesis, Auburn University, AL. 84 pp.

Mrosovsky, N., C. Lavin, and M.H. Godfrey. 1995. Thermal effects of condominiums on a turtle beach in Florida. Biological Conservation 74:151-156.

Mrosovsky, N., G.D. Ryan, and M.C. James. 2009. Leatherback turtles: The menace of plastic. Marine Pollution Bulletin 58(2):287-289.

Mueller, M.S., J. Froeschke, and D. Naar. 2014. Progressing from data to information: Incorporating GIS into coral and fisheries management. In: Bortone, S.A., ed. Interrelationships between corals and fisheries. CRC Press. 321 pp.

Mulabagal, V., F. Yin, G.F. John, J.S. Hayworth, and T.P. Clement. 2013. Chemical fingerprinting of petroleum biomarkers in *Deepwater Horizon* oil spill samples collected from Alabama shoreline. Marine Pollution Bulletin 70:147-154.

Muller-Karger, F.E., F. Vukovich, R. Leben, B. Nababan, C. Hu, and D. Myhre. 2001. Surface circulation and the transport of the Loop Current into the northeastern Gulf of Mexico: Final report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2001-102. 39 pp.

Mullin, K.D. and G.L. Fulling. 2004. Abundance of cetaceans in the oceanic northern Gulf of Mexico, 1996-2001. Marine Mammal Science 20:787-807.

Mullin, K.D. and W. Hoggard. 2000. Visual surveys of cetaceans and sea turtles from aircraft and ships: Chapter 4. In: Davis, R.W., W.E. Evans, and B. Würsig, eds. Cetaceans, sea turtles and birds in the northern Gulf of Mexico: Distribution, abundance and habitat associations. Volume II: Technical report. U.S. Dept. of the Interior, Geologic Survey, Biological Resources Division, USGS/BRD/CR-1999-005 and U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2000-003. 364 pp.

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, 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. Fishery Bulletin 92:773-786.

Mullin, K.D., L.V. Higgins, T.A. Jefferson, and L.J. Hansen. 1994b. Sightings of the Clymene dolphin (*Stenella clymene*) in the Gulf of Mexico. Marine Mammal Science 10:464-470.

Mullins, J., H. Whitehead, and L.S. Weilgart. 1988. Behavior and vocalizations of two single sperm whales, *Physeter macrocephalus*, off Nova Scotia. Canadian Journal of Fisheries and Aquatic Sciences 45:1736-1743.

Murawski, S.A., W.T. Hogarth, E.B. Peebles, and L. Barbeiri. 2014. Prevalence of external skin lesions and polycyclic aromatic hydrocarbon concentrations in Gulf of Mexico fishes, post-*Deepwater Horizon*. Transactions of the American Fisheries Society 143(4):1084-1097.

Murphy, T.M. and S.R. Hopkins. 1984. Aerial and ground surveys of marine turtle nesting beaches in the southeast region, United States. Final report to the U.S. Dept. of Commerce, National

Marine Fisheries Service, Southeast Fisheries Science Center. NMFS Contract No. NA83-GA-C-00021. 73 pp.

Murray, S.P. 1997. 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.

Musick, J.A. and C.J. Limpus. 1997. Habitat utilization and migration in juvenile sea turtles. The Biology of Sea Turtles 1:137-163.

Nalco. 2010. Oil dispersant expert testimony. Internet website: http://www.nalco.com/news-and-events/4259.htm. Accessed December 27, 2010.

Nash, H.L., S.J. Furiness, and J.W. Tunnell, Jr. 2013. What is known about species richness and distribution on the outer-shelf South Texas banks? Gulf and Caribbean Research 25:9-18.

Nassauer, J.I. and M.K. Benner. 1984. Visual preferences for a coastal landscape including oil and gas development. Journal of Environmental Management 18:323-338.

National Academy of Sciences. 1975. Assessing potential ocean pollutants, a report of the study panel on assessing potential ocean pollutants to the Ocean Affairs Board, Commission on Natural Resources, National Research Council. 438 pp.

National Association of Corrosion Engineers (NACE). 2003. Standard material requirements—methods for sulfide stress cracking and stress corrosion cracking resistance in sour oilfield environments. National Association of Corrosion Engineers. ANSI/NACE MR1075-2003. 44 pp.

National Center for Disease Preparedness. 2013. Impact on children and families of the *Deepwater Horizon* oil spill: Preliminary findings of the coastal population impact study. Earth Institute, Columbia University. Internet website: http://ncdptraining.cumc.columbia.edu/~columbia/files/GCPI_Community_Brochure_FINAL.pdf. Accessed September 9, 2015.

National Center for Disease Preparedness. 2014. The Gulf Coast population impact project. Shoreline: Youth helping youth recover from disaster. Earth Institute, Columbia University. Internet website: http://ncdptraining.cumc.columbia.edu/~columbia/files/gulf-coast-brochure.pdf. Accessed September 9, 2015.

National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. 2011. Deep water: The Gulf oil disaster and the future of offshore drilling. Report to the President (January 2011). Internet website: http://tinyurl.com/p8d7c8b. Accessed August 5, 2015.

National Conference of State Historic Preservation Officers. 2014. Testimony before the U.S. House of Representatives Committee on Appropriations, Subcommittee on Interior, Environment and Related Agencies. April 3, 2014. Internet website: http://docs.house.gov/meetings/AP/AP06/20140410/101761/HHRG-113-AP06-Wstate-HughesE-20140410.pdf.

National Conference of State Historic Preservation Officers. 2015. Historic Preservation Fund. Internet website: http://www.ncshpo.org/historicpreservationfund.shtml. Accessed July 20, 2015.

National Education Association. 2015. Rankings & estimates: Rankings of the States 2014 and estimates of school statistics 2015. NEA Research, March 2015. Internet website: http://www.nea.org/assets/docs/NEA_Rankings_And_Estimates-2015-03-11a.pdf. Accessed September 9, 2015.

National Fish and Wildlife Foundation. 2015. Gulf Environmental Benefit Fund funding priorities. Internet website: http://www.nfwf.org/gulf/Pages/fundingpriorities.aspx. Accessed March 11, 2015.

National Fish and Wildlife Foundation. 2016. Gulf Environmental Benefit Fund in Louisiana. Internet website: http://www.nfwf.org/gulf/Pages/GEBF-Louisiana.aspx. Accessed December 7, 2016.

National Institute of Environmental Health Science. 2014. GuLF STUDY gears up for second round of health exams. News release. April 11, 2014. Internet website: http://www.niehs.nih.gov/news/newsroom/releases/2014/april11/index.cfm. Accessed September 13, 2015.

National Offshore Safety Advisory Commission (NOSAC). 1999. Deepwater facilities in the Gulf of Mexico: Final report. NOSAC Subcommittee on Collision Avoidance, New Orleans, LA.

National Petroleum Council. Operations and Environment Task Group. Offshore Operations Subgroup. 2011. Subsea drilling, well operations and completions. Working document of the NPC North American Resource Development Study made available September 15, 2011. Internet website: http://www.npc.org/Prudent_Development-Topic_Papers/2-11_Subsea_Drilling-Well_Ops-Completions_Paper.pdf.

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. Pp. 18-21.

National Research Council (NRC). 1990. Decline of the sea turtles: Causes and prevention. Committee on Sea Turtle Conservation. Washington, DC: National Academy Press. 280 pp.

National Research Council (NRC). 1996. An assessment of techniques for removing offshore structures. Washington, DC: National Academy Press. 86 pp.

National Research Council (NRC). 2003. Oil in the sea III: Inputs, fates, and effects (Committee on Oil in the Sea: J.N. Coleman, J. Baker, C. Cooper, M. Fingas, G. Hunt, K. Kvenvolden, J. McDowell, J. Michel, K. Michel, J. Phinney, N. Rabalais, L. Roesner, and R.B. Spies). Washington, DC: The National Academies Press. 265 pp.

National Research Council (NRC). 2005. Oil spill dispersants: Efficacy and effects. Committee on understanding oil spill dispersants: Efficacy and Effects, Ocean Studies Board, Division on Earth and Life Studies, National Research Council, National Academy Press, Washington, DC. 400 pp.

National Research Council (NRC). 2010. Advancing the science of climate change. America's climate choices: Panel on advancing the science of climate change. Washington, DC: The National Academies Press. 528 pp.

National Research Council (NRC). 2014. Evaluating the effectiveness of fish stock rebuilding plans in the United States. National Research Council, Ocean Studies Board. Washington, DC: National Academies Press. Pp. 1-143.

National Response Corporation. 2015. National Response Corporation's major equipment list. Internet website: http://nrcc.com/pdf/Website.pdf. Accessed June 11, 2015.

National Wetlands Inventory Group. 1985. Status and trends of wetlands and deepwater habitats in the conterminous United States, 1950's to 1970's. Transactions of the North American Wildlife and Natural Resources Conference 50:440-448.

NaturalGas.org. 2010. Offshore drilling. Internet website: http://www.naturalgas.org/naturalgas/extraction_offshore.asp. Accessed December 21, 2010.

Navigant Consulting, Inc. 2013. Offshore wind market and economic analysis: Annual market assessment. Internet website: http://www1.eere.energy.gov/wind/pdfs/offshore_wind_market_and_economic_analysis.pdf. Accessed May 14, 2014.

Neal Adams Firefighters Inc. 1991. Joint industry program for floating vessel blowout control. Prepared for the U.S. Dept. of the Interior, Minerals Management Service. TA&R Project 150. 476 pp.

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, UK: 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. 2002. Fates and effects of mercury from oil and gas exploration and production operations in the marine environment. Prepared under contract for the American Petroleum Institute, Washington, DC.

Neff, J.M. 2005. Composition, environmental fates, and biological effects of water based drilling muds and cuttings discharged to the marine environment: A synthesis and annotated bibliography. Prepared for the Petroleum Environmental Research Forum and American Petroleum Institute. Duxbury, MA: Battelle. 83 pp. Internet website: http://www.perf.org/pdf/APIPERFreport.pdf.

Neff, J.M. and T.C. Sauer, Jr. 1991. Review: Findings of the American Petroleum Institute study on produced waters. In: Geo-Marine, Inc. Proceedings: Eleventh Annual Gulf of Mexico Information Transfer Meeting. November, 1990. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 91-0040. 524 pp.

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. 118 pp.

Negri, A.P. and A.J. Heyward. 2000. Inhibition of fertilization and larval metamorphosis of the coral *Acropora milepora* (Ehrenberg, 1834) by Petroleum Products. Marine Pollution Bulletin 41:420-427.

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 Publication No. 15. Tulsa, OK: SEPM.

Nero, R.W., M. Cook, A.T. Coleman, M. Solangi, and R. Hardy. 2013. Using an ocean model to predict likely drift tracks of sea turtle carcasses in the north central Gulf of Mexico. Endangered Species Research 21:191-203.

Nicholls, J.L. and G.A. Baldassarre. 1990. Winter distribution of piping plovers along the Atlantic and Gulf Coasts of the United States. Wilson Bulletin 102:400-412.

Nixon, Z., S. Zengel, M. Baker, M. Steinhoff, G. Fricano, S. Rouhani, and J. Michel. 2016. Shoreline oiling from the Deepwater Horizon oil spill. Marine Pollution Bulletin 107(1):170-178.

Nola.com. 2014. Judge blocks Mississippi offshore drilling rules. Internet website: http://www.nola.com/environment/index.ssf/2014/06/judge_blocks_mississippi_offsh.html.

Normandeau Associates, Inc. 2012. Effects of noise on fish, fisheries, and invertebrates in the U.S. Atlantic and Arctic from energy industry sound-generating activities. A literature synthesis for the U.S. Dept. of the Interior, Bureau of Ocean Energy Management. Contract No. M11PC00031. 135 pp.

Norris, D.R. 2005. Carry-over effects and habitat quality in migratory populations. Oikos 109:178-186.

Norris, K.S. and G.W. Harvey. 1972. A theory for the function of the spermaceti organ of the sperm whale (*Physeter catodon L.*). In: Galler, S.R., K. Schmidt-Koenig, G.J. Jacobs, and R.E. Belleville, eds. Animal orientation and navigation. National Aeronautics and Space Administration, Washington, DC. Pp. 397-417.

Norris K.S. and B. Mohl. 1983. Can odontocetes debilitate prey with sound? American Naturalist 122(1):85-104.

North American Water Fowl Management Plan. 2004. North American Waterfowl Management Plan 2004 implementation framework: Strengthening the biological foundation. Environment Canada, U.S. Fish and Wildlife Service, Secretaria de Medio Ambiente y Recursos Naturales.

Nott, M.P., O.L. Bass, Jr., D.M. Fleming, S.E. Killeffer, N. Fraley, L. Manne, J.L. Curnutt, J.M. Brooks, R. Powell, and S.L. Pimm. 1998. Water levels, rapid vegetational changes, and the endangered Cape Sable seaside sparrow. Animal Conservation 1:23-32.

Nowacek, S.M. and R.S. Wells. 2001. Short-term effects of boat traffic on bottlenose dolphins, *Tursiops truncatus*, in Sarasota Bay, Florida. Marine Mammal Science 17:673-688.

Nowacek, D.P., L.H. Thorne, D.W. Johnston, and P.L. Tyack. 2007. Responses of cetaceans to anthropogenic noise. Mammal Review 37(2):81-115.

Nowlin, W.D., Jr. 1972. Winter circulation patterns and property distributions. In: Capurro, L.R.A. and J.L. Reid, eds. Contributions on the physical oceanography of the Gulf of Mexico. Texas A&M University Oceanographic Studies, Volume 2. Houston, TX: Gulf Publishing Co. Pp. 3-51.

Nyman, J.A., D.M. Baltz, M.D. Kaller, P.L. Leberg, C.P. Richards, R.P. Romaire, and T.M. Soniat. 2013. Likely changes in habitat quality for fish and wildlife in coastal Louisiana during the next fifty years. In: Peyronnin, N. and D. Reed, eds. Louisiana‘s 2012 Coastal Master Plan Technical Analysis. Journal of Coastal Research Special Issue 67:60-74.

Nymo, I.H., M. Tryland, and J. Godfroid. 2011. A review of Brucella infection in marine mammals, with special emphasis on Brucella pinnipedialis in the hooded seal (*Cystophora cristata*). Veterinary Research 42:93.

O'Hara, J. 1980. Thermal influences on the swimming speed of loggerhead turtle hatchlings. Copeia 1980:773-780.

O'Hara, J. and J.R. Wilcox. 1990. Avoidance responses of loggerhead turtles, *Caretta caretta*, to low frequency sound. Copeia (1990)2:564-567.

O'Keefe, D.J. and G.A. Young. 1984. Handbook on the environmental effects of underwater explosives. U.S. Dept. of the Navy, Naval Surface Warfare Center, Dahlgren, VA, and Silver Spring, MD. NSWC TR 83-240.

O'Neil, J.M., T.W. Davis, M.A. Burford, and C.J. Gobler. 2012. The rise of harmful cyanobacteria blooms: The potential roles of eutrophication and climate change. Harmful Algae 14:313-334.

O'Shea, T., J. Moore, and H. Kochman. 1984. Contaminant concentrations in manatees in Florida. The Journal of Wildlife Management 48:741-748.

O'Shea, T.J., B.B. Ackerman, and H.F. Percival, eds. 1995. Population biology of the Florida manatee. National Biological Service, Information and Technology Report 1.

Obenour, D.R., D. Scavia, N.N. Rabalais, R.E. Turner, and A.M. Michalak 2013. Retrospective analysis of midsummer hypoxic area and volume in the northern Gulf of Mexico, 1985-2011. Environmental Science & Technology 47:9808-9815.

Ocean Conservancy. 2007. National Marine Debris Monitoring Program. Submitted to the U.S. Environmental Protection Agency: Grant No. 83053401-02. 74 pp.

Ocean Conservancy. 2014. Turning the tide on trash: 2014 report. Internet website: http://www.oceanconservancy.org/our-work/marine-debris/icc-data-2014.pdf.

Odell, C. 2015. Construction expected to be down in 2015 and 2016. Offshore Magazine 75(7). Internet website: http://www.offshore-mag.com/articles/print/volume-75/issue-7/rig-report/new-rig-orders-slow-almost-to-a-halt.html. Accessed August 31, 2015.

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, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 86-0070.

Offshore Inland. 2014. OIMO expands operations at the Port of Pensacola. Offshore Inland Marine Oilfield. July 23, 2014. Internet website: http://offshoreinland.com/oimo-expands-operations-port-pensacola/. Accessed September 24, 2015.

Ogden, J.C., D.A. McCrimmon, Jr., G.T. Bancroft, and B.W. Patty. 1987. Breeding populations of the wood stork in the southern United States. Condor 89:752-759.

Ogren, L.H. 1989. Distribution of juvenile and subadult Kemp's ridley turtles: Preliminary results from the 1984-1987 surveys. In: Proceedings from the 1st Symposium on Kemp's Ridley Sea Turtle Biology, Conservation, and Management. Sea Grant College Program, Galveston, TX. Volume 116.

Onuf, C.P. 1996. Biomass patterns in seagrass meadows of the Laguna Madre, Texas. Bulletin of Marine Science 58(2):404-420.

Operational Science Advisory Team (OSAT). 2010. Summary report for sub-sea and sub-surface oil and dispersant detection: Sampling and monitoring. Unified Area Command, New Orleans, LA. Internet website: http://www.restorethegulf.gov/sites/default/files/documents/pdf/OSAT_Report_FINAL_17DEC.pdf. Released December 17, 2010. Accessed March 14, 2011.

Operational Science Advisory Team (OSAT-2). 2011. Summary report for fate and effects of remnant oil in the beach environment. Operational Science Team (OSAT-2), Gulf Coast Incident Management Team. Prepared for Lincoln H. Stroh, CAPT, U.S. Coast Guard, Federal On-Scene Coordinator, Deepwater Horizon MC 252. 35 pp. Internet website: http://www.dep.state.fl.us/deepwaterhorizon/files2/osat_2_report__10feb.pdf.

Orth, R.J., T.J.B. Carruthers, W.C. Dennison, C.M. Duarte, J.W. Fourqurean, K.L. Heck, Jr., A.R. Hughes, G.A. Kendrick, W.J. Kenworthy, S. Olyarnik, F.T. Short, M. Waycott, and S.L. Williams. 2006. A global crisis for seagrass ecosystems. BioScience 56(12):987-996.

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. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA.

Owens, E.H., E. Taylor, A. Graham, and R.W. Castle. 2011. Sand beach treatment studies and field trials conducted during the *Deepwater Horizon*-Macondo response operation. In: Proceedings, 2011 International Oil Spill Conference, May 23-26, 2011, Portland, OR. 9 pp.

Oynes, C. 2006. Deepwater expansion continues in the Gulf of Mexico. Pipeline & Gas Journal 231(6):58.

Papastavrou, Y., S.C. Smith, and H. Whitehead. 1989. Diving behavior of the sperm whale, *Physeter macrocephalus*, off the Galapagos Islands. Canadian Journal of Zoology 7:839-846.

Parker, R.O., Jr., D.R. Colby, and T.P. Willis. 1983. Estimated amount of reef habitat on a portion of the U.S. South Atlantic and Gulf of Mexico continental shelf. Bulletin of Marine Science 33:935-940.

Parr, A.E. 1939. Quantitative observations on pelagic Sargassum vegetation of the western North Atlantic. Bulletin of the Bingham Oceanographic Collection 6:1-94.

Parsons, J.J. 1972. The hawksbill turtle and the tortoise shell trade. In: Études de géographie tropicale offertes a Pierre Gourou. Paris, France: Mouton. Pp. 45-60.

Parsons, G. and A. Kang. 2007. Valuing beach closures on the Padre Island National Seashore. University of Delaware, Graduate College of Marine Studies. U.S. Dept. of Commerce, NOAA Grant No. NA04NOS4190063. Project No. 06-090. 31 pp.

Passow, U., K. Ziervogel, V. Asper, and A. Diercks. 2012. Marine snow formation in the aftermath of the *Deepwater Horizon* oil spill in the Gulf of Mexico. Environmental Research Letters 7. doi:10.1088/1748-9326/7/3/035301.

Patrick, S.R., D.R. Patrick, and S.W. Fardo. 1993. Energy conservation guidebook. Lilburn, GA: The Fairmont Press, Inc. 471 pp. Internet website: http://books.google.com/books?id=f45IIzt4DCIC&pg=PA143&lpg=PA143&dq=ship,+%22discharge+water+temperature%22&source=bl&ots=CEHy0wpaMz&sig=BZam0pB-2mDwo4vO5zGM9jBsQWY&hl=en&ei=nMEpTYnqJsSBlAf_-7joAQ&sa=X&oi=book_result&ct=result&resnum=5&ved=0CC0Q6AEwBA#v=onepage&q&f=false. Accessed January 10, 2011.

Pattengill, C.V. 1998. The structure and persistence of reef fish assemblages of the Flower Garden Banks National Marine Sanctuary. Ph.D. Thesis, Texas A&M University, College Station, TX.

PCCI Marine and Environmental Engineering. 1999. Oil spill containment, remote sensing and tracking for deepwater blowouts: Status of existing and emerging technologies. Report prepared for the U.S. Dept. of the Interior, Minerals Management Service. TA&R Project 311. 66 pp. + apps.

Pearson, C.E., D.B. Kelley, R.A. Weinstein, and S.W. Gagliano. 1986. Archaeological investigations on the outer continental shelf: A study within the Sabine River valley, offshore

Louisiana and Texas. U.S. Dept. of the Interior, Minerals Management Service, Reston, VA. OCS Study MMS 86-0119. 314 pp.

Pearson, C.E., S.R. James, Jr., M.C. Krivor, S.D. El Darragi, and L. Cunningham. 2003. Refining and revising the Gulf of Mexico outer continental shelf region high-probability model for historic shipwrecks: 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 2003-060, 2003-061, and 2003-062. 13, 338, and 138 pp., respectively.

Peele, R.H., J.I. Snead, and W. Feng. 2002. Outer continental shelf pipelines crossing the Louisiana coastal zone: A geographic information system approach. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans LA. OCS Study MMS 2002-038. 24 pp.

Pennycuick, C.J. and P.F. Battley. 2003. Burning the engine: A time-marching computation of fat and protein consumption in a 5420-km non-stop flight by great knots, *Calidris tenuirostris*. Oikos 1032:323-332.

Pensacola News Journal. 2014. Hayward announces 200 new jobs at Port of Pensacola. July 10, 2014. Internet website: http://www.pnj.com/story/money/business/2014/07/10/mayor-announces-new-jobs-port/12472063/. Accessed September 24, 2015.

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, Gulf of Mexico OCS Region, New Orleans, LA. 398 pp.

Peres, L.C., E. Trapido, A.L. Rung, D.J. Harrington, E.Oral, Z. Fang, E. Fontham, and E.S. Peters. 2016. The Deepwater Horizon oil spill and physical health among adult women in southern Louisiana: The women and their children's health (WaTCH) Study. Environmental Health Perspectives. Advance Publication, January 22, 2016. Internet website: http://ehp.niehs.nih.gov/15-10348/. Accessed August 29, 2016.

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. Volume 5: First book of dolphins. London, UK: 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. Volume 5: The first book of dolphins. London, UK: 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. Volume 5: The first book of dolphins. London, UK: Academic Press. Pp. 161-171.

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. Volume 5: The first book of dolphins. London, UK: 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. Harrison, eds. Handbook of marine mammals. Volume 5: The first book of dolphins. London, UK: 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. Volume 5: The first book of dolphins. London, UK: Academic Press. Pp. 225-240.

Perry, S.L., D.P. DeMaster, and G.K. Silber. 1999. The great whales: History and status of six species listed as endangered under the U.S. Endangered Species Act of 1973. Marine Fisheries Review 61(1).

Peterson, M.S. and M.R. Lowe. 2009. Implications of cumulative impacts to estuarine and marine habitat quality for fish and invertebrate resources. Reviews in Fisheries Science 17(4):505-523.

Petkova, E.P., K.L. Ebi, D. Culp, and I. Redlener. 2015. Climate change and health on the U.S. Gulf Coast: Public health adaptation is needed to address future risks. International Journal of Environmental Research and Public Health 12:9342-9356. doi:10.3390/ijerph120809342. August 2015. Internet website: http://academiccommons.columbia.edu/catalog/ac:187854. Accessed September 9, 2015.

Petterson, J.S., E. Glazier, L.D. Stanley, C. Mencken, K. Eschbach, P. Moore, and P. Goode. 2008. Benefits and burdens of OCS activities on states, labor market areas, coastal counties, and selected communities. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2008-052. 470 pp.

Pezeshki, S.R., M.W. Hester, Q. Lin, and J.A. Nyman. 2000. The effects of oil spill and cleanup on dominant U.S. Gulf Coast marsh macrophytes: A review. Environmental Pollution 108:129-139.

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 Technical Memorandum NMFS-SEFSC-214.

Pollak, J. 2013. Extremes on the Mississippi River. Internet website: http://cuahsihis.blogspot.com/2013/01/extremes-on-mississippi-river.html. Accessed March 25, 2015.

Pollock, C.G., T.J. Code, I.F. Lundgren, M. Alter, A. Andres, P. Steinburg, and Z. Hillis-Starr. 2015. Buck Island sea turtles research program data summary. Technical report for the U.S. Dept. of Interior, National Park Service, Buck Island Reef National Monument. 13 pp.

Popper, A.N., R.R. Fay, C. Platt, and O. Sand. 2003. Sound detection mechanisms and capabilities of teleost fishes. In: Collin, S.P. and N.J. Marshall, eds. Sensory processing in aquatic environments. New York, NY: Springer-Verlag. Pp. 3-38.

Popper, A.N. and M.C. Hastings. 2009. Effects of anthropogenic sources of sound on fishes. Journal of Fish Biology 75:455-498.

Popper, A.N., M.E. Smith, P.A. Cott, B.W. Hanna, A.O. MacGillivray, M.E. Austin, and D.A. Mann. 2005. Effects of exposure to seismic airgun use on hearing of three fish species. Journal of the Acoustical Society of America 117(6):3958-3971.

Popper, A.N., A.D. Hawkins, R.R. Fay, D.A. Mann, S. Bartol, T.J. Carlson, S. Coombs, W.T. Ellison, R. Gentry, M.B. Halvorsen, S. Lokkeborg, P. Rogers, B.L. Southall, D.G. Zeddies, and W.N. Tavolga. 2014. ASA S3/SC1. 4 TR-2014 sound exposure guidelines for fishes and sea turtles. A technical report prepared by ANSI-Accredited Standards Committee S3/SC1 and Registered with ANSI. New York, NY: Springer. 78 pp.

Port of Gulfport. 2016. Port of Gulfport carriers and tenants. Internet website: http://shipmspa.com/carriers-customers/tenants/#sthash.5i5b1HH7.dpbs. Accessed February 19, 2016.

Port of Pascagoula. 2015. Port facts and stats. Internet website: http://www.portofpascagoula.com/port-facts.html. Accessed September 25, 2015.

Portnoy, J.W. 1978. Colonial waterbird population status and management on the north Gulf of Mexico coast. Proceedings of the Conference of the Colonial Waterbird Group 1:38-43.

Portnoy, J.W. 1981. Breeding abundance of colonial waterbirds on the Louisiana-Mississippi-Alabama coast. American Birds 35:868-872.

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.

Powers, S.P., F.J. Hernandez, R.H. Condon, J.M. Drymon, and C.M. Free. 2013. Novel pathways for injury from offshore oil spills: Direct, sublethal and indirect effects of the *Deepwater Horizon* oil spill on pelagic *Sargassum* communities. PLOS ONE (9):e74802. doi:10.1371/journal.pone.0074802.

Precht, W.F. and R.B. Aronson. 2004. Climate flickers and range shits of reef corals. Frontiers in Ecology and the Environment 2(6):307-334.

Price, J.M., W.R. Johnson, Z.-G. Ji, C.F. Marshall, and G.B. Rainey. 2001. Sensitivity testing for improved efficiency of a statistical oil spill risk analysis model. In: Proceedings, Fifth International Marine Environment Modeling Seminar, October 9-11, 2001, New Orleans, LA. Pp. 533-550.

Priest, T. and J. Lajaunie. 2014. Gulf Coast communities and the fabrication and shipbuilding industry: a comparative community study, Volume 1: Historical overview and statistical model. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Gulf of Mexico OCS Region, New Orleans, LA. OCS BOEM 2014-609. 185 pp.

Pritchard, P.C.H. 1982. Nesting of the leatherback turtle, *Dermochelys coriacea*, in Pacific Mexico, with a new estimate of the world population status. Copeia 1982:741-747.

Pritchard, P.C.H. 1997. Evolution, phylogeny, and current status. In: Lutz, P.L. and J.A. Musivk, eds. The biology of sea turtles. Boca Raton, FL: CRC Press. Pp. 1-28.

Prouty, N.G., C.R. Fisher, A.W.J. Demopoulos, and E.R.M. Druffel. 2014. Growth rates and ages of deep-sea corals impacted by the *Deepwater Horizon* oil spill. Deep Sea Research Part II: Topical Studies in Oceanography. doi:10.1016/j.dsr2.2014.10.021.

Pulsipher, A.G., O.O. Iledare, R.H. Baumann, D.E. Dismukes, and D.V. Mesyanzhinov. 1998. Environmental and safety risks of an expanding role for independents on the Gulf of Mexico OCS. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 98-0021. 40 pp.

Purser, J. and A.N. Radford. 2011. Acoustic noise induces attention shifts and reduces foraging performance in three-spined sticklebacks (*Gasterosteus aculeatus*). PLOS ONE 6:2.

Pusceddu, A., S. Bianchelli, J. Martin, P. Puig, A. Palanques, P. Masque, and R. Danovaro. 2014. Chronic and intensive bottom trawling impairs deap-sea biodiversity and ecosystem functioning. Proceedings of the National Academy of Sciences 111:24.

Putman, N.F. and K.L. Mansfield. 2015. Direct evidence of swimming demonstrates active dispersal in the sea turtle "lost years." Current Biology 25:1221-1227.

Putman, N.F., K.L. Mansfield, R. He, D.J. Shaver, and P. Verley. 2013. Predicting the distribution of oceanic-stage Kemp's ridley sea turtles. Biological Letters 9:20130345. Internet website: http://dx.doi.org/10.1098/rsbl.2013.0345.

Quattrini, A.M., S.E. Georgian, L. Byrnes, A. Stevens, R. Falco, and E.E. Cordes. 2013. Niche divergence by deep-sea octocorals in the genus *Callogorgia* across the continental slope of the Gulf of Mexico. Molecular Ecology 22(15):4123-4140. doi:10.1111/mec.12370.

Quest Offshore Resources, Inc. 2011. United States Gulf of Mexico oil and natural gas industry economic impact analysis: The economic impacts of GOM oil and natural gas development on the U.S. economy. Prepared for the American Petroleum Institute and National Ocean Industries Association.

Rabalais, N.N. 2005. Relative contribution of produced water discharge in the development of hypoxia. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2005-044. 37 pp. Internet website: http://www.data.boem.gov/PI/PDFImages/ESPIS/2/2964.pdf.

Rabalais, N.N. and R.E Turner. 2001. Coastal hypoxia: Consequences for living resources and ecosystems, coastal and estuarine studies, Volume 58. American Geophysical Union. 464 pp. New York, NY: John Wiley & Sons. ISBN:978-0-87590-272-2.

Rabalais, N.N., B.A. McKee, D.J. Reed, and J.C. Means. 1991. Fate and effects of nearshore discharges of OCS produced waters. Volume II: Technical report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 1991-0005. 359 pp.

Radford, C.A., J.A. Stanley, C.T. Tindle, J.C. Montgomery, and A.G. Jeffs. 2010. Localized coastal habitats have distinct underwater sound signatures. Marine Ecological Press Series 401:21-29.

Radford, A.N., E. Kerridge, and S.D. Simpson. 2014. Acoustic communication in a noisy world: Can fish compete with anthropogenic noise? Behavioral Ecology 00(00):1-9. doi:10.1093/beheco/aru029.

Railroad Commission of Texas. 2015. Offshore production. Internet website: http://www.rrc.state.tx.us/oil-gas/research-and-statistics/production-data/offshore-production/. Updated June 21, 2015.

Ramírez, E., G. Marín, J. Mpodozis, and J.C. Letelier. 2014. Extracellular recordings reveal absence of magneto sensitive units in the avian optic tectum. Journal of Comparative Physiology A, 200(12):983-996.

Raymond, W.W., M.A. Albins, and T.J. Pusack. 2014. Competitive interactions for shelter between invasive Pacific red lionfish and native Nassau grouper. Environmental Biology of Fishes 98(1):57-65.

Rees, M.A. 2010. Paleoindian and early archaic. In: Reese, M.A., ed. Archaeology of Louisiana. Baton Rouge, LA: Louisiana State University Press. Pp. 34-62.

Reeves, R.R. and H. Whitehead. 1997. Status of the sperm whale, *Physeter macrocephalus*, in Canada. Canadian-Field Naturalist 111(2):293-307.

Reible, D. 2010. After the oil is no longer leaking. The University of Texas, Austin. Environmental Science & Technology 44(15):5685-5686.

Reich, K.J., K.A. Bojorndal, and A.B. Bolten. 2007. The 'lost years' of green turtles: Using stable isotopes to study cryptic lifestages. Biology Letters 3:712-714.

Reimer, A.A. 1975. Effects of crude oil on corals. Marine Pollution Bulletin 6:39-43.

Renaud, M.L. 1995. Movements and submergence patterns of Kemp's ridley turtles (*Lepidochelys kempii*). Journal of Herpetology 29:370-374.

Renaud, M.L. and J.A. Williams. 2005. Kemp's ridley sea turtle movements and migrations. Chelonian Conservation and Biology 4:808-816.

RestoreTheGulf.gov. 2010. Shoreline treatment recommendation report. 27 pp. Internet website: http://www.restorethegulf.gov/sites/default/files/imported_pdfs/external/content/document/2931/737627/1/9JUN%20LAJF01-008-003-STR%20for%20Jeff%20Par-Grand%20Isle%20Beach.pdf. Posted June 10, 2010.

Reynolds, J.E. III. 1980. Aspects of the structural and functional anatomy of the gastrointestinal tract of the West Indian manatee, *Trichechus manatus*. Ph.D. Thesis, University of Miami, Coral Gables, FL.

Rezak, R. and T.J. Bright. 1979. Northwestern Gulf of Mexico topographic features study. Executive summary of the final report. U.S. Dept. of the Interior, Bureau of Land Management, New Orleans OCS Office, New Orleans, LA. Study No. 1979-14.

Rezak, R. and T.J. Bright. 1981a. Northern Gulf of Mexico topographic features study: Final report to the U.S. Dept. of the Interior, Bureau of Land Management, New Orleans OCS Office, New Orleans, LA. Contract No. AA551-CT8-35. 5 vols.

Rezak, R. and T.J. Bright. 1981b. A biological and reconnaissance of selected topographical features on the Texas continental shelf: A final report. U.S. Dept. of the Interior, Bureau of Land Management, New Orleans OCS Office, New Orleans, LA. Contract No. 08550-CT5-4. 381 pp.

Rezak, R., T.J. Bright, and D.W. McGrail. 1983. Reefs and banks of the northwestern Gulf of Mexico: Their geological, biological, and physical dynamics. Final Technical Report No. 83-1-T.

Rezak, R., T.J. Bright, and D.W. McGrail. 1985. Reefs and banks of the northwestern Gulf of Mexico: Their geological, biological, and physical dynamics. New York, NY: Wiley and Sons. 259 pp.

Rezak, R., S.R. Gittings, and T.J. Bright. 1990. Biotic assemblages and ecological controls on reefs and banks of the northwest Gulf of Mexico. American Zoologist 30:23-35.

Rice, D.W. 1989. Sperm whale—*Physeter macrocephalus* Linnaeus, 1758. In: Ridgway, S.H. and R. Harrison. Handbook of marine mammals. Volume 4: River dolphins and the larger toothed whales. London, England: Academic Press. Pp. 177-234.

Richardson, W.J. and B. Würsig. 1997. Influences of man-made noise and other human actions on cetacean behaviour. Marine and Freshwater Behaviour and Physiology 29:183-209.

Richardson, W.J., C.R. Greene, C.I. Mame, and D.H. Thomson. 1995. Marine mammals and noise. San Diego, CA: Academic Press Inc.

Richardson, G.E., L.D. Nixon, C.M. Bohannon, E.G. Kazanis, T.M. Montgomery, and M.P. Gravois. 2008. Deepwater Gulf of Mexico 2008: America's offshore energy future. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Report MMS 2008-013. 102 pp. Internet website: http://www.bsee.gov/Exploration-and-Production/Development-and-Production/Gulf/2008-013-pdf/.

Richmond, E.A. 1962. The fauna and flora of Horn Island, Mississippi. Gulf Research Reports 1(2):59-106.

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 64:884-890.

Roberts, D. and A.H. Nguyen. 2006. Degradation of synthetic-based drilling mud base fluids by Gulf of Mexico sediments: Final report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2006-028. 122 pp.

Roberts, H.H. and T.W. Neurauter. 1990. Direct observations of a large active mud vent on the Louisiana continental slope. Association of Petroleum Geologists Bulletin 74:1508.

Roberts, H.H., P. Aharon, R. Carney, J. Larkin, and R. Sassen. 1990. Sea floor responses to hydrocarbon seeps, Louisiana continental slope. Geo-Marine Letter 10(4):232-243.

Roberts, H.H., W. Shedd, and J. Hunt, Jr. 2010. Dive site geology: DSV ALVIN (2006) and ROV JASON II (2007) dives to the middle-lower continental slope, northern Gulf of Mexico. Deep Sea Research Part II: Topical Studies in Oceanography 57(21-23):1837-1858.

Roberts, J., B. Best, L. Mannocci, E. Fujioka, P. Halpin, D. Palka, L. Garrison, K. Mullin, T. Cole, C. Khan, W. McLellan, D.A. Pabst, and G. Lockhart. 2016. Habitat-based cetacean density models for the U.S. Atlantic and Gulf of Mexico. Scientific Reports 6:22615. doi:10.1038/srep22615.

Roche, E.A., J.B. Cohen, D.H. Catlin, D.L. Amirault-Langlais, F.J. Cuthbert, C.L. Gratto-Trevor, J. Felio, and J.D. Fraser. 2010. Range-wide piping plover survival: Correlated patterns and temporal declines. Journal of Wildlife Management 74:1784-1791.

Rodgers, J.A., Jr., S.T. Schwiker, G.A. Griffin, W.B. Brooks, D. Bear-Hull, P.M. Elliott, K.J. Ebersol, and J. Morris. 2008. Productivity of wood storks (*Mycteria americana*) in north and central Florida. Waterbirds 31(Special Publication):25-34.

Rogers, C.S. 1990. Responses of coral reefs and reef organisms to sedimentation. Marine Ecology Progress Series 62:185-202.

Rogers, C.S. and V.H. Garrison. 2001. Ten years after the crime: Lasting effects of damage from a cruise ship anchor on a coral reef in St. John, U.S. Virgin Islands. Bulletin of Marine Science 69(2):793-803.

Rooker, J.R., S.A. Holt, M.A. Soto, and G.J. Holt. 1998. Postsettlement patterns of habitat use by Sciaenid fishes in subtropical seagrass meadows. Estuaries 21(2):318-327.

Rooker, J., L. Kitchens, M. Dance, R. Wells, B. Falterman, and M. Cornic. 2013. Spatial, temporal, and habitat-related variation in abundance of pelagic fishes in the Gulf of Mexico: Potential implications of the *Deepwater Horizon* oil spill. PLOS ONE 8(10):e76080.

Rosel, P.E. and H. Watts. 2008. Hurricane impacts on bottlenose dolphins in the northern Gulf of Mexico. Gulf of Mexico Science 1:88-94.

Rosel, P. and L. Wilcox. 2014. Genetic evidence reveals a unique lineage of Bryde's whales in the northern Gulf of Mexico. Endangered Species Research 25:19-34.

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. Volume 5: The first book of dolphins. London, UK: Academic Press. Pp. 387-404.

Ross, B.J. and P. Hallock. 2014. Chemical toxicity on coral reefs: Bioassay protocols utilizing benthic foraminifers. Journal of Experimental Marine Biology and Ecology 457:226-235.

Rotkin-Ellman, M. and G. Soloman. 2012. FDA risk assessment of seafood contamination after the BP oil spill: Rotkin-Ellman and Soloman respond. Environmental Health Perspectives 120(2):A55-A56.

Rotkin-Ellman, M., K.Wong, and G. Soloman. 2012. Seafood contamination after the BP Gulf oil spill and risks to vulnerable populations: A critique of the FDA risk assessment. Environmental Health Perspectives 120(2):157-161.

Rowe, G.T. and M.C. Kennicutt II, eds. 2009. Northern Gulf of Mexico continental slope habitats and benthic ecology study: Final report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2009-039. 456 pp.

Rowe, G. and D.W. Menzel. 1971. Quantitative benthic samples from the deep Gulf of Mexico with some comments on the measurements of deep-sea biomass. Bulletin of Marine Science 21(2):556-566.

Rozas, L.P. and W.E. Odum. 1988. Occupation of submerged aquatic vegetation by fishes: Testing the roles of food and refuge. Oecologia 77:101-106.

Russell, R.W. 1999. Comparative demography and life-history tactics of seabirds: Implications for conservation and marine monitoring. American Fisheries Society Symposium 23:51-76.

Russell, R.W. 2005. Interactions between migrating birds and offshore oil and gas platforms in the northern Gulf of Mexico: Final report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2005-009. 327 pp.

Russo, M. 1992. Variations in late archaic subsistence and settlement patterning in peninsular Florida. In: Jeter, M., ed. Southeastern Archaeological Conference: Abstracts of the Forty-Ninth Annual Meeting, Little Rock, AR.

Ruzicka, R.R., M.A. Colella, J.W. Porter, J.M. Morrison, J.A. Kidney, V. Brinkuis, K.S. Lunz, K.A. Macaulay, L.A. Bartlett, M.K. Meyers, and J. Colee. 2013. Temporal changes in benthic assemblages on Florida Keys reefs 11 years after the 1997/1998 El Niño. Marine Ecology Progress Series 489:125-141.

Rybitski, M.J., R.C. Hale, and J.A. Musick. 1995. Distribution of organochlorine pollutants in Atlantic sea turtles. Copeia 1995:379-390.

Ryerson, T.B., R. Camilli, J.D. Kessler, E.B. Kujawinski, C.M. Reddy, D.L. Valentine, E. Atlas, D.R. Blake, J. de Gouw, S. Meinardi, D.D. Parrish, J. Peischl, J.S. Seewald, and C. Warneke. 2011. Chemical data quantify *Deepwater Horizon* hydrocarbon flow rate and environmental distribution. Proceedings of the National Academy of Sciences. doi/10.1072/pnas.1110564109.

S.L. Ross Environmental Research Ltd. 2000. Technology assessment of the use of dispersants on spills from drilling and production facilities in the Gulf of Mexico outer continental shelf. Prepared for the U.S. Dept. of the Interior, Minerals Management Service, Engineering and Research Branch, Herndon, VA. 19 pp. Internet website: http://www.boemre.gov/tarprojects/349/349AB.pdf.

Sadiq, M. and J.C. McCain. 1993. The Gulf War aftermath: An environmental tragedy. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Sager, W. 1997. Geophysical detection and characterization of seep community sites. In: 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. Pp. 49-60.

Sager, W.W., W.W. Schroeder, J.S. Laswell, K.S. Davis, R. Rezak, and S.R. Gittings. 1992. Mississippi-Alabama outer continental shelf topographic features formed during the late Pleistocene-Holocene transgression. Geo-Marine Letters 12:41-48.

Sammarco, P.W., A.D. Atchinson, G.S. Boland, J. Sinclair, and A. Lirette. 2012. Geographic expansion of hermatypic and ahermatypic corals in the Gulf of Mexico, and implications for dispersal and recruitment. Journal of Experimental Marine Biology & Ecology 436-437:36-49.

Sammarco, P.W., S.R. Kolian, R.A. Warby, J.L. Bouldin, W.A. Subra, and S.A. Porter. 2013. Distribution and concentrations of petroleum hydrocarbons associated with the BP/*Deepwater Horizon* oil spill, Gulf of Mexico. Marine Pollution Bulletin 73(1):129-143.

Samson, J.E., T.A. Mooney, S.W. Gussekloo, and R.T. Hanlon. 2014. Graded behavioral responses and habituation to sound in the common cuttlefish *Sepia officinalis*. The Journal of Experimental Biology 217(24):4347-4355.

Sanchez, M. and R. Tibbles. 2007. Frac packing: Fracturing for sand control. Middle East and Asia Reservoir Review 8:36-49. Internet website: http://www.slb.com/~/media/Files/resources/mearr/num8/37_49.pdf. Accessed June 17, 2015.

Sanders, R. 2015. Official communication. U.S. Dept. of the Interior mail; draft summary of water quality inspection function and attachment BSEE water quality program. February 6, 2015.

Sanders, R. 2016. Official communication. U.S. Dept. of the Interior mail; NPDES inspections table. November 10, 2016.

Santos, R.G., R. Andrades, M.A. Boldrini, and A.S. Martins. 2015. Debris ingestion by juvenile marine turtles: An underestimated problem. Marine Pollution Bulletin 93:37-43.

Sargent, F.J., T.J. Leary, D.W. Crewz, and C.R. Kruer. 1995. Scarring of Florida's seagrasses: Assessment and management options. FRMI TR-1, Florida Marine Research Institute, St. Petersburg, FL. 37 pp. + app.

Sarti, L., S.A. Eckert, N. Garcia, and A.R. Barragan. 1996. Decline of the world's largest nesting assemblage of leatherback turtles. Marine Turtle Newsletter 74:2-5.

Sassen, R. 1998. Origins of hydrocarbons and community stability. In: MacDonald, I.R., ed. 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 98-00034. Pp. 71-76.

Schiff, K., D. Diehl, and A. Valkirs. 2004. Copper emissions from antifouling paint on recreational vessels. Marine Pollution Bulletin 48:371-377.

Schmid, J.R. and W.N. Witzell. 1997. Age and growth of wild Kemp's ridley turtles (*Lepidochelys kempii*): Cumulative results of tagging studies in Florida. Chelonian Conservation and Biology 2(4):532-537.

Schreiber, E.A. and J. Burger. 2002. Seabirds in the marine environment. In: Schreiber, E.A. and J. Burger, eds. Biology of marine birds. Boca Raton, FL: CRC Press. Pp. 1-15.

Schroeder, W.W. 2000. Shelf hard bottom habitats. In: Schroeder, W.W. and C.F. Wood, eds. Physical/Biological Oceanographic Integration Workshop for DeSoto Canyon and Adjacent Shelf, October 19-21, 1999. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2000-074. Pp. 67-71.

Schroeder, D.M. and M.S. Love. 2004. Ecological and political issues surrounding decommissioning of offshore oil facilities in the southern California Bight. Ocean and Coastal Management 47:21-48.

Schroeder, W.W., A.W. Shultz, and J.J. Dindo. 1988. Inner-shelf hardbottom areas, northeastern Gulf of Mexico. Transactions of the Gulf Coast Association of Geological Societies 38:535-541.

Schroeder, W.W., M.R. Dardeau, J.J. Dindo, P. Fleisher, K.L. Heck Jr., and A.W. Shultz. 1989. Geophysical and biological aspects of hardbottom environments on the MAFLA shelf, northern Gulf of Mexico. Proceedings Oceans '88 Conference. Pp. 17-21.

Schroeder, W.W., S.D. Brooke, J.B. Olson, B. Phaneuf, J.J. McDonough, III, and P. Etnoyer. 2005. Occurrence of deep-water *Lophelia pertusa* and *Madrepora oculata* in the Gulf of Mexico. Cold-Water Corals and Ecosystems, Erlangen Earth Conference Series, pp. 297-307.

Schuler, M. 2014. Harvey Gulf breaks ground on nation's first LNG bunkering facility. Internet website: http://gcaptain.com/harvey-gulf-breaks-ground-on-nations-first-lng-bunkering-facility/. Posted February 14, 2014. Accessed September 25, 2015.

Schultz, J.P. 1975. Sea turtles nesting in Surinam. Nederlandsche Commissie voor Internationale Natuurbescherrning. Mededrlingen No·.23. 143 pp.

Schumacher, H. and H. Zibrowius. 1985. What is hermatypic? A redefinition of ecological groups in corals and other organisms. Coral Reefs 4:1-9.

Schuyler, Q., B.D. Hardesty, C. Wilcox, and K. Townsend. 2012. To eat or not to eat? Debris selectivity by marine turtles. PLOS ONE 7(7):e40884. doi:10.1371/journal.pone.0040884.

Schuyler, Q., B.D. Hardesty, C. Wilcox, and K. Townsend. 2014. Global analysis of anthropogenic debris ingestion by sea turtles. Conservation Biology 28(1):129-139.

Schwacke, L.H., C.R. Smith, F.I. Townsend, R.S. Wells, L.B. Hart, B.C. Balmer, T.K. Collier, S. De Guise, M.M. Fry, L.J. Guillette, Jr., S.V. Lamb, S.M. Lane, W.E. McFee, N.J. Place, M.C. Tumlin, G.M. Ylitalo, E.S. Zolman, and T.K. Rowles. 2013. Health of common bottlenose dolphins (*Tursiops truncatus*) in Barataria Bay, Louisiana, following the *Deepwater Horizon* oil spill. Environmental Science & Technology 2014, 48(1):93-103. doi:10.1021/es403610f.

Schwartz, F.J. 1988. Aggregations of young hatchling loggerhead sea turtles in the *Sargassum* off North Carolina. Marine Turtle Newsletter 42:9-10.

Scott, L.C. 2014. The energy sector: Still a giant economic engine for the Louisiana economy – an update. Loren C. Scott and Associates, Inc. for Mid-Continent Oil and Gas Association. 51 pp.

Scyphers, S.B., T.C. Gouhier, J.H. Grabowski, M.W. Beck, J. Mareska, and S.P. Powers. 2015. Natural shorelines promote the stability of fish communities in an urbanized coastal system. PLOS ONE 10(6):e0118580.

Sebastian, S. 2011. Fuelfix: Feds say aging equipment sparked platform fire. Internet website: http://fuelfix.com/blog/2011/05/26/feds-say-aging-equipment-sparked-platform-fire-2/. Accessed October 6, 2015.

Secor, D.H., J.R. Rooker, B.I. Gahagan, M.R. Siskey, and R.W. Wingate. 2014. Depressed resilience of bluefin tuna in the western Atlantic and age truncation. Conservation Biology 29(2):400-408.

Secretariat of Environment & Natural Resources, National Commission of Natural Protected Areas, Federal Attorney of Environmental Protection (PROFEPA) Mexico, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and U.S. Department of the Interior, Fish and Wildlife Service. 2011. Bi-National recovery plan for the Kemp's ridley sea turtle (*Lepidochelys kempii*). Second revision. 177 pp. Internet website: https://content.sierraclub.org/grassrootsnetwork/sites/content.sierraclub.org.activistnetwork/files/teams/documents/kempsridley_revision2.pdf.

Seegar, W.S., M.A. Yates, G.E. Doney, J.P. Jenny, T.C. Seegar, C. Perkins, and M. Giovanni. 2015. Migrating tundra peregrine falcons accumulate polycyclic aromatic hydrocarbons along Gulf of Mexico following Deepwater Horizon oil spill. Ecotoxicology 1-10.

Selman, W., T.J. Hess Jr., and J. Linscombe. 2016. Long-term population and colony dynamics of brown pelicans (*Pelecanus occidentalis*) in rapidly changing coastal Louisiana, USA. Waterbirds 39(1):45-57. doi:http://dx.doi.org/10.1675/063.039.0106.

Setälä, O., V. Fleming-Lehtinen, and M. Lehtiniemi. 2014. Ingestion and transfer of microplastics in the planktonic food web. Environmental Pollution 185:77-83.

Shaffer, G.P., J.W. Day, S. Mack, G.P. Kemp, I. van Heerden, M.A. Poirrier, K.A.Westphal, D. FitzGerald, A. Milanes, C.A. Morris, R. Bea, and P.S. Penland. 2009. The MRGO navigation project: A massive human-induced environmental, economic, and storm disaster. Journal of Coastal Research 54:206-224.

Share the Beach. 2015. Alabama sea turtle nesting statistics. Internet website: http://www.alabamaseaturtles.com/nesting-season-statistics. Accessed March 8, 2016.

Sharp, J.M. and D.W. Hill. 1995. Land subsidence along the northeastern Texas Gulf Coast: Effects of deep hydrocarbon production. Environmental Geology 25(3):181-191. Internet website: http://www.springerlink.com/content/t5072854ukl2r262/.

Shaver, D.J. 1991. Feeding ecology of wild and head-started Kemp's ridley sea turtles in south Texas waters. Journal of Herpetology 25(3):327-334.

Shaver, D.J., K.M. Hart, I. Fujisaki, C. Rubio, A.R. Sartain, J. Pena, P.M. Burchfield, D.G. Gamez, and J. Ortiz. 2013. Foraging area fidelity for Kemp's ridleys in the Gulf of Mexico. Ecology and Evolution 3(7):2002-2012. doi:10.1002/ece3.594.

Shaw, R.F., D.C. Lindquist, M.C. Benfield, T. Farooqi, and J.T. Plunket. 2002. Offshore petroleum platforms: Functional significance for larval fish across longitudinal and latitudinal gradients. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2002-077. 107 pp.

Sheavly, S.B. 2007. National marine debris monitoring program: Final program report, data analysis and summary. Prepared for the U.S. Environmental Protection Agency by Ocean Conservancy. Grant No. X83053401-02. 76 pp.

Sheavly, S.B. and K. Register. 2007. Marine debris & plastics: Environmental concerns, sources, impacts and solutions. Journal of Polymers and the Environment 15:301-305.

Shedd, W. 2015. Official communication. Email regarding studies of the seafloor in the vicinity of the *Deepwater Horizon* explosion, oil spill, and response. April 13, 2015. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Gulf of Mexico OCS Region, New Orleans, LA.

Shigenaka, G., S. Milton, P. Lutz, R. Hoff, R. Yender, and A. Mearns. 2010. Oil and sea turtles: Biology, planning and response. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Oceanic and Atmospheric Administration, Office of Restoration and Response. 116 pp.

Shinn, E.A., J.H. Hudson, D.M. Robbin, and C.K. Lee. 1980. Drilling mud plumes from offshore drilling operations: Implications for coral survival. In: Geyer, R.A., ed. Marine environmental pollution. Elsevier Oceanography Series 27A. Amsterdam, The Netherlands: Elsevier Scientific Publishing Company. Pp. 471-495.

Shipp, R. 1999. Status of exploited fish species in the Gulf of Mexico. In: Kumpf, H., K. Steidinger, and K. Sherman, eds. The Gulf of Mexico large marine ecosystem: Assessment, sustainability, and management. Malden, MA: Blackwell Science, Inc.

Shipp, R. and S. Bortone. 2009. A perspective of the importance of artificial habitat on the management of red snapper in the Gulf of Mexico. Reviews in Fisheries Science 17(1):41-47.

Shipp, R.L. and T.L. Hopkins. 1978. Physical and biological observations of the northern rim of the DeSoto Canyon made from a research submersible. Northeast Gulf Science 2(2):113-121.

Shively, A. 2015. Official communication. Email to Deputy Tribal Historic Preservation Officer, Jena Band of Choctaw Indians regarding OCS activities. June 8-9, 2015.

Shoop, C.R. and R.D. Kenney. 1992. Seasonal distributions and abundances of loggerhead and leatherback sea turtles in waters of the northeastern United States. Herpetological Monographs 6:43-67. Internet website: http://www.jstor.org/stable/1466961.

Short, F.T., R.G. Coles, and C. Pergent-Martini. 2001. Global seagrass distribution. In: Short, F.T. and R.G. Coles, eds. 2001. Global seagrass research methods. Amsterdam, The Netherlands: Elsevier Science B.V. Pp. 5-6, 20.

Silva, M., P.J. Etnoyer, and I.R. MacDonald. 2015. Coral injuries observed at mesophotic reefs after the *Deepwater Horizon* oil discharge. Deep Sea Research II: Topical Studies in Oceanography. TBD-Accepted Manuscript. doi:10.1016/j.dsr2.2015.05.013.

Simmonds, M. and S. Isaac. 2007. The impacts of climate change on marine mammals, early signs of significant problems. Oryx 41:1-8.

Simmons, C., A.B. Collins, and R. Ruzicka. 2014. Distribution and diversity of coral habitat, fishes, and associated fisheries in U.S. waters of the Gulf of Mexico. In: Bortone, S.A., ed. Interrelationships between corals and fisheries. CRC Press, Taylor & Francis Group. 321 pp.

Skagen, S.K. 2006. Migration stopovers and the conservation of Arctic-breeding Calidridine sandpipers. Auk 123:313-322.

Slabbekoorn, H., N. Bouton, I. van Opzeeland, A. Coers, C. ten Cate, and A.N. Popper. 2010. A noisy spring: The impact of globally rising underwater sound levels on fish. Trends in Ecology & Evolution 25:419-427.

Slay, C.K. and J.I. Richardson. 1988. King's Bay, Georgia: Dredging and turtles. In: Schroeder, B.A., comp. Proceedings of the Eighth Annual Conference on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFC-214. Pp. 109-111.

Smith, M.F., ed. 1984. Ecological characterization atlas of coastal Alabama: Map narrative. U.S. Dept. of the Interior, Fish and Wildlife Service, FWS/OBS-82/46 and U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 84-0052. 189 pp.

Smith, P. 2015. Official communication. Pipeline information. U.S. Dept. of Interior, Bureau of Safety and Environmental Enforcement, Gulf of Mexico OCS Region, New Orleans, LA. June 2015.

Smith, G.M. and C.W. Coates. 1938. Fibro-epithelial growths of the skin in large marine turtles, *Chelonia mydas* (Linnaeus). Zoologica 24:93-98.

Smith, R.A., J.R. Slack, T. Wyant, and K.J. Lanfear. 1982. The oil spill risk analysis model of the U.S. Geological Survey. U.S. Dept. of the Interior, Geological Survey. Professional Paper 1227.

Smith, T.G., J.R. Geraci, and D.J. St. Aubin. 1983. The reaction of bottlenose dolphins, *Tursiops truncatus*, to a controlled oil spill. Canadian Journal of Fisheries and Aquatic Sciences 40(9):1,522-1,527.

Smith, C., B. Hurley, C. Toms, A. Mackey, M. Solangi, and S. Kuczaj II. 2013. Hurricane impacts on the foraging patterns of bottlenose dolphins *Tursiops truncatus* in Mississippi Sound. Marine Ecology Progress Series 487:231-244.

Smultea, M. and B. Würsig. 1991. Bottlenose dolphin reactions to the *Mega Borg* oil spill, summer 1990. Ninth Biennial Conference on the Biology of Marine Mammals, Chicago, IL.

Smultea, M.A. and B. Würsig. 1995. Behavioral reactions of bottlenose dolphins to the *Mega Borg* oil spill, Gulf of Mexico 1990. Aquatic Mammals 21:171-181.

Snyder D.B. 2000. Chapter 10: Fishes and fisheries. In: Continental Shelf Associates, Inc. Deepwater Gulf of Mexico environmental and socioeconomic data search and literature synthesis. Volume I: Narrative report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2000-049. Pp. 255-283.

Snyder, S.M., E.L. Pulster, D.L. Wetzel, and S.A. Murawski. 2015. PAH exposure in Gulf of Mexico demersal fishes, post-*Deepwater Horizon*. Environmental Science & Technology.

Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene, Jr., D. Kastak, D.R. Ketten, J.H. Miller, P.E. Nachtigall, W.J. Richardson, J.A. Thomas, and P. Tyack. 2007. Marine mammal noise exposure criteria: Initial scientific recommendations. Aquatic Mammals 33:411-521.

Spalding, E.A. and M.W. Hester. 2007. Effects of hydrology and salinity on oligohaline plant species productivity: Implications of relative sea-level rise. Estuaries and Coasts 30(2):214-225.

Sparks, T.D., J.C. Norris, R. Benson, and W.E. Evans. 1996. Distributions of sperm whales in the northwestern Gulf of Mexico as determined from an acoustic survey. In: Proceedings of the 11th Biennial Conference on the Biology of Marine Mammals, 14-18 December 1995, Orlando, FL. P. 108.

St. Aubin, D.J. and V. Lounsbury. 1990. Chapter 11. Oil effects on manatees: Evaluating the risks. In: Geraci, J.R. and D.J. St. Aubin, eds. Sea mammals and oil: Confronting the risks. San Diego, CA: Academic Press, Inc. Pp. 241-251.

Stanley, D.R. and C.A. Wilson. 1997. Seasonal and spatial variation in the abundance and size distribution of fishes associated with a petroleum platform in the northern Gulf of Mexico. Canadian Journal of Fisheries and Aquatic Sciences 54(5):1166-1176.

Stanley, D.R. and C.A. Wilson. 2000. Seasonal and spatial variation in the biomass and size frequency distribution of fish associated with oil and gas platforms in the northern Gulf of Mexico. U.S. Dept. of the Interior, Minerals Mgmt. Service, Gulf of Mexico OCS Region, New Orleans, LA OCS Study MMS 2000-005. 252 pp.

State of Alabama. Oil and Gas Board. 2015. Petroleum exploration and development offshore Alabama. Geological Survey of Alabama, State Oil and Gas Board. Internet website: http://www.gsa.state.al.us/ogb/ogal.html. Accessed April 3, 2015.

State of Florida. Dept. of Environmental Protection. 2011. Letter dated May 5, 2011, requesting change in Region IV dispersant preapproval zones for the State of Florida. Internet website: http://www.nrt.org/production/NRT/RRTHome.nsf/Resources/DUP/$file/Florida_Environmental_Protection.pdf.

State of Florida. Dept. of Natural Resources. 1991. Part I, 1988 and 1989 Florida petroleum production and exploration. Information Circular 107. Prepared by Jacqueline M. Lloyd, P.G. #74. Printed for Florida Geological Survey. Internet website: http://ufdcweb1.uflib.ufl.edu/UF00001168/00001/3x.

State of Florida. Fish and Wildlife Conservation Commission. 2015a. Manatee synoptic surveys. Internet website: http://myfwc.com/research/manatee/research/population-monitoring/synoptic-surveys/. Accessed December 2, 2015.

State of Florida. Fish and Wildlife Conservation Commission. 2015b. 2013 preliminary red tide manatee mortalities. Marine Mammal Pathobiology Laboratory. Internet website: http://myfwc.com/media/2477220/2013PreliminaryRedTide.pdf. Last updated March 17, 2015. Accessed August 14, 2015.

State of Florida. Fish and Wildlife Conservation Commission. 2015c. Manatee mortality statistics. Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute. Internet website: http://myfwc.com/research/manatee/rescue-mortality-response/mortality-statistics/. Accessed August 13, 2015.

State of Florida. Fish and Wildlife Conservation Commission. 2016a. Manatee synoptic surveys. Internet website: http://myfwc.com/research/manatee/research/population-monitoring/synoptic-surveys/. Accessed August 30, 2016.

State of Florida. Fish and Wildlife Conservation Commission. 2016b. Cold-related mortality event, winter 2009-2010. Internet website: http://myfwc.com/research/manatee/rescue-mortality-response/mortality-statistics/cold-related-2009-2010/. Accessed September 19, 2016.

State of Florida. Fish and Wildlife Conservation Commission. 2016c. Manatee mortality statistics. Internet website: http://myfwc.com/research/manatee/rescue-mortality-response/mortality-statistics/.

State of Florida. Fish and Wildlife Conservation Commission. 2016d. Fish and Wildlife Research Institute sea turtle nesting. Internet website: http://myfwc.com/research/wildlife/sea-turtles/nesting. Accessed March 8, 2016.

State of Florida. Fish and Wildlife Conservation Commission. 2016e. FLSTSSN archived sea turtle stranding data. Internet website: http://myfwc.com/research/wildlife/sea-turtles/mortality/archived-stranding-data/. Accessed March 3, 2016.

State of Louisiana. Coastal Protection and Restoration Authority. 2007. Integrated ecosystem restoration and hurricane protection: Louisiana's comprehensive master plan for a sustainable coast. State of Louisiana, Coastal Protection and Restoration Authority, Baton Rouge, LA.

State of Louisiana. Coastal Protection and Restoration Authority. 2012. Louisiana's 2012 coastal master plan. May 23, 2012. 190 pp.

State of Louisiana. Coastal Protection and Restoration Authority. 2014. CWPPRA's role key as restoration gains speed. Water Marks, December 2014, No. 50.

State of Louisiana. Coastal Protection and Restoration Authority. 2015. FY2015 annual plan. Internet website: http://coastal.la.gov/a-common-vision/annualplan/. Accessed March 24, 2015.

State of Louisiana. Dept. of Natural Resources. n.d. History of oil and gas in Louisiana and the Gulf Coast region. Internet website: http://dnr.louisiana.gov/assets/TAD/education/BGBB/6/la_oil.html. Accessed August 24, 2016.

State of Louisiana. Dept. of Natural Resources. 1998. Coast 2050: Toward a sustainable coastal Louisiana. Report of the Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority. Baton Rouge, LA. 173 pp. Internet website: http://www.coast2050.gov/products/docs/orig/2050report.pdf.

State of Louisiana. Dept. of Natural Resources. 2009. Louisiana is proud to be a hub of industry. 6 pp. Internet website: http://dnr.louisiana.gov/assets/docs/hub-of-business_brochure.pdf. Accessed September 14, 2015.

State of Louisiana. Dept. of Natural Resources. 2015a. Louisiana state crude oil production. Internet website: http://assets.dnr.la.gov/TAD/OGTABLES/Table01.htm. Last updated October 27, 2015. Accessed November 9, 2015.

State of Louisiana. Dept. of Natural Resources. 2015b. Louisiana state natural gas production wet after lease separation. Internet website: http://assets.dnr.la.gov/TAD/OGTABLES/table09.htm. Last updated October 27, 2015. Accessed November 9, 2015.

State of Louisiana. Dept. of Natural Resources. 2015c. Leasing manual how to acquire a mineral lease on state and state agency lands and water bottoms in the State of Louisiana. State Mineral Board, Office of Mineral Resources. Internet website: http://dnr.louisiana.gov/index.cfm?md=pagebuilder&tmp=home&pid=178.

State of Louisiana. Dept. of Wildlife and Fisheries. 1987. Louisiana artificial reef plan. Louisiana Dept. of Wildlife and Fisheries. Technical Bulletin No. 41.

State of Mississippi. Dept. of Marine Resources. 1999. Mississippi's coastal wetlands. Coastal Reserves Program. 19 pp.

State of Texas. Commission on Environmental Quality. 2014. Revisions to the State of Texas air quality implementation plan concerning regional haze: Five-year regional haze project report. Project No. 2013-013-SIP-NR. 99 pp. Internet website: http://www.tceq.texas.gov/assets/public/implementation/air/sip/haze/13012SIP_ado.pdf. Accessed May 15, 2014.

State of Texas. Dept. of State Health Services. 2015. Harmful algal blooms – Seafood and aquatic life. Internet website: http://www.dshs.state.tx.us/seafood/harmful-algal-blooms.aspx. Accessed September 28, 2015.

State of Texas. General Land Office. 2015. Coastal erosion. Internet website: http://www.glo.texas.gov/what-we-do/caring-for-the-coast/coastal-erosion/. Accessed June 3, 2015.

State of Texas. Parks and Wildlife Dept. 1990. Texas artificial reef fishery management plan. Fishery Management Plan Series Number 3.

Stavros, H., R. Bonde, and P. Fair. 2008. Concentrations of trace elements in blood and skin of Florida manatees (*Trichechus manatus latirostris*). Marine Pollution Bulletin 56:1221-1225.

Stedman, S. and T.E. Dahl. 2008. Status and trends of wetlands in the coastal watersheds of the eastern United States 1998-2004. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service and U.S. Dept. of the Interior, Fish and Wildlife Service, Washington, DC. 36 pp.

Steinmetz, J.H. 2010. Examining mid-Atlantic Ocean shipwrecks and commercial fish trawling & dredging. Master's Thesis, East Carolina University.

Stephens, B.P. 2009. Basement controls on subsurface geologic patterns and coastal geomorphology across the northern Gulf of Mexico: Implications for subsidence studies and coastal restoration. Transactions Gulf Coast Association of Geological Societies 59:729-751. Internet website: http://www.searchanddiscovery.net/abstracts/html/2009/gcags/abstracts/stephens.htm. Accessed January 27, 2017.

Stephens, B.P. 2010. Basement controls on subsurface geologic patterns and coastal geomorphology across the northern Gulf of Mexico: Implications for subsidence studies and coastal restoration. Adapted from the presentation given to New Orleans Geological Society, July 14, 2010.

Steyn, P. 2010. *Exxon Valdez* oil spill. Internet website: http://www.answers.com/topic/exxon-valdez-oil-spill. Accessed November 23, 2010.

Stickney. K. 2015. Schlumberger announces layoffs to 11,000 employees. The Advertiser. April 16, 2015. Internet website: http://www.theadvertiser.com/story/money/business/2015/04/16/schlumberger-announces-layoffs/25918819/. Accessed September 7, 2015.

Stone, R.B. 1974. A brief history of artificial reef activities in the United States. In: Proceedings: Artificial Reef Conference, Houston, TX. Pp. 24-27.

Stoner, A.W. 1983. Pelagic *Sargassum*: Evidence for a major decrease in biomass. Deep Sea Research Part A: Oceanographic Research Papers 30(4):469-474. doi:10.1016/0198-0149(83)90079-1.

Strauss, G. 2015. Baker Hughes to lay off 7,000 as oil patch layoffs mount. USA Today. January 20, 2015. Internet website: http://www.usatoday.com/story/money/2015/01/20/baker-hughes-latest-hit-by-oil-slump-to-lay-off-7000/22042433/. Accessed September 7, 2015.

Stright, M.J., E.M. Lear, and J.F. Bennett. 1999. Spatial data analysis of artifacts redeposited by coastal erosion: A case study of McFaddin Beach, Texas. U.S. Dept. of the Interior, Minerals Management Service, Herndon, VA. OCS Study MMS 99-0068. 2 vols.

Stucker, J.H. and F.J Cuthbert. 2006. Distribution of nonbreeding Great Lakes piping plovers along Atlantic and Gulf coastlines: 10 years of band resightings. Report to the U.S. Dept. of the Interior, Fish and Wildlife Service, East Lansing, MI, and Panama City, FL, Field Offices. 20 pp.

Stucker, J.H., F.J. Cuthbert, B. Winn, B.L. Noel, S.B. Maddock, P.R. Leary, J. Cordes, and L.C. Wemmer. 2010. Distribution of non-breeding Great Lakes piping plovers (*Charadrius melodus*) along Atlantic and Gulf of Mexico coastlines: Ten years of band sightings. Waterbirds 33:22-32.

Sturges, W., E. Chassignet, and T. Ezer. 2004. Strong mid-depth currents and a deep cyclonic gyre in the Gulf of Mexico: Final report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS-2004-040. 89 pp.

Stutzenbaker, C.D. and M.W. Weller. 1989. The Texas coast. In: Smith, L.M., R.L. Pederson, and R.K. Kaminski, eds. Habitat management for migrating and wintering waterfowl in North America. Lubbock, TX: Texas Technical University Press. Pp. 385-405.

Substance Abuse and Mental Health Services Administration and Centers for Disease Control and Prevention (SAMSA and CDCP). 2013. Behavioral health in the Gulf Coast region following the *Deepwater Horizon* oil spill. HHS Publication No. (SMA) 13-4737, Rockville, MD; Atlanta, GA. Internet website: http://www.samhsa.gov/data/sites/default/files/NSDUH-GSPS-GulfCoast-Apps-2012/NSDUH-GSPS-GulfCoast-2012.pdf. Accessed September 13, 2015.

Sulak, K.J., R.A. Brooks, K.E. Luke, A.D. Norem, M.T. Randall, A.J. Quaid, G.E. Yeargin, J.M. Miller, W.M. Harden, J.H. Caruso, and S.W. Ross. 2008. Demersal fishes associated with *Lophelia pertusa* coral and associated biotopes on the continental slope, northern Gulf of Mexico. In: Sulak, K.J., M.T. Randall, K.E. Luke, A.D. Norem, and J.M. Miller, eds. Characterization of northern Gulf of Mexico deepwater hard bottom communities with emphasis on *Lophelia* coral – Lophelia reef megafaunal community structure, biotopes, genetics, microbial ecology, and geology. U.S. Dept. of the Interior, Geological Survey Open-File Report 2008-1148. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2008-015. Pp. 2-1 to 2-6.

Switzer, T.S., D.M. Tremain, S.F. Keenan, C.J. Stafford, S.L. Parks, and R.H. McMichael, Jr. 2015. Temporal and spatial dynamics of the lionfish invasion in the eastern Gulf of Mexico: Perspectives from a broadscale trawl survey. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 7:10-17. doi:10.1080/19425120.2014.987888.

Systems Applications International, Sonoma Technology, Inc., Earth Tech, Alpine Geophysics, and A.T. Kearney. 1995. Gulf of Mexico air quality study: Final report. 3 vols. 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. 650, 214, and 190 pp., respectively.

Szedlmayer, S.T. and J.D. Lee. 2004. Diet shifts of red snapper, *Lutjanus campechanus*, with changes in habitat and fish size. Fisheries Bulletin 102:366-375.

Tabb, D. and A. Jones. 1962. Effect of Hurricane Donna on the aquatic fauna of north Florida Bay. Transactions of the American Fisheries Society 91:375-378.

Tacha, T.C., S.A. Nesbitt, and P.A. Vohs. 1992. Sandhill crane (*Grus canadensis*). In: Poole, A., ed. The birds of North America online, Number 31. Cornell Lab of Ornithology, Ithaca, NY. doi:10.2173/bna.31. Internet website: http://bna.birds.cornell.edu/bna/species/031. Accessed April 23, 2012.

Tarpley, R.J. and S. Marwitz. 1993. Plastic debris ingestion by cetaceans along the Texas coast: Two case reports. Aquatic Mammals 19(2):93-98.

Teal, J.M. and R.W. Howarth. 1984. Oil spill studies: A review of ecological effects. Environmental Management 8:27-44.

Teal, J.M., J.W. Farrington, K.A. Burns, J.J. Stegeman, B.W. Tripp, B. Woodin, and C. Phinney. 1992. The West Falmouth oil spill after 20 years: Fate of fuel oil compounds and effects on animals. Marine Pollution Bulletin 24(12):607-614.

Texas Almanac. n.d. History of oil discoveries in Texas. Internet website: http://texasalmanac.com/topics/business/history-oil-discoveries-texas. Accessed August 24, 2016.

Thatcher, C.A., S.B. Hartley, and S.A. Wilson. 2011. Bank erosion of navigation canals in the western and central Gulf of Mexico. U.S. Dept. of the Interior, Geological Survey, National Wetlands Resource Center, Open-File Report 2010-1017 and U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation and Enforcement, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study BOEMRE 2010-039. 32 pp. + 2 apps. Internet website: http://pubs.usgs.gov/of/2010/1017/pdf/OF10-1017.pdf.

Thatcher, C., J.C. Brock, and E.A. Pendleton. 2013. Economic vulnerability to sea-level rise along the northern U.S. Gulf Coast. Journal of Coastal Research 63(1):234-243.

The Encyclopedia of Earth. 2008. Gulf of Mexico large marine ecosystem. Internet website: http://www.eoearth.org/article/Gulf_of_Mexico_large_marine_ecosystem?topic=49522. Updated December 28, 2010. Accessed January 11, 2011.

The Louis Berger Group, Inc. 2004. OCS-related infrastructure in the Gulf of Mexico fact book. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2004-027. 234 pp.

The White House. 2012. Executive Order—Gulf Coast ecosystem restoration. The White House, Office of Press Secretary, Washington DC. Internet website: http://www.whitehouse.gov/the-press-office/2012/09/10/executive-order-gulf-coast-ecosystem-restoration. Posted September 10, 2012. Accessed July 29, 2013.

The White House. 2015. Fact sheet: U.S. reports its 2025 emissions target to the UNFCCC. March 31, 2015.

The White House. 2016. Technical support document: Technical update of the social cost of Carbon for 12 regulatory impact analysis under Executive Order 12866. Internet website: https://obamawhitehouse.archives.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf. Accessed August 30, 2016.

Thompson, L.J. 1979. Overpressured marine sediments: The thermomechanics of progressive burial. Final report for Phase II for U.S. Dept. of the Interior, Geological Survey. Grant No. 14-08-0001-G-444. A report from the Texas A&M Research Foundation, College Station, TX. Project No. 3641.

Thompson, R. 2016. Historic lows: Tumbling oil prices taking toll on energy jobs, production in Louisiana. *The Advocate*, January 2, 2016. Internet website: http://www.theadvocate.com/new_orleans/news/business/article_2c9546d3-c4cf-5da5-975c-532a32795b14.html. Accessed August 25, 2016.

Thompson, M.J., W.W. Schroeder, and N.W. Phillips. 1999. Ecology of live bottom habitats of the northeastern Gulf of Mexico: A community profile. U.S. Dept. of the Interior, Geological Survey, Biological Resources Division, USGS/BRD/CR-1999-0001 and U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 99-0004. x + 74 pp.

Thresher, R.E., J.M. Guinotte, R.J. Matear, and A.J. Hobday. 2015. Options for managing impacts of climate change on a deep-sea community. Nature Climate Change 5(7)635-639. July 2015.

Tiner, R.W. 1984. Wetlands of the United States: Current status and recent trends. U.S. Dept. of the Interior, Fish and Wildlife Service, Newton Corner, MA. vii + 59 pp.

Tkalich, P. and E.S. Chan. 2002. Vertical mixing of oil droplets by breaking waves. Marine Pollution Bulletin 44:1219-1229.

Tolstoy, M., J. Diebold, L. Doermann, S. Nooner, and S.C. Webb. 2009. Broadband calibration of the R/V *Marcus G*. Langseth four-string seismic sources. Geochemistry, Geophysics, Geosystems 10, Q08011. doi:10.1029/2009GC002451.

Torres, R., M. Chiappone, F. Geraldes, Y. Rodriguez, and M. Vega. 2001. Sedimentation as an important environmental influence on Dominican Republic reefs. Bulletin of Marine Science 69(2):805-818.

Townsend, C.H. 1935. The distribution of certain whales as shown by logbook records of American whale ships. Zoologica 19:1-50.

Traywick, C. 2016. Louisiana's sinking coast is a $100 billion nightmare for Big Oil. Bloomberg News, August 17, 2016. Internet website: http://www.bloomberg.com/news/features/2016-08-17/louisiana-s-sinking-coast-is-a-100-billion-nightmare-for-big-oil. Accessed August 26, 2016.

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). Volume II-B. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Environmental Research Laboratory. Pp. 225-259.

Trefry, J.H., K.L. Naito, R.P. Trocine, and S. Metz. 1995. Distribution and bioaccumulation of heavy metals from produced water discharges to the Gulf of Mexico. Water Science and Technology 32(2):31-36.

Trefry, J.H., R. Trocine, M. McElvaine, R. Rember, and L. Hawkins. 2007. Total mercury and methlymercury in sediments near offshore drilling sites in the Gulf of Mexico. Environmental Geology 53:375-385.

Tucker, A.D., B.D. MacDonald, and J.A. Seminoff. 2014. Foraging site fidelity and stable isotope values of loggerhead turtles tracked in the Gulf of Mexico and northwest Caribbean. Marine Ecology Progress Series 502:267-279.

Tuler, S., T. Weber, R. Lord, and K. Dow. 2010. A case study into the human dimensions of the DM-932 oil spill in New Orleans. Greenfield, MA: Social and Environmental Research Institute. 32 pp.

Turner, R.E. and D.R. Cahoon. 1987. Causes of wetland loss in the coastal Central Gulf of Mexico. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 87-0119, 87-0120, and 87-0121. 32, 400, and 122 pp., respectively.

Turner, R.E., J.M. Lee, and C. Neill. 1994. Backfilling canals to restore wetlands: Empirical results in coastal Louisiana. Wetlands Ecology and Management 3(1):63-78.

Turner, R.E., N.N. Rabalais, E.M. Swenson, M. Kasprzak, and T. Romaire. 2005. Summer hypoxia in the northern Gulf of Mexico and its prediction from 1978 to 1995. Marine Environmental Research 59:65-77.

Turner, R.E., N.N. Rabalais, and D. Justić. 2012. Predicting summer hypoxia in the northern Gulf of Mexico: Redux. Marine Pollution Bulletin 64(2):319-324.

Turner, R.E., G. McClenachan, and A.W. Tweel. 2016. Islands in the oil: Quantifying saltmarsh shoreline erosion after the Deepwater Horizon oiling. Marine Pollution Bulletin 110(1):316-323.

Turner-Tomaszewicz, C. and J. Seminoff. 2012. Turning off the heat: Impacts of power plant decommissioning on green turtle research in San Diego Bay. Coastal Management 40:73-87. doi:10.1080/08920753.2012.640267.

Turtle Expert Working Group. 1998. An assessment of the Kemp's ridley (*Lepidochelys kempii*) and loggerhead (*Caretta caretta*) sea turtle populations in the western North Atlantic. NOAA Technical Memorandum NMFS-SEFSC-409. 96 pp.

Tuttle, J.R. and A.J. Combe III. 1981. Flow regime and sediment load affected by alterations of the Mississippi River. In: Cross, R.D. and Williams, D.L., eds. Proceedings, National Symposium: Freshwater Inflow Estuaries. U.S. Dept. of the Interior, Fish and Wildlife Service, Office of Biological Services. FWS/OBS-81/104. Pp. 334-348.

Twachtman, Snyder, & Byrd, Inc. and Louisiana State University, Center for Energy Studies. 2004. Operational and socioeconomic impact of nonexplosive removal of offshore structures. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2004-074. 59 pp.

Tyack, P.L. 2008. Implications for marine mammals of large-scale changes in the marine acoustic environment. Journal of Mammology 89(3):549-558.

Tynan, C. and D. DeMaster. 1997. Observations and predictions of arctic climatic change, potential effects on marine mammals. Arctic 50:308-322.

Underwood, A.J. and P.G. Fairweather. 1989. Supply side ecology and benthic marine assemblages. Trends in Ecology & Evolution 4(1):16-20.

United Nations Environmental Programme. 2005. Marine litter: An analytical overview. 58 pp. Internet website: http://cep.unep.org/content/about-cep/amep/marine-litter-an-analytical-overview/at_download/file. Accessed November 21, 2016.

United Nations Framework Convention on Climate Change (UNFCC). 2016. Paris agreement. Internet website: http://unfccc.int/files/essential_background/convention/application/pdf/ english_paris_agreement.pdf.

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. 70 pp. Internet website: http://www.fas.org/ota/reports/9011.pdf. Accessed December 27, 2010.

U.S. Dept. of Agriculture. Economic Research Service. 2008. County typology codes. Internet website: http://www.ers.usda.gov/data-products/county-typology-codes.aspx. Accessed June 16, 2015.

U.S. Dept. of Agriculture. Natural Resource Conservation Service. 2015. Nutrient management. Internet website: http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/technical/ecoscience/mnm/?cid=stelprdb1044741. Accessed April 2, 2015.

U.S. Dept. of Commerce. Census Bureau. 2010a. Coastline population trends in the United States: 1960-2008, population estimates and projections. May 2010. Internet website: https://www.census.gov/prod/2010pubs/p25-1139.pdf. Accessed September 8, 2015.

U.S. Dept. of Commerce. Census Bureau. 2010b. Census Bureau report documents rapid expansion of Gulf Coast population in recent decades. U.S. Census Bureau Newsroom Archive. May 26, 2010. Internet website: http://www.census.gov/newsroom/releases/archives/population/cb10-76.html. Accessed September 8, 2015.

U.S. Dept. of Commerce. Census Bureau. 2013a. S1701 poverty status in the past 12 months. 2009-2013 American community survey 5-year estimates. American fact finder. Internet website: http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml. Accessed August 17, 2015.

U.S. Dept. of Commerce. Census Bureau. 2013b. About poverty: 2013 highlights. Internet website: https://www.census.gov/hhes/www/poverty/about/overview/index.htmlhttp://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml. Accessed September 9, 2015.

U.S. Dept. of Commerce. Census Bureau. 2013c. B02001: Race – universe: Total population. 2009-2013 community survey 5-year estimates. American fact finder. Internet website: http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml. Accessed August 18, 2015.

U.S. Dept. of Commerce. Census Bureau. 2014. PEPANNRES: Annual estimates of the resident population: April 1, 2010 to July 1, 2014. American fact finder. Internet website: http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml. Accessed August 17, 2015.

U.S. Dept. of Commerce. Census Bureau. 2015a. Resident population in Alabama [ALPOP], retrieved from FRED, Federal Reserve Bank of St. Louis. Internet website: https://fred.stlouisfed.org/series/ALPOP. Accessed August 25, 2016.

U.S. Dept. of Commerce. Census Bureau. 2015b. Resident population in Florida [FLPOP], retrieved from FRED, Federal Reserve Bank of St. Louis. Internet website: https://fred.stlouisfed.org/series/FLPOP. Accessed August 25, 2016.

U.S. Dept. of Commerce. Census Bureau. 2015c. Resident population in Louisiana [LAPOP], retrieved from FRED, Federal Reserve Bank of St. Louis. Internet website: https://fred.stlouisfed.org/series/LAPOP. Accessed August 25, 2016.

U.S. Dept. of Commerce. Census Bureau. 2015d. Resident population in Mississippi [MSPOP], retrieved from FRED, Federal Reserve Bank of St. Louis. Internet website: https://fred.stlouisfed.org/series/MSPOP. Accessed August 25, 2016.

U.S. Dept. of Commerce. Census Bureau. 2015e. Resident population in Texas [TXPOP], retrieved from FRED, Federal Reserve Bank of St. Louis. Internet website: https://fred.stlouisfed.org/series/TXPOP. Accessed August 25, 2016.

U.S. Dept. of Commerce. Census Bureau. 2015f. Facts for feature: Hurricane Katrina 10th anniversary: Aug. 29, 2015. Release number: CP15-FF.16. July 2015. Internet website: http://census.gov/newsroom/facts-for-features/2015/cb15-ff16.html. Accessed September 9, 2015.

U.S. Dept. of Commerce. Economics & Statistics Administration. 2015. Census bureau data shows Gulf Coast's recovery from Hurricane Katrina. August 25, 2015. Internet website: http://www.esa.doc.gov/under-secretary-blog/us-census-bureau-data-shows-gulf-coasts-recovery-hurricane-katrina. Accessed September 9, 2015.

U.S. Dept. of Commerce. National Aeronautics and Space Administration. 2003. SeaWiFS Project—detailed description. Internet website: http://oceancolor.gsfc.nasa.gov/SeaWiFS/BACKGROUND/SEAWIFS_970_BROCHURE.html. Updated July 30, 2003. Accessed January 11, 2011.

U.S. Dept. of Commerce. National Marine Fisheries Service. 2001. Stock assessments of loggerhead and leatherback sea turtles and an assessment of the impact of the pelagic longline fishery on the loggerhead and leatherback sea turtles of the western north Atlantic. NOAA Technical Memorandum NMFS-SEFSC-455.

U.S. Dept. of Commerce. National Marine Fisheries Service. 2007a. Endangered Species Act Section 7 consultation on the effects of the five-year outer continental shelf oil and gas leasing program (2007-2012) in the Central and Western Planning Areas of the Gulf of Mexico. Biological Opinion. June 29, 2007. F/SER/2006/02611. 127 pp.

U.S. Dept. of Commerce. National Marine Fisheries Service. 2007b. Report to Congress on the impact of Hurricanes Katrina, Rita, and Wilma on commercial and recreational fishery habitat of Alabama, Florida, Louisiana, Mississippi, and Texas. July 2007. 191 pp. + apps. Internet website: http://www.nmfs.noaa.gov/msa2007/docs/HurricaneImpactsHabitat_080707_1200.pdf. Accessed December 30, 2010.

U.S. Dept. of Commerce. National Marine Fisheries Service. 2009. Fishery management plan for regulating offshore marine aquaculture in the Gulf of Mexico—final programmatic environmental impact statement. 569 pp.

U.S. Dept. of Commerce. National Marine Fisheries Service. 2010a. Marine fisheries habitat assessment improvement plan. NOAA Technical Memorandum NMFS-F/SPO-108.

U.S. Dept. of Commerce. National Marine Fisheries Service. 2010b. Final recovery plan for the sperm whale (*Physeter macrocephalus*). U.S. Dept. of Commerce, National Marine Fisheries Service, Silver Spring, MD. 165 pp. Internet website: http://www.nmfs.noaa.gov/pr/pdfs/recovery/final_sperm_whale_recovery_plan_21dec.pdf.

U.S. Dept. of Commerce. National Marine Fisheries Service. 2013. Biological report on the designation of marine critical habitat for the loggerhead sea turtle, *Caretta caretta*. 166 pp. Internet website: http://www.nmfs.noaa.gov/pr/pdfs/criticalhabitat/loggerhead_criticalhabitat_biological.pdf.

U.S. Dept. of Commerce. National Marine Fisheries Service. 2014. Recreational fisheries statistics. Internet website: http://www.st.nmfs.noaa.gov/st1/recreational/queries/index.html. Accessed June 25-26, 2014.

U.S. Dept. of Commerce. National Marine Fisheries Service. 2015a. Status of stocks 2014: Annual report to Congress on the status of U.S. fisheries. Internet website: http://www.nmfs.noaa.gov/sfa/fisheries_eco/status_of_fisheries/archive/2014/2014_status_of_stocks_final_web.pdf.

U.S. Dept. of Commerce. National Marine Fisheries Service. 2015b. Marine mammal stock assessment reports (SARS) by species/stock. Internet website: http://www.nmfs.noaa.gov/pr/sars/species.htm. Accessed December 2, 2015.

U.S. Dept. of Commerce. National Marine Fisheries Service. 2015c. Sperm whale (*Physeter microcephalus*) 5-year review: Summary and evaluation. Internet website: http://www.fisheries.noaa.gov/pr/species/Status%20Reviews/sperm_whale_5-year_review_final_june_2015.pdf.

U.S. Dept. of Commerce. National Marine Fisheries Service. 2015d. Cetacean unusual mortality event in northern Gulf of Mexico (2010-present). Internet website: http://www.nmfs.noaa.gov/pr/health/mmume/cetacean_gulfofmexico.htm. Accessed August 13, 2015.

U.S. Dept. of Commerce. National Marine Fisheries Service. 2015e. Morbillivirus infection in dolphins, porpoises, and whales. Internet website: http://www.nmfs.noaa.gov/pr/health/mmume/midatlantic2013/morbillivirus_cetaceans.pdf. Accessed August 13, 2015.

U.S. Dept. of Commerce. National Marine Fisheries Service. 2015f. Marine mammal unusual mortality events. Internet website: http://www.nmfs.noaa.gov/pr/health/mmume/. Accessed June 8, 2015.

U.S. Dept. of Commerce. National Marine Fisheries Service. 2015g. Sea turtle strandings in the Gulf of Mexico. Internet website: http://www.nmfs.noaa.gov/pr/species/turtles/gulfofmexico.htm. Accessed September 14, 2015.

U.S. Dept. of Commerce. National Marine Fisheries Service. 2015h. Impacts of oil on marine mammals and sea turtles. 2 pp.

U.S. Dept. of Commerce. National Marine Fisheries Service. 2015i. Draft recovery plan for elkhorn (*Acropora palmata*) and staghorn (*A. cervicornis*) corals. Prepared by the Acropora Recovery Team for the National Marine Fisheries Service, Silver Spring, MD. 167 pp.

U.S. Dept. of Commerce. National Marine Fisheries Service. 2015j. Fisheries of the United States: 2013. 144 pp.

U.S. Dept. of Commerce. National Marine Fisheries Service. 2015k. Federal waters off Texas closed to shrimping on May 15, 2015. Southeast Fishery Bulletin FB15-034, May 6, 2015. 1 p.

U.S. Dept. of Commerce. National Marine Fisheries Service. 2015l. NOAA Fisheries announces commercial and recreational quota increases for red snapper and the recreational seasons in the Gulf of Mexico. Southeast Fishery Bulletin FB15-032, April 30, 2015. 1 p.

U.S. Dept. of Commerce. National Marine Fisheries Service. 2016a. Technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing—underwater acoustic thresholds for onset of permanent and temporary threshold shifts. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. NOAA Technical Memorandum NMFS-OPR-55.

U.S. Dept. of Commerce. National Marine Fisheries Service. 2016b. Cetacean unusual mortality event in northern Gulf of Mexico (2010-2014). Internet website: http://www.nmfs.noaa.gov/pr/health/mmume/cetacean_gulfofmexico.htm. Accessed May 26, 2016.

U.S. Dept. of Commerce. National Marine Fisheries Service. 2016c. Fisheries economics of the U.S. in 2014: Gulf of Mexico Region. 30 pp.

U.S. Dept. of Commerce. National Marine Fisheries Service. 2016d. Commercial fishery landings by port ranked by dollar value. Internet website: http://www.st.nmfs.noaa.gov/pls/webpls/MF_LPORT_YEARD.RESULTS. Accessed August 12, 2016.

U.S. Dept. of Commerce. National Marine Fisheries Service and U.S. Dept. of the Interior, Fish and Wildlife Service. 1991. Recovery plan for U.S. population of Atlantic green turtle. U.S. Dept. of Commerce, National Marine Fisheries Service, Washington, DC. 52 pp.

U.S. Dept. of Commerce. National Marine Fisheries Service and U.S. Dept. of Interior, Fish and Wildlife Service. 2007a. Kemp's ridley sea turtle (*Lepidochelys kempii*) 5-year review: Summary and evaluation. Internet website: http://www.nmfs.noaa.gov/pr/pdfs/species/kempsridley_5yearreview.pdf. August 2007. 50 pp.

U.S. Dept. of Commerce. National Marine Fisheries Service and U.S. Dept. of Interior, Fish and Wildlife Service. 2007b. Loggerhead sea turtle (*Caretta caretta*) 5-year review: Summary and evaluation. Internet website: http://www.nmfs.noaa.gov/pr/pdfs/species/loggerhead_5yearreview.pdf. August 2007. 67 pp.

U.S. Dept. of Commerce. National Marine Fisheries Service and U.S. Dept. of Interior, Fish and Wildlife Service. 2007c. Green sea turtle (*Chelonia mydas*) 5-year review: Summary and evaluation. Internet website: http://www.nmfs.noaa.gov/pr/pdfs/species/greenturtle_5yearreview.pdf. August 2007. 105 pp.

U.S. Dept. of Commerce, National Marine Fisheries Service and U.S. Dept. of the Interior, Fish and Wildlife Service. 2007d. Kemp's ridley sea turtle (*Lepidochelys kempii*); 5-year review: Summary and evaluation. U.S. Dept. of Commerce, National Marine Fisheries Service, Silver Spring, MD, and U.S. Dept. of the Interior, Fish and Wildlife Service, Southeast Region, Jacksonville Ecological Service Field Office, Jacksonville, FL. 50 pp. Internet website: http://www.fws.gov/northflorida/SeaTurtles/2007-Reviews/2007-Kemps-ridley-turtle-5-year-review-final.pdf.

U.S. Dept. of Commerce. National Marine Fisheries Service and U.S. Dept. of Interior, Fish and Wildlife Service. 2013a. Leatherback sea turtle (*Dermochelys coriacea*) 5-year review:

Summary and evaluation. Internet website: http://www.nmfs.noaa.gov/pr/listing/5yearreview_leatherbackturtle.pdf. November 2013. 93 pp.

U.S. Dept. of Commerce. National Marine Fisheries Service and U.S. Dept. of Interior, Fish and Wildlife Service. 2013b. Hawksbill sea turtle (*Eretmochelys imbricata*) 5-year review: Summary and evaluation. Internet website: http://www.nmfs.noaa.gov/pr/pdfs/species/hawksbillseaturtle2013_5yearreview.pdf. June 2013. 92 pp.

U.S. Dept. of Commerce. National Marine Fisheries Service and U.S. Dept. of Interior, Fish and Wildlife Service. 2015. Kemp's Ridley sea turtle (*Lepidochelys kempii*) 5-year review: Summary and evaluation. Internet website: http://www.nmfs.noaa.gov/pr/listing/final_july_2015_kemp_s_5_year_review.pdf. July 2015. 63 pp.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. n.d. NOAA's state of the coast. Population living in coastal watershed counties, 1970-2030. U.S. Dept. of Commerce, Census Bureau data, 2011. Internet website: http://stateofthecoast.noaa.gov/population/welcome.html. Accessed November 13, 2013.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 1988. Interagency task force on persistent marine debris. U.S. Dept. of Commerce, National Marine Fisheries Service, Office of the Chief Scientist, Ecology and Conservation.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2005. NOAA attributes recent increase in hurricane activity to naturally occurring multi-decadal climate variability. NOAA Magazine. November 29, 2005. Internet website: http://www.magazine.noaa.gov/stories/mag184.htm.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2007. National artificial reef plan (as amended): Guidelines for siting, construction, development, and assessment of artificial reefs.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2008a. The Gulf of Mexico at a glance. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, Washington, DC. 34 pp. Internet website: http://gulfofmexicoalliance.org/pdfs/gulf_glance_1008.pdf. Accessed July 31, 2015.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2008b. Interagency report on marine debris sources, impacts, strategies, and recommendations. Interagency Marine Debris Coordinating Committee, Silver Spring, MD. 62 pp.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2010a. Tarballs. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, Office of Response and Restoration. Internet website: http://www.noaa.gov/deepwaterhorizon/publications_factsheets/documents/2055_understanding_tar_balls_070810.pdf.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2010b. Characteristic coastal habitats: Choosing spill response alternatives. Internet website: http://response.restoration.noaa.gov/sites/default/files/Characteristic_Coastal_Habitats.pdf.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2010c. Flower Gardens National Marine Sanctuary species list. Internet website: http://flowergarden.noaa.gov/document_library/aboutdocs/fgbnmscoralcapspecies.pdf. Accessed September 16, 2010.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2010d. 2010 dead zone – one of the largest ever. Internet website: http://www.gulfhypoxia.net/research/Shelfwide%20Cruises/2010/PressRelease2010.pdf.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2011. The Gulf of Mexico at a glance: A second glance. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Washington, DC. Internet website: http://stateofthecoast.noaa.gov/features/gulf-of-mexico-at-a-glance-2.pdf. Accessed September 9, 2015.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2013a. Shoreline assessment manual, 4th edition. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Office of Response and Restoration, Energy Response Division, Seattle, WA. 73 pp + apps. Internet website: http://response.restoration.noaa.gov/oil-and-chemical-spills/oil-spills.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2013b. Risk assessment for potentially polluting wrecks in U.S. waters. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Office of Response and Restoration. 195 pp. Internet website: http://sanctuaries.noaa.gov/protect/ppw/pdfs/2013_potentiallypollutingwrecks.pdf.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2013c. Draft damage assessment and restoration plan/environmental assessment for the tank barge DBL 152 oil spill. 77 pp. Internet website: http://www.darrp.noaa.gov/southeast/dbl152/pdf/2404%20DBL_152_DRAFT_DARP_EA%203_18_13%20%28final%29.pdf.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2014a. Deep sea coral research and technology program: 2014 Report to Congress. 54 pp. Internet website: http://www.habitat.noaa.gov/pdf/FINAL_DSCRtC_4_17_2014_Interactive.pdf.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2014b. Ocean explorer: *Sargassum* is a genus of large brown seaweed (a type of algae) that floats in island-like masses. Internet website: http://oceanexplorer.noaa.gov/facts/sargassum.html. Updated July 16, 2014. Accessed November 1, 2016.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2015a. NOAA chart 411. Internet website: http://www.charts.noaa.gov/OnLineViewer/411.shtml. Accessed June 15, 2015.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2015b. Stellwagen Bank National Marine Sanctuary – ocean and dredged material disposal. Internet website: http://stellwagen.noaa.gov/about/sitereport/dredge.html. Accessed April 13, 2015.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2015c. Phase III of early restoration. Internet website: http://www.gulfspillrestoration.noaa.gov/restoration/early-restoration/phase-iii/. Accessed September 14, 2015.

U.S. Dept. of Commerce. National Ocean and Atmospheric Administration. 2015d. U.S. linear relative mean sea level (MSL) trends and 95% confidence intervals (CI) in mm/year and in ft/century. Internet website: http://tidesandcurrents.noaa.gov/sltrends/mslUSTrendsTable.htm. Accessed April 17, 2015.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2015e. *Deepwater Horizon* NRDA trustees commend Gulf Task Force efforts. Internet website: http://www.gulfspillrestoration.noaa.gov/2011/10/deepwater-horizon-nrda-trustees-commend-gulf-task-force-efforts/. Accessed March 12, 2015.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2015f. Trustees: Working cooperatively. Internet website: http://www.gulfspillrestoration.noaa.gov/about-us/co-trustees/. Accessed March 12, 2015.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2015g. Phase III of early restoration. Internet website: http://www.gulfspillrestoration.noaa.gov/restoration/early-restoration/phase-iii/. Accessed March 12, 2015.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2015h. 2015 Gulf of Mexico dead zone "above average." Internet website: http://www.noaanews.noaa.gov/stories2015/080415-gulf-of-mexico-dead-zone-above-average.html. Accessed August 4, 2015.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2015i. National database for deep-sea corals and sponges. Internet website: https://deepseacoraldata.noaa.gov/. Accessed August 19, 2015.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2015j. National centers for environmental information coastal ecosystem maps – Gulf of Mexico. Internet website: http://service.ncddc.noaa.gov/website/CHP. Accessed March 25, 2015.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2015k. NOAA's oil spill response: Effects of oil on marine mammals and sea turtles. May 12, 2010. Internet website: http://www.noaa.gov/factsheets/new%20version/marinemammals_seaturtles.pdf.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2015l. Marine protected areas center: MPA mapping products. Internet website: http://www.marineprotectedareascenter.noaa.gov/dataanalysis/maps/. Accessed July 22, 2015.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2015m. Environmental response management application (ERMA). Internet website: http://gomex.erma.noaa.gov.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2016a. NOAA and partners cancel Gulf Dead Zone summer cruise; scientist had predicted average zone for 2016.

July 29, 2016. Internet website: http://www.noaa.gov/media-release/noaa-and-partners-cancel-gulf-dead-zone-summer-cruise. Accessed November 28, 2016.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2016b. NOAA habitat conservation; highlights; two new projects proposed to restore the Gulf. Internet website: http://www.habitat.noaa.gov/highlights/newprojectstorestorethegulf.html. Accessed March 8, 2016.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2016c. Gulf spill restoration; early restoration projects atlas. Internet website: http://www.gulfspillrestoration.noaa.gov/restoration/early-restoration/early-restoration-projects-atlas/. Accessed March 8, 2016.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. Office of Ocean Exploration and Research. 2010. Smaller fishes, such as filefishes and triggerfishes, reside in and among the brown *Sargassum*. Internet website: http://oceanexplorer.noaa.gov/explorations/03edge/background/sargassum/media/small_fishes.html. Revised August 26, 2010. Accessed August 31, 2016.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. Office of Ocean Exploration and Research. 2014. What is *Sargassum*? Internet website: http://oceanexplorer.noaa.gov/facts/sargassum.html. Last revised July 16, 2014. Accessed August 31, 2016.

U.S. Dept. of Energy. 2011. A national offshore wind strategy: Creating an offshore wind energy industry in the United States. Internet website: http://energy.gov/sites/prod/files/2013/12/f5/national_offshore_wind_strategy.pdf. Accessed May 14, 2014.

U.S. Dept. of Energy. Energy Information Administration. 2007. Regional underground natural gas storage, close of 2007. Internet website: ftp://ftp.eia.doe.gov/pub/oil_gas/natural_gas/analysis_publications/ngpipeline/undrgrnd_storage.html. Accessed July 1, 2015.

U.S. Dept. of Energy. Energy Information Administration. 2011. Natural gas processing plants in the United States: 2010 update regional analysis. U.S. Dept. of Energy, Energy Information Administration, Office of Oil and Gas, Washington DC. Internet website: http://www.eia.gov/pub/oil_gas/natural_gas/feature_articles/2010/ngpps2009/gom.cfm. Accessed July 1, 2015.

U.S. Dept. of Energy. Energy Information Administration. 2012. Potential of gas hydrates is great, but practical development is far off. Internet website: http://www.eia.gov/todayinenergy/detail.cfm?id=8690. Accessed April 2015.

U.S. Dept. of Energy. Energy Information Administration. 2014a. Texas state energy profile. Internet website: http://www.eia.gov/state/print.cfm?sid=TX. Updated March 27, 2014.

U.S. Dept. of Energy. Energy Information Administration. 2014b. Sales of fossil fuels produced from Federal and Indian lands, FY 2003 through FY 2013. Internet website: http://www.eia.gov/analysis/requests/federallands/pdf/eia-federallandsales.pdf. Accessed April 17, 2015.

U.S. Dept. of Energy. Energy Information Administration. 2015a. Short-term energy outlook; U.S. petroleum and other liquids; March 10, 2015. Internet website: http://www.eia.gov/forecasts/steo/report/us_oil.cfm. Accessed April 1, 2015.

U.S. Dept. of Energy. Energy Information Administration. 2015b. Total natural gas production, consumption, and imports in reference case, 1990-2040 (trillion cubic feet). Internet website: http://www.eia.gov/forecasts/aeo/excel/figmt42_data.xls. Accessed April 1, 2015.

U.S. Dept. of Energy. Energy Information Administration. 2015c. Table 3. Capacity of operable petroleum refineries by state as of January 1, 2015. Internet website: http://www.eia.gov/petroleum/refinerycapacity/table3.pdf. Accessed August 20, 2015.

U.S. Dept. of Energy. Energy Information Administration. 2015d. Frequently asked questions. When was the last refinery built in the United States? Internet website: http://www.eia.gov/tools/faqs/faq.cfm?id=29&t=6. Accessed August 20, 2015.

U.S. Dept. of Energy. Energy Information Administration. 2015e. Gulf of Mexico factsheet. Internet website: http://www.eia.gov/special/gulf_of_mexico/. Accessed July 22, 2015.

US Dept. of Energy. Energy Information Administration. 2016a. Frequently asked questions: How much oil is consumed in the United States? Internet website: http://www.eia.gov/tools/faqs/faq.cfm?id=33&t=6. Accessed November 14, 2016.

US Dept. of Energy. Energy Information Administration. 2016b. Frequently asked questions: How much natural gas is consumed in the United States? Internet website: http://www.eia.gov/tools/faqs/faq.cfm?id=50&t=8. Accessed November 14, 2016.

U.S. Dept. of Energy. Energy Information Administration. 2016c. Primary energy consumption by source. Internet website: http://www.eia.gov/totalenergy/data/monthly/#summary. Accessed June 24, 2016.

U.S. Dept. of Energy. Energy Information Administration. 2016d. Annual energy outlook 2016. Internet website: http://www.eia.gov/forecasts/aeo/. Accessed August 19, 2016.

US Dept. of Energy. Energy Information Administration. 2016e. Short-term energy outlook – February 2016: Data tables. Internet website: http://www.eia.gov/forecasts/steo/. Accessed February 18, 2016.

US Dept. of Energy. Energy Information Administration. 2016f. Oil production in federal Gulf of Mexico projected to reach record high in 2017. Today in Energy: February 18, 2016. Internet website: http://www.eia.gov/todayinenergy/detail.cfm?id=25012. Accessed February 18, 2016.

U.S. Dept. of Energy. Federal Energy Regulatory Commission. 2015a. North American LNG import/export terminals approved. September 15, 2015. Internet website: https://www.ferc.gov/industries/gas/indus-act/lng/lng-approved.pdf. Accessed September 25, 2015.

U.S. Dept. of Energy. Federal Energy Regulatory Commission. 2015b. LNG. Internet website: http://www.ferc.gov/industries/gas/indus-act/lng.asp. Accessed September 14, 2015.

U.S. Dept. of Energy. Office of Energy Efficiency and Renewable Energy. 2015. Offshore wind advanced technology demonstration projects. Internet website: http://energy.gov/eere/wind/offshore-wind-advanced-technology-demonstration-projects. Accessed September 14, 2015.

U.S. Dept. of Homeland Security. Coast Guard. 2008. Aids to navigation on artificial islands and fixed structures. Title 33, Part 67.

U.S. Dept. of Homeland Security. Coast Guard. 2012. Polluting incidents in and around U.S. waters. A spill/release compendium: 1969-2011. U.S. Dept. of Homeland Security, Coast Guard, Office of Investigations & Compliance Analysis (CG-INV), Washington, DC.

U.S. Dept. of Homeland Security. Coast Guard. 2015. Tar balls in the coastal environment. Internet website: http://www.nrt.org/production/NRT/RRTHome.nsf/resources/RRTIV-Pamphlets/$File/23_RRT4_Tar_Ball_Pamphlet.pdf. Accessed August 20, 2015.

U.S. Dept. of Homeland Security. Coast Guard. 2016. Marine casualty and pollution data for researchers. Internet website: https://homeport.uscg.mil/mycg/portal/ep/programView.do?channelId=-18374&programId=91343&programPage=%2Fep%2Fprogram%2Feditorial.jsp&pageTypeId=1348. Accessed September 28, 2015.

U.S. Dept. of Homeland Security, Coast Guard and U.S. Dept. of Transportation, Maritime Administration (MARAD). 2003. Final environmental impact statement for the Port Pelican LLC Deepwater Port License Application. Commandant, U.S. Dept. of Homeland Security, Coast Guard, Washington, DC.

U.S. Dept. of Labor. Occupational Safety and Health Administration. 2010a. OSHA statement on 2-butoxyethanol & worker exposure. July 9, 2010. Internet website: https://www.osha.gov/oilspills/oilspill-statement.html. Accessed March 14, 2012.

U.S. Dept. of Labor. Occupational Safety and Health Administration. 2010b. General health and safety information for the Gulf oil spill. August 19, 2010.

U.S. Dept. of the Army. Corps of Engineers. 1992. Planning assistance to states program, Section 22 report, inlets along the Texas Gulf Coast. Galveston District, Southwestern Division, August 1992. 56 pp. Internet website: http://cirp.usace.army.mil/pubs/archive/Inlets_Along_TX_Gulf_Coast.pdf.

U.S. Dept. of the Army. Corps of Engineers. 2004. Louisiana coastal area (LCA), Louisiana: Ecosystem restoration study. Volume I: LCA Study—main report and Volume II: Programmatic environmental impact statement. U.S. Dept. of the Army, Corps of Engineers, New Orleans District, New Orleans, LA. 506 and 918 pp., respectively. Internet website: http://www.lca.gov/Library/ProductList.aspx?Prodtype=0&folder=1118. Accessed March 18, 2011.

U.S. Dept. of the Army. Corps of Engineers. 2008. Maintenance dredging and disposal of dredged materials Mississippi and Louisiana portions of the Gulf Intracoastal Waterway federally authorized navigation project: Draft environmental assessment, January 2008. Mobile District Office, Mobile, AL. 232 pp. Internet website: http://www.sam.usace.army.mil/pd/EAs/GIWW_DRAFTEAforPUBLIC(2)jj.pdf.

U.S. Dept. of the Army. Corps of Engineers. 2009a. Louisiana coastal protection and restoration (LACPR): Final technical report. Programmatic cumulative effects analysis appendix. U.S. Dept. of the Army, Corps of Engineers, New Orleans District, Mississippi Valley Division. 49 pp. with annexes. Internet website: http://www.hsdl.org/?view&did=9380.

U.S. Dept. of the Army. Corps of Engineers. 2009b. Louisiana coastal protection and restoration (LACPR): Final technical report. U.S. Dept. of the Army, Corps of Engineers, New Orleans District, Mississippi Valley Division. 265 pp. with attachments. Internet website: http://www.mvd.usace.army.mil/lcast/pdfs/06jun/LaCPR.pdf.

U.S. Dept. of the Army. Corps of Engineers. 2013. Beneficial use of dredged material. Internet website: http://www.mvn.usace.army.mil/About/Offices/Operations/BeneficialUseofDredgedMaterial.aspx. Accessed December 12, 2013.

U.S. Dept. of the Army. Corps of Engineers. 2015a. Ocean disposal database: Dredging operations technical support. Internet website: http://el.erdc.usace.army.mil/odd/DisposalSearch.cfm. Accessed August 26, 2015.

U.S. Dept. of the Army. Corps of Engineers. 2015b. The Mississippi drainage basin. Internet website: http://www.mvn.usace.army.mil/Missions/MississippiRiverFloodControl/MississippiRiverTributaries/MississippiDrainageBasin.aspx. Accessed February 19, 2015, and March 19, 2015.

U.S. Dept. of the Army. Corps of Engineers. 2015c. Waterborne commerce statistics center: Principal ports of the United States. Internet website: http://www.iwr.usace.army.mil/About/TechnicalCenters/WCSCWaterborneCommerceStatisticsCenter.aspx.

U.S. Dept. of the Army. European Research Office. 2008. Current and historical sediment loads in the lower Mississippi River. University of Nottingham, School of Geography. Contract No. 1106-EN-01.

U.S. Dept. of the Interior. 2010. Increased safety measures for energy development on the outer continental shelf, May 27, 2010. U.S. Dept. of the Interior, Washington, DC. 44 pp.

U.S. Dept. of the Interior. 2015. Economic report for FY 2014, June 23, 2015. U.S. Dept. of the Interior, Washington DC. 57 pp.

U.S. Dept. of the Interior. 2017. Record of decision and approval of the 2017-2022 Outer Continental Shelf Oil and Gas Leasing Program. Signed Secretary of the Interior, Sally Jewell, on January 17, 2017.

U.S. Dept. of the Interior. Bureau of Ocean Energy Management. 2012a. Proposed final outer continental shelf oil & gas leasing program: 2012-2017. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Herndon, VA. 223 pp.

U.S. Dept. of the Interior. Bureau of Ocean Energy Management. 2012b. Gulf of Mexico OCS oil and gas lease sales: 2012-2017; Western Planning Area Lease Sales 229, 233, 238, 246, and 248; Central Planning Area Lease Sales 227, 231, 235, 241, and 247—final environmental impact statement. 3 vols. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Gulf of Mexico OCS Region, New Orleans, LA. OCS EIS/EA BOEM 2012-019.

U.S. Dept. of the Interior. Bureau of Ocean Energy Management. 2013. Report to Congress: The comprehensive inventory of U.S. Outer Continental Shelf oil and natural gas resources: 2013 update. Internet website: http://www.boem.gov/Final-Comprehensive-Inventory-Report-Delivered-to-Congress/. Accessed November 9, 2015.

U.S. Dept. of the Interior. Bureau of Ocean Energy Management. 2014a. Atlantic OCS proposed geological and geophysical activities; Mid-Atlantic and South-Atlantic planning areas—final programmatic environmental impact statement. 3 vols. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Gulf of Mexico OCS Region, New Orleans, LA. OCS EIS/EA BOEM 2014-001. Internet website: http://www.boem.gov/Atlantic-G-G-PEIS/.

U.S. Dept. of the Interior. Bureau of Ocean Energy Management. 2014b. Exploration and development plans online query. Internet website: http://www.data.boem.gov/homepg/data_center/plans/plans/master.asp. Accessed December 8, 2014.

U.S. Dept. of the Interior. Bureau of Ocean Energy Management. 2015a. 2017-2022 outer continental shelf oil and gas leasing: Draft proposed program. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Herndon, VA. 299 pp.

U.S. Dept. of the Interior. Bureau of Ocean Energy Management. 2015b. Seismic water bottom anomalies map gallery. Internet website: http://www.boem.gov/Seismic-Water-Bottom-Anomalies-Map-Gallery/.

U.S. Dept. of the Interior. Bureau of Ocean Energy Management. 2015c. Fair market value. Internet website: http://www.boem.gov/Oil-and-Gas-Energy-Program/Energy-Economics/Fair-Market-Value/econFMV.aspx. Accessed September 14, 2015.

U.S. Dept. of the Interior. Bureau of Ocean Energy Management. 2015d. Royalty relief information. Internet website: http://www.boem.gov/Royalty-Relief-Information/. Accessed October 5, 2015.

U.S. Dept. of the Interior. Bureau of Ocean Energy Management. 2016a. 2017-2022 outer continental shelf oil and gas leasing: Proposed final program. November 2016. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Sterling, VA. 269 pp.

U.S. Dept. of the Interior. Bureau of Ocean Energy Management. 2016b. Outer Continental Shelf oil and gas leasing program: 2017-2022—final environmental impact statement. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Herndon, VA. OCS EIS/EA BOEM 2016-060.

U.S. Dept. of the Interior. Bureau of Ocean Energy Management. 2016c. 2017-2022 outer continental shelf oil & gas leasing: Proposed program. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Herndon, VA. 279 pp.

U.S. Dept. of the Interior. Bureau of Ocean Energy Management. 2016d. Essential fish habitat assessment for the Gulf of Mexico. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, New Orleans, LA. OCS Report BOEM 2016-016. iv + 52 pp.

U.S. Dept. of the Interior. Bureau of Ocean Energy Management. 2016e. BOEM reserves inventory program. Internet website: http://www.boem.gov/Reserves-Inventory-Program-Gulf-of-Mexico-OCS-Region/. Accessed August 12, 2016.

U.S. Dept. of the Interior. Bureau of Ocean Energy Management. 2016f. Offshore statistics by water depth. Internet website: https://www.data.boem.gov/homepg/data_center/leasing/WaterDepth/WaterDepth.asp. Accessed September 16, 2016.

U.S. Dept. of the Interior. Bureau of Ocean Energy Management. 2016g. Table 2. Gulf of Mexico oil & gas lease offerings. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Gulf of Mexico OCS Region, New Orleans, LA. Internet website: http://www.boem.gov/OCS-Lease-Sale-Statistics-GOM-Oil-and-Gas-Lease-Offerings/. Accessed August 24, 2016.

U.S. Dept. of the Interior. Bureau of Ocean Energy Management. 2017. Catastrophic spill event analysis: High-volume, extended-duration oil spill resulting from loss of well control on the Gulf of Mexico outer continental shelf; 1st revision. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, New Orleans, LA. OCS Report BOEM 2017-007.

U.S. Dept. of the Interior. Bureau of Ocean Energy Management, Regulation and Enforcement. 2011. Status and applications of acoustic mitigation and monitoring systems for marine mammals. Internet website: http://www.data.boem.gov/PI/PDFImages/ESPIS/4/5113.pdf.

U.S. Dept. of the Interior. Bureau of Safety and Environmental Enforcement. 2015a. Incidents of noncompliance. Internet website: http://www.bsee.gov/Inspection-and-Enforcement/Enforcement-Programs/Incidents-of-Non-Compliance/. Accessed September 10, 2015.

U.S. Dept. of the Interior. Bureau of Safety and Environmental Enforcement. 2015b. Collisions – statistics and summaries 2007-2014. Internet website: http://www.bsee.gov/Inspection-and-Enforcement/Accidents-and-Incidents/Collisions/. Accessed May 14, 2015.

U.S. Dept. of the Interior. Bureau of Safety and Environmental Enforcement. 2015c. Spills – statistics and summaries archive ≥50 bbls. Internet website: http://www.bsee.gov/Inspection-and-Enforcement/Accidents-and-Incidents/Spills-Archive/. Accessed March 31, 2015.

U.S. Dept. of the Interior. Bureau of Safety and Environmental Enforcement. 2015d. Yearly oil and gas production. Internet website: http://www.data.bsee.gov/homepg/data_center/production/ocsprod.asp. Accessed November 9, 2015.

U.S. Dept. of the Interior. Bureau of Safety and Environmental Enforcement. 2015e. Installations and removals – offshore production facilities in federal waters. Internet website: http://www.bsee.gov/uploadedFiles/BSEE/Newsroom/Offshore_Stats_and_Facts/OCSPlatformActivity%20%201942-%202013final.pdf. Accessed November 9, 2015.

U.S. Dept. of the Interior. Bureau of Safety and Environmental Enforcement. 2015f. Rigs to reefs information. Internet website: https://www.bsee.gov/what-we-do/environmental-focuses/rigs-to-reefs. Accessed July 31, 2015.

U.S. Dept. of the Interior. Bureau of Safety and Environmental Enforcement. 2015g. Installations and removals: Offshore production facilities in federal waters. Internet website: http://www.bsee.gov/BSEE-Newsroom/Offshore-Stats-and-Facts/Offshore-Stats-and-Facts/. Accessed August 10, 2015.

U.S. Dept. of the Interior. Bureau of Safety and Environmental Enforcement. 2016a. Loss of well control—statistics and summaries. Internet website: http://www.bsee.gov/Inspection-and-Enforcement/Accidents-and-Incidents/Loss-of-Well-Control/. Accessed August 16, 2015.

U.S. Dept. of the Interior. Bureau of Safety and Environmental Enforcement. 2016b. Yearly oil and gas production. Internet website: http://www.data.bsee.gov/homepg/data_center/production/ocsprod.asp. Accessed September 16, 2016.

U.S. Dept. of the Interior. Fish and Wildlife Service. 1991. Recovery plan–Mississippi sandhill crane (third revision). U.S. Dept. of the Interior, Fish and Wildlife Service, Region 4, Division of Migratory Bird Management Office, Atlanta, GA. 48 pp.

U.S. Dept. of the Interior. Fish and Wildlife Service. 1999. National wetlands inventory: 1996 coastal Mississippi habitat data. U.S. Dept. of the Interior, Fish and Wildlife Service, National Wetlands Center, Lafayette, LA.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2001. Florida manatee recovery plan, (*Trichechus manatus latirostris*), third revision. U.S. Dept. of the Interior, Fish and Wildlife Service. Atlanta, GA. 144 pp. + apps.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2006. West Indian manatee response plan. U.S. Dept. of the Interior, Fish and Wildlife Service, Ecological Services Field Office, Jacksonville, FL. 7 pp.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2007. Wood stork (*Mycteria americana*): 5-year review, summary and evaluation. U.S. Dept. of the Interior, Fish and Wildlife Service, Region 4, Jacksonville Ecological Services Field Office, Jacksonville, FL. 34 pp.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2010a. Final recovery plan for the St. Andrew beach mouse (*Peromyscus polionotus peninsularis*). U.S. Dept. of the Interior, Fish and Wildlife Service, Atlanta, GA. 95 pp.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2010b. Five-year review for the Cape Sable Seaside Sparrow (*Ammodramus maritimus mirabilis*). U.S. Dept. of the Interior, Fish and Wildlife Service, Vero Beach, FL. 22 pp.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2010c. Caribbean roseate tern and North Atlantic roseate tern (*Sterna dougallii dougallii*): 5-year review, summary and evaluation.

U.S. Dept. of the Interior, Fish and Wildlife Service, Region 5, New England Field Office, Concord, NH. 148 pp.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2011. Endangered Species Act – Section 7 consultation on the construction of a second explosive handling wharf at Bangor Navy Base, Kitsap County. Conducted by the U.S. Dept. of the Interior, Fish and Wildlife Service, Lacey, WA. 137 pp.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2012. Five-year review: Summary and evaluation for the whooping crane (*Grus Americana*). Corpus Christi and Austwell, TX. 44 pp.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2014. Florida manatee stock assessment report. U.S. Dept. of the Interior, Fish and Wildlife Service, Jacksonville, FL. 17 pp.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2015a. Dead birds collected during colony sweep activities. Technical report, Deepwater Horizon/Mississippi Canyon 252 Oil Spill Natural Resource Damage Assessment. August 2015.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2015b. Quantification of fledglings lost in 2010. Technical report, Deepwater Horizon/Mississippi Canyon 252 Oil Spill Natural Resource Damage Assessment. August 2015.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2015c. Quantification of fledglings lost in 2011. Technical report, Deepwater Horizon/Mississippi Canyon 252 Oil Spill Natural Resource Damage Assessment. August 2015.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2015d. Simplified live oiled bird model avian injury estimation. Technical report, Deepwater Horizon/Mississippi Canyon 252 Oil Spill Natural Resource Damage Assessment. August 2015.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2015e. Estimation of avian mortality in regions not included in the shoreline deposition model. Technical report, Deepwater Horizon/Mississippi Canyon 252 Oil Spill Natural Resource Damage Assessment. August 2015. Internet website: https://pub-dwhdatadiver.orr.noaa.gov/dwh-ar-documents/788/DWH-AR0141544.pdf.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2015f. Hawksbill sea turtle, *Eretmochelys imbricata*. In: South Florida Multi-Species Recovery Plan. Pp. 4-615 through 4-648. Internet website: http://www.fws.gov/verobeach/ListedSpeciesMSRP.html. Accessed September 17, 2015.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2015g. Kemp's ridley sea turtle, *Lepidochelys kempii*. In: South Florida Multi-Species Recovery Plan. Pp. 4-649 through 4-664. Internet website: http://www.fws.gov/verobeach/ListedSpeciesMSRP.html. Accessed September 17, 2015.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2015h. Leatherback sea turtle, *Dermochelys coriacea*. In: South Florida Multi-Species Recovery Plan. Pp. 4-665 through 4-703. Internet website: http://www.fws.gov/verobeach/ListedSpeciesMSRP.html. Accessed September 17, 2015.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2015i. Aransas National Wildlife Refuge, Texas, whooping crane updates, whooping crane survey results: Winter 2014-2015. Internet website: https://web.archive.org/web/20160120180031/http://www.fws.gov/refuge/Aransas/wwd/science/updates.html. Accessed January 20, 2017.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2016. Mississippi sandhill crane: Jan 2016 wild population. Internet website: https://www.fws.gov/uploadedImages/Region_4/NWRS/Zone_2/Mississippi_Sandhill_Crane_Complex/Mississippi_Sandhill_Crane/Home/Promos/Wild%20Crane%20Population%20Slide.jpg. Accessed November 15, 2016.

U.S. Dept. of the Interior. Geological Survey. 1988. Report to Congress: Coastal barrier resource system. Recommendations for additions to or deletions from the Coastal Barrier Resource System. Vol. 18, Louisiana.

U.S. Dept. of the Interior. Geological Survey. 2008. Coastal change hazards: Hurricanes and extreme storms. Internet website: http://coastal.er.usgs.gov/hurricanes/. Accessed April 15, 2011.

U.S. Dept. of the Interior. Geological Survey. 2010. NAS—nonindigenous aquatic species. *Pterois volitans/miles*. Internet website: http://nas.er.usgs.gov/queries/collectioninfo.aspx?NoCache=8%2F11%2F2009+10%3A53%3A53+AM&SpeciesID=963&State=&County=&HUCNumber=. Accessed October 18, 2010.

U.S. Dept. of the Interior. Geological Survey. 2011. An evaluation of the science needs to inform decisions on outer continental shelf energy development in the Chukchi and Beaufort Seas, Alaska. June 2011. 4 pp.

U.S. Dept. of the Interior. Geological Survey. 2014. Press release: Interior, Agriculture Departments partner to measure conservation impacts on water quality. Internet website: http://www.usgs.gov/newsroom/article.asp?ID=4034&from=rss#.VQH8fPnF8k0. Accessed March 12, 2015.

U.S. Dept. of the Interior. Geological Survey. 2015. Non-indigenous species mapper. Internet website: http://nas2.er.usgs.gov/viewer/omap.aspx?SpeciesID=963. Accessed March 25, 2015.

U.S. Dept. of the Interior. Minerals Management Service. 1983. Memorandum of understanding between the Environmental Protection Agency and the Department of the Interior concerning the coordination of NPDES permit issuance with the outer continental shelf oil and gas lease program. Internet website: http://www.bsee.gov/uploadedFiles/BSEE/Newsroom/Publications_Library/001_1984-MOU.pdf.

U.S. Dept. of the Interior. Minerals Management Service. 1984. Port Arthur and Bouma Bank quads, sheets I-VIII. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Map MMS 84-0003.

U.S. Dept. of the Interior. Minerals Management Service. 1989. Memorandum of agreement between the U.S. Environmental Protection Agency (EPA), Region 6, and the Gulf of Mexico Regional Office, Minerals Management Service (MMS), coordinating the EPA NPDES permit compliance program with the MMS offshore inspection program. Internet website: http://www.bsee.gov/uploadedFiles/BSEE/Newsroom/Publications_Library/1989%20NPDES%20MOA%20EPA-R6%20and%20GOMR.pdf.

U.S. Dept. of the Interior. Minerals Management Service. 1991. Provide clarification, description, and interpretation with regard to pipeline requirements. Internet website: https://www.bsee.gov/sites/bsee.gov/files/federal-register-notice/notices-to-lessees/ntl-t248c2.pdf.

U.S. Dept. of the Interior. Minerals Management Service. 1999. Investigation of Chevron Pipe Line Company pipeline leak, South Pass Block 38, September 29, 1998.

U.S. Dept. of the Interior. Minerals Management Service. 2000a. Deepwater development: A reference document for the deepwater environmental assessment Gulf of Mexico OCS (1998 through 2007). U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Report MMS 2000-015. 94 pp.

U.S. Dept. of the Interior. Minerals Management Service. 2000b. 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. 264 pp.

U.S. Dept. of the Interior. Minerals Management Service. 2001. 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. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS EIS/EA MMS 2000-090. 782 pp.

U.S. Dept. of the Interior. Minerals Management Service. 2004a. Fate and effects of a spill of synthetic-based drilling fluid at Mississippi Canyon Block 778. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Report MMS 2004-039. 18 pp.

U.S. Dept. of the Interior. Minerals Management Service. 2004b. Geological and geophysical exploration for mineral resources on the Gulf of Mexico outer continental shelf—final programmatic environmental assessment. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS EIS/EA MMS 2004-054. 466 pp.

U.S. Dept. of the Interior. Minerals Management Service. 2005. Structure-removal operations on the Gulf of Mexico outer continental shelf—programmatic environmental assessment. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS EIS/EA MMS 2005-013. 358 pp.

U.S. Dept. of the Interior. Minerals Management Service. 2006. Deepwater Gulf of Mexico 2006: America's expanding frontier. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Report MMS 2006-022. 144 pp.

U.S. Dept. of the Interior. Minerals Management Service. 2007a. Gulf of Mexico OCS oil and gas lease sales: 2007-2012; Western Planning Area Lease Sales 204, 207, 210, 215, and 218; Central Planning Area Lease Sales 205, 206, 208, 213, 216, and 222—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 2007-018.

U.S. Dept. of the Interior. Minerals Management Service. 2007b. Final programmatic environmental impact statement for alternative energy development and production and alternate use of facilities on the outer continental shelf. U.S. Dept. of the Interior, Minerals Management Service, Herndon, VA. OCS EIS/EA 2007-046.

U.S. Dept. of the Interior. Minerals Management Service. 2008a. Preliminary evaluation of in-place gas hydrate resources: Gulf of Mexico outer continental shelf. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Report MMS 2008-004.

U.S. Dept. of the Interior. Minerals Management Service. 2008b. MMS completes assessment of destroyed and damaged facilities from Hurricanes Gustav and Ike. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. News Release R-08-3932. Internet website: http://www.onrr.gov/PDFDocs/20081121a.pdf.

U.S. Dept. of the Interior. National Park Service. 2001. Oil and gas management plan for Padre Island National Seashore. March 2001. 194 pp.

U.S. Dept. of the Interior. National Park Service. 2005. November 2005 archeology e-gram. Internet website: http://www.nps.gov/archeology/pubs/egrams/0511.pdf. Accessed July 20, 2010.

U.S. Dept. of the Interior. National Park Service. 2011a. Managing sea turtles during the oil spill response. 2 pp. Internet website: http://www.restorethegulf.gov/sites/default/files/imported_pdfs/external/content/document/2931/771879/1/NPS_Turtles_Web.pdf. Accessed September 16, 2015.

U.S. Dept. of the Interior. National Park Service. 2011b. Beach vehicle environmental assessment for Padre Island National Seashore.

U.S. Dept. of the Interior. National Park Service. 2014a. General management plan, environmental impact statement; Gulf Islands National Seashore; Florida and Mississippi. July 2014. 562 pp.

U.S. Dept. of the Interior. National Park Service. 2014b. The Historic Preservation Fund annual report. Internet website: http://www.nps.gov/shpo/downloads/2014%20Historic%20Annual%20Report_Web.pdf.

U.S. Dept. of the Interior. National Park Service. 2016. Padre Island National Seashore; sea turtle science and recovery. Internet website: http://www.nps.gov/pais/learn/nature/stsr-index.htm. Accessed March 8, 2016.

U.S. Dept. of the Interior. Office of Natural Resources Revenue. 2016. ONRR statistical information online query regarding sales, volumes, sales values, and revenues. Internet website: http://statistics.onrr.gov/ReportTool.aspx. Accessed August 4, 2016.

U.S. Dept. of Transportation. Maritime Administration (MARAD). 2012. North American cruises, key statistics (capacity and traffic in thousands). Internet website: http://www.marad.dot.gov/documents/north_america_cruise_summary_data.xls. Accessed June 19, 2013.

U.S. Dept. of Transportation. Maritime Administration (MARAD). 2013. Vessel calls in U.S. ports and terminals – privately-owned, oceangoing merchant vessels over 1,000 gross tons. Internet website: http://www.marad.dot.gov/wp-content/uploads/xls/Tanker_Calls_at_U_S__Ports.xls. Accessed September 14, 2015.

U.S. Dept. of Transportation. Maritime Administration (MARAD). 2015a. Vessel calls at U.S. ports by vessel type. Internet website: http://www.marad.dot.gov/wp-content/uploads/xlsx/DS_U.S.-Port-Calls-2013.xlsx. Current as of June 17, 2015. Accessed September 14, 2015.

U.S. Dept. of Transportation. Maritime Administration (MARAD). 2015b. Approved application and operational facilities. Internet website: http://www.marad.dot.gov/ports/office-of-deepwater-ports-and-offshore-activities/. Accessed September 14, 2015.

U.S. Dept. of Transportation. National Transportation Safety Board. 1998. Safety recommendation M-98-124.

U.S. Environmental Protection Agency. 1991. Evaluation of dredged material proposed for ocean disposal. U.S. Environmental Protection Agency and U.S. Dept. of the Army, Corps of Engineers. EPA 503/9-91/001.

U.S. Environmental Protection Agency. 1993a. Development document for effluent limitations guidelines and new source performance standards for the offshore subcategory of the oil and gas extraction point source category, final. January 1993. EPA-821-R-93-003. U.S. Environmental Protection Agency, Office of Water, Washington, DC. 386 pp.

U.S. Environmental Protection Agency. 1993b. Supplemental information for effluent limitation guidelines and new source performance standards for the offshore subcategory of the oil and gas extraction point source category (49 CFR 435); Office of Water, Washington, DC. 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. 12,453-12,512. March 4, 1993.

U.S. Environmental Protection Agency. 1998. Final guidance for incorporating environmental justice concerns in EPA's NEPA compliance analysis. April 1998. Internet website:

https://www.epa.gov/sites/production/files/2015-04/documents/ej-guidance-nepa-compliance-analyses.pdf. Accessed August 29, 2016.

U.S. Environmental Protection Agency. 1999. 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. EPA-821-B-98-021. 289 pp.

U.S. Environmental Protection Agency. 2000a. Environmental assessment of final 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. December 2000. EPA-821-B00-014. U.S. Environmental Protection Agency, Office of Water, Washington, DC. 292 pp.

U.S. Environmental Protection Agency. 2000b. Development document for final 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. December 2000. EPA-821-B-00-013. U.S. Environmental Protection Agency, Office of Water, Washington, DC. 518 pp.

U.S. Environmental Protection Agency. 2004. Final NPDES general permit for new and existing sources and new dischargers in the offshore subcategory of the oil and gas extraction category for the western portion of the outer continental shelf of the Gulf of Mexico (GMG290000). U.S. Environmental Protection Agency. 117 pp. Internet website: http://www.epa.gov/region6/water/npdes/genpermit/gmg290000finalpermit2004.pdf.

U.S. Environmental Protection Agency. 2006. Technical development document for the final Section 316(b) Phase III rule. EPA-821-R-06-003. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

U.S. Environmental Protection Agency. 2007. NPDES general permit for new and existing sources and new dischargers in the offshore subcategory of the oil and gas extraction category for the western portion of the outer continental shelf of the Gulf of Mexico (GMG290000). U.S. Environmental Protection Agency. 15 pp. Internet website: http://www.epa.gov/Region06/water/npdes/genpermit/gmg290000fedreg.pdf.

U.S. Environmental Protection Agency. 2009a. Marine debris factsheet. Internet website: http://water.epa.gov/type/oceb/marinedebris/upload/2009_05_11_oceans_debris_marine_debris_final.pdf.

U.S. Environmental Protection Agency. 2009b. Region 4 environmental assessment for the National Pollutant Discharge Elimination System permitting for eastern Gulf of Mexico offshore oil and gas exploration, development and production. Permit 904/P-09-001. 129 pp.

U.S. Environmental Protection Agency. 2010a. Region 4, final National Pollutant Discharge Elimination System (NPDES) general permit No. GEG460000 for offshore oil and gas activities in the eastern Gulf of Mexico.

U.S. Environmental Protection Agency. 2010b. Air monitoring on Gulf coastline (monitoring air quality along the Gulf Coast, 2011). Internet website: http://www.epa.gov/BPSpill/air.html. Accessed June 29, 2010.

U.S. Environmental Protection Agency. 2012a. Region 6, the NPDES general permit for new and existing sources and new discharges in the offshore subcategory of the oil and gas extraction point source category for the western portion of the outer continental shelf of the Gulf of Mexico (GMG290000). Internet website: https://www3.epa.gov/region6/water/npdes/genpermit/gmg290000final/gmg290000finalpermit2012.pdf.

U.S. Environmental Protection Agency. 2012b. National Coastal Condition Report IV, September 2012. Internet website: http://water.epa.gov/type/oceb/assessmonitor/nccr/upload/0_NCCR_4_Report_508_bookmarks.pdf.

U.S. Environmental Protection Agency. 2013a. Future climate change: Future sea level change. Internet website: http://www.epa.gov/climatechange/science/future.html#sealevel. Accessed July 26, 2013.

U.S. Environmental Protection Agency. 2013b. Our built and natural environments: A technical review of the interactions among and use, transportation and environmental quality. Internet website: http://www2.epa.gov/sites/production/files/2014-03/documents/our-built-and-natural-environments.pdf. Accessed September 7, 2015.

U.S. Environmental Protection Agency. 2014a. Small Vessel General Permit for discharges incidental to the normal operation of vessels less than 79 feet (Final 2014 sVGP).

U.S. Environmental Protection Agency. 2014b. National Contingency Plan Subpart J. Internet website: http://www2.epa.gov/emergency-response/national-contingency-plan-subpart-j. Accessed March 18, 2014.

U.S. Environmental Protection Agency. 2014c. General facts about the Gulf of Mexico. Internet website: http://www.epa.gov/gmpo/about/facts.html. Accessed July 31, 2015.

U.S. Environmental Protection Agency. 2015a. Central data exchange. Internet website: www.cdx.epa.gov. Accessed November 10, 2015.

U.S. Environmental Protection Agency. 2015b. NetDMR. Internet website: http://echo.epa.gov/. Accessed November 10, 2015.

U.S. Environmental Protection Agency. 2015c. Enforcement and compliance history online. Internet website: https://netdmr.epa.gov/netdmr/public/home.htm. Accessed November 10, 2015.

U.S. Environmental Protection Agency. 2015d. Hypoxia 101. Internet website: http://water.epa.gov/type/watersheds/named/msbasin/hypoxia101.cfm. Accessed April 2, 2015.

U.S. Environmental Protection Agency. 2015e. National list of beaches. Internet website: http://www2.epa.gov/beach-tech/national-list-beaches. Accessed July 22, 2015.

U.S. Environmental Protection Agency. 2016a. Region 4 draft ocean discharge criteria evaluation for the National Pollutant Discharge Elimination system general permit for the eastern Gulf of Mexico outer continental shelf. February 2016. Draft 03-29-2016.

U.S. Environmental Protection Agency. 2016b. Region 4 fact sheet for draft NPDES general permit GEG460000. April 8, 2016.

U.S. Environmental Protection Agency. 2016c. Fact sheet: Decision; National Ambient Air Quality Standards for lead. September 16, 2016. 4 pp.

U.S. Environmental Protection Agency. 2016d. Climate impacts in the southeast. Internet website: https://www3.epa.gov/climatechange/impacts/southeast.html. Last updated February 23, 2016. Accessed June 22, 2016.

U.S. Environmental Protection Agency. 2016e. Promising practices for EJ methodologies in NEPA reviews: Report for the Federal Interagency Working Group on Environmental Justice & NEPA Committee. March 2016. Internet website: https://www.epa.gov/environmentaljustice/ej-iwg-promising-practices-ej-methodologies-nepa-reviews. Accessed August 29, 2016.

U.S. Environmental Protection Agency. Region IV Regional Response Team. 1996. Use of dispersants in Region IV. Internet website: http://ocean.floridamarine.org/ACP/KWACP/Documents/RRTIVDocs/RRT4DispersantPlan.pdf. Accessed November 9, 2015.

U.S. Government Accountability Office. 2007. Coastal wetlands: Lessons learned from past efforts in Louisiana could help guide future restoration and protection. Government Accountability Office, Washington DC. GAO 08-130. 62 pp. Internet website: http://www.gao.gov/new.items/d08130.pdf.

U.S. Government Accountability Office. 2010. Opportunities exist to capture vented and flared natural gas, which would increase royalty payments and reduce greenhouse gases. Report to Congressional Requesters. GAO-11-34.

U.S. National Response Team. 2010. Oil spill response strategies for coastal marshes during the *Deepwater Horizon* MC252 spill. 10 pp. Internet website: http://www.nrt.org/Production/NRT/NRTWeb.nsf/AllAttachmentsByTitle/SA-1061NRT_Marsh_Cleanup_Options_DWH.06032010.pdf/$File/NRT_marsh_cleanup_overview_6-15.pdf?OpenElement. Accessed December 23, 2010.

Urick, R.J. 1972. Noise signature of an aircraft in level flight over a hydrophone in the sea. Journal of the Acoustical Society of America 52:993-999.

Valentine, D.L., G.B. Fisher, S.C. Bagby, R.K. Nelson, C.M. Reddy, S.P. Sylvia, and M.A. Woo. 2014. Fallout plume of submerged oil from *Deepwater Horizon*. Proceedings of the National Academy of Sciences 111(45):15906-15911. doi:10.1073/pnas.1414873111.

van Dam, R. and C. Diez. 1998. Home range of immature hawksbill turtles (*Eretmochelys imbricata*) at two Caribbean islands. Journal of Experimental Marine Biology and Ecology 220(1):15-24.

Van Houtan, K.S. and J.M. Halley. 2011. Long-term climate forcing in loggerhead sea turtle nesting. PLOS ONE 6(4):e19043. doi:10.1371/journal.pone.0019043.

Van Houtan, K.S., O.L. Bass, Jr., J. Lockwood, and S.L. Pimm. 2010. Importance of estimating dispersal for endangered bird management. Conservation Letters 00(2010):1-7.

Van Houtan, K.S., C.M. Smith, M.L. Dailer, and M. Kawachi. 2014. Eutrophication and the dietary promotion of sea turtle tumors. PeerJ 2:e602. doi:10.7717/peerj.602.

Van Vleet, E.S. and G. Pauly. 1987. Characterization of oil residues scraped from stranded sea turtles from the Gulf of Mexico. Caribbean Journal of Science 23:77-83.

Van Vleet, E.S., W.M. Sackett, F.F. Weber Jr., and S.B. Reinhardt. 1983. Input of pelagic tar into the northwest Atlantic from the Gulf Loop Current: Chemical characterization and its relationship to weathered IXTOC-I oil. Canadian Journal of Fisheries and Aquatic Sciences 40(S2):s12-s22.

Vanderlaan, A.S.M. and C.T. Taggart. 2007. Vessel collisions with whales: The probability of lethal injury based on vessel speed. Marine Mammal Science 23:144-156.

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. Volume II: Technical report. 3 vols. U.S. Dept. of the Interior, Minerals Management Service, Atlantic OCS Region, Washington, DC. OCS Study MMS 86-0070. 181 pp.

Veil, J. 1999. Update on onshore disposal of offshore drilling wastes. U.S. Environmental Protection Agency, Engineering and Analysis Division. USDOE Contract W-31-109-Eng-38. 18 pp.

Veil, J. 2015. U.S. produced water volumes and management practices in 2012. Prepared for the Ground Water Protection Council. 119 pp. Internet website: http://www.gwpc.org/sites/default/files/Produced%20Water%20Report%202014-GWPC_0.pdf.

Veil, J., T.A. Kimmell, and A.C. Rechner. 2005. Characteristics of produced water discharged to the Gulf of Mexico hypoxic zone. Prepared for the U.S. Dept. of Energy, National Energy Technology Laboratory. Contract W-31-109-Eng-38. Internet website: http://www.perf.org/images/Archive_Hypoxic_Report.pdf.

Venn-Watson S., K. Colegrove, J. Litz, M. Kinsel, K. Terio, J. Saliki, S. Fire, R. Carmichael, C. Chevis, W. Hatchett, J. Pitchford, M. Tumlin, C. Field, S. Smith, R. Ewing, D. Fauquier, G. Lovewell, H. Whitehead, D. Rotstein, W. McFee, E. Fourgeres, and T. Rowles. 2015. Adrenal gland and lung lesions in Gulf of Mexico common bottlenose dolphins (*Tursiops truncatus*) found dead following the *Deepwater Horizon* oil spill. PLOS ONE 10(5):e0126538. doi:10.1371/journal.pone.0126538.

Veron, J.E.N. 1995. Corals in space and time: The biogeography and evolution of the Scleractinia. Australian Institute of Marine Science. Sydney, Australia: University of New South Wales Press.

Veron, J.E.N. 2000. Corals of the world. Volumes 1-3. Australian Institute of Marine Science, Townsville, Australia. 1410 pp.

Vittor, B.A. 2000. Benthic macroinfauna of the northeastern Gulf of Mexico OCS, near DeSoto Canyon. In: Schroeder, W.W. and C.F. Wood, eds. Physical/Biological Oceanographic

Integration Workshop for the DeSoto Canyon and Adjacent Shelf, October 19-21, 1999. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2000-074. 168 pp.

Volz, D. 2013. Port Fourchon completes dredging as part of big expansion project. Professional Mariner. March 27, 2013. Internet website: http://www.professionalmariner.com/April-2013/Port-Fourchon-completes-dredging-as-part-of-big-expansion-project/. Accessed September 7, 2015.

Voss, G.L. and T.F Brakoniecki. 1985. Squid resources of the Gulf of Mexico and southeast Atlantic coasts of the United States. NAFO Scientific Council Studies 9:27-37.

Wade, T.L., Y. Soliman, S.T. Sweet, G.A. Wolff, and B.J. Presley. 2008. Trace elements and polycyclic aromatic hydrocarbons (PAHs) concentrations in deep Gulf of Mexico sediments. Deep-Sea Research II 55:2585-2593.

Walker, N. 2001. Tropical storm and hurricane wind effects on water level, salinity, and sediment transport in the river-influenced Atchafalaya-Vermilion Bay System, Louisiana, USA. Estuaries 24:489-508.

Wallace, R.K. 1996. Coastal wetlands in Alabama. Auburn University, Marine Extension and Research Center, Mobile, AL. Circular ANR-831 MASGP-96-018.

Wang, F.C. 1987. Effects of levee extension on marsh flooding. Journal of Water Resources Planning and Management 113:161-176.

Wang, F.C. 1988. Saltwater intrusion modeling: The role of man-made features. In: Turner, R.E. and D.R. Cahoon, eds. Causes of wetland loss in the coastal central Gulf of Mexico. Volume 2. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 87-0120. Pp. 71-100.

Ward, M.P., B. Semel, and J.R. Herkert. 2010. Identifying the ecological causes of long-term declines of wetland-dependent birds in an urbanizing landscape. Biodiversity and Conservation 19:3287-3300.

Wardle, C.S., T.J. Carter, G.G. Urquhart, A.D.F. Johnstone, A.M. Ziolkowski, G. Hampson, and D. Mackie. 2001. Effects of seismic air guns on marine fish. Continental Shelf Research 21(8):1005-1027.

Waring, G.T., E. Josephson, K. Maze-Foley, and P.E. Rosel, eds. 2013. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments – 2012. NOAA Technical Memorandum NMFS-NE-223. 419 pp. Internet website: http://www.nefsc.noaa.gov/nefsc/publications/.

Waring, G.T., E. Josephson, K. Maze-Foley, and P.E. Rosel, eds. 2014. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments – 2013. NOAA Technical Memorandum NMFS-NE-228. 464 pp. Internet website: http://www.nefsc.noaa.gov/nefsc/publications/.

Waring, G.T., E. Josephson, K. Maze-Foley, and P.E. Rosel, eds. 2016. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments – 2015. NOAA Technical Memorandum NMFS-NE-238. 512 pp.

Waters, M.R., S.L. Forman, T.A. Jennings, L.C. Nordt, S.G. Driese, J.M. Feinberg, J.L. Keene, J. Halligan, A. Lindquist, J. Pierson, C.T. Hallmark, M.B. Collins, and J.E. Wiederhold. 2011. The Buttermilk Creek complex and the origins of Clovis at the Debra L. Friedkin Site, Texas. Science 331:1599-1603.

Watkins, W.A. and W.E. Scheville. 1977. Sperm whale codas. Journal of the Acoustical Society of America 62:1485-1490.

Watkins, W.A., K.E. Moore, and P. Tyack. 1985. Sperm whales acoustic behaviour in the southeast Caribbean. Cetology 49:1-15.

Watkins, W.A., M.A. Daher, K.M. Fristrup, Y.J. Howald, and G.N. Disciara. 1993. Sperm whales tagged with transponders and tracked underwater by sonar. Marine Mammal Science 9:55-67.

Waycott, M., C.M. Duarate, T.J.B. Carruthers, R.J. Orth, W.C. Dennison, S. Olyamik, A. Calladine, J.W. Fourqurean, K. Heck, Jr., A.R. Hughes, G.A. Kendrick, W.J. Kentworthy, F.T. Short, and S.L. Williams. 2009. Accelerating loss of seagrass across the globe threatens coastal ecosystems. Proceedings for the National Academy of Sciences 106(3):12377-12381. Internet website: http://www.pnas.org/content/106/30/12377.full.

Weatherly, G. 2004. Intermediate depth circulation in the Gulf of Mexico: PALACE float results for the Gulf of Mexico between April 1998 and March 2002. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2004-013. 51 pp.

Weaver, D.C., G.D. Dennis, and K.J. Sulak. 2002. Northeastern Gulf of Mexico coastal and marine ecosystem program: Community structure and trophic ecology of demersal fishes on the pinnacles reef tract; final synthesis report. U.S. Dept. of the Interior, Geological Survey, USGS BSR-2001-0008 and U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA, OCS Study MMS 2002-034. 92 pp. + apps.

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. Environmental Pollution Series A, Ecological and Biological 38(4):321-337.

Webster, R.K. and T. Linton. 2013. Development of implementation of *Sargassum* early advisory system (SEAS). Shore and Beach. Journal of the American Shore and Beach Preservation Association 81:43-48.

Wei, C., G.T. Rowe, C.C. Nunnally, and M.K. Wicksten. 2012. Anthropogenic "litter" and macrophyte detritus in the deep northern Gulf of Mexico. Marine Pollution Bulletin 64:966-973.

Weilgart, L.S. and H. Whitehead. 1988. Distinctive vocalizations from mature male sperm whales (*Physeter macrocephalus*). Canadian Journal of Zoology 66:1931-1937.

Weilgart, L. and H. Whitehead. 1997. Group-specific dialects and geographical variation in coda repertoire in South Pacific sperm whales. Behavioral Ecology and Sociobiology 40:277-285.

Wells, P.G. 1989. Using oil spill dispersants on the sea—issues and answers. In: Duke, T.W. and G. Petrazzuolo. Oil and dispersant toxicity testing. Proceedings of a Workshop on Technical Specifications held in New Orleans, LA, January 17-19, 1989. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 89-0042. Pp. 1-4.

Wells, R.J.D. and J.R. Rooker. 2004. Spatial and temporal habitat use by fishes associated with *Sargassum* mats in the NW Gulf of Mexico. Bulletin of Marine Science 74:81-99.

Wells, R.S. and M.D. Scott. 1997. Seasonal incidence of boat strikes on bottlenose dolphins near Sarasota, Florida. Marine Mammal Science 13:475-480.

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. Volume 6: Second book of dolphins. San Diego, CA: Academic Press. Pp. 137-182.

Wells, R.J.D., J.H. Cowan Jr., and W.F. Patterson III. 2008. Habitat use and the effect of shrimp trawling on fish and invertebrate communities over the northern Gulf of Mexico continental shelf. Journal of Marine Science 65:1610-1619.

Welsh, S.E., M. Inoue, L.J. Rouse, Jr., and E. Weeks. 2009. Observation of the deepwater manifestation of the Loop Current and Loop Current rings in the eastern Gulf of Mexico. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2009-050. 110 pp.

Wenger, A.S., M.I. McCormick, G.G. Endo, I.M. McLeod, F.J. Kroon, and G.P. Jones. 2014. Suspended sediment prolongs larval development in a coral reef fish. The Journal of Experimental Biology 217(7):1122-1128.

Wheaton, J.W. and W.C. Jaap. 1988. Corals and other prominent benthic cnidaria of Looe Key National Marine Sanctuary, FL. Florida Marine Research Publication 43.

White, D.R.M. 1998. Cultural gumbo? An ethnographic overview of Louisiana's Mississippi River delta and selected adjacent areas. Applied Cultural Dynamics. Report prepared for Jean Lafitte National Historical Park and Preserve, New Orleans, LA. 462 pp.

White, C. 2014. Gulf Islands National Seashore acoustic monitoring report. Natural Resource Technical Report NPS/NRSS/NRTR-2014/835.

White, W.A., T.R. Calnan, R.A. Morton, R.S. Kimble, T.G. Littleton, J.H. McGowen, H.S. Nance, and K.E. Schmedes. 1986. Submerged lands of Texas, Brownsville-Harlingen area. University of Texas at Austin, Bureau of Economic Geology, Austin, TX.

White, H.K., P. Hsing, W. Cho, T.M. Shank, E.E. Cordes, A.M. Quattrini, R.K. Nelson, R. Camilli, A.W.J. Demopoulos, C.R. German, J.M. Brooks, H.H. Roberts, W. Shedd, C.M. Reddy, and C.R. Fisher. 2012. Impact of the *Deepwater Horizon* oil spill on a deep-water coral community in the Gulf of Mexico. Proceedings of the National Academy of Sciences of the United States of America, early edition, special feature, March 27, 2012. Internet website: http://www.pnas.org/content/early/2012/03/23/1118029109.full.pdf+html. Accessed April 9, 2012.

White, H.K., S.L. Lyons, S.J. Harrison, D.M. Findley, Y. Liu, and E.B. Kujawinski. 2014. Long-term persistence of dispersants following the *Deepwater Horizon* oil spill. Environmental Science & Technology Letters 1(7):295-299. doi:10.1021/ez500168r.

Whitehead, H. 2002. Estimates of the current global population size and historical trajectory for sperm whales. Marine Ecology Progress Series 242:295-304.

Wicker, K.M., R.E. Emmer, D. Roberts, and J. van Beek. 1989. Pipelines, navigation channels, and facilities in sensitive coastal habitats: An analysis of outer continental shelf impacts, Coastal Gulf of Mexico. Volume I: Technical narrative. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 89-0051. 470 pp.

Wiese, F.K., W.A. Montevecchi, G.K. Davoren, F. Huettmann, A.W. Diamond, and J. Linke. 2001. Seabirds at risk around offshore oil platforms in the north-west Atlantic. Marine Pollution Bulletin 42:1285-1290.

Wilber, D.H., W. Brostoff, D.G. Clarke, and G.L. Ray. 2005. Sedimentation: Potential biological effects from dredging operations in estuarine and marine environments. DOER Technical Notes Collection. ERDC TN-DOER-E20. U.S. Dept. of the Army, Engineer Research and Development Center, Vicksburg, MS.

Wilcox, C., E. Van Sebille, and B.D. Hardesty. 2015. Threat of plastic pollution to seabirds is global, pervasive, and increasing. Proceedings of the National Academy of Sciences 112:11899-11904.

Williams, S.L. 1988. *Thalassia testudinum* productivity and grazing by green turtles in a highly disturbed seagrass bed. Marine Biology 98(3):447-455.

Wilson, C.A., A. Pierce, and M.W. Miller. 2003. Rigs and reefs: A comparison of the fish communities at two artificial reefs, a production platform, and a natural reef in the northern Gulf of Mexico. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2003-009. 95 pp.

Wilson, D., J. Fanjoy, and R. Billings. 2004. Gulfwide emission inventory study for the regional haze and ozone modeling effort: Final report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2004-072. 241 pp.

Wilson, D., R. Billings, R. Oommen, and R. Chang. 2007. Year 2005 Gulfwide emission inventory study: Final report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2007-067. 149 pp.

Wilson, D., R. Billings, R. Oommen, B. Lange, J. Marik, S. McClutchey, and H. Perez. 2010. Year 2008 Gulfwide emission inventory study: Final report. U.S. Dept. of the Interior, Minerals

Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study BOEM 2010-045. 185 pp.

Wilson, D., R. Billings, R. Chang, H. Perez, and J. Sellers. 2014. Year 2011 Gulfwide emissions inventory study. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study BOEM 2014-666. 182 pp.

Winge, O. 1923. The Sargasso Sea, its boundaries and vegetation. Report on the Danish Oceanography Expedition 1908-1910. Volume III: Miscellaneous papers. Carlsberg Physiological Laboratory, Copenhagen, Denmark.

Wise, C.F., J.T.F. Wise, S.S. Wise, W.D. Thompson, J.P. Wise Jr., and J.P Wise Sr. 2014. Chemical dispersants used in the Gulf of Mexico oil crisis are cytotoxic and genotoxic to sperm whale skin cells. Aquatic Toxicology 152:335-340.

Wiseman, W.J., Jr. and W. Sturges. 1999. Physical oceanography of the Gulf of Mexico: Processes that regulate its biology. In: Kumpf, H., K. Steidinger, and K. Sherman, eds. The Gulf of Mexico large marine ecosystem: Assessment, sustainability, and management. Malden, MA: Blackwell Science, Inc.

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, 14-17 June 1978, Keystone, CO. American Institute of Biological Sciences. Pp. 629-632.

Witham, R. 1983. A review of some petroleum impacts on sea turtles. In: Keller, C.E. and J.K. Adams, eds. Proceedings of a Workshop on Cetaceans and Sea Turtles in the Gulf of Mexico: Study planning for effects of outer continental shelf development. U.S. Dept. of the Interior, Fish and Wildlife Service and U.S. Dept. of the Interior, Minerals Management Service. FWS/OBS-83-03. Pp. 7-8.

Witham, R. 1995. Disruption of sea turtle habitat with emphasis on human influence. In: Bjorndal, K.A., ed. Biology and conservation of sea turtles; revised edition. Washington, DC: Smithsonian Institution Press. Pp. 519-522.

Witherington, B.E. 1994. Flotsam, jetsam, post-hatchling loggerheads, and the advecting surface smorgasbord. In: Bjorndal, K.A., A.B. Bolten, D.A. Johnson, and P.J. Eliazar, comps. Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-351.

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.

Witherington, B., P. Kubilis, B. Brost, and A. Meylan. 2009. Decreasing annual nest counts in a globally important loggerhead sea turtle population. Ecological Applications 19:30-54.

Witherington, B., S. Hirama, and R. Hardy. 2012. Young sea turtles of the pelagic *Sargassum*-dominated drift community: Habitat use, population density, and threats. Marine Ecology Progress Series 463:1-22.

Witzell, W.N. 1992. The incidental capture of sea turtles in commercial non-shrimping fisheries in southeastern U.S. waters. Report to the U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Miami Laboratory, Miami, FL. Contribution No. MIA-91/92-43.

Wolbers, D. and R. Hovinga. 2003. Installation of deepwater pipelines with sled assemblies using the new J-Lay system of the DCV Balder. Paper presented at the Offshore Technology Conference, May 5-8, 2003, Houston, Texas. OTC 15336.

Wolvovsky, E. and W. Anderson. 2016. OCS oil and natural gas: Potential lifecycle greenhouse gas emissions and social cost of carbon. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Sterling, VA. OCS Report BOEM 2016-065. 56 pp.

Woods & Poole Economics, Inc. 2016. The 2016 complete economic and demographic data source (CEDDS) on CD-ROM.

World Oil. 2016. Port Fourchon: The Gulf's energy connection. Gulf Publishing Company. Internet website: http://www.la1coalition.org/phire-content/assets/files/2016%209pg%20World%20Oil%20Port%20Fourchon%20Special%20Report%20ONLY.pdf. Accessed August 24, 2016.

World Port Source. 2015. Port Panama City; port commerce. Internet website: http://www.worldportsource.com/ports/commerce/USA_FL_Port_Panama_City_27.php. Accessed September 23, 2015.

Wright, S.L., R.C. Thompson, and T.S. Galloway. 2013. The physical impacts of microplastics on marine organisms: A review. Environmental Pollution 178:483-492.

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, CA: Academic Press. Pp. 129-165.

Würsig, B., T.A. Jefferson, and D.J. Schmidly. 2000. The marine mammals of the Gulf of Mexico. College Station: Texas A&M University Press. 232 pp.

Würsig, B., R.R. Reeves, and J.G. Ortega-Ortiz. 2002. Global climate change and marine mammals. In: Evans, P.G.H. and J.A. Raga, eds. Marine mammals – biology and conservation. New York, NY: Kluwer Academic/Plenum Publishers. Pp. 589-608.

Wyers, S.C., H.R. Frith, R.E. Dodge, S.R. Smith, A.H. Knap, and T.D. Sleeter. 1986. Behavioral effects of chemically dispersed oil and subsequent recovery in *Diploria strigosa*. Marine Ecology 7:23-42.

Wysocki, L.E. and F. Ladich. 2005. Hearing in fishes under noise conditions. Journal of the Association for Research in Otolaryngology 6:28-36.

Yelverton, J.T., D.R. Richmond, E.R. Fletcher, and R.K. Jones. 1973. Safe distances from underwater explosions for mammals and birds. Report by the Lovelace Foundation for Medical Education and Research, Albuquerque, NM, for Defense Nuclear Agency, Washington, DC. Technical Report No. 3114 T. 72 pp.

Yender, R.A. and J. Michel, eds. 2010. Oil spills in coral reefs: Planning and response considerations. Second edition. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Office of Response and Restoration. 82 pp. Internet website: http://response.restoration.noaa.gov/sites/default/files/Oil_Spill_Coral.pdf.

Yuill, B., D. Lavoie, and D.J. Reed. 2009. Understanding subsidence processes in coastal Louisiana. Journal of Coastal Research SI(54):23-36.

Yuro, A.M. 2011. The impact of storm surge from successive hurricanes on the Alabama beach mouse population. Master's Thesis, The University of Alabama. 75 pp.

Zafonte, M. and S. Hampton. 2005. Lost bird-years: Quantifying bird injuries in natural resource damage assessments for oil spills. In: Proceedings of the 2005 International Oil Spill Conference, May 2005. Pp. 15-19.

Zambrano, R.H., H.T. Smith, and M. Robson. 2000. Summary of breeding roseate terns in the Florida Keys: 1974-1998. Florida Field Naturalist 28:64-68.

Zavala-Hidalgo, J., A. Gallegos-García, B. Martínez-López, S.L. Morey, and J.J. O'Brien. 2006. Seasonal upwelling on the western and southern shelves of the Gulf of Mexico. Ocean Dynamics 56:333-338. doi:10.1007/s10236-006-0072-3.

Zengel, S., B. Bernik, N. Rutherford, Z. Nixon, J. Michel, and F. Csulak. 2014. Salt marsh remediation and the Deepwater Horizon oil spill: The role of planting in ecological recovery. Gulf of Mexico Oil Spill & Ecosystem Science Conference, 26-29 January 2004, Mobile, AL, USA.

Zengel S., B.M. Bernik, N. Rutherford, Z. Nixon, and J. Michel. 2015. Heavily oiled salt marsh following the *Deepwater Horizon* oil spill, ecological comparisons of shoreline cleanup treatments and recovery. PLOS ONE 10(7):e0132324. doi:10.1371/journal.pone.0132324.

Zieman, J.C. 1982. The ecology of the seagrasses of south Florida: A community profile. U.S. Dept. of the Interior, Fish and Wildlife Service. FWS/OBS-82/25. 123 pp.

Zieman, J.C., R. Orth, R.C. Phillips, G. Thayer, and A. Thorhaug. 1984. The effects of oil on seagrass ecosystems. In: Cairns, J., Jr. and A.L. Buikema, Jr., eds. Restoration of habitats impacted by oil spills. Boston, MA: Butterworth Publishers.

Zug, G.R. and J.F. Parham. 1996. Age and growth in leatherback turtles, *Dermochelys coriacea*: A skeletochronological analysis. Chelonian Conservation and Biology 2(2):244-249.

CHAPTER 7

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CHAPTER 8

GLOSSARY

8 GLOSSARY

Acute—Sudden, short term, severe, critical, crucial, intense, but usually of short duration, as opposed to chronic. Effects associated with acute can vary depending on the context of its use (e.g., acute [short-term] exposure could be more or less problematic than chronic [long-term] exposure).

Anaerobic—Capable of growing in the absence of molecular oxygen.

Annular preventer—A component of the pressure control system in the BOP that forms a seal in the annular space around any object in the wellbore or upon itself, enabling well control operations to commence.

Anthropogenic—Coming from human sources, relating to the effect of humankind on nature.

Antipatharian Transitional Zone—The area located between 50 and 90 m (164 and 295 ft), where available light is reduced and there is a gradual ecosystem change from tropical shallow-water corals that are dependent on light to deeper water species, such as antipatharian black corals that are not.

API gravity—A standard adopted by the American Petroleum Institute for expressing the specific weight of oil.

Aromatic—Class of organic compounds containing benzene rings or benzenoid structures.

Attainment area—An area that is shown by monitored data or by air-quality modeling calculations to be in compliance with primary and secondary ambient air quality standards established by USEPA.

Barrel (bbl)—A volumetric unit used in the petroleum industry; equivalent to 42 U.S. gallons or 158.99 liters.

Benthic—On or in the bottom of the sea.

Biological Opinion—The FWS or NMFS evaluation of the impact of a proposed action on endangered and threatened species, in response to formal consultation under Section 7 of the Endangered Species Act.

Block—A geographical area portrayed on official BOEM protraction diagrams or leasing maps that contains approximately 5,760 ac (2,331 ha; 9 mi^2).

Blowout—An uncontrolled flow of fluids below the mudline from appurtenances on a wellhead or from a wellbore.

Blowout preventer (BOP)—One of several valves installed at the wellhead to prevent the escape of pressure either in the annular space between the casing and drill pipe or in open hole (i.e., hole with no drill pipe) during drilling completion operations. Blowout preventers on jackup or platform rigs are located at the water's surface; on floating offshore rigs, BOPs are located on the seafloor.

Cetacean—Aquatic mammal of the order Cetacea, such as whales, dolphins, and porpoises.

Chemosynthetic—Organisms that obtain their energy from the oxidation of various inorganic compounds rather than from light (photosynthetic).

Coastal waters—Waters within the geographical areas defined by each State's Coastal Zone Management Program.

Coastal wetlands—forested and nonforested habitats, mangroves, and marsh islands exposed to tidal activity. These areas directly contribute to the high biological productivity of coastal waters by input of detritus and nutrients, by providing nursery and feeding areas for shellfish and finfish, and by serving as habitat for birds and other animals.

Coastal zone—The coastal waters (including the lands therein and thereunder) and the adjacent shorelands (including the waters therein and thereunder) strongly influenced by each other and in proximity to the shorelines of several coastal states; the zone includes islands, transitional and intertidal areas, salt marshes, wetlands, and beaches, and it extends seaward to the outer limit of the United States territorial sea. The zone extends inland from the shorelines only to the extent necessary to control shorelands, the uses of which have a direct and significant impact on the coastal waters. Excluded from the coastal zone are lands the use of which is by law subject to the discretion of or which is held in trust by the Federal Government, its officers, or agents (also refer to State coastal zone boundaries).

Completion—Conversion of a development well or an exploration well into a production well.

Condensate—Liquid hydrocarbons produced with natural gas; they are separated from the gas by cooling and various other means. Condensates generally have an API gravity of 50°-120°.

Continental margin—The ocean floor that lies between the shoreline and the abyssal ocean floor, includes the continental shelf, continental slope, and continental rise.

Continental shelf—General term used by geologists to refer to the continental margin province that lies between the shoreline and the abrupt change in slope called the shelf edge, which generally occurs in the Gulf of Mexico at about the 200-m (656-ft) water depth. The continental shelf is characterized by a gentle slope (about 0.1°). This is different from the juridical term used in Article 76 of the United Nations Convention on the Law of the Sea Royalty Payment (refer to the definition of Outer Continental Shelf).

Continental slope—The continental margin province that lies between the continental shelf and continental rise, characterized by a steep slope (about 3°-6°).

Critical habitat—Specific areas essential to the conservation of a protected species and that may require special management considerations or protection.

Crude oil—Petroleum in its natural state as it emerges from a well or after it passes through a gas-oil separator, but before refining or distillation. An oily, flammable, bituminous liquid that is essentially a complex mixture of hydrocarbons of different types with small amounts of other substances.

Delineation well—A well that is drilled for the purpose of determining the size and/or volume of an oil or gas reservoir.

Demersal—Living at or near the bottom of the sea.

Development—Activities that take place following discovery of economically recoverable mineral resources, including geophysical surveying, drilling, platform construction, operation of onshore support facilities, and other activities that are for the purpose of ultimately producing the resources.

Development and Production Plan (DPP)—A document that must be prepared by the operator and submitted to BOEM for approval before any development and production activities are conducted on a lease or unit in any OCS area other than the western Gulf of Mexico.

Development Operations Coordination Document (DOCD)—A document that must be prepared by the operator and submitted to BOEM for approval before any development or production activities are conducted on a lease in the western Gulf of Mexico.

Development well—A well drilled to a known producing formation to extract oil or gas; a production well; distinguished from a wildcat or exploration well and from an offset well.

Direct employment—Consists of those workers involved in the primary industries of oil and gas exploration, development, and production operations (Standard Industrial Classification Code 13—Oil and Gas Extraction).

Discharge—Something that is emitted; flow rate of a fluid at a given instant expressed as volume per unit of time.

Dispersant—A suite of chemicals and solvents used to break up an oil slick into small droplets, which increases the surface area of the oil and hastens the processes of weathering and microbial degradation.

Dispersion—A suspension of finely divided particles in a medium.

Drilling mud—A mixture of clay, water or refined oil, and chemical additives pumped continuously downhole through the drill pipe and drill bit, and back up the annulus between the pipe and the walls of the borehole to a surface pit or tank. The mud lubricates and cools the drill bit, lubricates the drill pipe as it turns in the wellbore, carries rock cuttings to the surface, serves to keep the hole from crumbling or collapsing, and provides the weight or hydrostatic head to prevent extraneous fluids from entering the well bore and to downhole pressures; also called drilling fluid.

Economically recoverable resources—An assessment of hydrocarbon potential that takes into account the physical and technological constraints on production and the influence of costs of exploration and development and market price on industry investment in OCS exploration and production.

Effluent—The liquid waste of sewage and industrial processing.

Effluent limitations—Any restriction established by a State or USEPA on quantities, rates, and concentrations of chemical, physical, biological, and other constituents discharged from point sources into U.S. waters, including schedules of compliance.

Epifaunal—Animals living on the surface of hard substrate.

Essential habitat—Specific areas crucial to the conservation of a species and that may necessitate special considerations.

Estuary—Coastal semienclosed body of water that has a free connection with the open sea and where freshwater meets and mixes with seawater.

Eutrophication—Enrichment of nutrients in the water column by natural or artificial methods accompanied by an increase of respiration, which may create an oxygen deficiency.

Exclusive Economic Zone (EEZ)—The maritime region extending 200 nmi (230 mi; 370 km) from the baseline of the territorial sea, in which the United States has exclusive rights and jurisdiction over living and nonliving natural resources.

Exploration Plan (EP)—A plan that must be prepared by the operator and submitted to BOEM for approval before any exploration or delineation drilling is conducted on a lease.

Exploration well—A well drilled in unproven or semi-proven territory to determining whether economic quantities of oil or natural gas deposit are present.

False crawls—Refers to when a female sea turtle crawls up on the beach to nest (perhaps) but does not and returns to the sea without laying eggs.

Field—An accumulation, pool, or group of pools of hydrocarbons in the subsurface. A hydrocarbon field consists of a reservoir in a shape that will trap hydrocarbons and that is covered by an impermeable, sealing rock.

Floating production, storage, and offloading (FPSO) system—A tank vessel used as a production and storage base; produced oil is stored in the hull and periodically offloaded to a shuttle tanker for transport to shore.

Gathering lines—A pipeline system used to bring oil or gas production from a number of separate wells or production facilities to a central trunk pipeline, storage facility, or processing terminal.

Geochemical—Of or relating to the science dealing with the chemical composition of and the actual or possible chemical changes in the crust of the earth.

Geophysical survey—A method of exploration in which geophysical properties and relationships are measured remotely by one or more geophysical methods.

Habitat—A specific type of environment that is occupied by an organism, a population, or a community.

Hermatypic coral—Reef-building corals that produce hard, calcium carbonate skeletons and that possess symbiotic, unicellular algae within their tissues.

Harassment—An intentional or negligent act or omission that creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns that include, but are not limited to, feeding or sheltering.

Hermatypic—Corals in the order Scleractinia that build reefs by depositing hard calcareous material for their skeletons, forming the stony framework of the reef. Corals that do not contribute to coral reef development are referred to as ahermatypic (non-reef-building) species.

Hydrocarbons—Any of a large class of organic compounds containing primarily carbon and hydrogen. Hydrocarbon compounds are divided into two broad classes: aromatic and aliphatics. They occur primarily in petroleum, natural gas, coal, and bitumens.

Hypoxia—Depressed levels of dissolved oxygen in water, usually resulting in decreased metabolism.

Incidental take—Takings that result from, but are not the purpose of, carrying out an otherwise lawful activity (e.g., fishing) conducted by a Federal agency or applicant (refer to Taking).

Infrastructure—The facilities associated with oil and gas development, e.g., refineries, gas processing plants, etc.

Jack-up rig—A barge-like, floating platform with legs at each corner that can be lowered to the sea bottom to raise the platform above the water.

Kick—A deviation or imbalance, typically sudden or unexpected, between the downward pressure exerted by the drilling fluid and the upward pressure of *in-situ* formation fluids or gases.

Landfall—The site where a marine pipeline comes to shore.

Lease—Authorization that is issued under Section 8 or maintained under Section 6 of the Outer Continental Shelf Lands Act and that authorizes exploration for, and development and production of, minerals.

Lease sale—The competitive auction of leases granting companies or individuals the right to explore for and develop certain minerals under specified conditions and periods of time.

Lease term—The initial period for oil and gas leases, usually a period of 5, 8, or 10 years depending on water depth or potentially adverse conditions.

Lessee—A party authorized by a lease, or an approved assignment thereof, to explore for and develop and produce the leased deposits in accordance with regulations at 30 CFR part 250 and 30 CFR part 550.

Littoral zone—Marine ecological realm that experiences the effects of tidal and longshore currents and breaking waves to a depth of 5-10 m (16-33 ft) below the low-tide level, depending on the intensity of storm waves.

Longshore sediment transport—The cumulative movement of beach sediment along the shore (and nearshore) by waves arriving at an angle to the coastline and by currents generated by such waves.

Macondo—Prospect name given by BP to the Mississippi Canyon Block 252 exploration well that the *Deepwater Horizon* rig was drilling when a blowout occurred on April 20, 2010.

***Macondo* spill**—The name given to the oil spill that resulted from the explosion and sinking of the *Deepwater Horizon* rig from the period between April 24, 2010, when search and recovery vessels on site reported oil at the sea surface, and September 19, 2010, when the uncontrolled flow from the *Macondo* well was capped.

Marshes—Persistent, emergent, nonforested wetlands characterized by predominantly cordgrasses, rushes, and cattails.

Military warning area—An area established by the U.S. Department of Defense within which military activities take place.

Minerals—As used in this document, minerals include oil, gas, sulphur, and associated resources, and all other minerals authorized by an Act of Congress to be produced from public lands as defined in Section 103 of the Federal Land Policy and Management Act of 1976.

Naturally occurring radioactive materials (NORM)—naturally occurring material that emits low levels of radioactivity, originating from processes not associated with the recovery of radioactive material. The radionuclides of concern in NORM are Radium-226, Radium-228, and other isotopes in the radioactive decay chains of uranium and thorium.

Nepheloid—A layer of water near the bottom that contains significant amounts of suspended sediment.

Nonattainment area—An area that is shown by monitoring data or by air-quality modeling calculations to exceed primary or secondary ambient air quality standards established by USEPA.

Nonhazardous oil-field wastes (NOW)—Wastes generated by exploration, development, or production of crude oil or natural gas that are exempt from hazardous waste regulation under the Resource Conservation and Recovery Act (*Regulatory Determination for Oil and Gas and Geothermal Exploration, Development and Production Wastes,* dated June 29, 1988, 53 FR 25446; July 6, 1988). These wastes may contain hazardous substances.

Oceanic zone—Offshore water >200 m (656 ft) deep. It is the region of open sea beyond the edge of the continental shelf and includes 65 percent of the ocean's completely open water.

Offloading—Unloading liquid cargo, crude oil, or refined petroleum products.

Operational discharge—Any incidental pumping, pouring, emitting, emptying, or dumping of wastes generated during routine offshore drilling and production activities.

Operator—An individual, partnership, firm, or corporation having control or management of operations on a leased area or portion thereof. The operator may be a lessee, designated agent of the lessee, or holder of operating rights under an approved operating agreement.

Organic matter—Material derived from living plants or animals.

Outer Continental Shelf (OCS)—All submerged lands that comprise the continental margin adjacent to the United States and seaward of State offshore lands.

Passerines—Perching birds (members of the Order Passeriformes) and songbirds.

Potential Biological Removal (PBR)—Of or pertaining to the open sea; associated with open water beyond the direct influence of coastal systems.

Pelagic—Of or pertaining to the open sea; associated with open water beyond the direct influence of coastal systems.

Plankton—Passively floating or weakly motile aquatic plants (phytoplankton) and animals (zooplankton).

Platform—A steel or concrete structure from which offshore development wells are drilled.

Play—A prospective subsurface area for hydrocarbon accumulation that is characterized by a particular structural style or depositional relationship.

Primary production—Organic material produced by photosynthetic or chemosynthetic organisms.

Produced water—Total water discharged from the oil and gas extraction process; production water or production brine.

Production—Activities that take place after the successful completion of any means for the extraction of resources, including bringing the resource to the surface, transferring the produced resource to shore, monitoring operations, and drilling additional wells or workovers.

Province—A spatial entity with common geologic attributes. A province may include a single dominant structural element such as a basin or a fold belt, or a number of contiguous related elements.

Ram—The main component of a blowout preventer designed to shear casing and tools in a wellbore or to seal an empty wellbore. A blind shear ram accomplishes the former and a blind ram the latter.

Recoverable reserves—The portion of the identified hydrocarbon or mineral resource that can be economically extracted under current technological constraints.

Recoverable resource estimate—An assessment of hydrocarbon or mineral resources that takes into account the fact that physical and technological constraints dictate that only a portion of resources can be brought to the surface.

Recreational beaches—Frequently visited, sandy areas along the Gulf of Mexico shorefront that support multiple recreational activities at the land-water interface. Included are National Seashores, State Park and Recreational Areas, county and local parks, urban beachfronts, and private resorts.

Refining—Fractional distillation of petroleum, usually followed by other processing (e.g., cracking).

Relief—The difference in elevation between the high and low points of a surface.

Reserves—Proved oil or gas resources.

Rig—A structure used for drilling an oil or gas well.

Riser insertion tube tool—A "straw" and gasket assembly improvised during the *Macondo* spill response that was designed to siphon oil and gas from the broken riser of the *Deepwater Horizon* rig lying on the sea bottom (an early recovery strategy for the *Macondo* spill in May 2010).

Royalty—A share of the minerals produced from a lease paid in either money or "in-kind" to the landowner by the lessee.

Saltwater intrusion—Saltwater invading a body of freshwater.

Sciaenids—Fishes belonging to the croaker family (Sciaenidae).

Seagrass beds—More or less continuous mats of submerged, rooted, marine, flowering vascular plants occurring in shallow tropical and temperate waters. Seagrass beds provide habitat, including breeding and feeding grounds, for adults and/or juveniles of many of the economically important shellfish and finfish.

Sediment—Material that has been transported and deposited by water, wind, glacier, precipitation, or gravity; a mass of deposited material.

Seeps (hydrocarbon)—Gas or oil that reaches the surface along bedding planes, fractures, unconformities, or fault planes.

Sensitive area—An area containing species, populations, communities, or assemblages of living resources, that is susceptible to damage from normal OCS oil- and gas-related activities. Damage includes interference with established ecological relationships.

Shear ram—The component in a BOP that cuts, or shears, through the drill pipe and forms a seal against well pressure. Shear rams are used in floating offshore drilling operations to provide a quick method of moving the rig away from the hole when there is no time to trip the drill stem out of the hole.

Site fidelity or philopatry—The tendency to return to a previously occupied location.

Spill of National Significance—Designation by the USEPA Administrator under 40 CFR § 300.323 for discharges occurring in the inland zone and the Commandant of the U.S. Coast Guard for discharges occurring in the coastal zone, authorizing the appointment of a National Incident Commander for spill-response activity.

State coastal zone boundary—The State coastal zone boundaries for each CZMA-affected State are defined at https://coast.noaa.gov/czm/media/StateCZBoundaries.pdf.

Structure—Any OCS facility that extends from the seafloor to above the waterline; in petroleum geology, any arrangement of rocks that may hold an accumulation of oil or gas.

Subarea—A discrete analysis area.

Subsea isolation device—An emergency disconnection and reconnection assembly for the riser at the seafloor.

Supply vessel—A boat that ferries food, water, fuel, and drilling supplies and equipment to an offshore rig or platform and returns to land with refuse that cannot be disposed of at sea.

Taking—To harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect any endangered or threatened species, or to attempt to engage in any such conduct (including actions that induce stress, adversely impact critical habitat, or result in adverse secondary or cumulative impacts). Harassments are the most common form of taking associated with OCS Program activities.

Tension-leg platform (TLP)—A production structure that consists of a buoyant platform tethered to concrete pilings on the seafloor with flexible cable.

Tidal prism—The volume of water in an estuary or inlet between mean high tide and mean low tide, or the volume of water leaving an estuary at ebb tide.

Trunkline—A large-diameter pipeline receiving oil or gas from many smaller tributary gathering lines that serve a large area; common-carrier line; main line.

Turbidity—Reduced water clarity due to the presence of suspended matter.

Volatile organic compound (VOC)—Any organic compound that is emitted to the atmosphere as a vapor.

Water test areas—Areas within the eastern Gulf where U.S. Department of Defense research, development, and testing of military planes, ships, and weaponry take place.

Weathering (of oil)—The aging of oil due to its exposure to the atmosphere, causing marked alterations in its physical and chemical makeup.

The Department of the Interior Mission

The Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities.

The Bureau of Ocean Energy Management Mission

The Bureau of Ocean Energy Management (BOEM) is responsible for managing development of U.S. Outer Continental Shelf energy and mineral resources in an environmentally and economically responsible way.